GOVERNMENT OF
WESTERN AUSTRALIA

Browse LNG Precinct

Browse Liquefied Natural Gas Precinct

Strategic Assessment Report

(draft for public comment)

December 2010

PART 4

Environmental Assessment – Terrestrial Impacts

Browse LNG Precinct

Strategic Assessment Report – Structure Display

The State of Western Australia, through the Minister for State Development, has developed the Browse LNG Precinct Strategic Assessment Report (SAR) to enable consideration of a proposed common user liquefied natural gas (LNG) Precinct to process natural gas from the Browse Basin gas fields, at a location near James Price Point, approximately 60 kilometres north of Broome. This SAR is presented in six parts as shown in the following diagram. You are invited to make a submission by visiting the Environmental Protection Authority website at http://public-consult.epa.wa.gov.au/portal. Appendices are also available at http://www.dsd.wa.gov.au/browseLNG.

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Nomenclature, Acronyms, Measurements and Units List

Acronym	Definition
ABS	Australian Bureau of Statistics
ACMC	Aboriginal Cultural Materials Committee
AGRU	Acid Gas Removal Unit
AGT	Aero Derivative Gas Turbines
AH Act	*Aboriginal Heritage Act 1972(WA)*
AHC	Aboriginal Heritage Commission
AHD	Australian Height Datum
AIHW	Australian Institute of Health and Welfare
AIMS	Australian Institute of Marine Science
aMDEA	activated methyl-di-ethanol amine
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment Conservation Council
AQIS	Australian Quarantine Inspection Service
ARI	Average Recurrence Interval
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ARR	Australian Rainfall and Runoff
ARRP Act	*Agriculture and Related Resources Protection Act 1976*
ASIA	Aboriginal Social Impact Assessment
ASS	Acid Sulphate Soils
ATSIHP Act	*Aboriginal and Torres Strait Islander Heritage Protection Act 1984*
AWAC	Acoustic Doppler Wave and Current Profiler
BLNG	Browse Liquefied Natural Gas
BLNG Precinct	Browse Liquefied Natural Gas Precinct
BoM	Bureau of Meteorology
BPA	Broome Port Authority
BPEMP	BLNG Precinct Environmental Management Plan
BPMF	Broome Prawn Managed Fishery
BPP	Benthic Primary Producer
BPPH	Benthic Primary Producer Habitat
Bq kg-^{1}	Becquerels per kilogram
BRAC	Broome Recreation and Aquatic Centre
BRAMS	Broome Regional Aboriginal Medical Service
BRUVS	Baited Remote Underwater Video Surveys
BTEX	benzene, toluene, ethybenzene and xylene
°C	degrees celsius, degrees centigrade
$CaCO_3$	Calcium Carbonate
CAEPR	Centre for Aboriginal Economic Policy Research
CALM	Department of Conservation and Land Management , now DEC
CAMBA	China-Australia Migratory Bird Agreement
Category A	These are the core elements of the BLNG Precinct, including associated infrastructure, necessary to process and export hydrocarbons.
Category B	These are indirect activities and actions as a result of the BLNG Precinct that are considered in the impact assessment but do not form part of the approvals process.

Acronym	Definition
Category C	Related projects that are outside the scope of the Strategic Assessment but form part of the cumulative impact assessment.
CCIMP	Committee for Introduced Marine Pest Emergencies
CEMP	Construction Environment Management Plan
CDEP	Community Development Employment Projects
CEO	Chief Executive Officer
CH_4	Methane
CHMP	Cultural Heritage Management Plan
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2 -e	Carbon Dioxide Equivalents
CPI	Consumer Price Index
CPRS	Carbon Pollution Reduction Scheme
CSD	Cutter Suction Dredger
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTM	Chemical Transport Model
CWR	Centre for Whale Research
Cwth	Commonwealth
DAFF	Department of Agriculture, Fisheries and Forestry
DAFWA	Department of Agriculture and Food Western Australia
dB	decibels
dB(A)	A-weighted decibels
DCCEE	Department of Climate Change and Energy Efficiency
DDSDMP	Dredging and Dredge Spoil Disposal Management Plan
DEC	Department of Environment and Conservation
DEEWR	Commonwealth Department of Education, Employment and Workplace Relations
DEWHA	Commonwealth Department for the Environment, Water, Heritage and the Arts, now SEWPAC
DIA	Department of Indigenous Affairs
DLGRD	Department of Local Government and Regional Development
DLNG	Darwin Liquefied Natural Gas
DMAG	Dredging Management Advisory Group
DMP	Department of Mines and Petroleum
DoF	Department of Fisheries
DoIR	Department of Industry and Resources
DoLA	Depart of Land Administration
DoP	Department of Planning
DoT	Department of Transport
DoW	Department of Water
DPI	Department for Planning and Infrastructure
DRDL	Department of Regional Development and Lands
DRET	Commonwealth Department of Resources, Energy and Tourism
DRF	Declared Rare Flora
DSD	Department of State Development
DSDG	Dredge Spoil Disposal Ground

Acronym	Definition
DSDMP	Dredging and Dredge Spoil Disposal Management Plan
EAG3	Environmental Assessment Guideline 3
ECHT	Environment and Cultural Heritage Team
EIA	Environmental Impact Assessment
EMP	Environment Management Plan
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
eq.	Acid Equivalents
EVT	Evergreen Vine Thickets
FEED	Front End Engineering Design
FESA	Fire and Emergency Services Authority of Western Australia
FID	Final Investment Decision
FIFO	Fly in/Fly out
FIS	Fishing Industry Impact Study
FLNG	Floating LNG
FM Act	*Fish Resources Management Act 1994*
Foundation Proponent	Woodside is a potential Foundation Proponent
FRMR	Fisheries Resource Management Regulations 1995
FRP	Filterable reactive phosphorus
GBRMPA	Great Barrier Reef Marine Park Authority
GBS	Gravity Based Structure
GCA	Gaffney Cline and Associates
GDEs	Groundwater Dependant Ecosystems
GDP	Gross Domestic Product
GHG	Greenhouse Gas
G	grams
GJ	gigajoule
GL	gigalitre
GL/yr	gigalitres per year
GGAP	Greenhouse Gas Abatement Plan
GROH	Government Regional Officer Housing
GRP	Gross Regional Product
GSP	Gross State Product
GST	Goods and Services Tax
GWP	Global Warming Potential
H_2S	hydrogen sulphide
ha	hectare
HAT	Highest astronomical tide
HCWA	Heritage Council of Western Australia
HDD	Horizontal Directional Drilling
HFCs	Hydroflurocarbons
HIA	Heritage Impact Assessment
HNO_3	Nitric Acid

Acronym	Definition
HoA	Heads of Agreement
HONO	Nitrous Acid
HPA	Heritage Protection Agreement
hr	hour
HSE	Health, Safety and Environment
HYPE	Helping Young People Engage
IBRA	Interim Biogeographic Regionalisation of Australia
ICC	Indigenous Coordination Centres
IFPIC	Indigenous Free Prior Informed Consent
IGCC	Integrated Gasification Combined Cycle
ILUA	Indigenous Land Use Agreement
IMO	International Maritime Organisation
IMS	Invasive Marine Species
IMSMP	Invasive Marine Species Management Plan
IP	Important Population
IPCC	Intergovernmental Panel on Climate Change
IS	Integrated System
ISQG	Interim Sediment Quality Guidelines
ITF	Indonesian Throughflow
IUCN	International Union for Conservation of Nature
JAMBA	Japan-Australia Migratory Bird Agreement
JPP	James Price Point
KAMSC	Kimberley Aboriginal Medical Services Council
KAC	Kimberley Aquaculture Corporation
KACS	Kimberley Aged and Community Services
KDC	Kimberley Development Commission
KES	Kullari Employment Services
kg	kilogram
$kgCO_2$-e	kilogram of Carbon Dioxide Equivalents
kmh^{-1}, km/h	kilometres per hour
kHz	kilohertz
KLC	Kimberley Land Council
km	kilometre
km^2	square kilometre
kn	knot
KPP	Kadar Pearson and Partners
kt	kilotonne
LAU	Local Assessment Unit
LCUs	Landscape Character Units
LGA	Local Government Area
LIA	Light Industrial Area
LiDAR	Light Detection and Ranging
LIGT	Large Industrial Gas Turbines
LNG	Liquefied Natural Gas
LNG Hub	Alternative wording for BLNG Precinct

Acronym	Definition
LoR	Limit of Reporting
LPG	Liquefied Petroleum Gas
LPS	Local Planning Strategy
LSR	Light Sensitive Receptors
LVIA	Landscape and Visual Impact Assessment
$\mu g/m^3$	microgram per cubic metre
$\mu g\ g^{-1}$, $\mu g/g$	microgram per gram
$\mu g\ L^{-1}$, $\mu g/L$	microgram per litre
µm	micrometre
$\mu g\ m^{-3}$, $\mu g/m^3$	microgram per metre cubed
µMol	micromole
m	metre
m^2	square metre
m^3	cubic metre
m^3/hr	cubic metre per hour
m/s	metres per second
Ma	Mega annum (million years)
mAHD	Metres Australian Height Datum
MDS	Multi Dimensional Scaling
MEG	Mono-ethylene glycol
MF	Marine Facility
$mg\ L^{-1}$, mg/L	milligram per litre
MIGT	Medium Industrial Gas Turbines
ML	megalitre
mm	millimetre
MMbtu	Millions of British Thermal Units
MNES	Matters of National Environmental Significance
MODIS	Moderate Resolution Imaging Spectroradiometer
MOF	Materials Offloading Facility
mol%	Mole percentage
MPA	Marine Protected Areas
MPB	Microphytobenthos
ms^{-1}, m/s	metre per second
MSL	Metres below sea level
Mt	megatonne (million tonne)
Mtpa	million tonnes per annum
MVT	Monsoon Vine Thicket
MWDMP	Marine Wasterwater Discharge Management Plan
MWh	megawatt hour
NAGD	National Assessment Guidelines for Dredging
NDT	Northern Development Taskforce
NE	North-east
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NES	National Environmental Significance (i.e. matters of NES)

Acronym	Definition
NGA	National Greenhouse Accounts
NGCC	Natural Gas Combined Cycle
NGER Act	*National Greenhouse and Energy Reporting Act 2007*
NH_3	Ammonia
NH_4	Ammonium
NILF	not in labour force
Nm	nautical mile
NNTT	National Native Title Tribunal
NNW	north-north-west
NO_2	nitrogen dioxide
NO_X	oxides of Nitrogen (NO and NO_2)
NPI	National Pollutant Inventory
NRIF	*National Recreational and Indigenous Fishing Survey*
NRM	Natural Resource Management
NSW	New South Wales
NT	Northern Territory
NTA	*Native Title Act 1993*
NTU	Nephelometric Turbidity Units
NWMR	Northwest Marine Region
NWQMS	National Water Quality Management Strategy
O_3	Ozone
OSCP	Oil Spill Contingency Plan
PAH	Polycyclic Aromatic Hydrocarbons
PAR	Photosynthetically Available Radiation
PASS	Potential Acid Sulphate Soils
PBC	Prescribed Body Corporate
PCG	Precinct Control Group
PECs	Priority Ecological Communities
Plan	The formal Plan for the BLNG Precinct under Commonwealth legislation (see also Precinct Plan)
PM	particulate matter
PF	Port Facility
PFCEMP	Port Facilities Construction Environmental Management Plan
PFCs	Perfluorocarbons
ppb	Parts per billion
Ppt	parts per thousand
Precinct Plan	The formal Plan for the BLNG Precinct under Commonwealth legislation (see also Plan)
proponent	Commercial proponents will undertake projects within the Precinct.
Proponent	The Proponent for the Precinct is the Minister for State Development
PRRT	Petroleum Rent Resource Tax
PSD	Particle size distribution
PTS	Permanent Threshold Shift
QA/QC	Quality Assurance/ Quality Control
QMP	Quarantine Management Plan
QLD	Queensland

Acronym	Definition
RBA	Reserve Bank of Australia
RBWG	Roebuck Bay Working Group
RIWI Act	*Rights in Water and Irrigation Act 1914*
RMS	Root Mean Square
RNE	Register of National Estate
RO	Reverse Osmosis
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RORO	Roll on Roll off
RoW	Right of Way
RTO	Registered Training Organisation
SA	Strategic Assessment
SAA	Strategic Assessment Agreement
SAP	Sediment Sampling and Analysis Plan
SAR	Strategic Assessment Report
SE	south-east
SEL	Sound Pressure Level
SEP	State Environmental Policy
SEWPAC	Commonwealth Department of Sustainability, Environment, Water, Population and Community
SF_6	Sulphur Hexafluoride
SIA	Social Impact Assessment
SO_x	oxides of sulphur
SO_2	sulphur dioxide
SOPEP	Shipboard Oil Pollution Emergency Plan
SoSA	Scope of the Strategic Assessment
SPL	Sound Pressure Level
SPMT	Self Propelled Module Trailers
SPRAT	Species Profile and Threats Database
SRE	Short Range Endemic
SRG	Stakeholder Reference Group
SSIMP	Strategic Social Impact Management Plan
STI	Sexually Transmitted Infection
SWIS	South West Interconnected System
TAFE	Technical and Further Education
TAPM	The Air Pollution Model
TBT	Tributyltin
tcf	trillion cubic feet
TCU	Thermal Combustion Units
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
TIA	Tourism Impact Assessment
TJ	terajoules
TM	Thematic Mapper
TN	Total Nitrogen
TOC	Total Organic Carbon
TONC	Traditional Owner Negotiating Committee

Acronym	Definition
ToR	Terms of Reference
TOTF	Traditional Owner Taskforce
TP	Total Phosphorous
tpa	tonne per annum
TPH	Total Petroleum Hydrocarbons
TSHD	Trailer Suction Hopper Dredger
TSS	Total Suspended Solids
TTS	Temporary Threshold Shift
UNDRIP	United Nations Declaration of Rights of Indigenous People
UNFCCC	United Nations Framework Convention on Climate Change
UV	Ultraviolet
VET	Vocational Education and Training
VMP	Vessel Management Plan
VOC	Volatile Organic Compounds
VSR	Visually Sensitive Receptors
WA	Western Australia
WACHS	Western Australian Country Health Service
WALFA	West Arnhem Land Fire Abatement
WAM	Western Australian Museum
WAPC	Western Australian Planning Commission
WC Act	*Wildlife Conservation Act 1950*
WEED	Weed Education Eradication Delivery
WHO	World Health Organisation
WNW	west-north-west
WONS	Weed of National Significance
Woodside	Woodside Energy Limited
WRC	Water and Rivers Commission, now Department of Water (DoW)
WSW	west-south-west
WWF	World Wildlife Fund
WWTP	Waste Water Treatment Plant

1. Environmental Overview

The State of Western Australia (**WA**), through the Minister for State Development (the **Proponent**), proposes to develop an onshore, common-user Liquefied Natural Gas (**LNG**) precinct to process natural gas from Browse Basin gas fields off the west Kimberley coast. The Department of State Development (**DSD**) has been charged with advancing this proposal under direction of the Proponent.

The Browse Liquefied Natural Gas Precinct (**BLNG Precinct** or **Precinct**) would consist of LNG processing facilities and associated infrastructure, and would be located in the vicinity of James Price Point, approximately 60 kilometres (**km**) north of Broome, on the west Kimberley coast of Western Australia. The BLNG Precinct would provide a location for processing gas and associated products from the Browse Basin with an LNG production capacity of up to 50 million tonnes per annum (**Mtpa**). If it were to occur, full development of the Precinct would most likely be phased in as demand for additional processing capacity arises. The Precinct would accommodate a minimum of two proponents at one location and enable sharing of common-user facilities such as the port, roads, infrastructure corridors and workers' accommodation. A **Precinct Plan** has been developed to meet the requirements of the State and Commonwealth Governments.

Woodside Energy Limited (**Woodside**), on behalf of the Browse LNG Development Joint Venture participants, was appointed as a potential Foundation Proponent for the Precinct under the Preliminary Development Agreement signed in October 2009. This Agreement established Woodside as a partner with the State Government in bringing the project to completion.

A detailed and comprehensive assessment has considered the environmental, social, economic, heritage and strategic implications of the Precinct should it reach its full capacity. The assessment process has involved desktop studies, field surveys, modelling, data analysis, impact assessment and stakeholder consultation, the results of which are documented in the BLNG Precinct Strategic Assessment Report (**SAR**).

The purpose of this Strategic Assessment Report is to meet the requirements of the State and Commonwealth governments in accordance with the Terms of Reference. The Strategic Assessment includes a high level impact assessment (including social factors), a description of the strategic proposal, identifying 'future proposals' (to be approved under the *Environmental Protection Act 1986* (the **EP Act**)) and the Precinct Plan (to be endorsed under the *Environment Protection and Biodiversity Conservation Act 1999* (the **EPBC Act**)), and includes the Proponent's proposed draft conditions that may be applied to future proposals. The document includes a summary of existing information, identifying main impact areas and sets out the proposed management arrangements, mitigation and safeguards to ensure impacts are managed.

The SAR is presented in six parts:

Part 1: Executive Summary

Part 2: Strategic Assessment Process including Site Selection, Facilities Description and Consultation Process

Part 3: Environmental Assessment – Marine Impacts

Part 4: Environmental Assessment – Terrestrial Impacts

Part 5: Social Assessment

Part 6: Commonwealth Matters including Precinct Plan, Management Arrangements and Matters of National Environmental and Social Significance

This document (**Part 4**) of the Strategic Assessment Report provides an overview of the existing terrestrial environment, and assessment of potential impacts and proposed mitigative measures.

Although the SAR is formatted into 6 parts it is important to note that they are not standalone parts and in particular key sections in **Part 2** will help inform an understanding of this Part. Information in **Part 2** of relevance to this Part includes

the site selection process, the description of facilities and activities, indirect activities and related projects and the impact assessment methodology.

The proposed BLNG Precinct is situated within the Kimberley Region, however from a terrestrial bioregional perspective it is more accurately defined as being in the Dampierland Bioregion and the Pindanland subregion of this Bioregion which includes the Dampier Peninsula. The area is associated with a number of important features including monsoon vine thickets, vast grassland of the Roebuck Plains, coastal swamps adjacent to Eighty Mile Beach and a number of rare plants. The Kimberley region also supports an active population of people with a diversity of backgrounds, experiences, and interests with many utilising the marine resources of the bioregion. These are discussed further in **Part 5** (Social Assessment).

This section (**Section 1**) provides a description of the existing physical and ecological terrestrial environment of the Dampierland Bioregion and in particular the more localised James Price Point coastal area. The description has been compiled from a composite of desktop studies, physical and ecological baseline surveys and investigations undertaken to support the site selection and Strategic Assessment processes. The section is structured to provide information relevant from the Kimberley region, as well as that from the Dampier Peninsula and James Price Point coastal area. This section provides an understanding of the key terrestrial environmental values that may be affected by the proposed BLNG Precinct development and to place the James Price Point coastal area into a regional context.

Subsequent sections (**Part 4, Section 2**) discuss the impacts and mitigation measures for the key terrestrial environmental values discussed earlier and provide summary tables of the assessment of impacts and mitigation measures proposed to ensure these impacts are minimised to the extent possible. For convenience, the following provides a cross-reference to the summary tables provided for each terrestrial environmental factor:

Soils and Geomorphology	**Table 2.1-5**
Surface Water	**Table 2.2–4**
Groundwater	**Table 2.3–4**
Terrestrial Flora and Vegetation	**Table 2.4–10**
Species of Ethno-biological Significance	**Table 2.5–5**
Terrestrial Fauna	**Table 2.6–8**
Terrestrial Ecosystem Integrity	**Table 2.7–4**
Air Quality	**Table 2.8–13**
Greenhouse Gas Emissions	**Table 2.9–11**

In most instances, the significance of residual impact, following the implementation of mitigation measures, was assessed to be low or very low. One exception to this was related to impacts on Terrestrial Flora and Vegetation where the clearing for the development is unable to be avoided and the impact was assessed as high, in particular because of the necessity to clear a small area of monsoon vine thicket on the coastal fringe. To the extent possible this impact was minimised through the refined site selection process by setting the Precinct back from the coast. This resulted in a reduction of potential disturbance to monsoon vine thicket by an estimated 118ha. However it could not be totally avoided without the likelihood of significantly increasing marine impacts and risks to indigenous heritage. To address this residual impact, increased protection and improved management of the vegetation on the Dampier Peninsula, in particular monsoon vine thicket, is proposed.

The only other instance where residual impacts were not assessed as low or very low related to the impact which the physical presence of the BLNG Precinct would have on groundwater recharge which was assessed as medium significance. Although this potential impact was considered to be very localised, it would be long term. Monitoring of the impacts of this would be undertaken and responses developed as necessary. The management framework presented in the SAR is focused on the mitigation of potential downstream ecological impacts relevant to this assessment.

Overall, the assessment of the impacts on the terrestrial environment demonstrates that the site selection process undertaken by the Northern Development Taskforce (**NDT**) succeeded in ensuring that most areas of environmental significance or sensitivity were avoided. It also supports the S16(e) advice of the Environmental Protection Authority (**EPA**) that environmental risks and impacts were likely to be manageable (EPA, 2008). For example the site selection resulted in most impacts being on Pindan vegetation which is very common on the Dampier Peninsula (representing approximately 90% of known extent of all vegetation communities) and which, through improved management measures, can have its environmental condition enhanced to maintain or improve overall environmental outcomes on the Peninsula.

1.1. Existing Terrestrial Environment

This section provides a description of the existing regional and local terrestrial environment of the proposed BLNG Precinct at James Price Point. A regional context to the project is provided by examining the existing terrestrial environment of the Kimberley region and Dampier Peninsula, whilst examination of the existing terrestrial environment of the James Price Point coastal area establishes the local setting. This information has been compiled based on desktop studies, surveys and investigations undertaken to support the NDT site selection process, in addition to studies and investigations undertaken as outlined in the Scope of the Strategic Assessment (**SoSA**) (DSD, 2010b; **Appendix A-2**).

1.1.1. Environmental Context

James Price Point is located on the Dampier Peninsula in the west Kimberley region of WA, approximately 60km north of the town of Broome.

1.1.1.1. The Kimberley

The Kimberley region extends northwards from the Great Sandy Desert to the rugged uplands, escarpments and coastal islands of the Kimberley Plateau and east to the NT border. It covers a land area of 424,500 square kilometres (**km^2**), equivalent to 1.8 times the size of Victoria (DEC, 2009a). The Kimberley region has a tropical monsoonal climate, that is characterised by a hot and humid 'wet' season from November to March (summer) and a 'dry' season (winter) from April to October. Ninety percent of the Kimberley's rainfall occurs during the wet season, resulting in vast volumes of water being discharged into the ocean from the region's main rivers. Upon the transition into winter, south-easterly winds bring dry continental air over the region, resulting in clear days and cool nights.

The north, central, south and eastern Kimberley regions each contain distinct geomorphologies, soil landscapes and biota that has resulted in different land-use histories and current land condition (DEC, 2009a). The Kimberley has historically been subject to ongoing impacts as a result of resource development and pastoral activities (DEC, 2009a). In addition, the spread of cattle, changes to fire regimes and degradation to savannahs has led to the reduction of some small mammal and bird abundances (DEC, 2009a). These factors are important in understanding the environmental values of the Dampier Peninsula and James Price Point in relation to the surrounding Kimberley.

The Kimberley coastline consists of an assortment of habitats resulting from diverse localised environmental conditions. These include sandy beaches, cliffs and headlands, small inlets, mudflats and mangrove lined shores, as well as numerous offshore islands.

1.1.1.2. Dampier Peninsula

The Dampier Peninsula is used as the basis for describing the 'regional' environmental context, although it in itself is a sub-region of the Kimberley.

The Interim Biogeographic Regionalisation of Australia (**IBRA**) recognises 85 distinct bioregions which are delineated according to the dominant vegetation and land systems (DEWHA, 2004). The BLNG Precinct area is located in the Dampierland Bioregion which covers approximately 83,700km^2; extending from south of Pardoo, northwards along Eighty Mile Beach to the north of Derby (**Figure 1-1**). This bioregion is divided into two distinct subregions: Fitzroy Trough and Pindanland (DEC, 2009a). The BLNG Precinct is located on the western coast of the Pindanland subregion which covers an area of approximately 51,989km^2. This subregion includes the Dampier Peninsula.

The known rare features of the Pindanland subregion include:

- numerous patches of rainforest found mainly behind the primary dune system with a structure unique to the Dampier Peninsula (monsoon vine thickets);
- vast grasslands of the Roebuck Plains;
- coastal swamps adjacent to Eighty Mile Beach;
- the Declared Rare Flora (**DRF**) species *Keraudrenia exastia* and *Pandanus spiralis* var. f*lammeus;* and
- claypans supporting populations of the uncommon aquatic plant *Nymphaea beaglensis* (Biota, 2009c; **Appendix C-18**).

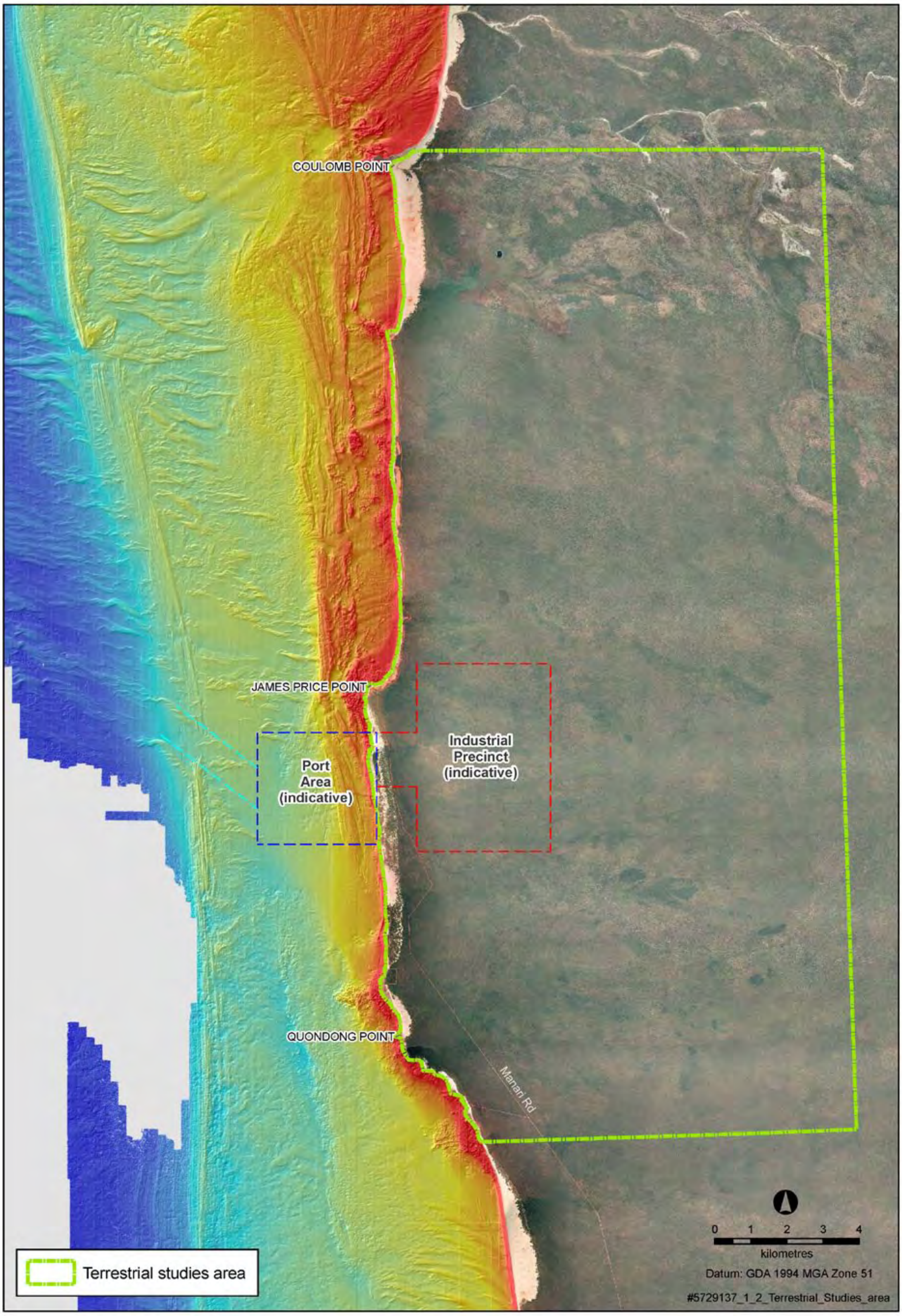
▪ **Figure 1-1 IBRA Bioregions in the Kimberley Region.**

A number of threatening processes, as identified by the Commonwealth Department for the Environment, Heritage, Water and the Arts (**DEWHA**) (now the Department of Sustainability, Environment, Water, Population and Community (**SEWPAC**)) and the Department of Environment and Conservation (**DEC**), are currently operating on the Dampier Peninsula. SEWPAC lists 19 Key Threatening Processes under the EPBC Act of which, predation by feral cats and the European red fox, are particularly relevant to the BLNG Precinct area based on existing knowledge of the area. Altered fire regimes, introduced flora pests (weeds), grazing pressures and introduced fauna pests have been identified by local DEC officers as high priority threats operating within the Dampierland Bioregion.

1.1.1.3. James Price Point Coastal Area

The study area at James Price Point surveyed by ENV (2008a; **Appendix C-14**, 2008b; **Appendix C-15** and 2008c; **Appendix C-16**), Biota (2009b; **Appendix C-17** and 2009c; **Appendix C-18**) and AECOM (2010a; **Appendix C-19** and 2010b; **Appendix C-20**) is used as the basis for describing the local environmental context (**Figure 1-2**). This is referred to from herein as the James Price Point coastal area.

The James Price Point coastal area, as described in this report and representing the combined study areas described above, covers approximately 31,500 hectares (**ha**) and extends from Cape Boileau (20km south of James Price Point) to Coulomb Point (15km north of James Price Point) and 9km inland. It is approximately 195km north of Eighty Mile Beach and approximately 65km north of Roebuck Bay, both listed Ramsar wetland sites. The area is characterised by Pindan sandplain fringed by narrow bands of sand dunes and Pindan cliffs along its coastal fringe. Narrow ephemeral drainage lines cross east-west towards the coast, some discharging into the ocean periodically with others causing seasonal flooding behind coastal ridges and foredunes that prevent flows from reaching the ocean.



- **Figure 1-2 James Price Point Coastal Area Subject to Terrestrial Studies.**

1.2. Studies and Surveys

There has been a long history of botanical and zoological collection in most parts of the Kimberley. Some studies have covered entire ecosystems (mangrove, rainforest, Devonian ranges), while others have focussed on sampling the landscapes of an individual conservation reserve (Prince Regent, Purnululu) or a particular area or situation (Dampier Peninsula, Edgar Ranges, North Kimberley islands, Mitchell Plateau), or on a particular group of organisms (flora, birds, mammals, frogs, reptiles, fish, land snails, spiders) either locally or Kimberley-wide (DEC, 2009a).

As part of the site selection process and scoping phase for the Precinct Strategic Assessment (**SA**) process, a range of additional studies were identified to support the environmental assessment. The following terrestrial studies have been undertaken to inform the impact assessment process and support decision-making:

- Wet and Dry Season Flora & Fauna Surveys:
  - ENV 2008a (**Appendix C-14**), ENV 2008b (**Appendix C-15**) and ENV 2008c (**Appendix C-16**);
  - Biota 2009b (**Appendix C-17**) and Biota 2009c (**Appendix C-18**); and
  - AECOM 2010a (**Appendix C-19**) and AECOM 2010b (**Appendix C-20**).
- Ethnobiological information (Kimberley Land Council (**KLC**), Margetts and Grabasch, 2010a; **Appendix E-6**);
- Stygofauna and Groundwater dependant ecosystems (**GDE**) (Biota, 2009b);
- Remote Sensing (Terrestrial) (CSIRO, 2010; **Appendix C-21**);
- Ambient Meteorological and Air Quality Monitoring (Woodside, ongoing);
- Migratory Bird Study, James Price Point (Galaxia, 2010; **Appendix C-1**);
- Hydrogeological Review (Rockwater, 2009; **Appendix C-22**); and
- Hydrological Review (BG&E, 2010a; **Appendix C-23** and BG&E, 2010b; **Appendix C-24**).

These are described in more detail in the following sections.

1.2.1. The Kimberley Region

Broad-scale environmental mapping and datasets are available for much of the Kimberley as well as biodiversity information collected from numerous biodiversity and taxon-specific surveys (DEC, 2009a). In addition to the Kimberley Science and Conservation Strategy (DEC, 2009a), a number of other reviews of Kimberley biodiversity, its condition and conservation have also been produced. These sources are listed in the Kimberley Science and Conservation Strategy (DEC, 2009a) and include:

- Kimberley Regional Planning Study (Burbidge *et al*., 1991);
- Biodiversity Audit (May and McKenzie, 2003 and McKenzie *et al*., 2003); and
- Kimberley Regional Plan (Portlock *et al*., 2001).

1.2.2. Dampier Peninsula

There has been limited development on the Dampier Peninsula that has required terrestrial environmental studies to support impact assessment. Kenneally *et al.* (1996) published Broome and Beyond, Plants and People of the Dampier Peninsula, which provides an introduction to the flora and fauna species and vegetation communities that are known to occur. In addition, Ecologia (2005) completed detailed flora and fauna surveys as part of the proposed Beagle Bay Big Tree Company Plantation Project on the Dampier Peninsula, approximately 80km north east of James Price Point.

Since the announcement of the SA process for the LNG precinct, several terrestrial biological and physical studies have been commissioned by the WA Government.

The NDT commissioned ENV to undertake (dry season) environmental studies on the Dampier Peninsula as part of the LNG precinct site selection process.

The following three reports were produced from these studies (supporting ecological studies DFS1 and DFS2):

- ENV (2008a) Perpendicular Head – North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vegetation Assessment (**Appendix C-14**);
- ENV (2008b) Perpendicular Head – North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Flora Assessment (**Appendix C-15**); and
- ENV (2008c) Perpendicular Head – North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vertebrate Fauna Assessment (**Appendix C-16**).

Importantly, these studies, combined with those described previously, provide an indication of the presence and distribution of vegetation communities and fauna habitats within each survey area and provide important context as to the likely presence and distribution of such communities and habitats on the Dampier Peninsula.

In addition to these reports, the Commonwealth Scientific and Industrial Research Organisation (**CSIRO**) used remote sensing to classify monsoon vine thickets on the northern Dampier Peninsula based on thematic mapper (Landsat) imagery. This study (supporting study scope DFS5) was undertaken to gain a further understanding of the likely distribution of monsoon vine thicket on the Dampier Peninsula.

1.2.3. James Price Point Coastal Area

Following the EPA's strategic advice on the suitability of James Price Point as the preferred site for the LNG Precinct in late 2008, Biota Environmental Services Pty Ltd was commissioned to undertake further detailed environmental studies (wet season) within the area in 2009. In addition, AECOM was commissioned to undertake further studies to supplement the preceding reports.

The following reports were developed from these surveys, supporting terrestrial ecological studies:

- Biota Environmental Services (2009b; **Appendix C-17**) James Price Point Terrestrial Fauna Survey: Wet Season 2009;
- Biota Environmental Services (2009c; **Appendix C-18**) A Vegetation and Flora Survey of James Price Point: Wet Season 2009;
- AECOM Australia Pty Ltd (2010a; **Appendix C-19**) Supplementary Terrestrial Flora and Vegetation Assessment James Price Point WA;
- AECOM Australia Pty Ltd (2010b; **Appendix C-20**) Supplementary Terrestrial Fauna and Habitat Assessment James Price Point WA);
- Kimberley Land Council (Margetts and Grabasch, 2010a; **Appendix E-6**), Kimberley LNG Precinct Strategic Assessment Ethnobiological Report; and
- Galaxia Marine Consulting Pty Ltd (2010; **Appendix C-1**) Browse LNG Development Migratory Bird Study, James Price Point.

These studies provide an understanding of existing environmental conditions upon which a baseline understanding can be developed as the basis for a strategic environmental assessment.

All the studies listed above have been extensively drawn upon as part of the existing environment descriptions contained within this section.

1.3. Physical Terrestrial Environment

The physical terrestrial environment at the BLNG Precinct and surrounds is discussed in the following sub-sections. It includes information on the geology, soils and landforms, and the hydrology in the James Price Point coastal area.

1.3.1. Geology

The proposed BLNG Precinct is located on the western central coast of the Dampier Peninsula in WA. The following sub-sections describe the physical setting, the geology and soils that underlie the James Price Point coastal area as well as the current understanding of the tectonic history of the area.

No detailed geological or geotechnical site investigations have been conducted at the James Price Point coastal area to date, although such investigations are planned to support future assessments. Desktop studies completed to date (Rockwater, 2009; **Appendix C-22**) and (Atteris, 2010a) provide some information on likely geological conditions at the James Price Point coastal area. Information from public domain publications and maps as well as review of publically available satellite imagery is also available to provide an initial understanding of underlying geological conditions.

1.3.1.1. Physiographic Setting

Topographic relief across the Dampier Peninsula ranges from 0 metres (**m**) Australian Height Datum (m **AHD**) to approximately 245m AHD at a location roughly 34km east of James Price Point. This topographically high ground is located roughly in the centre of the peninsula and ground surfaces generally fall gradually outward toward the coasts to the west, north and east. The relatively flat lying slopes are incised by surface drainage lines that are ephemeral in nature (flow only during the wet season).

In the vicinity of the James Price Point coastal area, surface elevation slopes generally toward the west with an estimated maximum topographic height of approximately 75m AHD along the north eastern side of the proposed BLNG Precinct (**Figure 1-3**).

Stratigraphic Units

The rocks and sediments interpreted to underlie the Dampier Peninsula are described in detail by Gibson and Walton (1982) and in general comprise Precambrian age, greater than 542 million years or mega annums (**Ma**), metamorphosed sediments and crystalline intrusive rocks overlain by a sequence of Ordovician to Cretaceous Age (488 to 99Ma) lithified sediments (Canning Basin sediments), which are themselves overlain by Tertiary to Quaternary Age (65Ma to recent) chemical precipitates and unconsolidated and partially consolidated sediments.

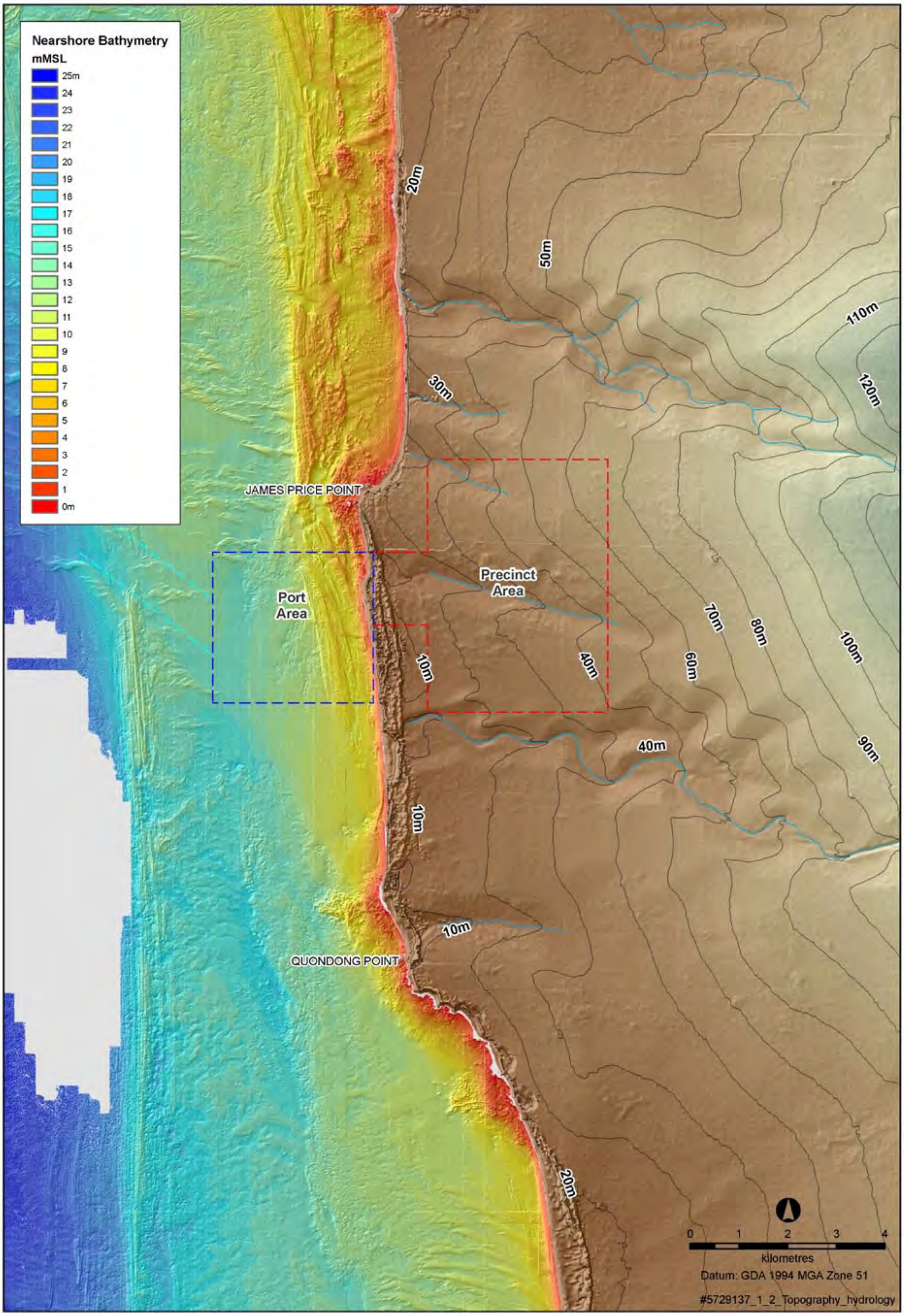
The lithologic units most likely to be affected by establishment of the BLNG Precinct at the James Price Point coastal area are presented in **Table 1-1**. The information provided below does not include lithologic units that might laterally correlate or inter-bed with those units presented, though the possibility of additional interbedded lithologies is not explicitly excluded.

- **Table 1-1 Lithologic Units Associated with the BLNG Precinct.**

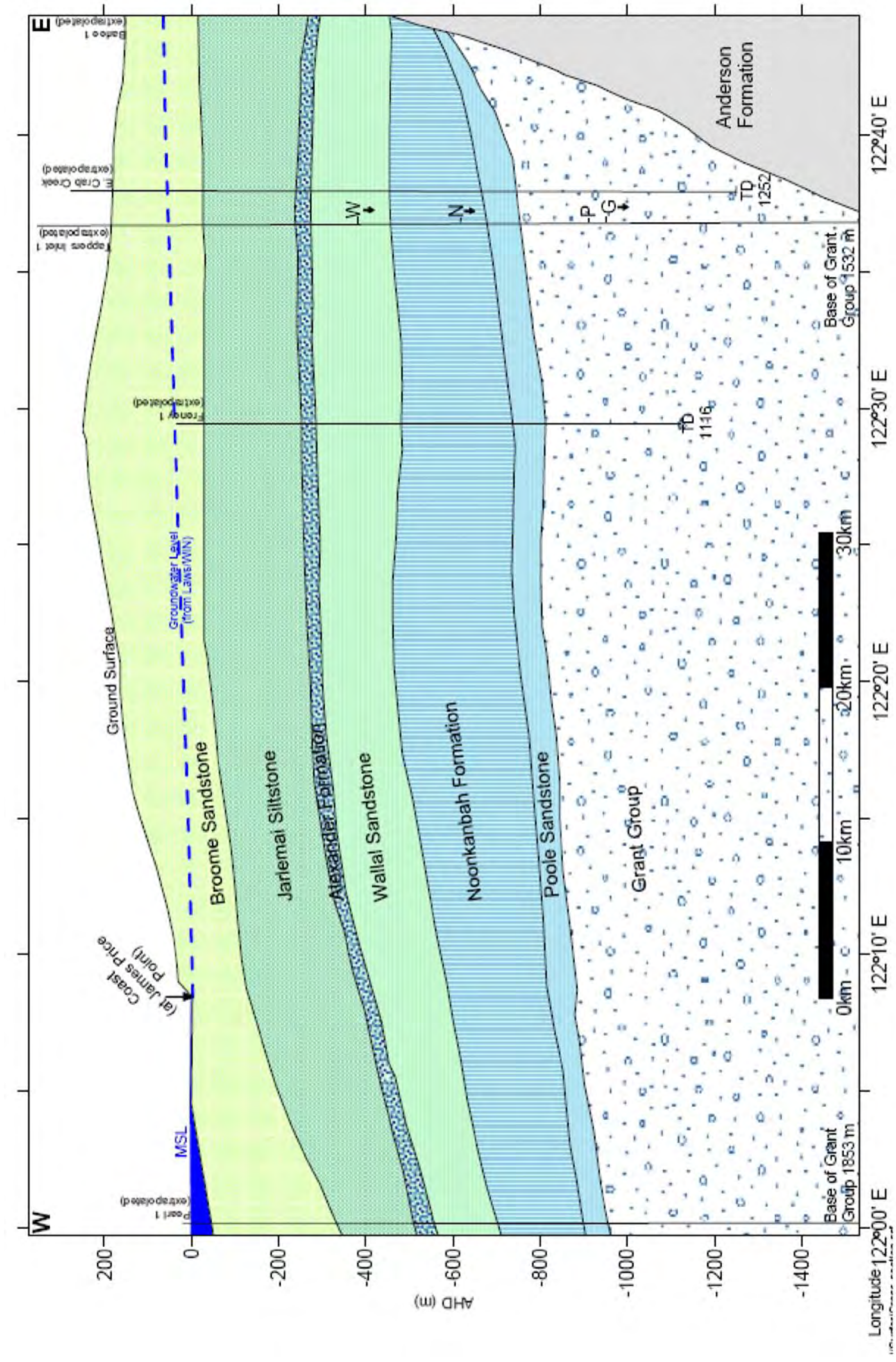
Age	Rock Unit Name and Map Symbol	Maximum Reported Thickness (m)	Characteristic Lithology
Quaternary	Sand Plain (Qzs)	10	Sand or gravel plains; quartz sand sheets commonly with ferruginous pisoliths or pebbles, minor clay; local calcrete, laterite, silcrete, silt, clay, alluvium, colluvium, aeolian sand and Pindan sands.
Quaternary	Beach Dune Complex (Qdc)	20	Beach sand, sand dunes, coastal dunes, beaches, and beach ridges; calcareous and siliceous, locally shelly and/or cemented (beach rock) reworked sediments.
Early Cretaceous	Broome Sandstone (Kb)	300	Fine- to very coarse-grained sandstone with minor mudstone and conglomerate. Considered to be a deltaic sedimentary sequence.
Early Cretaceous to Late Jurassic	Jarlemai Siltstone (JKr)	238	Shallow marine laminated pink and purple siltstone with a sugary texture, massive and partly sandy mudstone and limestone.
Late Jurassic	Alexander Formation (Ja)	219	Fine to medium grained sandstone, interbedded mudstone; bioturbated; minor conglomerate lenses; fossiliferous.
Cretaceous to Early Jurassic	Wallal Sandstone (Jl)	500	Sandstone, siltstone and minor conglomerate with abundant microflora and fauna as well as lignite.

Note: Lithologic units derived from a combination of online map sources (Geoview.WA and Australian Stratigraphic Units Database) and Gibson and Walton (1982) “Broome, sheet SE/51-6 - Explanatory Notes”.

Figure 1-4 provides a subset of the Gibson and Walton (1982) 1:250,000 scale Broome geologic map (sheet SE/51-6) showing the surficial geology in the vicinity of the James Price Point coastal area. The regional east-west geological cross section of the Dampier Peninsula is diagrammatic, and the depths are approximate only (Rockwater, 2009; **Appendix C-22**).



■ **Figure 1-3 Topography and Surface Hydrology of the James Price Point Coastal Area.**



■ **Figure 1-4 Surface Geology of the James Price Point Coastal Area.**

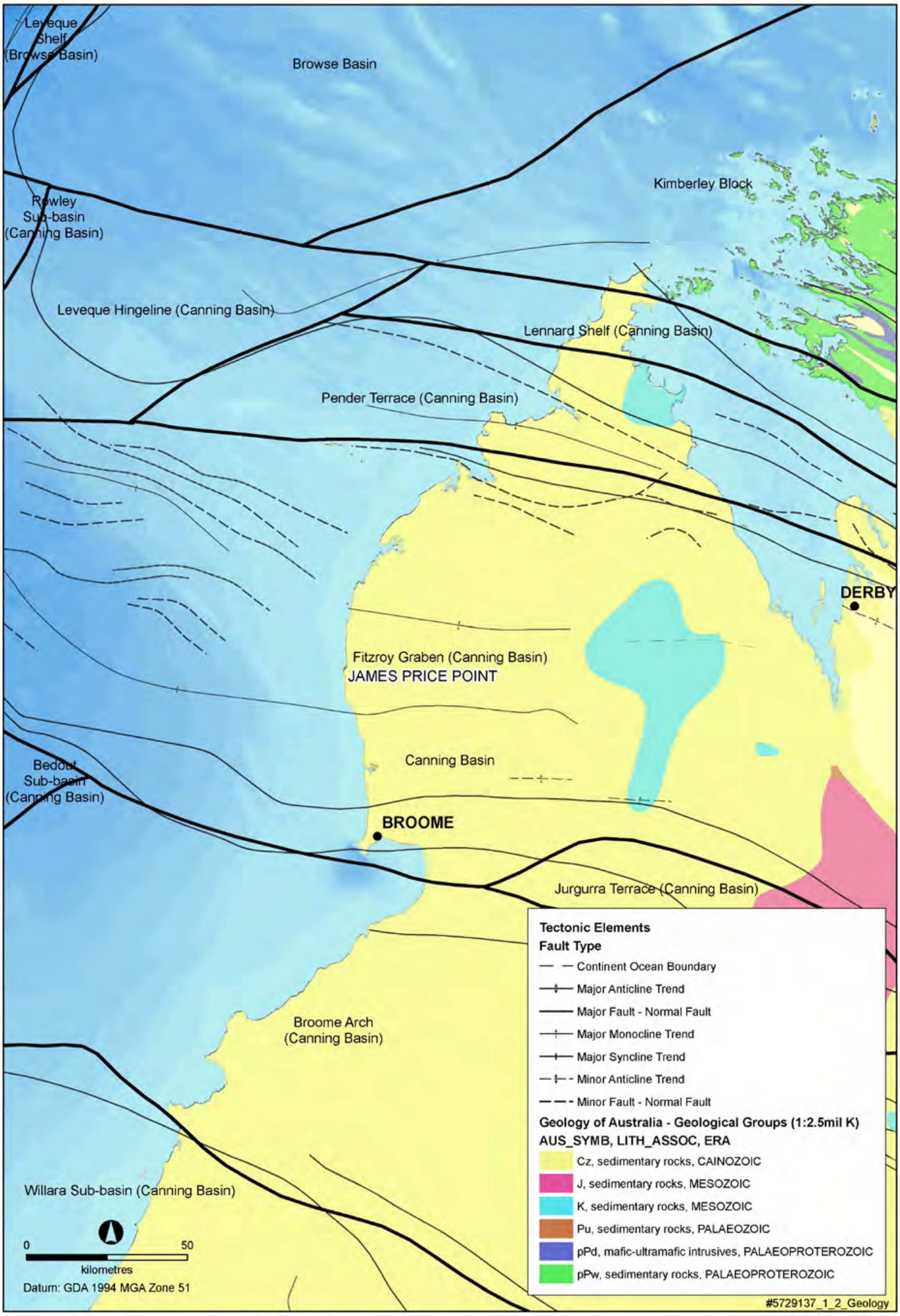
1.3.1.2. Tectonic History and Structural Setting

The current understanding of the tectonic setting underlying the James Price Point coastal area and its surrounds is based almost exclusively on interpretation of geophysical surveys and drilling conducted by the petroleum industry.

This tectonic history of the area begins in the Precambrian Age (over 542Ma) with the deposition of sediments onto the primary crystalline basement. These sediments were subsequently modified by crystalline intrusive rocks and the whole sequence metamorphosed. A hiatus of roughly 54Ma ensued during which the existing rocks were eroded. Sedimentation during transgressions (relative sea level highs) interspersed with erosional periods as a result of emergence (relative sea level lows) resulted in greater than 7,000m (vertical displacement) of marine and near shore sedimentary rocks of the Canning Basin sequence being deposited in the precinct area. The Canning Basin sequence of rocks was deposited from the Early Ordovician (488Ma) to the Early Cretaceous (130Ma). Subsequent to the deposition and lithification of these rocks, Triassic age intrusive rocks (dykes and sills) locally cut the basement and sedimentary sequences.

The James Price Point coastal area is situated on a large portion of the Dampier Peninsula that is in a structural graben (a fault bound block that has undergone downward displacement with respect to the surrounding crustal elements) known as the Fitzroy Trough. The Fitzroy Trough and its bounding faults are oriented roughly west northwest – east – southeast. Drilling data suggests that the Fitzroy Trough was initiated in approximately the Middle Devonian (392Ma). The Fenton Fault system (the southern bounding fault system of the Fitzroy Trough) is located in the vicinity of Broome and has an estimated vertical displacement of approximately 4,000m. A number of east-west oriented folds have been identified in the Canning Basin sedimentary rocks within the Fitzroy Trough system. The origin of these folds has been attributed to right lateral shear along the Fenton and northern bounding faults of the Fitzroy Trough. One such anticlinal fold (the Baskervile Anticline) is preserved in bedrock units underlying this part of the Dampier Peninsula that includes the James Price Point coastal area.

A map showing the estimated thickness of Canning Basin sedimentary rocks and bounding faults of the Fitzroy Trough is presented in **Figure 1-5**.



- **Figure 1-5 Canning Basin Sediment Thickness and Bounding Faults of the Fitzroy Trough.**

Soils and Landforms

Developing an understanding of the soils and landforms at the James Price Point coastal area is of particular importance to understanding the processes that have produced this environment as well as the relationship between local ground conditions and native flora and fauna.

The following sections provide information to date on the soils and landforms, both underlying the potential BLNG Precinct site and in the general James Price Point coastal area. Future studies may provide information refining this interpretation of the present surficial geologic environment or provide evidence of new soil or landforms in the area.

1.3.1.3. Soil Types and Characteristics

The sediments and rocks available to a specific area form the building blocks of geomorphologic landform. Subtle differences in these materials can result in significantly different landforms. Variability in characteristic grain size, specific gravity of sediments, the degree of cementation and angularity of particles are a few of the characteristics that may influence the resulting presence, absence or shape of a landform. The soils present have been identified from published sources or inferred from review of aerial imagery of the precinct. In the vicinity of the James Price Point coastal area, these soils are expected to lie directly on the Broome Sandstone which may itself act as a source of sand and silt sized material as a result of weathering.

The areal distribution of some of the surficial soil material (regolith) present in the vicinity of the James Price Point coastal area is provided on **Figure 1-6**. This figure does not include areas of coastal dune sands or fine grained sediments associated with small sedimentary basins east of the dunes which are known to occur.

Following is a brief description of the soil types expected to be present at or adjacent to the BLNG Precinct. These materials are presented in east to west order.

Pindan Sands

Pindan sands are characterised by the combination of sand sized (0.0625 to 1.68 millimetres (**mm**)) particles (generally quartz rich) intermixed with silt and clay sized particles of clay minerals. When present in sufficient amounts, the clay minerals act to cement the sand grains, providing weak bridging cementation. This material is sensitive to water; the clays weaken when wetted and the weakly cemented sands lose cohesion, disaggregating into a mix of loose sands and clay slurry. Where undisturbed, the Pindan sands form relatively planar, gently west dipping, slopes that underlie the precinct and its surrounds. When exposed to the erosive effects of the near shore beach environment, they form beach cliffs from James Price Point heading northward.

Alluvial and Colluvial Sands (Sand Plain Sands)

These materials are undifferentiated alluvial, colluvial or eolian sediments. They may be interbedded with, or contain discrete clasts or lenses of gravel size material as well as local interbeds or mixtures of silt and clay. These sands cover the majority of the surface at and surrounding the BLNG Precinct. They can be expected to have highly variable degrees of compaction and resulting soil strength and may be susceptible to erosion. Based on the primary source of the Broome Sandstone and the extended time these materials have been exposed to terrestrial weathering, the dominant mineral component of the sands is likely to be quartz. These materials may be found in stream channels or adjacent slopes of the local ephemeral drainages as well as locally overlying the Pindan sands.

Fine Grained Soils and Potential Acid Sulphate Soils

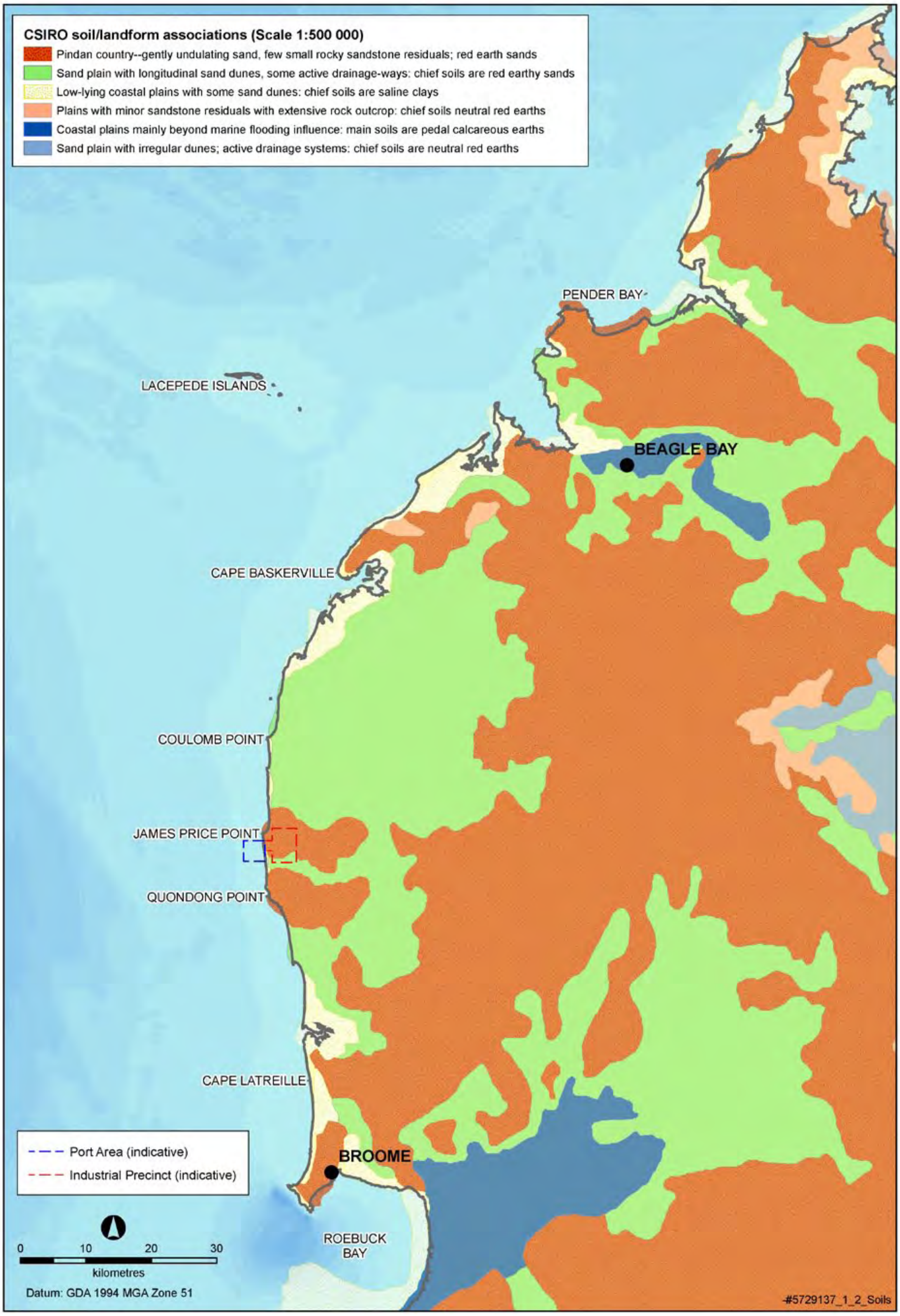
Some of the ephemeral streams identified from topographic maps of the James Price Point coastal area appear to terminate at the eastern toe of the Coastal Dune system. These small basins have the potential to contain increased organic material (primarily decaying vegetation) and finer grained sediments (protected low-energy environment). The combination of these elements can be favourable for the precipitation of iron pyrite if the environments are sufficiently anoxic and the sediments are maintained in a saturated state. Subsequent exposure of these soils to oxidising conditions (excavation or dewatering leading to contact with air) may result in the production of highly acid soils or leachate. The presence of such potential acid producing soils has not been confirmed in these back-dune sedimentary basin areas to date but will be subject to further investigation as part of detailed geotechnical studies.

Dune Sands

These sediments are limited in extent to the near-shore region parallel and adjacent to the western beach face south of James Price Point. Sand is the likely dominant sediment size. Review of the aerial imagery of the dunes composed of these sands suggests the possibility that there may have been significant cementation of these sediments (likely calcretisation). If this is the case, calcium carbonate (**$CaCO_3$**) may form a significant proportion of the sediment mineral type.

Beach Sands

The sediments are likely medium to coarse sands composed of quartz and carbonate skeletal shell fragments. The aerial extent of this material is limited to the beach face below and west of the Pindan sand cliffs and coastal dunes. The beach sands lie directly on submerged or partially submerged outcrops of the Broome Sandstone or near shore carbonate reef which along with weathered Pindan soils may act as sources of sedimentary material for this unit.



■ **Figure 1-6 Surficial Soil Materials in the Vicinity of James Price Point.**

Landforms

The James Price Point coastal area is contained within the Sandland physiographic province as defined by Jutson (1950). This province is characterised by sheet and dunal sand beds overlying either crystalline (usually granitic) or sedimentary bedrock sequences.

A description of the local landforms, identified from available publications or review of the surficial topography and public domain satellite imagery, is provided in the following sub-sections.

1.3.1.4. Sand Plain

In the vicinity of the James Price Point coastal area, the surface terrain is dominated by relatively planar surficial bodies of sand. The predominately sand-sized sediments of this surficial blanket of soils have been locally incised by ephemeral drainages where concentrations of seasonal surface water flow have locally eroded the sediments. This landform underlies the majority of the area.

The planar topography of the majority of sand plain surface suggests that sheet flow is the dominant surface flow mechanism with localised channelling into shallow broad ephemeral stream channels. There is insufficient flow to self-scour the mouths of the ephemeral drainages and the westward (beach) portions of these drainages are likely to be dominated by longshore transport of sediments.

There are also two separate ephemeral stream morphologies expressed in the vicinity of the BLNG Precinct. North and south of the BLNG Precinct, the ephemeral streams show meanders and a connected distributed stream network that extends inland to the eastward topographic high. Near the coast there are several small linear stream valleys with broad relatively 'V' shaped cross sections that may be influenced by bedrock structure. Meandering stream valleys usually represent established streams while linear 'V' shaped stream valleys are either younger or controlled by preferentially oriented weaknesses in the bedrock or overlying sedimentary units.

1.3.1.5. Back Dune Sedimentary Basins

The surface trace of some of the ephemeral stream systems (identifiable by inspection of the contour map) terminate at the westward edge of the dune system. Based on available topography and aerial imagery these stream terminations form basins which are relatively small in lateral extent and have no apparent surface outflows. The basins generally have denser vegetative cover and appear to be in direct contact with the steep (lee) faces of the coastal dunes. It is possible that the fine grained sediments that are expected to be contained in these basins could locally extend westward beneath the western edges of the coastal dune system.

1.3.1.6. Coastal Dune System

South of James Price Point is a beach-parallel dune sequence that can be readily identified from both aerial imagery and the pattern of complex contours adjacent to the shoreline. The dune system extends from south of James Price Point to Quondong Point covering a linear distance of approximately 7km. The width of the dune system ranges from 400 to 500m and tapers rapidly at the southern end near Quondong Point. The northern end of the dune system has a more abrupt termination, which may have been influenced by the underlying bedrock structure.

This landform is dominated by eolian processes. The continued existence of the dune system in its present form is expected to be most susceptible to changes in airflow and/or sediment source. Apparent post-depositional calcretisation (cementing) of the dune may have stabilised the seaward portions of the structure and could make it less susceptible to changing environmental factors.

1.3.1.7. Beach Cliffs

North of James Price Point the Pindan sands form steep beach cliffs or scarps where they are exposed along the western beach face. These scarps are in the order of 3 to 12m high and are characterised by red sand outwash fans at the base of irregular hummocky cliff faces. In the vicinity of the James Price Point coastal area, the Pindan sands appear to be eroding by a process of mass wasting. The weakly cemented Pindan sands maintaining some integrity are spalling off the scarp face in relatively large blocks (up to 350 square metres (**m^2**)). The intact blocks would be acting as 'biological rafts' supporting the original vegetation until they are gradually eroded into constituent parts. The surfaces of

these rafts appear to have moderate slopes toward the west (seaward) and they gradually decrease in height to the west, suggesting that erosion is taking place from the lower portions of the blocks or that the blocks are sliding toward the sea on a layer of softer sediment.

Further north and potentially south of James Price Point, the beach cliff faces have a smaller horizontal footprint and appear to be closer to the shoreline.

1.3.1.8. Beach Face

The beach face in the vicinity of the James Price Point coastal area appears to be an erosional environment. The beach face in general is of limited width and is predominately bounded to the east by relatively steep cliff faces. The western extent of the beach face is tidally controlled but can be seen in the vicinity of the James Price Point coastal area to thin and in places disappear onto shallow rock or reef platforms. North of James Price Point, the beach face appears to be from 20 to 30m wide from the surf zone to the toe of the Pindan cliffs. Immediately adjacent to James Price Point, the beach face is locally overprinted by the sediments derived from mass wasting of the Pindan cliffs. To the south of James Price Point, the beach face blends into the coastal dune sands, where it is not locally limited by what appear to be wave cut scarps at the western edge of the linear dune system. The beach face ranges in width in from 30 to 70m where it is associated with the coastal dunes.

Initial review of aerial imagery does not provide a clear indication of longshore transport of sand along the beach face near the precinct. The erosional environment that dominates the beach face in this region makes the transport direction difficult to accurately predict by this method alone.

1.3.1.9. Rocky Headland

Immediately east of and underlying the sands of the beach face environment at the James Price Point coastal area, is a rocky substrate that appears to be a sub tidal rock platform. Inspection of available imagery suggests that the platform has a flat lying or gently west dipping planar surface. The rock is identified on geologic maps as belonging to the Broome Sandstone, though it may be locally overlain by coastal carbonate reef deposits. This rocky headland forms the point east of the BLNG Precinct.

1.3.2. Surface Water and Hydrology

The following sub-sections describe the surface water hydrology on a regional and local scale.

1.3.2.1. Dampier Peninsula

The Dampier Peninsula has a tropical monsoon climate with a wet season from November to March. Over 75% of the average annual rainfall falls between January and March, associated with thunderstorms and tropical cyclones, and very little rainfall occurs during the dry season months from April to October with September and October being the driest months (Water and Rivers Commission, (**WRC**) 1997).

The Department of Water (**DoW**) is currently developing a regional water plan for the Kimberley, contributing to a framework for water management, and has published several discussion papers as part of this work. The purpose of the Kimberley regional water plan will be to establish the future directions regarding identified water management issues. It will define Department of Water commitments to the region for the next 10 to 20 years, while acknowledging other activities that enhance water resource management in the area. The Kimberley regional water plan is expected to be issued for public comment in 2010.

Of significant importance to the region is the Fitzroy Trough, as it separates the alluvial plains of the Fitzroy River catchment from the undulating sandplains of the Dampier Peninsula.

The discussion paper "Fitzroy catchment subregion overview and future directions" published by Department of Water in October 2009 (DoW, 2009a), states that the Fitzroy River basin covers roughly 95,000km^2 within the Timor Sea Drainage division. The Timor Sea Drainage division has previously been referred to as the Timor Sea Drainage region within a report by the Water and Rivers Commission (now DoW) (WRC, 1997).

As a result of the prevailing meteorological conditions, most of the Dampier Peninsula is arid and the rivers are ephemeral, flowing only following infrequent heavy rainfall events.

Due to the extensive Pindan sandplain soils, few drainage features, low elevation, and heavy seasonal (summer) rainfall patterns, surface water flows on the Dampier Peninsula are largely dominated by sheet flooding/flow (overland flow). The southern half of the Peninsula does, however, contain a number of smaller peripheral drainage channels that drain to the ocean. These are most prominent near the Coulomb Point Nature Reserve, approximately 10km to the north of the James Price Point, and to the east of Mount Jowlaenga (Fraser River and associated tributaries south east of Derby).

The alluvial river plains of the Fitzroy River occur north of the Fitzroy Trough. Importantly, this geological boundary represents the first of the large river systems that are typical of the northern and central Kimberley bioregions. As noted above, drainage patterns of the Dampier Peninsula are dominated by smaller peripheral drainage lines, some of which support tidal mudflat and mangrove communities, particularly within the northern Dampier Peninsula.

The Department of Water discussion paper "Dampier Peninsula subregion overview and future directions," published in September 2009 (DoW, 2009b), identifies that the subregion as a whole supports a diverse range of nature reserves, waterways and Threatened Ecological Communities (**TEC**) (Graham, 2002). Of particular note, mound springs and perennial wetlands are a feature of the Dampier Peninsula, with several of these springs classified as TECs or 'ecosystems at risk'. The coastal dunes of the Dampier Peninsula support monsoonal vine thicket communities, which are also listed as State TECs (Graham, 2002). Furthermore, it is of particular significance to the region that Roebuck Bay, which is located on the south of Broome on the southern boundary of the Dampier subregional boundary, is listed as a Ramsar wetland. Roebuck Bay is approximately 65km south of the James Price Point coastal area.

Figure 1-7 shows the drainage divisions within the Kimberley region as published by Department of Water.

Source: DoW, 2010.

- **Figure 1-7 Drainage Divisions.**

1.3.2.2. James Price Point Coastal Area

The nearest permanent surface water features occur at Coulomb Point, approximately 20km north of James Price Point, and Willie Creek, approximately 30km south.

No major river or creek systems occur within the James Price Point coastal area (**Figure 1-3**), however, construction is likely to occur within an area of minor ephemeral drainage lines located between James Price Point and Quondong Point and to the north of James Price Point. Drainage occurs from east to west along a slight gradient. During wet season rains, overland sheet flow would most likely occur which would drain into these ephemeral areas, and then towards the coast. The natural drainage basins are assumed to be created as a result of the natural dune system interrupting the surface water drainage south of James Price Point. Catchments to the north of James Price Point and south of Quondong Beach are expected to discharge to the ocean following wet season rainfall. There do not appear to be defined catchment outlets for small and localised drainage lines (less than one kilometre in length) that occur within the area between James Price Point and Quondong Beach.

Two drainage basin communities have been identified within the local area between James Price and Quondong Point. These areas are expected to become inundated after wet season rainfall and, because a large dune system currently acts as a barrier, it is not likely that these areas drain into the ocean. It is likely that this would occur in situations where the runoff volume exceeds the infiltration capacity of the dune system. Instead, runoff drains into the local landscape, particularly in the area where the drainage basin community has been identified. Based on the presence of species such as Melaleuca dealbata and Lophostemon grandiflorus at these locations, it is likely that vegetation within the drainage basin community would be somewhat reliant on wet season flows to this area. Hydrogeological investigations are being undertaken to understand the fate and direction of surface water infiltration at these dune locations. Currently, it is understood that this infiltration may contribute to local groundwater or migrate through the dune and discharge to the marine environment.

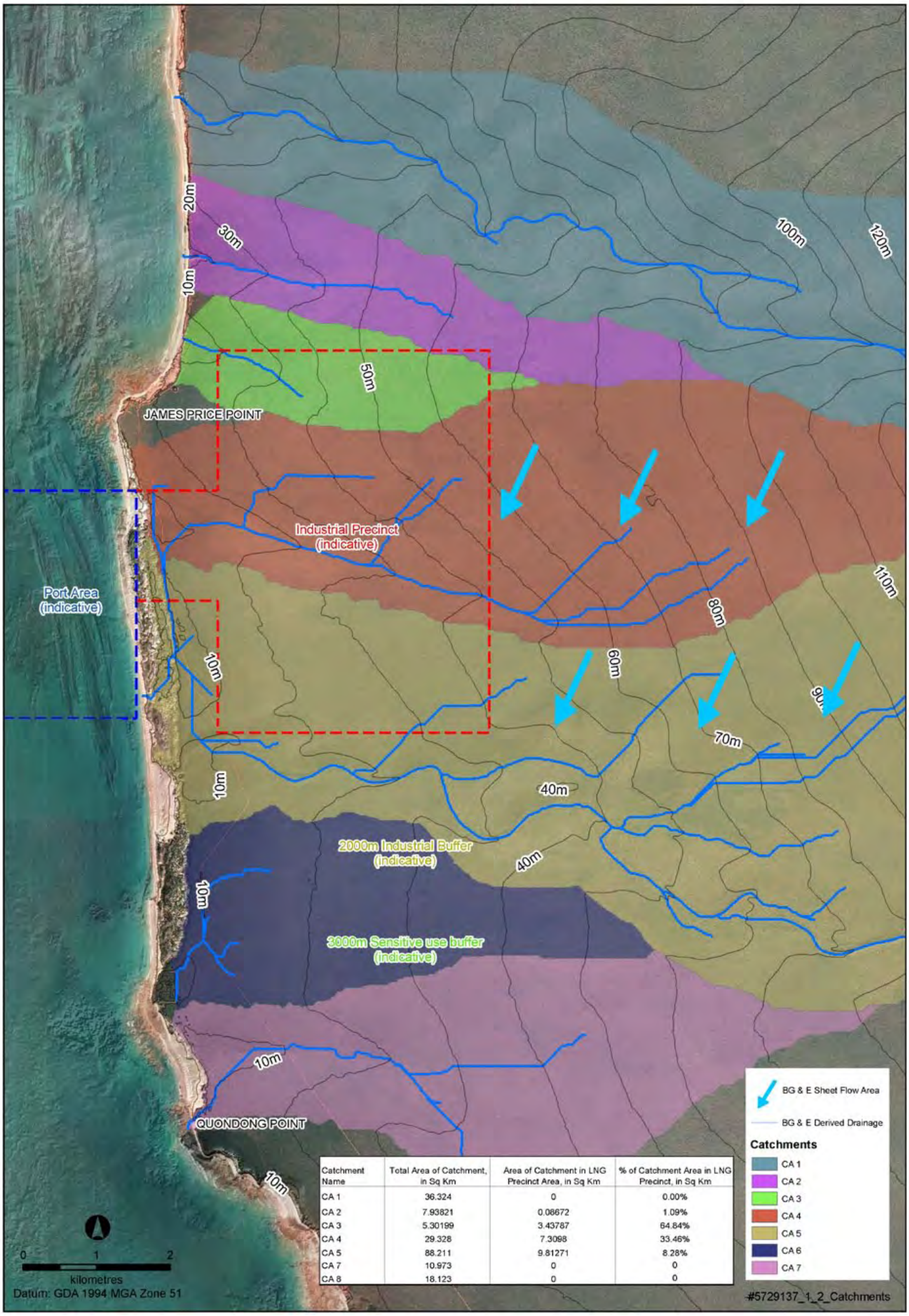
The BLNG Precinct is situated on a low lying drainage area which appears to be an old alluvial fan near the coast by James Price Point (Rockwater, 2009; **Appendix C-22**). The BG&E (2010b; **Appendix C-24**) study identified that the local catchment in the area of the BLNG Precinct is divided into seven sub-catchments, with areas ranging from 5 to 88km^2, Three of these sub-catchments, CA3, CA4 and CA5 are included within the BLNG Precinct footprint (see **Figure 1-8**), with CA4 and CA5 being the most significant in terms of area. The main stream of sub catchment CA5 is measured to be 22.3km in length and runs immediately to the south of the BLNG Precinct.

As there are no river flow gauging stations within the immediate vicinity of the BLNG Precinct, an estimation of peak stream flow (predicted peak flow) for each of the seven sub-catchments has been conducted using the Australian Rainfall and Runoff (**AR&R**) methodology (BG&E, 2010a; **Appendix C-23**). However, the sizes of the catchments identified in the BG&E study are small compared to those included within the procedure for determining stormwater flows in the Kimberly region in AR&R. The catchments used for the AR&R procedure are located in the north and east Kimberley, with catchment areas ranging between 29.6km^2 and 44,900km^2 (BG&E, 2010a; **Appendix C-23**).

Of the three sub-catchments located within the BLNG Precinct area:

- Sub-catchment CA3 is a small catchment (5.3km^2), which discharges directly to the coast north of James Price Point. A large proportion (65%) of CA3 lies within the BLNG Precinct boundary.
- Sub-catchment CA4 has an existing defined channel of 10.2km in length flowing east to west through the centre of the BLNG Precinct, and discharging immediately east of the dune sands in the vicinity of monsoon vine thicket vegetation. The majority of the lower part of this catchment lies within the BLNG Precinct boundary.
- Sub-catchment CA5 is the largest of the seven sub catchments identified within the flood study (BG&E, 2010b; **Appendix C-24**). The southern half of the BLNG Precinct overlies a large portion of the downstream part of this sub-catchment, which has a main channel flowing adjacent to the southern boundary of the BLNG Precinct and discharging immediately east of the dune sands in the vicinity of monsoon vine thicket vegetation.

The predicted peak flows for CA3, CA4 and CA5 are summarised in **Table 1-2**. Predicted peak flows relate to an Average Recurrence Interval (**ARI**) which is inversely proportional to the probability of the stream flow exceeding the predicted peak flow e.g. the predicted peak flow for a 5 year ARI has a 20% (1 in 5) chance of occurring every year within a 5 year period.



Catchment Name	Total Area of Catchment, in Sq Km	Area of Catchment in LNG Precinct Area, in Sq Km	% of Catchment Area in LNG Precinct, in Sq Km
CA 1	36.324	0	0.00%
CA 2	7.93821	0.08672	1.09%
CA 3	5.30199	3.43787	64.84%
CA 4	29.328	7.3098	33.46%
CA 5	88.211	9.81271	8.28%
CA 7	10.973	0	0
CA 8	18.123	0	0

- **Figure 1-8 Existing Catchment Drainage Flows within the Vicinity of the James Price Point Coastal Area.**

- **Table 1-2 Summary of Predicted Peak Flows for Catchments CA3, CA4 and CA5.**

Probability of stream flow exceeding Design Flow	50%	20%	10%	1%	0.05%
Catchment	**Predicted peak flows for 2 year ARI (m^3/s)**	**Predicted peak flows for 5 year ARI (m^3/s)**	**Predicted peak flows for 10 year ARI (m^3/s)**	**Predicted peak flows for 100 year ARI (m^3/s)**	**Predicted peak flows for 2000 year ARI (m^3/s)**
CA3	29	46	61	146	328
CA3 (modified)*	10	15	20	49	109
CA4	72	124	175	445	1287
CA4 (modified)*	24	41	58	148	429
CA5	123	226	332	894	2688
CA5 (modified)*	41	75	111	298	896

Note: * Modified to assume a lesser proportion (1/3) of rainfall creates run off.

In order to estimate the predicted peak flows in **Table 1-2**, assumptions have been made regarding rainfall and the proportion of rainfall which creates run off.

The average rainfall for the BLNG Precinct is estimated to be 929mm/year (BG&E, 2010a; **Appendix C-23**) and this is based on data from the nearest gauging station which is situated at Tanjungpandan (BoM Gauging Station 003087). A previous estimate of rainfall for the Precinct (705mm/year) was made using data from Broome Airport (Rockwater, 2009; **Appendix C-22**). Whilst Broome Airport has a longer time span of records (69 years as opposed to only 7 years at Tanjungpandan) rainfall is known to vary over the Dampier Peninsula (Rockwater, 2009; **Appendix C-22**) and therefore an estimate of 929mm/year is considered to be more appropriate for the calculation of predicted peak flows. It is also important to note that annual rainfall has been greater in recent years within northern Western Australia. This observation is supported by the measurement of mean annual rainfall at Broome Airport which showed an increase from 598mm to 664mm, over the 70 year period since first data collection (BG&E, 2010a; **Appendix C-23**).

The predicted peak flows shown in **Table 1-2** have also been modified to show what flows may occur if a lesser proportion of rainfall creates run off. The industry standard for the estimation of predicted peak flows are generally made by using procedures presented in the Australian Rainfall and Runoff for the Kimberley Region. However, these procedures are based on catchments in the north and east Kimberley which have a different groundwater/surface water interaction characteristic (i.e. the proportion of rainfall which creates run off) than those experienced at the BLNG Precinct (west Kimberley). It is stated that high infiltration rates can be expected in the west Kimberley and low infiltration rates can be expected within the north and east Kimberley (BG&E, 2010a; **Appendix C-23**). This distinction is made as the surface geology of the west Kimberley is dominated by deep sand soils (known as 'Pindans'), whereas the surface geology of the north and east Kimberley is dominated by 'rocky and stony' soils. The BG&E (2010a; **Appendix C-23**) study further states that estimation of predicted peak flows using the AR&R for the Kimberley region are likely to be three times greater than those expected at the BLNG Precinct due to the greater infiltration rates assumed in the west Kimberley. The 'modified' predicted peak flows are shown in **Table 1-2**).

1.3.3. Groundwater Resources and Hydrogeology

The regional groundwater resources and hydrogeology of the Dampier Peninsula are described in Laws (1991), while Rockwater (2009; **Appendix C-22**) completed a desktop assessment of hydrogeology specific to the James Price Point coastal area. Due to site access considerations, intrusive investigations in proximity to the BLNG Precinct have been limited to the vicinity of Manari Road near James Price Point (Fugro LADS, 2010). It is possible to quantitatively describe the existing hydrogeological conditions based on available information. Further hydrogeological investigations will be conducted to further characterise existing groundwater conditions and inform detailed design and management.

The Dampier Peninsula is located in the Canning Basin, a large basin that contains sedimentary rocks up to 18 kilometres thick. Groundwater on the Dampier Peninsula occurs in three major and two minor aquifer systems (Rockwater, 2009; **Appendix C-22**):

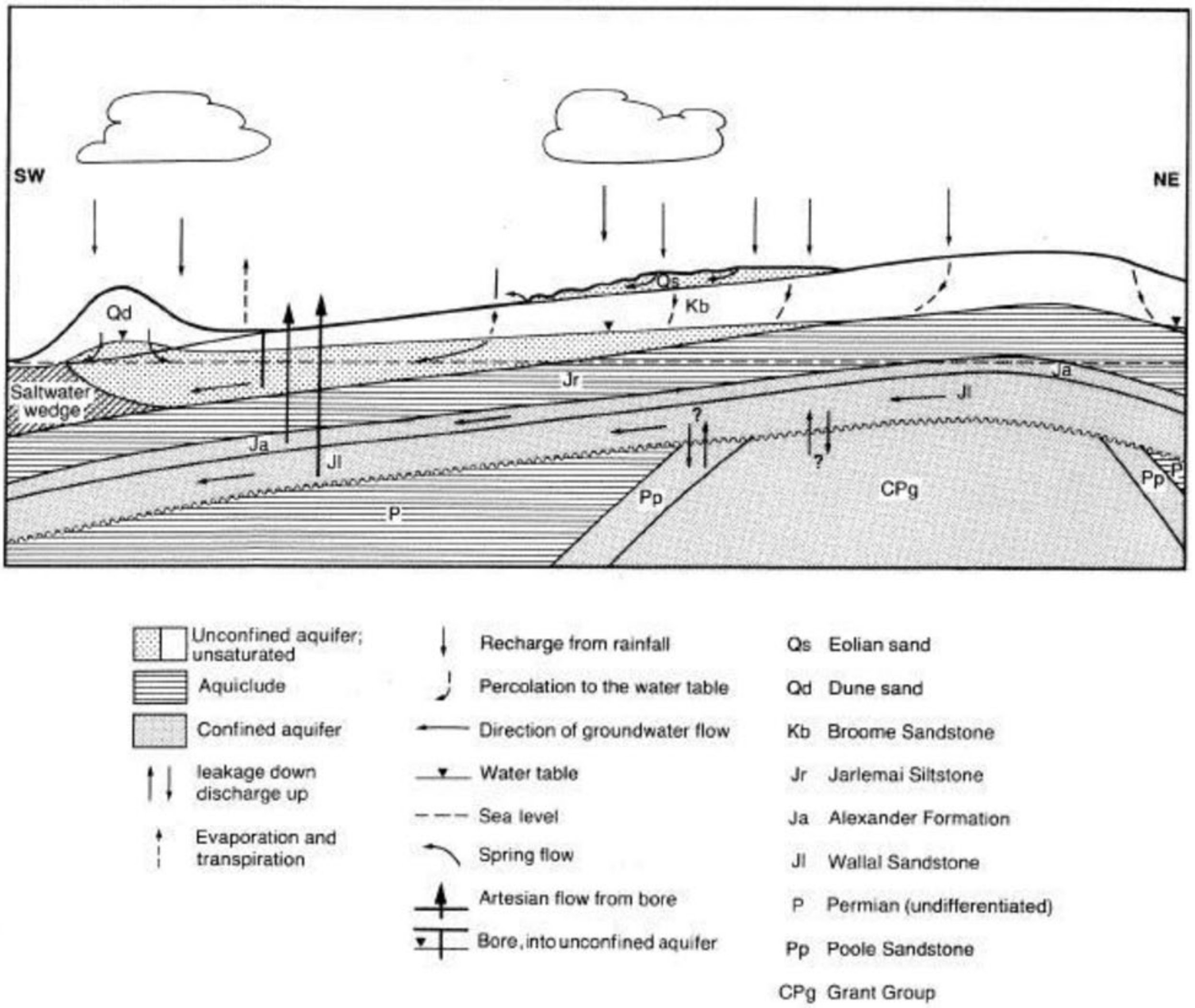
Major Aquifer Systems

- Broome Sandstone aquifer (approximately 0 to -150m AHD);
- Wallal aquifer (approximately 360m thick below -400m AHD); and
- Permian age rock units of the Poole Sandstone and Grant Group (up to 800m thick below -850m AHD).

Minor Aquifer Systems

- Superficial aquifers in the Quaternary age Sand Plain and Beach Dune Complex sit discontinuously on top of the Broome Sandstone at the surface; and
- Permian age Poole Sandstone which lies between the Wallal and Grant Group aquifers.

A generalised conceptual hydrogeological diagram showing aquifer relationships is shown on **Figure 1-9** (after Laws, 1991).



Source: Laws, 1991.

- **Figure 1-9 Aquifer Relationships.**

Further discussion of the regional groundwater resources and hydrogeology is limited to those aquifer systems relevant to groundwater abstraction or related development of the BLNG Precinct, these being the Quaternary Superficial aquifer, Broome Sandstone aquifer, Wallal aquifer and possibly the Grant Group (including Poole Sandstone).

Groundwater in the Permian age rock units, with the exception of the Grant Group, is unlikely to be abstracted by proposed BLNG Precinct activities given the depth of these units (greater than 1,000m) and/or the amount of groundwater that could be efficiently abstracted from them.

Each of the relevant aquifer systems are described in further detail below.

Superficial Aquifers

The Quaternary Superficial deposits contain both the Sand Plain deposits, which directly underlie the BLNG Precinct (e.g. Pindan sands) and the Beach Dune Complex which is found along the coast. Both of these deposits have the ability to be recharged directly through rainfall and surface water flows and therefore are referred to as superficial aquifers. Groundwater within these deposits are likely to either discharge directly into any depression deep enough to intersect the watertable (e.g. the drainage basin), or form leakage (Laws, 1991) into strata below (e.g. the Broome Sandstone aquifer). Evaporation from the drainage basin, will account for some water loss from the aquifer, but it is likely that the majority of groundwater would ultimately discharge into the marine environment either indirectly via surface water streams or directly via off-shore outcrops.

Groundwater levels within the superficial aquifers are unknown, but given the likely connectivity between these deposits and the underlying Broome Sandstone, a shallow depth to the watertable near the coast may be present. There is also anecdotal evidence that groundwater may be present at shallow depths within the Pindan soils. Cone penetration tests were conducted near the coast and these returned typically high 'N' values (which are proportional to soil density) near surface in response to encountering cemented layers within the Pindan sands. However, the cone penetration test results also highlighted a zone of low 'N' values between 2m AHD and -3m AHD (Fugro LADS 2010) and this is indicative of the presence of low density soils, possibly due to the presence of groundwater.

1.3.3.1. Broome Sandstone Aquifer

The Broome Sandstone is the most utilised aquifer on the Dampier Peninsula, being the source of the Broome town water supply, together with a range of other users including agro-forestry, community water supply, petroleum exploration and road infrastructure maintenance by Main Roads (Laws, 1991 and DoW, 2009b).

It is a multi-layered, unconfined aquifer system typically comprised of unconsolidated coarse-grained sandstone and conglomerates with intervening minor lenses of siltstone and claystone and thin coal seams (Laws, 1991). The relatively coarser grained materials produce higher yields and better quality water than the lower permeability siltstone, claystone and coal seams. Despite the aquifer being comprised of several water-bearing zones, there is little vertical difference in groundwater elevations between these water-bearing zones (Laws, 1991).

Groundwater levels in the Broome Sandstone are about 2m AHD near the coast, reflecting an unconfined aquifer with groundwater flow to the sea (Rockwater, 2009; **Appendix C-22**). Inland, based on sparse data except near Broome, the groundwater levels form a mound in the centre of the Dampier Peninsula up to 59m AHD. Shallow groundwater levels that potentially support phreatophytic vegetation may be present between the coast and the 10m AHD topographic contour line, excluding the coastal dune sands. It is possible that the Broome Sandstone aquifer also supports mound springs and perched aquifers (e.g. those in the superficial aquifer) in coastal and inland areas. Any such springs may be of ecological and cultural significance.

Groundwater salinities in the Broome Sandstone aquifer are in the range of 250 to 500 milligrams per litre (**mg/L**) total dissolved solids (**TDS**) inland from the coast. A wedge of salt water occupies the lower part of the aquifer near the coast. The toe of the saltwater wedge at the BLNG Precinct is estimated to lie about 6km inland based on data extrapolated from near Broome (Rockwater, 2009; **Appendix C-22**).

Groundwater recharge to the Broome Sandstone aquifer is by:

- direct rainfall where the Broome Sandstone outcrops;
- leakage from overlying Pindan soils (present over much of the peninsula) and coastal dune sands; and
- infiltration of surface water from wetlands and drainage systems.

The Broome Sandstone aquifer may also receive preferential groundwater recharge from infiltration of surface waters from mound springs, wetlands and drainage systems following rainfall events and seepage from the overlying Quaternary sands. Groundwater recharge is expected to vary throughout the peninsula according to rainfall intensity, depth to water table, location of drainage systems and the permeability of the Broome Sandstone materials. Groundwater recharge is estimated to be 4 to 5% of annual rainfall (Laws, 1991).

Regional groundwater flow in the Broome Sandstone aquifer is influenced by topography and the location of groundwater recharge and discharge areas (Laws, 1991). At the James Price Point coastal area, the direction of regional groundwater flow is interpreted to be in a westerly direction towards the coast. Horizontal hydraulic gradients are reported to be relatively flat at around 4×10^{-4} near the coast (Laws, 1991).

Groundwater discharge on the peninsula typically occurs into the ocean over a saline interface at the coast. Some discharge via seepage faces along the coast and evapotranspiration may also be expected.

1.3.3.2. Wallal Aquifer

The Wallal aquifer is interpreted to lie between the elevations of -400 to -600m AHD below the proposed BLNG Precinct (Rockwater, 2009; **Appendix C-22**). It is confined or semi-confined by the Jarlemai Siltstone which forms an aquitard and separates it from the overlying Broome Sandstone (Laws, 1991). The aquifer includes the sedimentary sequences of the Alexander Formation (a fine-grained, weakly cemented sandstone) and Wallal Sandstone (a fine to coarse-grained, poorly consolidated sandstone). Intervening lenses of siltstone are present in the Alexander Formation and Wallal Sandstone. Laws (1991) reports artesian pressures in bores at Broome and Cable Beach, suggesting the aquifer may be artesian along the coast.

Based on limited groundwater quality information, groundwater salinity is expected to range from around 1,500mg/L TDS up to 5,500mg/L TDS and is sodium-chloride type. Noticeable concentrations of sulphate, calcium and magnesium are present in groundwater in the Wallal Sandstone (Laws, 1991).

Groundwater recharge would occur via direct rainfall where the Alexander Formation and Wallal Sandstone outcrop and from leakage from overlying aquifers such as the Broome Sandstone. Regional groundwater flows in a westerly direction, likely discharging off the coast.

Groundwater in the Wallal Sandstone aquifer at Broome is brackish, with salinity of about 5,500mg/L TDS (Rockwater, 2009; **Appendix C-22**). Groundwater salinity is typically higher than the Broome Sandstone aquifer. Wallal Sandstone is potentially a source of large supplies of brackish water, with resources probably exceeding those of the Broome Sandstone. Near the base of the aquifer, where the saltwater wedge is present, groundwater salinity would be more than 30,000mg/L TDS.

1.3.3.3. Grant Group

The Grant Group contains a deep aquifer system underlying the Wallal Sandstone aquifers and includes the Poole Sandstone aquifer. It is a major aquifer of the Canning Basin and in other parts of the Kimberley is known to be capable of high yields. Hydrogeological information on the occurrence of the Grant Group in the East Kimberley is available, however will be subject of further investigations to determine groundwater availability on the Dampier Peninsula in the vicinity of the James Price Point coastal area The Grant Group is likely to occur below -900m AHD under the proposed BLNG Precinct and be 500 to 800m thick.

Based on limited hydrogeological information from investigations conducted 300km east of Broome, groundwater is fresh, with salinity in the range of 250 to 400mg/L total dissolved solids (Rockwater, 2009; **Appendix C-22**). In the vicinity of the BLNG precinct the salinity in the Grant aquifer is not known. Because the groundwater is recharged via the

Wallal Sandstone on the anticlines, its salinity is likely to be similar to or higher than those in the Wallal, and therefore in excess of 5,000mg/L TDS in a local context (Rockwater, 2009; **Appendix C-22**).

Rockwater (2009; **Appendix C-22**) identified the following characteristics of the Grant Group, based on current information:

- groundwater in this aquifer is likely to be slightly to moderately saline, although limited data exists;
- there appear to be no existing users of groundwater from the Grant Group; and
- the aquifer is deep (about 500m thick in the vicinity of the BLNG Precinct), and probably confined over most the area.

1.3.3.4. Groundwater Use

The Dampier Peninsula is located within the Canning-Kimberley Groundwater Area. Groundwater abstraction is subject to licensing under the *Rights in Water and Irrigation Act 1914*.

There are 10 groundwater licences on the Dampier Peninsula outside the Broome groundwater area, totalling around 0.35 gigalitres (**GL**) per year. The groundwater is used for a variety of purposes including agro-forestry, community water supply, petroleum exploration and road infrastructure maintenance by Main Roads. Future use of groundwater may potentially include pastoral diversification and development of a timber plantation near Beagle Bay (DoW, 2009a).

The Broome town water supply is sourced from a borefield located within the southern quarter of the Broome Water Reserve (as proposed in the Broome Water Reserve Water Source Protection Plan (WRC, 2001) and to the northeast of the town in the Broome Sandstone aquifer. The Water Corporation has a current licensed allocation of 4.4GL per year, with a proposed increase to 5.4GL per year, to provide potable water for Broome (DoW, 2009b). The reserve boundaries have been set to reflect the expected capture zone of the existing and future expanded Broome town water supply borefield. The reserve is declared under the *Country Areas Water Supply Act 1947*, and enables the Broome Shire to promulgate bylaws to control land use activities that may contaminate bores within the reserve. The southern boundary of the BLNG Precinct is approximately 15km north of the northernmost boundary of the Broome Water Reserve.

Approximately a further 1.8GL of groundwater is used each year in the Broome Groundwater Area for small scale horticultural use, domestic self supply, watering of parks and gardens and small scale industry (DoW, 2009b).

There is one licensed user in the Cable Beach subarea abstracting groundwater from the Wallal Sandstone aquifer (DoW, 2009b). The Traditional Owners on the Dampier Peninsula have indicated a high level of concern over ensuring the ongoing sustainable use of groundwater resources on the Peninsula.

1.4. Ecological Terrestrial Environment

The following sections describe the known existing ecological terrestrial environment in the Kimberley, the Dampier Peninsula and in the James Price Point coastal area. This terrestrial environment includes vegetation and flora, ethno-biologically significant species, fauna and fauna habitats, and threatening processes to ecosystem integrity.

1.4.1. Kimberley Biodiversity Context

Australia is recognised as a ‘megadiverse’ country and is home to between 600,000 and 700,000 species, many of which are endemic. Endemic species account for 84 percent of plants, 83 percent of mammals and 45 percent of bird species found in Australia. Australia's biodiversity is threatened from the impacts of many human activities, with more than 50 fauna species and 60 flora species having become extinct since European settlement (DEWHA, 2009d). This high extinction has primarily been from the effects of extensive clearing of native vegetation which has removed, changed or fragmented habitats.

In a regional context relevant to northern WA, two particular areas are considered to be highly biodiverse (biodiversity hotspots). This includes the North Kimberley hotspot, which is approximately 250km to the north of James Price Point, and the Hamersley-Pilbara hotspot, approximately 350km to the south (**Figure 1-10**).

The North Kimberley hotspot has a variety of rare features including mound springs, swamp rainforests and the Airfield Swamp, which is a large wetland and paperbark forest. The North Kimberley hotspot supports populations of the endangered Gouldian Finch (*Erythrura gouldiae*) as well as other endemic and threatened mammals, including the Golden Bandicoot (*Isoodon auratus*), Scaly-tailed Possum (*Wyulda squamicaudata*) and Monjon (*Petrogale burbidgei*) (DEWHA, 2009d).

The Hamersley-Pilbara hotspot provides habitat for a number of threatened, endemic and fire-sensitive species and communities. The Hamersley Range provides relatively protected habitats for many species, including the Ghost Bat (*Macroderma gigas*), Crest-tailed Mulgara (*Dasycercus cristicauda*), Brush-tailed Mulgara (*D. blythi*) and Spectacled Hare-wallaby (*Lagorchestes conspicillatus*). Aquifers support endemic cave-dwelling animals. The Pilbara is home to small mammals such as the Little Red Antechinus (*Dasykaluta rosamondae*) and the Western Pebble-mound Mouse (*Pseudomys chapmani*). The arid climate favours endemic reptiles, including gecko and goanna species, and the coastal islands are refuges for vulnerable species that are rare or extinct on the mainland, such as the Western Chestnut Mouse (*Pseudomys nanus*). Coastal islands also provide breeding sites for marine turtles and seabirds (DEWHA, 2009d).

The James Price Point coastal area does not consist of the same assemblages of ecological features and landforms as either of the hotspots.

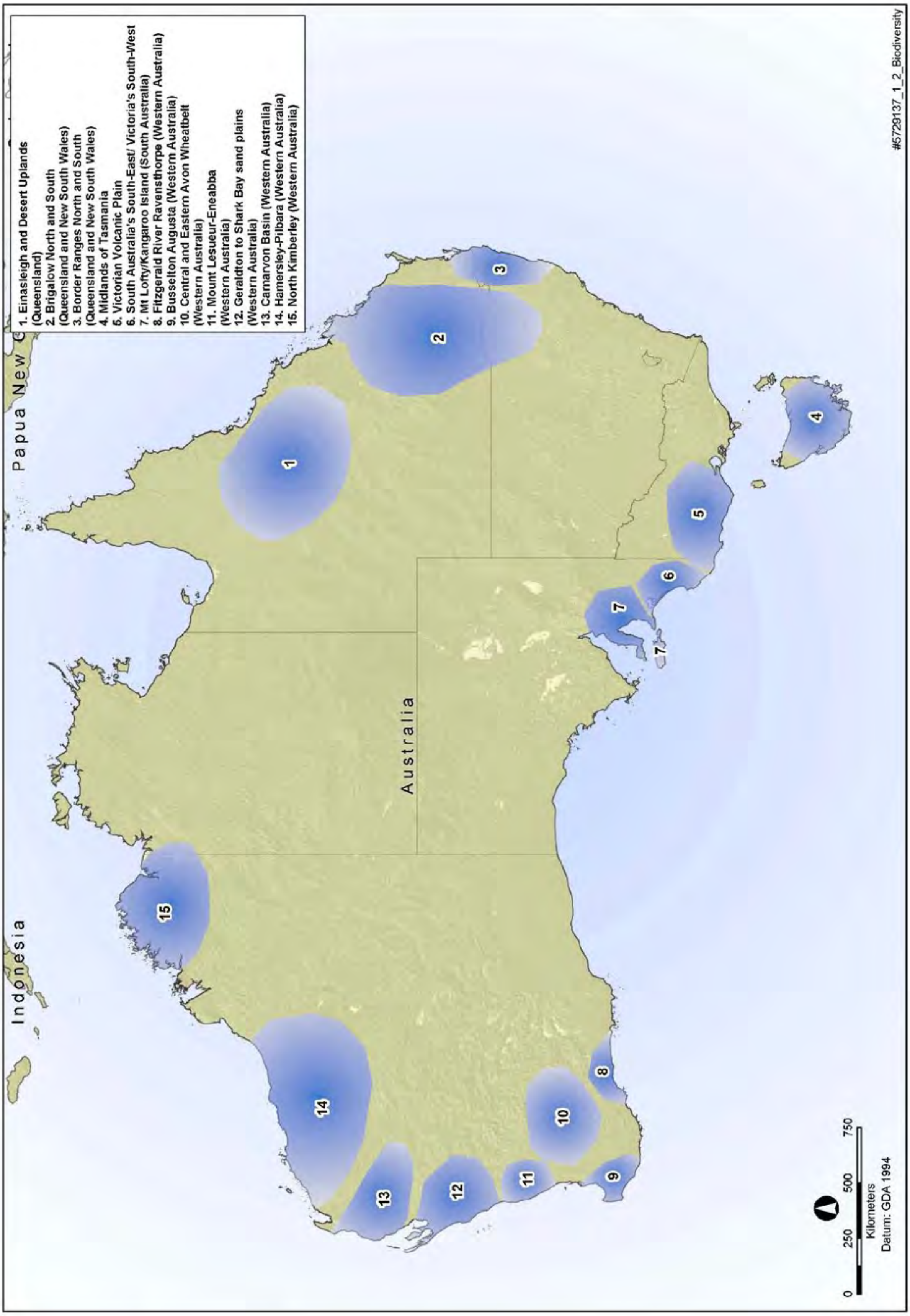
1.4.1.1. IBRA Bioregion

The Interim Biogeographic Regionalisation for Australia recognises 85 distinct bioregions (Environment Australia, 2000). James Price Point is located within the Dampierland bioregion and within the Pindanland sub-region. This subregion covers 5,198,904ha.

Graham (2001) outlined three basic components to the subregion. These comprised:

- Quaternary sandplain overlying Jurassic and Mesozoic sandstones with Pindan. There are hummock grasslands on hills.
- Quaternary marine deposits on coastal plains, with mangal, samphire - *Sporobolus* spp. grasslands, *Melaleuca alsophila* low forests, and *Spinifex* species - *Crotalaria* species strand communities.
- Quaternary alluvial plains associated with the Permian and Mesozoic sediments of Fitzroy Trough support tree savannahs of Ribbon Grass (*Chrysopogon* species) - Bluegrass (*Dichanthium* species) grasses with scattered Coolibah (*Eucalyptus microtheca*) - *Bauhinia cunninghamii*. There are riparian forests of River Red Gum (*Eucalyptus camaldulensis*) and Cadjeput (*Melaleuca* species) fringe drainages.

The Pindanland subregion comprises sandplains of the Dampier Peninsula and the western part of Dampierland, including the hinterland of Eighty Mile Beach. It is a fine-textured sand-sheet with subdued dunes and includes the paleodelta of the Fitzroy River. The vegetation is described primarily as Pindan. This is the coastal, semi-arid, north-western margin of the Canning Basin.



Source: DEWHA, 2009d.

- **Figure 1-10 Biodiversity Hotspots.**

1.4.2. Vegetation

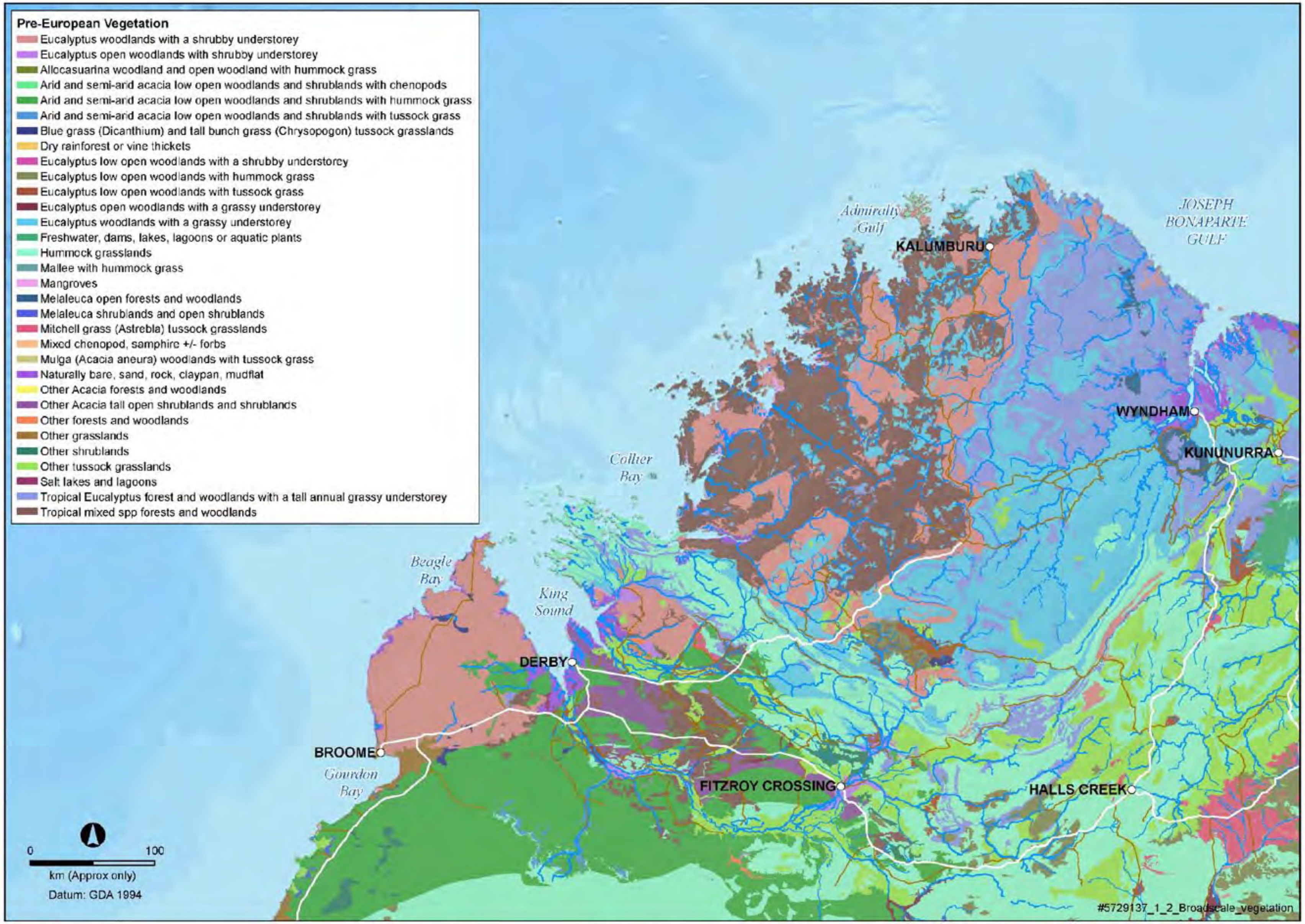
Vegetation is described as units or communities of plants within a specified area such as the James Price Point coastal area relevant to the BLNG Precinct, the Dampier Peninsula and the Kimberley region. Similarly, single plant species may also be discussed at a regional, local and site specific level such as the BLNG Precinct area. Significant vegetation communities are also protected under both Commonwealth and State.

1.4.2.1. Vegetation of the Kimberley

The Kimberley landscape supports a variety of vegetation units including, but not limited to, hummock grasslands, shrublands, tree slopes, woodlands, riverine forest, mangroves and rainforests. Broad scale mapping of the dominant vegetation units within the Kimberley is provided in **Figure 1-11**.

The DEC (2009a) describes the following four broad ecosystem classifications which are likely to encompass the known vegetation units occurring within the Kimberley:

- Tropical savannah ecosystems vary in their vegetation structure and species composition according to factors such as substrate, rainfall, biogeographic history and level of disturbance. They are the dominant Kimberley ecosystems. The array of savannah ecosystems are characterised by specific tree and grass communities (perennial hummock and tussock grasslands, annual cane grasslands), shrublands, tree steppes and woodlands.
- Riverine and freshwater swamps provide refuge during the dry season for many savannah species, as well as containing a vast array of aquatic species that are often poorly documented. These ecosystems are characterised by paperbark and River Red Gum forests and are more common in the northern and central regions where the iconic river gorges and floodplains of the Kimberley occur.
- Coastal ecosystems include mangroves, estuaries and tidal mudflats, beaches and rocky headlands. Some of the largest patches of mangrove in Australia occur along the Kimberley coast. They have a total area of 140,000ha, are rich in species, and considered to be among the most pristine in the world. Extensive tidal mudflats characterise Kimberley coastlines and support diverse assemblages of invertebrate fauna and marine, shore and migratory bird species. The islands of the Kimberley Region and the regions intertidal coastal environment and wetlands contain a number of important areas. Consolidated beach dunes behind the beaches are usually well vegetated with beach spinifex and, further back, with hummock grasslands stands of pandanus and patches of semi-deciduous monsoon vine thicket.
- Rainforest ecosystems occur as small, isolated patches on hillsides and scree slopes, in gorges and gullies, in swamps, along rivers and on coastal sand dunes across approximately 170,000km^2 of the Kimberley (DEC, 2009a). These communities occur predominately in the rugged high rainfall north-west (DEC, 2009a); however, monsoon vine thicket also occurs as far south as the Dampier Peninsula. They are rich in plant and vertebrate species not found in the surrounding savannah, and are characterised by high levels of invertebrate endemism. Nearly 25% of the 2,000 species that comprise the Kimberley Region flora have been recorded in the rainforests, and approximately a third of these are poorly suited to the surrounding environment (Ellison, 2009).



Source: DEC, 2009a.

Figure 1-11 Regional Broadscale Vegetation Mapping.

1.4.2.2. Vegetation of the Dampier Peninsula

A number of regional-scale reports and datasets identifying vegetation types and flora species that may occur at James Price Point have been reviewed in order to place the vegetation and flora of the James Price Point coastal area in a regional context. Information considered included the following (adapted from Biota, 2009c; **Appendix C-18**):

- Beard's 1979 broad scale vegetation mapping;
- features of the IBRA Pindanland subregion of the Dampierland bioregion;
- land systems; and
- threatened and priority ecological communities.

The Dampier Botanical District is contained within the Northern Botanical Province, one of three botanical provinces in WA. ENV (2008a; **Appendix C-14**) describe the Dampier Peninsula as being a transition zone between the subtropical Northern Botanical Province and the arid Eremaean Botanical Province to the south, thus containing flora and vegetation associated with both provinces.

Broadscale vegetation mapping (1:1,000,000 scale) of WA was undertaken by Beard (1979). The Dampier Peninsula lies within the Dampier Botanical District, which broadly corresponds with the Dampierland IBRA bioregion (Biota, 2009c; **Appendix C-18**). The vegetation is typically Pindan on sandplains, more or less densely wooded according to rainfall, tall-grass savannah with or without scattered trees on clay plains, spinifex steppe on sandstone and limestone outcrops (Biota, 2009c; **Appendix C-18**).

Land systems (rangeland) mapping covering the Dampier Peninsula has been prepared by the WA Department of Agriculture. Land systems are comprised of repeating patterns of topography, soils, and vegetation (Biota, 2009c; **Appendix C-18**). Vegetation of the Dampier Peninsula has been described for the different land systems including:

- coastal dune and beach communities of the Carpentaria Land System;
- sub-coastal vine thickets to closed vine forests of the Carpentaria Land System; and
- sandplain communities of the Yeeda and Wanganut Land Systems.

A number of Threatened Ecological Communities and Priority Ecological Communities (**PEC**) have been identified by the DEC for the Dampier Peninsula (Biota, 2009a). However, only three occur in habitats which have equivalent landforms in the James Price Point coastal area. These communities are described in further detail below:

- Monsoon vine thickets on coastal sand dunes of the Dampier Peninsula (State TEC); occur as semi-deciduous and evergreen vine thicket communities on and behind landward slopes of coastal sand dunes on the Dampier Peninsula. This community occurs at the James Price Point coastal area and is also known to occur in association with coastal dunes elsewhere on the Dampier Peninsula.
- Dwarf Pindan heath community of Broome coast (Priority 1 PEC); occurs between the Broome racecourse and Gantheaume Point lighthouse. There is insufficient survey effort outside of Broome townsite area to determine the full extent of this community but similar landform occurs in the James Price Point coastal area.
- *Corymbia paractia* dominated community on dunes (Priority 1 PEC); occurs behind dunes in the Broome township area, Dampier Peninsula and also in the port area north of Broome. Transition zone where coastal dunes (with vine thickets) merge with Pindan (desert) vegetation (such as in the James Price Point coastal area).

There are a number of other ecosystems in the Pindanland subregion that are considered by the DEC to be 'at risk', particularly by changed fire regimes (Biota, 2009c; **Appendix C-18**). These include:

- assemblages of permanent/ephemeral wetlands, damplands, and riparian habitat of the Dampierland bioregion;
- the Nimalaica clay pan community, inland from Willie Creek; and
- vine thickets on heavily ferruginised Emeriau sandstone at the northern end of the Dampier Peninsula.

ENV (2008a; **Appendix C-14**) conducted a dry season vegetation survey that recorded a total of eight vegetation communities from surveys conducted at four survey locations on the Dampier Peninsula (**Table 1-3**) including:

- Packer Island (approximately 125km northeast of James Price Point);

- Coulomb-Quondong Point (50-60km north of Broome and including James Price Point);
- Perpendicular Head-North Head (approximately 90km northeast of James Price Point); and
- Gourdon Bay (approximately 110km south-southwest of James Price Point).

The communities identified and mapped by ENV (2008a; **Appendix C-14**) currently provide the best indication as to the extent and distribution of discrete vegetation communities along the western Dampier Peninsula. It is likely that further targeted surveys elsewhere on the Dampier Peninsula may identify additional community types. However, it is considered that the ENV survey work, combined with other published information provides a sound understanding of the vegetation community composition of the coastal regions of the western Dampier Peninsula.

Table 1-3 Descriptions of Vegetation Communities on the Dampier Peninsula.

Vegetation Community Type	Description	Mapped Locations
Coastal communities	Sparsely vegetated mobile foredunes usually feature *Spinifex longifolius*, along with the sedges *Fimbristylis cymosa* and *F. sericea*. Beach creepers include *Ipomoea pes-caprae* and *Canavalia rosea*. At Quondong and Coulomb Point stabilised dunes are dominated by scattered *Crotalaria cunninghamii*.	PI, CQP, NH
Monsoon vine thickets	Discontinuous belts of monsoon vine thicket are found behind coastal dunes north of Broome, and are particularly well-developed at James Price Point and Cape Borda at the northern end of the Dampier Peninsula. Monsoon vine thickets contain many fleshy-fruited plants, providing an important food resource for wildlife such as Agile Wallabies, bats, Bower-birds and Fruit-doves. They are also an important traditional resource for Aboriginal people. Monsoon vine thickets are notable for their position on the landward side of coastal dunes and presence of evergreen tree species such as *Terminalia petiolaris*, *Diospyros humilis*, *Mimusops elengi*, *Celtis australiensis*, *Melaleuca dealbata* and, more rarely, the conservation Priority 4 species *Pittosporum moluccanum* which occurs at James Price Point.	PI, CQP, NH
Coastal heath	These heathlands occur as linear bands, typically on exposed coastal cliffs (Emeriau Point, Flat Rock to James Price Point and Gourdon Bay), and are dominated by low, wind-pruned shrubs such as *Acacia monticola* and *A. tumida*.	PI, CQP, NH
Pindan woodland	This community of the Dampier Peninsula dominates inland sandplains, developed over red and yellow soils with an annual rainfall over 500mm. Tree cover is relatively dense with an upper layer of Eucalypts (*E. miniata*, *E. tectifica*), Bloodwoods (*Corymbia dampieri*) and/or Ghost Gums (*Corymbia bella*, *C. flavescens*). A variably dense understorey of wattles includes *Acacia eriopoda, A. tumida, A. monticola, A. platycarpa* and *A. colei*. Grass species are similar to those in the Pindan shrubland but also include annual sorghum, *Heteropogon* and *Cymbopogon* species. Many areas surveyed had been severely impacted by frequent fires.	PI, CQP, NH
Ephemeral waters	These represent a mosaic of communities subject to ephemeral freshwater flooding and/or ponding. They include stands of *Melaleuca alsophila* that adjoin supra-tidal mudflats as well as *Lophostemon grandiflorus* and *Melaleuca dealbata* communities in areas behind coastal sand dunes subject to seasonal inundation.	PI,CQP, NH
Mangroves	Up to 12 species of mangrove have been recorded from the Dampier Peninsula with large stands being recorded in sheltered embayments at Chile Creek, Packer Island, Tappers Inlet and Port Smith. They usually occur between the spring tide-mark and mean sea level.	PI, NH
Mixed shrubland thicket	This community was mapped only northward of Beagle Bay. It includes dense thickets dominated *by Acacia tumida* on coastal dunes at Chile Creek, an area known locally as Byerugun Scrub, and on the landward side of Packer Island. This community also occurs as an extensive complex mosaic of mixed acacia species (*A. colei, A. monticola* and *A. tumida*) with *Calytrix exstipulata*, *Hakea arborescens* and *H. macrocarpa* on ferruginised sandstone behind cliffs at Perpendicular Head-North Head.	PI, NH
Supra tidal mudflats	Broad tidal mudflats often occur behind mangroves featuring expanses of hypersaline non-vegetated areas fringed with a low samphire shrub community, grading into saline grasslands. These areas are subject to freshwater inundation during the wet season.	PI, GB, NH
PI = Packer Island, NH = North Head, CQP = Coulomb – Quondong Point (which includes James Price Point)		

Source: ENV, 2008a; **Appendix C-14**.

1.4.2.3. Vegetation of the James Price Point Coastal Area

The area surrounding the potential precinct site was mapped by Beard as being representative of two vegetation units (Beard, 1979):

- Pindan woodland on monotonous sandplain comprising *Eucalyptus tectifica* and *Corymbia grandifolia* woodland over Acacia tumida shrubland over Chrysopogon and Triodia grasslands (Beard's unit 750), dominating the sandy plains; and
- bare areas of drift sand (Beard's unit 129), mapped in narrow bands along the coast.

The Department of Agriculture Land System mapping shows the area as being characterised by three land system units: Carpentaria, Wanganut, and Yeeda. **Table 1-4** below describes the broad regional distribution of land systems and habitats that occur within the James Price Point coastal area.

Table 1-4 Land Systems within the James Price Point Coastal Area.

Land System	Description	Broad Distribution	Area within the James Price Point Study Area (ha)
Carpentaria	Coastal flats, associated sandy margins and dunes; saline sands and muds; supporting various vegetation types including paperbark thickets, samphire meadows, and extensive bare mud flats with fringing mangrove forests.	Widespread through coastal areas of the Kimberley from Broome to the NT border. Mapped in narrow bands along the coast of the study area south of James Price Point.	631
Wanganut	Low-lying alluvial sandplains and dune fields with coordinated through-going drainage; supporting Pindan acacia shrublands/woodlands with emergent eucalypt trees over spinifex hummock grasslands and/or tussock grasslands.	Mapped only within the Dampierland bioregion of the Kimberley, but widespread and well-represented through the northern half of this bioregion. Dominates the northern third of the study area, and occurs in a broad band through the central section.	5,921
Yeeda	More elevated sandplains and dunes with red and yellow sands with uncoordinated drainage; supporting Pindan acacia shrublands/woodlands with emergent eucalypt trees over spinifex hummock grasslands and/or tussock grasslands.	Primarily mapped within the Dampierland bioregion of the Kimberley, where it is widespread and well-represented; extending into the adjacent Ord-Victoria Plains bioregion and (to a lesser extent) the Central Kimberley and Great Sandy Desert bioregions. Occurs over two broad areas in the central and southern sections of the study area.	8,544

Source: Biota, 2009a.

Biota (2009c; **Appendix C-18**) reviewed this land system mapping and the vegetation mapping conducted at broad scale by ENV (2008a; **Appendix C-14**) as part of its wet season vegetation survey in the James Price Point coastal area.

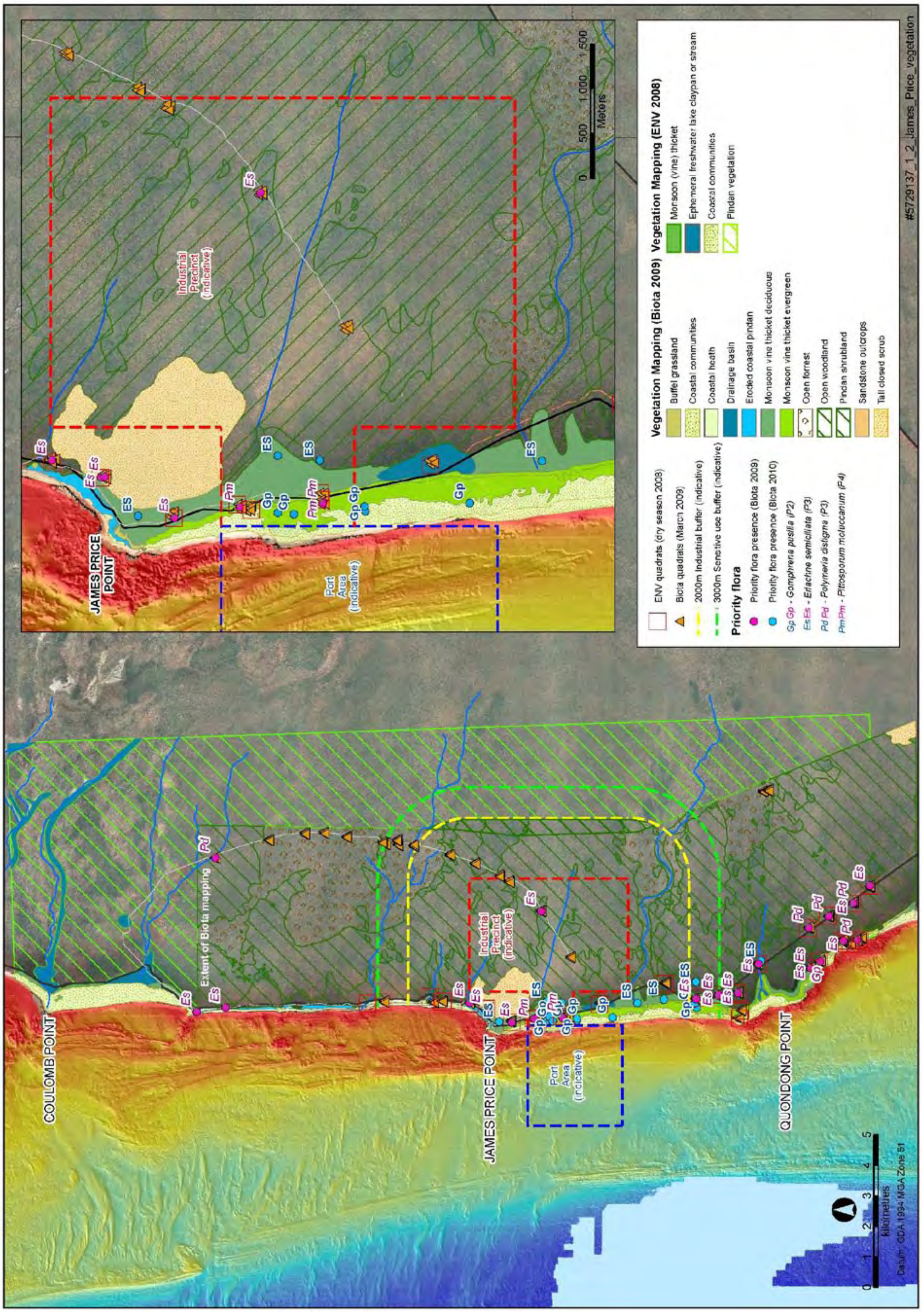
Biota (2009c; **Appendix C-18**) concluded that the geology and landforms of the James Price Point coastal area are representative of the broader Dampier Peninsula. Hence, the vegetation types recorded from the James Price Point coastal area were therefore likely to extend to the north and south. Where these occur the vegetation types can be inferred by looking where the broad scale vegetation units mapped in the James Price Point coastal area by ENV (2008b; **Appendix C-15**) occur elsewhere north and south of the area. However, there does appear to be regional differences in the floristic composition of the James Price Point survey sites from the other areas sampled by ENV (2008b; **Appendix C-15**), particularly with respect to the Pindan vegetation (Biota, 2009c; **Appendix C-18**). This conclusion is supported by other authors (for example, Kenneally *et al.*, 1996) who describe the northern tip of the

Dampier Peninsula as more mesic and with greater affinity to the tropical North Kimberley, while the southern half is more transitional, possessing both arid and tropical elements of the flora (Biota, 2009c; **Appendix C-18**).

As part of a wet season survey in 2009, Biota (2009c; **Appendix C-18**) identified a total of 12 vegetation communities in the James Price Point coastal area (see **Table 1-5** and **Figure 1-12**). The study area investigated by Biota (2009c; **Appendix C-18**) comprised a 10,000ha area centred on the preferred LNG precinct location at James Price Point and extended for approximately 24km along the Dampier Peninsula coastline from Flat Rock to just south of Quondong Point and approximately 6km inland (**Figure 1-2**).

During this survey, Biota (2009c; **Appendix C-18**) confirmed the presence of the monsoon vine thicket community TEC, identified a drainage basin vegetation community of local conservation significance, and inferred that the coastal heath vegetation present corresponds with the PEC (Priority 1) described as the dwarf Pindan heath community of the Broome coast.

Corresponding dry season data has been collected by ENV (2008a; **Appendix C-14**) and AECOM (2010a; **Appendix C-19**), which is also presented in **Table 1-5**. No new vegetation communities were located during an end-of-dry-season survey by AECOM (2010a; **Appendix C-19**). However, based on field observations and extrapolation from aerial imagery, AECOM mapped an area to the east of the existing Biota (2009c; **Appendix C-18**) mapping and confirmed that the Pindan vegetation communities extended inland for in the order of an additional 0.5km to approximately the 2,000m industrial buffer (indicative).



■ **Figure 1-12 Vegetation Communities of the James Price Point Coastal Area.**

- **Table 1-5 Summary of Vegetation Communities in the James Price Point Coastal Area including Conservation Significance.**

Vegetation Type/Map Code (Biota, 2009c)	Vegetation Description (Biota, 2009c)	Conservation Significance Ranking	ENV (2008a)
Eroded coastal Pindan/ecp	Eroded coastal Pindan occurred in the northern section of the study area between James Price Point and Flat Rock, where there were large areas of eroded Pindan abutting low coastal cliffs. In some areas gully erosion was a feature, exposing underlying gravels and sandstone. Almost all of the eroded Pindan was unvegetated, except in isolated discrete patches where it had been overlain by wind-blown sand deposits and was mapped as coastal communities bare (unvegetated) areas on eroded coastal plains.	**Nil** These areas are largely devoid of plants.	This unit was not mapped separately by ENV (2008a; **Appendix C-14**), being included under their "coastal heath" vegetation type.
Coastal heath/ch	The coastal heath community was restricted within the study area to discontinuous, narrow, linear bands, occurring on exposed Pindan coastal cliffs north from James Price Point to Flat Rock. These heath lands were dominated by low, wind-pruned shrubs typically of *Acacia tumida* var. *kulparn*, *A. monticola*, *Hakea macrocarpa*, *Hybanthus aurantiacus*, *Merremia davenportii* (at Flat Rock), *Solanum cunninghamii* and *Terminalia ferdinandiana*. This vegetation was considered to be in very good condition, with little evidence of weeds or other disturbance.	**Moderate** Corresponds with PEC (Priority 1) described as the "dwarf Pindan heath community" of the Broome coast.	This unit corresponds to the coastal heath community of ENV (2008a; **Appendix C-14**).
Coastal communities/cc	Coastal communities occurred mainly south of James Price Point, where there were well-developed coastal beaches backed by extensive, often mobile, white Holocene sand dunes and travertine. To the north of James Price Point, the coastal community was restricted to isolated pockets within the eroded Pindan. Sparsely vegetated mobile foredunes usually featured beach spinifex (*Spinifex longifolius*), along with the sedges *Fimbristylis cymosa* and *F. sericea*, which were usually dominant in blow-out areas. Beach creepers included *Ipomoea pes-caprae* subsp. *brasiliensis* and *Canavalia rosea*. Stabilised dunes were dominated by *Spinifex longifolius*, with scattered *Abutilon indicum*, *Cleome viscosa*, *Crotalaria crispata*, *C. cunninghamii*, *Cullen martinii*, *Myoporum montanum*, *Santalum lanceolatum* and *Tephrosia rosea* var. *rosea*. These areas are not particularly susceptible to fire due to the sparse nature of the vegetation, and were generally considered to be in very good condition. In coastal areas at Quondong Point and James Price Point, introduced buffel grass (*Cenchrus ciliaris*) and kapok bush (*Aerva javanica*) were found to be expanding into native dune vegetation These areas were considered to be in poor condition.	**Moderate** Small area of representation; support flora restricted to such habitats, including the Priority 2 species *Gomphrena pusilla*; susceptible to erosion and weed invasion.	This vegetation unit is equivalent to the "coastal communities" unit of ENV (2008a; **Appendix C-14**).
Buffel grassland/bf	The buffel grassland vegetation was mapped south of Quondong Point between Jajaal and Inbalmarra, where introduced buffel grass (*Cenchrus ciliaris*) had invaded the narrow belt of sandy plain that lies between the coastal sand dunes and the red Pindan plain. This tussock-forming perennial grass, introduced as a fodder species, formed a monotypic stand through this area that was extensive enough to	**Nil** This vegetation type has been extensively degraded by introduced buffel grass (*Cenchrus*	This vegetation unit was not mapped separately by ENV (2008a; **Appendix C-14**) due to the broader nature of that mapping exercise, but was

Vegetation Type/Map Code (Biota, 2009c)	Vegetation Description (Biota, 2009c)	Conservation Significance Ranking	ENV (2008a)
	be individually mapped. Due to its allelopathic nature, this perennial grass had suppressed most native flora, with few other species coexisting apart from occasional shrubs of green birdflower (*Crotalaria cunninghamii*). This vegetation was ranked as being in very poor to completely degraded condition.	*ciliaris*), which comprises the conspicuous species dominating this unit.	included within their mapping of the coastal heath and coastal communities units.
Monsoon evergreen vine thickets/evt	Monsoon evergreen vine thickets occurred in a narrow, linear coastal belt between James Price Point and Quondong Point. This community often formed discrete, closed-canopy patches, more commonly on the coastal dunes and sometimes extending into the swales. The evergreen trees included *Celtis philippensis*, *Diospyros humilis*, *Mimusops elengi*, *Sersalisia sericea* and rarely *Ficus virens* and the Priority 4 species *Pittosporum moluccanum*. Some of the tree species found here are at the southern limit of their distribution. Shrubs included *Exocarpos latifolius, Glycosmis macrophylla* and *G. trifoliata*. Typical vines included *Abrus precatorius, Caesalpinia major, Capparis lasiantha, Gymnanthera oblonga, Jacquemontia paniculata, Opilia amentacea, Sarcostemma viminale* subsp. *brunonianum, Tinospora smilacina* and *Tylophora cinerascens*. The introduced creeper wild passionfruit (*Passiflora foetida* var. *hispida*) was ubiquitous through this vegetation, often out-competing the native vine species. Taking into consideration the presence of these weed species, the condition of the monsoon vine thickets ranged between excellent and good.	**High** Identified as a TEC; well developed in the study area; support flora restricted to such habitats, including the Priority 4 species *Pittosporum moluccanum*; at risk from fragmentation, weed invasion and changed fire regimes.	This unit was mapped as Monsoon vine thickets vegetation unit of ENV (2008a; **Appendix C-14**). Between the Sarubin Block and James Price Point, there were extensive areas of deciduous vine thicket supporting emergent stands of the weeping ghost gum (*Corymbia bella*). This particular formation was not common within the study area and its occurrence may be dependent on seasonal freshwater ponding. Some of these stands correspond with areas mapped as the ephemeral freshwater lake claypan or stream unit of ENV (2008a; **Appendix C-14**).
Monsoon deciduous vine thickets/dvt	Monsoon deciduous vine thickets formed discontinuous patches from the southern boundary of the study area extending north to several gullies beyond James Price Point. This unit was typically restricted to the area along the base of the coastal dunes, and was ranked as being in very good to excellent condition. This vegetation type can form a closed-canopy during the wet-season and at this time is almost indistinguishable from the evergreen monsoon vine thicket. During the dry season, however, many of these patches are either deciduous or semi-deciduous and appear dead. Typical deciduous tree species included *Bauhinia cunninghamii, Croton habrophyllus, Grewia breviflora, Gyrocarpus americanus* and *Terminalia petiolaris*. Deciduous shrub species included *Bridelia tomentosa, Flueggea virosa* subsp. *melanthesoides, Grewia retusifolia, Pavetta kimberleyana* and *Premna acuminata*. Vine species were similar to those recorded in the evergreen monsoon vine thickets, and the mistletoe hemi-parasite *Amyema benthamii* was common on *Croton* and *Grewia* spp. The Priority 3 grass *Eriachne semiciliata* was only recorded from deciduous vine thickets.		
Tall closed Scrub/tcs	Tall Closed Scrub was only mapped at two locations within the study area, with the most extensive area immediately east of James Price Point, and another smaller stand in the south-eastern corner of the study area. This unit was characterised by being a complex	**Low** Although not common within the James Price Point study area, this vegetation type is	This unit was mapped as “Pindan woodland” by ENV (2008a; **Appendix C-14**).

Vegetation Type/Map Code (Biota, 2009c)	Vegetation Description (Biota, 2009c)	Conservation Significance Ranking	ENV (2008a)
	mosaic, devoid of eucalypts and dominated by dense wattles. The major dominants were *Acacia monticola* and *A. colei*, with some *A. eriopoda*, *Hakea arborescens* and *H. macrocarpa*, with *Acacia hippuroides*, *Calytrix exstipulata*, *Distichostemon hispidulus* and *Lithomyrtus retusa* in the understorey. The mistletoe (*Lysiana spathulata)* was common on *Acacia* species. This community had not been burnt for a considerable time, and showed little evidence of disturbance; it was considered to be in very good to excellent condition overall.	not considered to be restricted or uncommon on the Dampier Peninsula. There was a single record of the Priority 3 grass *Eriachne semiciliata* from this vegetation unit; however, this species is widespread in the study area.	
Pindan shrubland/ps	Pindan Shrubland is the ubiquitous vegetation that dominates the red sandplains of the Dampier Peninsula. Within the James Price Point coastal area, this vegetation type was dominated by mixed Acacia species (particularly *A. eriopoda* and *A. tumida*), with widely scattered ghost gums (*Corymbia flavescens*) near the coast and scattered bloodwoods (*Corymbia dampieri* and *C. zygophylla*) and occasional Darwin Box (*Eucalyptus tectifica*) elsewhere. In some areas inland from James Price Point, mallee-forms of *Eucalyptus miniata* were found. This may be a result of frequent hot fires in the study area. The principal grasses here were soft spinifex (*Triodia schinzii*), ribbon grass (*Chrysopogon pallidus*), sorghum (*Sorghum stipoideum*) and bunch speargrass (*Heteropogon contortus*). Annual grasses included Northern Kerosene Grass (*Aristida hygrometrica*) and *A. holathera* var. *holathera*, as well as Northern Wanderrie Grass (*Eriachne obtusa*). The Pindan shrubland, open woodland and open forest vegetation units identified by the current study together comprise the area mapped as Pindan woodland by ENV (2008a; **Appendix C-14**). Within the Pindan shrubland, red wattle or gawar (*Acacia monticola*) formed dense, somewhat impenetrable stands which were often associated with underlying ferruginised gravels. This community appeared to be relatively fire-resistant, often forming island-like remnants within the burnt Pindan that were distinct enough to be mapped. A wide range of other tree species lent variety to the Pindan, notably jigal tree (*Bauhinia cunninghamii*), lemonwood (*Dolichandrone heterophylla*), false cedar (*Ehretia saligna*), sandpaper fig (*Ficus aculeata*), mangarr (*Sersalisia sericea*) and several hakea and grevillea species. Other species included ironwood (*Erythrophleum chlorostachys*), native gardenia (*Gardenia pyriformis*), northern kurrajong (*Brachychiton diversifolius* subsp. *diversifolius*), cocky apple (*Planchonia careya*), native poplar (*Codonocarpus cotinifolius*) and wild pear (*Persoonia falcata*). Soap wattle (*Acacia colei*) often formed dense thickets on deep coastal sands and in disturbed areas such as grader spoil heaps. Understorey shrubs included conkerberry (*Carissa lanceolata*), *Distichostemon hispidulus*, camel bush	**Low** This broad vegetation type is widespread and well-represented on the Dampier Peninsula, dominating the red sandplain habitats. While some variation is evident in dominant shrub and tree species, none of the finer scale units described would be expected to be restricted to the James Price Point study area. Two Priority 3 species (*Eriachne semiciliata* and *Polymeria distigma*) were recorded from this unit; however, both are likely to be more widespread in the area.	This unit was mapped as “Pindan woodland” by ENV (2008a; **Appendix C-14**).

Vegetation Type/Map Code (Biota, 2009c)	Vegetation Description (Biota, 2009c)	Conservation Significance Ranking	ENV (2008a)
	(*Trichodesma zeylanicum*), *Acacia adoxa, Gyrostemon tepperi,* native cotton (*Gossypium australe*), *Gonocarpus leptothecus, Waltheria indica* and *Solanum cunninghamii*. Vine species were uncommon but included snakevine (*Tinospora smilacina*), magabala (*Marsdenia viridiflora* subsp. *tropica*) and *Jacquemontia paniculata*. The Pindan shrubland vegetation types were generally considered to be in very good condition.		
Open woodland/ow	Within the current study area, open woodland was restricted to a belt located between Quondong Point and James Price Point within five kilometres of the coast, as well as flanking Kundandu Creek. It was characterised by manowan or woollybutt (*Eucalyptus miniata*) on sandy soils, with long-fruited bloodwood (*Corymbia polycarpa*) confined to seasonally inundated areas such as along Kundandu Creek. Localised patches of wandi ironbark (*Eucalyptus jensenii*) occurred throughout the open woodland, and were often associated with *Acacia monticola*. Other species included *Acacia tumida*, *A. eriopoda* and *A. platycarpa*. In the Kimberley, Kundandu Creek is believed to be the southern limit for *Parinari nonda* and the lily *Crinum angustifolium*. This unit was considered to be in very good to excellent condition.	**Low** This vegetation is well-represented in the James Price Point locality.	This unit was mapped as "Pindan woodland" by ENV (2008a; **Appendix C-14**).
Open forest/of	The Open Forest vegetation unit dominated the unconsolidated, yellow, inland sandplains of the eastern section of the James Price Point coastal area. The tree cover was relatively dense, with an upper layer of *Eucalyptus miniata* up to 12m in height. Other species included occasional Bloodwoods such as *Corymbia dampieri.* There was a variably dense understorey of wattles that included *Acacia eriopoda*, *A. tumida* and *A. platycarpa*. Grass species were similar to those in the Pindan shrubland but also included annual sorghum (*Sorghum stipoideum*) and bunch speargrass (*Heteropogon contortus*). Other understorey shrubs included *Acacia hippuroides, Distichostemon hispidulus* and *Gossypium rotundifolium*. This unit was ranked as being in very good to excellent condition.	**Low** This vegetation is well-represented in the James Price Point locality.	This unit was mapped as "Pindan woodland" by ENV (2008a; **Appendix C-14**).
Drainage basins/db	Drainage Basins comprised areas subject to ephemeral freshwater flooding, ponding, or seepage and were found behind coastal sand dunes subject to seasonal inundation. Such areas were often associated with monsoon vine thicket but were characterised by the occurrence of lardik (*Lophostemon grandiflorus*) and the paperbark karnbor (*Melaleuca dealbata*), neither of which were recorded from monsoon vine thicket. Only two areas were mapped, both of which were in very good condition. Screwpines (*Pandanus spiralis* var. *convexus*) were rarely encountered in the study area, being restricted to coastal sand dunes, seepage areas and travertine outcrops. On the Sarubin Block, karst travertine overlain by sand supported patches of screwpines.	**High** This vegetation type supports flora restricted to such habitats; at risk from fragmentation, weed invasion and changed fire regimes.	These areas correspond to the "ephemeral freshwater lake claypan or stream" unit description of ENV (2008a; **Appendix C-14**); however, the mapping of the extent of this unit has been refined by the current study to remove substantial areas of deciduous and evergreen vine thicket included by the previous study.

Vegetation Type/Map Code (Biota, 2009c)	Vegetation Description (Biota, 2009c)	Conservation Significance Ranking	ENV (2008a)
Sandstone outcrops/so	Sandstone outcrops were rare within the study area. Near the coast they were of limited extent and were not large enough to support a distinct suite of species other than those normally encountered in the Pindan. At Murtjal Creek several small outcrops were located within an evergreen monsoon vine thicket. On the eastern boundary of the survey area, south of Kundandu Creek, sandstone outcrops were more extensive, forming several pavement areas within the *Eucalyptus miniata* open forest. This vegetation unit was considered to be in very good condition.	**Low** These outcrops were not typically large enough to support species distinct from those occurring more generally in the surrounding vegetation.	This unit was not mapped separately by ENV (2008a; **Appendix C-14**), being included under their "coastal communities" vegetation type.

Source: Biota, 2009c; **Appendix C-18**.

1.4.2.4. Vegetation Condition in the James Price Point Coastal Area

Broad scale vegetation mapping of the Pindan vegetation was undertaken by AECOM in November 2009 using an aerial-based condition assessment (undertaken by helicopter with mobile GIS). Data collected was ground-truthed against quadrat data provided in Biota (2009c; **Appendix C-18** and 2010, pers. comm., June 2010) and AECOM (2010b; **Appendix C-20**). The main determinant of vegetation condition within the James Price Point coastal area is altered vegetation structure as a result of changes in fire frequency (AECOM, 2010b; **Appendix C-20**). Weeds were not considered a significant feature of the Pindan vegetation within the James Price Point coastal area.

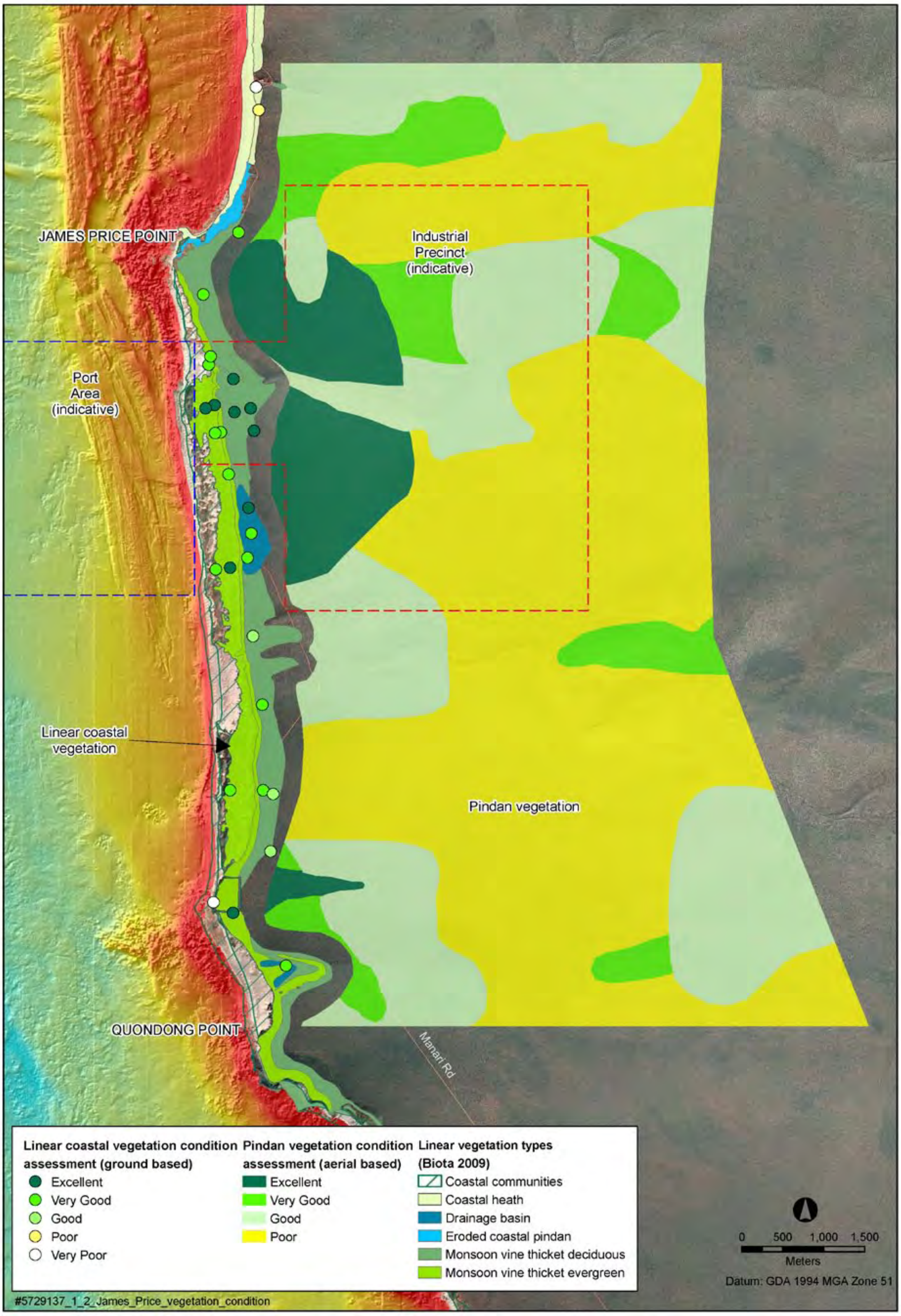
This condition mapping methodology was not considered appropriate for linear coastal vegetation types (monsoon vine thicket, drainage basin, coastal heath and coastal communities) as these are highly susceptible to boundary errors. In addition it is difficult to assess the understorey condition in closed canopy vegetation types such as monsoon vine thickets using the aerial method of assessment. Condition assessment for coastal linear vegetation was undertaken using best available ground-based condition assessment conducted by surveys in the area by Biota (2009c; **Appendix C-18** and 2010, pers. comm., June 2010) and AECOM (2010b; **Appendix C-20**). The results of this mapping are presented in **Figure 1-13**. The detailed results of the broad scale vegetation mapping survey are contained in **Appendix C-20**.

There are a number of vegetation condition scales in existence and for this assessment, the Trudgen (1988) condition scale was used as the basis for this broad scale assessment and consistent with other studies undertaken in the area (see **Appendix C-20** for condition scale).

Biota (2009c; **Appendix C-18**) originally assessed the overall vegetation of the James Price Point area to be in good to very good condition, however specific areas were found to be subject to disturbance as a result of weed invasion and altered fire regimes. Vegetation communities where there was no road access or were otherwise difficult to penetrate, showed little evidence of weed invasion or physical disturbance as a result of human activities. The main signs of human presence comprised assorted rubbish debris along the coast and public access road, arising from tourist visitation and camping in the locality, as well as the historic plantation site on the Sarubin Block at Quondong Point.

The Pindan vegetation, although not considered to be a significant vegetation community, was assessed to be in advanced decline due to excessive fire frequency over most of its range (AECOM, 2010b; **Appendix C-20**). The broad scale mapping of the Pindan vegetation (AECOM, 2010b; **Appendix C-20**) supported this view, showing very significant areas of poor condition vegetation (**Figure 1-13**). Generally Pindan vegetation was in better condition closer to the coast, with small pockets of excellent vegetation immediately adjacent to the coastal vegetation types. The two largest areas of excellent condition vegetation are located immediately to the south of James Price Point. It should be noted that vegetated areas graded as having excellent condition using this assessment method are not uncommon in the Kimberley, particularly in areas that have been sheltered from fire such as wetter, low-lying areas. Such areas are likely to form habitat refuges for fire sensitive fauna species. Areas identified as excellent are therefore pockets of areas that essentially have no obvious signs of disturbance. Areas which were assessed as being excellent showed minimal effects of disturbance when compared to those which were assessed as being very good, good and degraded. The latter areas showed that vegetation structure has been altered to various degrees by recent fires, frequent fires, weed infestation by aggressive weeds, clearing and grazing effects.

Using quadrat data collected by Biota (2009c; **Appendix C-18** and 2010, pers. comm.) and AECOM (2010b; **Appendix C-20**) the overall condition of the linear coastal vegetation can be assessed to be in very good to excellent condition. The main degrading factor within the coastal vegetation types was considered to be the presence of weeds. Apart from Buffel grass invasion along the coastal strip south of Quondong Point, weed infestations were relatively localised to some dunes spread along the coast and roadside areas associated with Manari Road. Species such as *Passiflora foetida var. hispida* (Wild Passionfruit) and *Macroptilium atropurpureum* (Siratro) were widespread and abundant in some areas of monsoon vine thicket. The presence of these weeds reduced the effective condition ranking of such areas from excellent to good (Biota, 2009c; **Appendix C-18**). Fire impacts on lower-lying wetter areas within the coastal vegetation types appear to be less than in the surrounding vegetation.



Source: Vegetation Condition Assessment Methodology based on Trudgen, 1988.

- **Figure 1-13 Vegetation Condition of the James Price Point Coastal Area.**

1.4.2.5. Vegetation Communities of Conservation Significance

The significance of vegetation communities can be assessed by a number of factors, including whether they represent (or potentially represent) TECs which are protected under both State and Federal legislation (see **Appendix C-18**) or PECs, and vegetation communities which may represent similar such communities. In addition, the significance of vegetation communities can be assessed through the condition of the vegetation on regional and local scales.

The consideration of conservation significance has been based on the community's conservation status, its representation within the James Price Point coastal area and broader Dampier Peninsula and the observed level of disturbance, as a result of human activities or factors such as weed invasion or disturbance due to inappropriate fire regimes. Communities recorded by Biota (2009c; **Appendix C-18**) which had restricted distributions within the James Price Point coastal area, and those which represent listed ecological communities within WA are generally considered to be of higher conservation value. An assessment of the conservation significance of vegetation communities within the James Price Point coastal area (**Table 1-5**) identified several as being of high or moderate conservation significance; namely, monsoon vine thicket, coastal heath, coastal communities and drainage basin vegetation. The local and regional extent of these communities and those of lower conservation significance is shown in **Table 1-6**.

- **Table 1-6 Vegetation Types and Representation at Surveyed Locations on the James Price Point Coastal Area and Dampier Peninsula.**

Vegetation Type	Conservation Status (Biota, 2009c)	Current extent within James Price Point Coastal Area (ha) (Biota, 2009c and ENV, 2008a)	Known surveyed community extent on the Dampier Peninsula (ha) (ENV, 2008a, Biota 2009c and CSIRO, 2010)
Monsoon vine thicket	High	572	1,479 (2,710*)
Drainage basins[1]	High	395	1,018
Coastal heath[1]	Moderate (PEC)	114	705
Coastal communities[1]	Moderate (small area of extent)	583	3,742
Pindan shrubland vegetation[1]**	Low	10,155	41,199 (including open woodland and open forest below, see footnote**)
Open woodland[1]**	Low	12,020	41,199 (included as part of Pindan woodland vegetation**)
Open forest[1]**	Low	2,621	41,199 (included as part of Pindan woodland vegetation**)
Eroded coastal Pindan[1]	Nil	51	51
Tall closed scrub[1]	Low	265	32,324
Sandstone outcrops[1]	Low	0.3	0.3
Buffel grassland[1]	Nil (Degraded)	35	35
Total survey area of all vegetation types		**26,811.3**	**80,553.3**

Note: [1] Remote sensing classification was not undertaken for these communities due to likely difficulties in delineating these communities using this method. In addition, ENV mapping provides an adequate understanding of the regional extent of these communities.

* Monsoon vine thicket extent based on recent studies conducted by the DEC (V. English, 2010, pers. comm. DEC, 20 July 2010).

** These communities considered likely to represent various forms of the Pindan Woodland vegetation type mapped by ENV (2008a; **Appendix C-14**).

Of the vegetation types identified by the current study of the James Price Point coastal area, the following are considered to be of particular conservation significance:

- Monsoon vine thickets occurring between James Price Point and Quondong Point behind the coastal sand dunes (high regional conservation value): identified as a TEC; well developed in the study area; support flora restricted to such habitats, including the Priority 4 species *Pittosporum moluccanum*; at risk from fragmentation and edge effects, weed invasion and changed fire regimes.
- Drainage basin vegetation (high local conservation value): supports flora restricted to such habitats; at risk from fragmentation and edge effects, weed invasion and changed fire regimes.
- Coastal heath vegetation (moderate local and regional conservation value): identified as a PEC (Priority 1); susceptible to fragmentation and edge effects and weed invasion.
- Coastal communities (moderate local and regional conservation value): small area of representation; support flora restricted to such habitats, including the Priority 2 species *Gomphrena pusilla*; susceptible to erosion and weed invasion.

1.4.2.5.1. Monsoon Vine Thickets on Coastal Sand Dunes of the Dampier Peninsula – Vulnerable

The monsoon vine thickets in the James Price Point coastal area are representative of the State TEC 'monsoon vine thickets on coastal sand dunes of the Dampier Peninsula' which is currently ranked as Vulnerable by the DEC. The monsoon vine thicket is further classified into Criteria C, meaning that while this ecosystem is still widespread it is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes (DEC, 2009c). Monsoon vine thickets, although widespread along the coast, have a small area of representation as they occur only in sheltered, protected areas on the leeward slopes and directly behind coastal dune systems on the Dampier Peninsula. They generally comprise discontinuous but discrete pockets of relatively dense vegetation, although there are number of occurrences where it is extensive and well connected. They spread further inland into Pindan woodland at the northern tip of the peninsula, and occasionally in association with near-coastal swamps and damplands (AECOM, 2010a; **Appendix C-19**). Monsoon vine thicket is not a listed TEC under the EPBC Act.

Monsoon vine thickets are allied to rainforest ecosystems, ranging from semi-deciduous vine thickets to closed evergreen vine thickets, both types of which occur in the James Price Point coastal area. The monsoon vine thicket communities form one of the most interesting plant communities on the Peninsula, containing a predominance of Indo-Malesian plant species more commonly found in the wetter northwest Kimberley (Biota, 2009c; **Appendix C-18**). Nearly 25% of the 2,000 plant species found in the Kimberley grow in rainforests and approximately a third of these species are confined to these ecosystems (Ellison, 2009).

These monsoon vine thickets are characterised by their relatively high proportion of vagile cosmopolitan genera, their rain-green canopy during the 'wet' season, and their deciduous (or semi-deciduous) appearance during the 'dry' season. Climbers are an important component of the thickets, providing increased canopy cover during the 'wet' season. Monsoon vine thickets contain many fleshy-fruited plants, providing an important food resource for wildlife such as Agile Wallabies, Bowerbirds and Fruit-doves. They are also an important traditional resource for Aboriginal people (Biota, 2009c; **Appendix C-18**).

The high conservation significance of the monsoon vine thickets is based on a number of factors including:

- its restricted area of representation along the Dampier Peninsula coastline;
- its value as an important fauna habitat type, particularly for fruit eating birds, terrestrial invertebrates and mammal species;
- the unique vegetation assemblage that it contains; and
- the highly vulnerability of this vegetation to disturbance such as weed invasion, inappropriate fire regimes and cattle grazing.

Monsoon vine thicket occurring between James Price Point and Quondong Point represents the second largest occurrence of this TEC on the Dampier Peninsula (Biota, 2009c; **Appendix C-18**). The largest vine thickets on the Dampier Peninsula are believed to be those lying between Cape Borda and Packer Island (at the northernmost end of the peninsula). The floristic composition of the monsoon vine thickets at James Price Point appears to be similar across

the surveyed areas of the Dampier Peninsula. This was determined through non-metric Multi Dimensional Scaling of vegetation data collected for vine thicket at James Price Point (Biota, 2009c; **Appendix C-18**) and regionally on the Dampier Peninsula (ENV, 2008a). In relation to the monsoon vine thickets at James Price Point, ordination found that the vine thicket communities were clustered together, with the exception of one quadrat (JP04, Biota, 2009c; **Appendix C-18**), which the analysis aligned with other vegetation communities rather than vine thicket, primarily as a result of the presence of Buffel Grass. Importantly, this analysis helped confirm the accuracy of the current mapping of monsoon vine thickets, and in fact of all vegetation communities. Ordination using the results of the ENV surveys showed that the monsoon vine thicket at James Price Point formed a loose aggregation with the five sites of vine thicket vegetation from the Packer Island study area (ENV, 2008a).

The results of this analysis indicate that vine thicket from James Price Point is similar in floristic composition to that occurring 110km north east. This is important as it provides some indication that vine thicket communities mapped at James Price Point are floristically similar to those occurring elsewhere on the Dampier Peninsula. While vine thicket at James Price Point represents a large area of this TEC's extent, the analysis suggests that this community is unlikely to be floristically distinct from vine thicket associations occurring in areas such as Packer Island.

GIS analysis of the areas of monsoon vine thicket mapped by ENV (2008a; **Appendix C-14**) and Biota (2009c; **Appendix C-18**) at the three survey sites on the Dampier Peninsula indicates that approximately 853ha of this community occurs however, additional areas of this community are likely to occur. It was apparent from TEC database information that a large number of monsoon vine thicket patches occur on the Northern Dampier Peninsula. Most recently DEC mapping has indicated that up to 2,710ha of vine thicket TEC occur on the Dampier Peninsula, with this number being conservative (V. English, 2010, pers. comm. DEC, 20 July 2010).

Prior to the most recent mapping estimates provided by the DEC, the CSIRO used remote sensing techniques to classify monsoon vine thicket on the northern Dampier Peninsula using Thematic Mapper (**TM**) imagery. The purpose of this was to map the extent of vine thicket on the Northern Dampier Peninsula, particularly in those areas outside of the locations mapped by ENV (2008a; **Appendix C-14**). Using available Landsat imagery the CSIRO was able to use image classification to recognise areas with a consistent numerical spectral signature associated with the groundcover type. The results of three years of TM imagery were combined to provide a spectral map of areas consistent with a spectral response for monsoon vine thicket (**Figure 1-14**).

Based on the results of TM imagery classification, aerial photo analysis and targeted ground truthing it was conservatively estimated that 830ha of Evergreen Vine Thicket (**EVT**) occurs on the northern Dampier Peninsula (**Figure 1-14**). The 830ha consists of areas assigned a pixel score of five or six over the three mapping years (CSIRO, 2010; **Appendix C-21**). Areas of likely EVT were assigned a score of two in each year while possible EVT was assigned a score of one and a minimum score of five would mean that a pixel was identified as possible EVT on at least two of the years analysed.

The 830ha as mapped is considered to be conservative as an additional 1,580ha were assigned a scoring of four over the three years of TM imagery. As such, these mapped pixels were assigned as likely EVT in at least one year and possible EVT in at least one of the remaining two years (CSIRO, 2010; **Appendix C-21**). Validation through the analysis of aerial photography and ground truthing was undertaken by AECOM (2010a) to confirm the findings of the remote sensing analysis and this confirmed that the area estimate of 830ha is likely to represent an under estimate of the extent of EVT on the Dampier Peninsula. Numerous small pockets of vine thicket not immediately apparent on prior Landsat-based mapping of monsoon vine thickets on the peninsula were subsequently mapped, and provide a degree of connectivity between the survey area and monsoon vine thickets further north on the Dampier Peninsula. A few very small patches of monsoon vine thicket were evident south of the survey area towards Broome.

The CSIRO study area includes monsoon vine thicket mapped by ENV (2008a) at Lombadina-Packer Island. By subtracting the 204ha of monsoon vine thicket within this location mapped by ENV from the 830ha of consistent EVT signature in the northern Dampier Peninsula it is possible that an additional 626ha of monsoon vine thicket occurs on the Dampier Peninsula to that already mapped by ENV and Biota (ENV mapped 77ha at North Head, while 572ha were mapped by Biota and ENV between Coulomb Point and James Price Point). Based on the results of the CSIRO spatial analysis, the total area of monsoon vine thicket on the Dampier Peninsula is at least 1,479ha. Given the most recent mapping information provided by the DEC, up to 2,710ha of monsoon vine thicket is present on the Dampier Peninsula.

Source: CSIRO, 2010; **Appendix C-21**.

- **Figure 1-14 Monsoon Vine Thicket Distribution on the Northern Dampier Peninsula.**

Community Type #85: Bunda Bunda – Vulnerable

Threatened ecological community mapping identified two Bunda Bunda communities as occurring to the North of Coulomb Point Nature Reserve.

These are communities that occur as organic mound springs on the tidal mudflats of Carnot Bay, approximately 50km north of James Price Point. These mounds, up to 3m in height, have a peaty composition and comprise accumulated leaf litter which supports a dense closed canopy rainforest and tall shrubland. No Bunda Bunda communities were recorded within the ENV (2008a; **Appendix C-14**) survey areas or within the James Price Point coastal area by Biota (2009a).

1.4.2.5.2. Drainage Basin Vegetation

Drainage basin vegetation is considered to be representative of the community described as permanent/ephemeral wetlands, damplands, and riparian habitat of the Dampierland bioregion (Biota, 2009c; **Appendix C-18** and CSIRO, 2010; **Appendix C-21**). Within the James Price Point coastal area this community is located in areas behind coastal dunes which are subject to seasonal inundation and is categorised by the presence of species such as *Melaleuca dealbata* and *Lophostemon grandiflorus*.

This community exhibits structural similarities to the monsoon vine thicket TEC. The two communities both occur in sheltered coastal locations adjacent to sand dunes and contain similar species compositions. Like areas of monsoon vine thicket, this community is currently subject to pressures associated with weed invasion and altered fire regimes within the James Price Point coastal area.

The drainage basin community occupies an area of approximately 395ha within the James Price Point coastal area. Biota (2009c; **Appendix C-18**) defined this community as an 'ecosystem at risk' with a high conservation status due to the small extent (**Table 1-5**). However, these areas are likely to correspond to the 'ephemeral freshwater lake claypan or stream' unit description from the ENV (2008c; **Appendix C-16**) study. While the vegetation unit described and mapped by ENV (2008c; **Appendix C-16**) is likely to encompass a slightly broader vegetation description than the drainage basin vegetation mapped within the James Price Point coastal area, it is apparent that this vegetation type is relatively well represented within the Dampier Peninsula.

It is of note that the Mookak Windmill site to the south of James Price Point, comprising approximately 19ha of drainage basin vegetation, is an old stockyard site (Biota, 2009c; **Appendix C-18**), which would suggest a level of degradation.

1.4.2.5.3. Coastal Heath Vegetation

The coastal heaths of *Acacia tumida var. kulparn* found in the James Price Point coastal area is considered to correspond with the DEC Priority 1 Ecological Community described as the dwarf Pindan heath community of the Broome coast by DEC (2009c). This vegetation does not appear to be uncommon along the coast of the Dampier Peninsula; however, it is relatively restricted in distribution to the narrow coastal fringe (Biota, 2009c; **Appendix C-18**).

Vegetation mapping identifies approximately 114ha of this community occurring within the James Price Point coastal area while approximately 705ha were mapped within those areas of the Dampier Peninsula surveyed by ENV (2008c; **Appendix C-16**).

1.4.2.5.4. Coastal Communities

Coastal communities are considered to be of moderate conservation significance. These communities are likely to be widespread along the coastline of the Dampier Peninsula, but have only a minor area of representation given the restricted position of this habitat type in the landscape.

1.4.2.6. Other Vegetation

Pindan vegetation, although not considered to be a significant vegetation community, is currently in advanced decline due to excessive fire frequency over most of its range. None of the Pindan in the survey area is considered truly pristine. Pristine Pindan vegetation should contain a significant component of vine species and mistletoe growing in the canopy of Acacia-based communities, or a very mixed age-class of regenerating juvenile eucalypts in woodland-based

communities. The opportunity for improved fire management in the vicinity of the development zone is considered to be of significant potential benefit for the local Pindan vegetation.

1.4.2.7. Surface and Groundwater Dependant Vegetation

Groundwater dependant ecosystems are described as vegetation communities with complete or partial reliance on underlying groundwater (that is, they contain groundwater-dependent, or phreatophytic vegetation). Key indicators of GDEs are generally species known to rely on groundwater for survival. It is unlikely that the species within the James Price Point coastal area are wholly dependent on groundwater for survival. These species are referred to as phreatophytes and are highly linked to permanent water sources for water uptake.

Areas within the James Price Point coastal area that are considered to potentially to support phreatophytic vegetation are those in areas less than 10m above sea level close to the coast where the groundwater is likely to be within 10m of the ground surface. This assumption is based on groundwater discharging at the coast high tide level and that vegetation growing in areas of less than 10m depth to groundwater may have some level of groundwater dependence. In particular, some areas along the coast are at or below 10m above sea level including areas of monsoon vine thicket and drainage basin vegetation communities adjacent to the dunes.

An initial desktop review indicated that the drainage basin community identified within the James Price Point coastal area may have a low to moderate likelihood of being groundwater dependant. This was primarily based on the presence of *Melaleuca dealbata* within this community. Further study has shown that monsoon vine thicket vegetation and drainage basin vegetation in the James Price Point area appears to be maintained by both surface water and groundwater infow (Ray Froend, 2010, pers. comm. Edith Cowan University, 25 June 2010). It is also considered likely that the drainage basin community is also somewhat reliant on surface water flows. The surface water input pathways are directly through run-on into the area during the wet season, and indirectly via recharge of the local superficial aquifer. Given the depth to the superficial aquifer surface and knowledge of the lithology in the monsoon vine thicket habitat, it is likely that some of the dominant plant species are utilising groundwater reserves. However the degree of groundwater used is likely to vary spatially and temporally and soil water in the vadose (unsaturated) zone could be the dominant source of water in places where the depth to the watertable is greater than 10m.

Further evaluation of the likely level of groundwater and/or surface water dependence of monsoon vine thicket and drainage basin vegetation communities will be conducted through onsite groundwater investigations and modelling.

1.4.3. Flora

Flora species are described in terms regional, local and site specific scale for the James Price Point coastal area. Significant flora species are protected under either the EPBC Act or the *Wildlife Conservation Act 1950* (**WC Act**) as discussed in **Appendix C18**.

1.4.3.1. Flora of the Kimberley

The Kimberley has been listed as a national biodiversity hotspot and, in addition to the presence of endemic fauna species, the region is thought to contain a total of 230 endemic plant species (DEC, 2009a). Up to 2,000 plant species have been recorded during various surveys within the Kimberley with nearly 25 percent of these species recorded in rainforests and a third of these species confined to rainforests (DEC, 2009a).

Two EPBC Act listed species occur in the Dampierland bioregion; *Keraudrenia exastia* and *Pandanus spiralis* var. *flammeus*. Both of these species are also listed as DRF at the State level by the DEC.

1.4.3.2. Flora of the Dampier Peninsula

Pindan woodland and shrub communities represent the dominant vegetation of the Dampier Peninsula with additional communities also occurring, particularly at coastal locations. Importantly, this includes deciduous and evergreen monsoon vine thicket communities which provide habitat refuge for a number of flora species.

A total of 717 species of vascular plants have been recorded on the Dampier Peninsula, representing 122 families and 361 genera (Kenneally *et al.,* 1996). The most widely represented families include Poaceae, Papillionaceae, Cyperaceae, Euphorbiaceae, Myrtaceae, Mimosaceae, Convolvulaceae and Malvaceae. Of these 717 species, 68

introduced species have been recorded, with the majority located on the northern tip of the Peninsula north of Beagle Bay (Keneally *et al.,* 1996).

No endangered or vulnerable flora species under the EPBC Act, or DRF under the WC Act, were recorded in the three Dampier Peninsula survey areas investigated by ENV (2008b; **Appendix C-15**).

It was, however, considered that *Keraudrenia exastia*, which is listed as DRF, may have the potential to occur on the Dampier Peninsula. Four DEC listed Priority flora species were recorded within the survey areas (ENV, 2008a; **Appendix C-14**) and it is likely that additional species may be located on the Dampier Peninsula, particularly during the wet season.

1.4.3.3. Flora of the James Price Point Coastal Area

A total of 308 native plant species were recorded within the James Price Point coastal area by both ENV (2008c; **Appendix C-16**) and Biota (2009c; **Appendix C-18**), while 22 introduced species were also recorded. Native species numbers for both the wet and dry season surveys are shown in **Table 1-7**. The Biota (2009c; **Appendix C-18**) wet season flora study is contained in full in **Appendix C-18**.

Table 1-7 Total Native Plant Species Observed during Wet Season and Dry Season Surveys.

Plant Group	Recorded in Wet Season Survey - Biota (2009c)	Recorded in Dry Season Survey - ENV (2008c)	Total for James Price Point Coastal Area
Native Species	276	182	308
Native Genera	164	134	175
Native Families	67	55	67
Introduced Species	21	12	22

1.4.3.4. Flora of Conservation Significance in James Price Point Coastal Area

No species listed under the EPBC Act or species listed as DRF were recorded in the James Price Point coastal area during the three surveys conducted of the area.

Keraudrenia exastia, which is listed under the EPBC Act, and the State-based DRF list, occurs on red sand in Pindan and coastal sites, both of which are widespread habitats at the James Price Point costal area. However, the nearest known population is over 33km south of the southern end of the James Price Point coastal area. This species also has not been identified in the area to date, despite intensive searches for further populations including targeted searches for the species in 2009 (AECOM, 2010a; **Appendix C-19**). It is therefore considered highly unlikely to occur in the James Price Point coastal area (Biota, 2009c; **Appendix C-18**).

Five Priority species were recorded during the field surveys:

- *Gomphrena pusilla* (Priority 2) was recorded from ten locations occurring on or immediately behind coastal dunes in the coastal communities and evergreen monsoon vine thicket vegetation units (Biota 2009c; **Appendix C-18**, Biota 2010, pers. comm., June 2010).
- *Eriachne semiciliata* (Priority 3) was recorded from numerous locations over the length of the study area and was widespread within most vegetation types.
- *Polymeria distigma* (Priority 3) was recorded from five locations in the northeastern and southwestern corners of the study area.
- *Pterocaulon* sp. (Priority 2) recorded from two locations to the south of the BLNG Precinct.
- *Pittosporum moluccanum* (Priority 4) was recorded from two locations in monsoon vine thicket habitat between 1.4km and 2.3km south of James Price Point.

In addition to the survey records, a search of the DEC and WA Herbarium Rare Flora database identified a further six Priority listed species as having previously been recorded within 15 km of the James Price Point coastal area (Biota, 2009c; **Appendix C-18**). The species were:

- *Aphyllodium parvifolium* (P1);
- *Corymbia paractia* (P1);
- *Glycine Pindanica* (P1);
- *Aphyllodium glossocarpum* (P3);
- *Schoenus punctatus* (P3); and
- *Stylidium costulatum* (P3).

Based on known habitat preferences it is considered that, with the exception of *Schoenus punctatus*, the above Priority species may also have the potential to occur within the James Price Point coastal area (Biota, 2009c; **Appendix C-18**). There were also a number of other species that are nominated for Priority flora listing by DEC that were recorded or may possibly occur in the James Price Point coastal area (**Table 1-8**).The moderate species richness recorded (308 native taxa recorded) has led Biota (2009c; **Appendix C-18**) to conclude, using Table 3 in Appendix 2 of EPA Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment (**EIA**) in WA (EPA, 2004b), that the James Price Point coastal area is one of moderate conservation value for flora. This conclusion is supported by the additional flora species of conservation interest that were identified by Biota (2009c; **Appendix C-18**) and AECOM (2010a; **Appendix C-19**). Some of these species could not be identified to a species level and were considered to potentially represent new taxa, while a number of species were considered to fall outside of their normal range and distribution or were considered to represent poorly collected taxa.

Table 1-8 below (AECOM, 2010a; **Appendix C-19**) lists State and Commonwealth listed flora of conservation significance that are either known to occur within the survey area or could potentially occur within the area. This information was compiled from Biota (2009a) and AECOM (2010a; **Appendix C-19**).

- **Table 1-8 Significant Flora Identified by Desktop Study and/or Recorded from the James Price Point Coastal Area.**

Species	Conservation Significance	Habitat	Flowering Period	Occurrence or Potential Occurrence within the BLNG Precinct	Conclusive Occurrence
Pandanus spiralis var. *flammeus*	DRF(WA) Endangered (EPBC)	White clay Rock faces Springs		Unlikely to occur within the BLNG Precinct due to the absence of preferred habitat and substrate.	Unlikely
Keraudrenia exastia	DRF(WA) Critically Endangered (EPBC)	Red sand in Pindan Coastal sites Relict desert dune swale	Apr–Dec	The nearest known population is over 33km south of the southern end of the James Price Point coastal area. This species has also not been identified in the area to date, despite intensive searches for further populations including targeted searches for the species in 2009 (AECOM, 2010a; **Appendix C-19**). It is considered highly unlikely to occur in the James Price Point coastal area (Biota, 2009c; **Appendix C-18**).	Unlikely
Aphyllodium parvifolium	Priority 1	Sand Sandhills	Apr/Jul	Considered rare within the area, but could possibly occur within drainage lines in the BLNG Precinct.	Possible
Corymbia paractia	Priority 1	Skeletal soils Transition zone between coastal beach dunes Red Pindan soils	Apr–May/Oct–Dec	The nearest known population is 6km south of the BLNG Precinct. Although not detected, it is possible this species may occur in the BLNG Precinct.	Possible
Glycine Pindanica	Priority 1	Pindan soils	Feb–Mar/Jun	The nearest known population is 6.4km east of the BLNG Precinct provides suitable habitat.	Possible
Gomphrena pusilla	Priority 2	Fine beach sand behind foredune, on limestone	Mar–Jun	Known to occur within the survey area. Several records on coastal dunes in coastal community habitat within the James Price Point coastal area.	Occurs
Pterocaulon sp. A Kimberley Flora (B.J. Carter 599)	Priority 2	Sand Coastal areas saline sandy flats Pindan sandplain	Apr–Aug	Two populations located to the south of the BLNG Precinct (AECOM, 2010a; **Appendix C-19**).	Occurs
Aphyllodium glossocarpum	Priority 3	Sand Pindan	Apr–Oct	Nearest known populations are 11km east of the northern end and 14km south of the James Price Point coastal area. James Price Point coastal area provides suitable habitat.	Possible

Species	Conservation Significance	Habitat	Flowering Period	Occurrence or Potential Occurrence within the BLNG Precinct	Conclusive Occurrence
Eriachne semiciliata	Priority 3	Shallow soils over rock Red sand Sandy clay Ridges Sand dunes	Mar–Apr	Known to occur within the survey area. Recorded by Biota (2009c; **Appendix C-18**). Recorded from several locations within the James Price Point coastal area by ENV (2008b; **Appendix C-15**).	Occurs
Polymeria distigma	Priority 3	Sandy soils	Apr–Jul	Known to occur within the BLNG Precinct footprint. Five records from the northeast and southwest of the study area by Biota (2009c; **Appendix C-18**).	Occurs
Schoenus punctatus	Priority 3	Watercourses	Aug	Nearest known population is 13.3km east of the northern end of the BLNG Precinct. Would not be expected to occur in the James Price Point coastal area (Biota, 2009c; **Appendix C-18**).	Unlikely
Stylidium costulatum	Priority 3	Sandy or clayey soils Creeks Seasonally wet areas	Apr–Aug	Nearest known population is 9.3km north of the BLNG Precinct. Although not detected, it is possible this species may occur in the BLNG Precinct.	Possible
Pittosporum moluccanum	Priority 4	White sand Sand dunes	Feb–Aug	Five records occur within the BLNG Precinct. Two locations were recorded by Biota between 1.4km and 2.3km south of James Price Point (Biota, 2009c; **Appendix C-18**) and confirmed by AECOM (2010a; **Appendix C-19**). Recorded from a single location near the coast, approximately 2.3km south of James Price Point by ENV (2008b; **Appendix C-15**) during the 2008 dry season survey of the current study area.	Occurs
Byblis guehoi	Nominated as Priority 1	Drainage lines		Only known from the vicinity of Bobby's Creek near Beagle Bay. May occur in drainage lines elsewhere on the Peninsula. Although not detected it is possible, this species may occur in the BLNG Precinct.	Possible
Cyperus haspan ssp. *haspan*	Nominated as Priority 1	Peat On banks at edge of spring		Only known from a single location near Beagle Bay.	Unlikely

Species	Conservation Significance	Habitat	Flowering Period	Occurrence or Potential Occurrence within the BLNG Precinct	Conclusive Occurrence
Jacquemontia sp. Broome (A.A. Mitchell 3028)	Nominated as Priority 1	Pindan sands		Restricted to Pindan sands between Broome and Beagle Bay. Whilst not recorded to date, this taxon is likely to occur within the study area.	Likely
Thespidium basiflorum	Nominated as Priority 1	Sandy soils Creeks	May–Aug	Only known from two populations in WA, both on the Dampier Peninsula, near Bobby's Creek, and at Coconut Well. May occur in drainage lines elsewhere on the Peninsula.	Possible
Isolepis humillima	Nominated as Priority 2	Red/brown clay Claypans seepages Along watercourses	Apr–Aug	Occurs in damplands on sand in the southwest Kimberley and may occur in the survey area.	Possible
Acacia sp. Broome (B.R. Maslin 4918)	Nominated as Priority 3	Rocky clay Red sand Coastal cliffs Low-lying areas	Apr–Jun	Known from nine populations between Broome and Camballin. Although not detected, it is possible this species may occur in the BLNG Precinct.	Possible
Acacia sp. Riddell Beach (T. Willing 71)	Nominated as Priority 3	Exposed cliff top Footscree below steep gorge Road verges	Jun	Restricted to the Dampier Peninsula, locally restricted in coastal areas.	Unlikely
Bonamia oblongifolia	Nominated as Priority 3	Sandy or gravelly soils	Feb	Known from three populations on the Dampier Peninsula.	Unlikely
Croton aridus	Nominated as Priority 3	Deep red sand Pindan soil Sandplains or ridges Spinifex sandplains	Aug	Known from four populations in WA, one on the Dampier Peninsula.	Likely
Dendrophthoe odontocalyx	Nominated as Priority 3	Aerial shrub-hemiparasitic on stems of *Melaleuca* spp	Jun–Aug	Only known from three populations in WA. One record from Lolly Spring on the Dampier Peninsula. Limited habitat.	Unlikely
Lophostemon grandiflorus ssp. *grandiflorus*	Nominated as Priority 3	Damp habitats Swamps and seepages	Jan–Dec	Known to occur within the BLNG Precinct, recorded by Biota (2009c; **Appendix C-18**). One population mapped by AECOM (2010a; **Appendix C-19**) within the BLNG Precinct and additional occurrences to the north of the BLNG Precinct.	Occurs

Species	Conservation Significance	Habitat	Flowering Period	Occurrence or Potential Occurrence within the BLNG Precinct	Conclusive Occurrence
Utricularia stellaris	Nominated as a Priority 3	Swamps Lagoons	Jun–Jul	One record from Lolly Spring on the Dampier Peninsula. A swamp-dwelling species which is unlikely to occur within the BLNG Precinct.	Unlikely
Parsonsia kimberleyensis	To be nominated for listing as DRF	Monsoon vine thickets	May–Jun	*Parsonsia kimberleyensis* was previously incorrectly recorded from the survey area based on sterile juvenile material which was later identified as *Tylophora cinerascens*. *P. kimberleyensis* remains known from a single locality on the northern Dampier Peninsula.	Unlikely
Pandanus spiralis var. *convexus*	Southern most population	Sand dunes Watercourses		This population was located to the south of the BLNG Precinct at Barred Creek.	Possible
Spermacoce spp.	The taxonomic (and conservation) status of two *Spermacoce* spp. collected during the Biota wet season survey requires further clarification			Recorded by Biota (2009c; **Appendix C-18**).	Occurs

1.4.4. Introduced Flora

Introduced flora species pose a significant threat to the vegetation communities of the Kimberley region. Weeds can degrade ecosystems by displacing native individual species and entire communities, changing fire regimes, creating loss of habitat for native species and changing nutrient cycles.

1.4.4.1. Introduced Flora of the Kimberley

Two hundred and thirty six weeds have been recorded in the Kimberley region (Ellison, 2009). Weeds, along with altered fire regimes and stock grazing are one of the serious environmental issues currently impacting flora and vegetation communities of the Kimberley and the regions biodiversity values. These impacts include the following;

- displacement of individual species as well as entire communities over time;
- resultant changes to fire regimes;
- loss of habitat and food resources for native species;
- changes to nutrient cycles; and
- provision of refuge habitat for invasive fauna species.

Invasive flora species, or weed invasion has been identified by the DEC as a threat to biodiversity conservation on the Dampier Peninsula.

Many introduced species thrive in the landscape where the impacts of cattle and fire have reduced the integrity of native vegetation communities (DEC, 2009a). While riparian areas may contain a wide variety of weed species the broader landscape is threatened by those weed species that are more tolerant to low moisture levels such as Buffel grass (DEC, 2009a). Priority weed species identified by the Department of Agriculture and Food WA (**DAFWA**) for the Kimberley region include Noogorra burr (*Xanthium strumarium*) and Parkinsonia (*Parkinsonia aculeata*) (DAFWA, 2009).

The DEC (2009a) has further recognised that species such as Wild Passionfruit (*Passiflora foetida*) are having a significant impact through increasing changes to Kimberley flora and vegetation, particularly in some rainforest communities. This report further identifies new weed species that have occasionally been located in the broader Kimberley region. This has included *Vachellia nilotica* (Rubbervine) and *Parthenium hysterophorus* (Parthenium weed).

Environs Kimberley community weed project work (i.e. the Community Weed Education Eradication Delivery (**WEED**) Project), has identified particularly problematic weed species that include Siratro (*Macroptilium atropurpureum*), Hairy Merremia Vine (*Merremia dissecta*), Lead Tree (*Leucaena leucocephala*) and Wild Passionfriut. In particular, Siratro has been identified through Federal Government funded community weed work as being a high priority species in monsoon vine thickets.

1.4.4.2. Introduced Flora of the Dampier Peninsula

Weeds are considered a major threat to the conservation of biodiversity assets on the Dampier Peninsula. The impact of invasive weeds on the condition of the Dampier Peninsula vegetation is not well quantified. Anecdotal information suggests that areas that are affected by networks of tracks in the southern part of the Peninsula experience greater weed impacts than remote locations. In general, weed invasions have been associated with the loss of native species, through smothering and/or shading out native vegetation and chocking waterways, and alteration of fire regimes by making the area more flammable in the dry season (Ellison, 2009).

ENV (2008b; **Appendix C-15**) identified 17 weed species during flora surveys on the Dampier Peninsula: Of these species, *Sida cordifolia* is a Priority 1 Declared plant under the *Agriculture and Related Resources Protection Act 1976* (ARRP Act). Four others have a high weed rating under the Environmental Weed Strategy for WA (CALM, 1999) based on their invasiveness and impact on the environment.

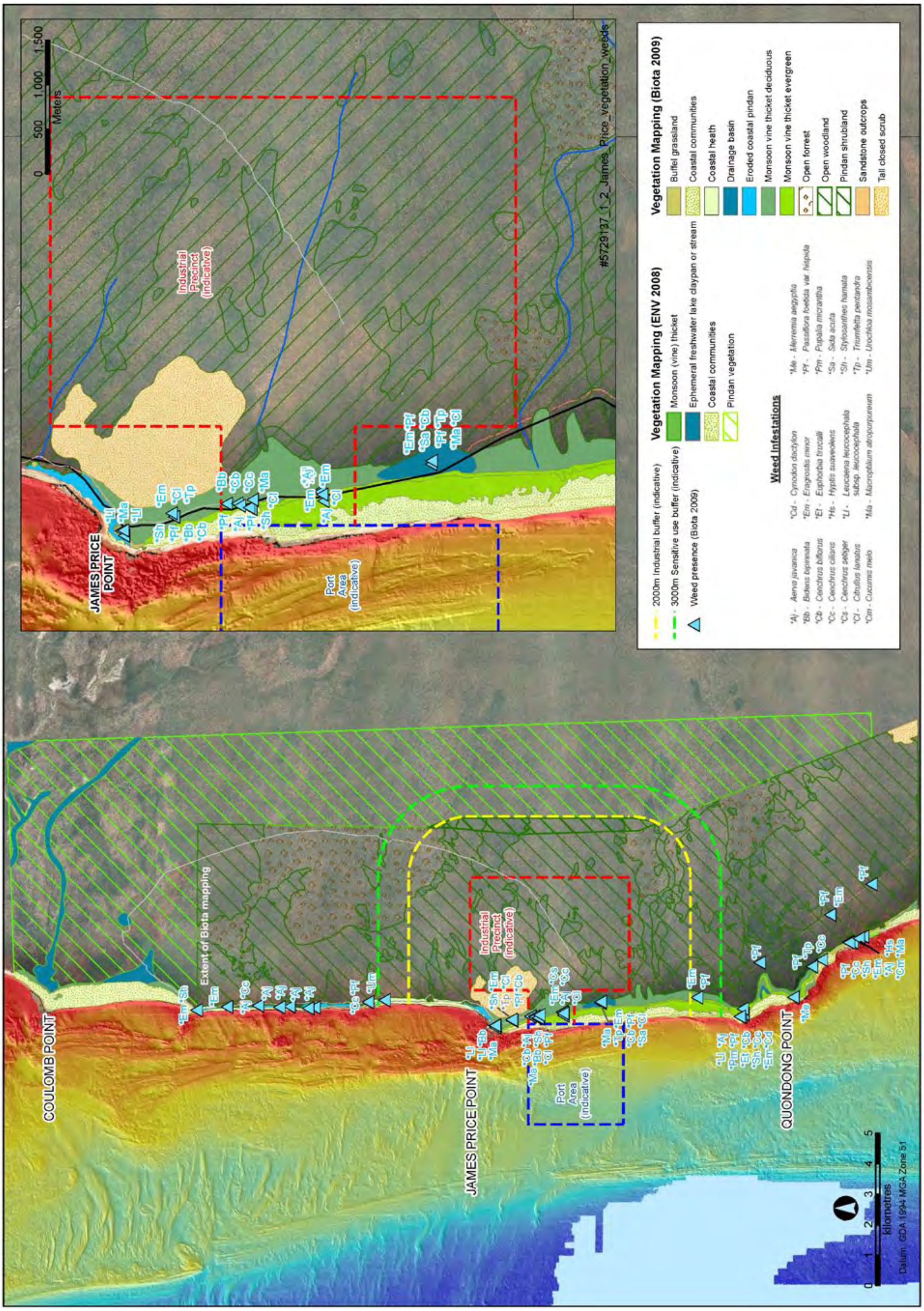
1.4.4.3. Introduced Flora of the James Price Point Coastal Area

Biota (2009c; **Appendix C-18**) and ENV (2008c; **Appendix C-16**) recorded 22 weed species in the James Price Point coastal area. This included the weed *Sida acuta*, which is a Priority 1 Declared Plant under the ARRP Act, and nine being serious environmental weeds as they are highly aggressive and can have significant impacts on vegetation (Biota, 2009c; **Appendix C-18**). The most widespread serious weeds within the James Price Point coastal area are Buffel grass (*Cenchrus ciliaris*) and Kapok bush (*Aerva javanica*) (Biota, 2009c; **Appendix C-18**). The rapid regrowth and high biomass of Buffel grass may alter the intensity, frequency and extent of fires, changing vegetation structure and composition (CRC Weed Management, 2010). Encouraged by fire, it is known to encroach into monsoon vine thicket communities, increasing fuel load and flammability, thus impacting on vine thicket incrementally and sustaining further weed spread (McGilvray, 2008).

Wild passionfruit, Hairy merremia, Siratro and Leucana all represent a threat to monsoon vine thicket vegetation. Biota (2009c; **Appendix C-18**) found that Wild passionfruit (*Passiflora foetida* var. *hispida*) was widespread and abundant in vine thickets, while Siratro (*Macroptilium atropurpureum*) was confined to localised infestations within vine thickets in the southern section of the study area. The presence of these weeds reduced the vegetation condition in such areas, but did not substantially diminish the overall conservation value of the vegetation type or the area (Biota, 2009c; **Appendix C-18**). It is considered that weed infestations at James Price Point are likely to be associated with areas of historical disturbance as a result of tracks and past cattle grazing, as well as disturbance along Manari road.

Significant populations of Buffel grassland were observed on the coastal dunes. A large number of ornamental species were observed on an abandoned tenement north of Quondong Point. AECOM (2010a; **Appendix C-19**) noted that while some of these species are not currently known as weeds, they do have the potential to spread and cause damage to adjacent monsoon vine thickets if not controlled.

A mapping of occurrence of invasive weeds in the James Price Point coastal area is shown in **Figure 1-15**.



■ **Figure 1-15 Invasive Weeds identified in the James Price Point Coastal Area.**

1.4.5. Fauna Habitats

The presence of habitats suitable for vertebrate fauna can be assessed at regional, local context and site specific levels in relation to the James Price Point coastal area. Fauna habitats can be assessed as being of conservation significance based upon their likely use by fauna of conservation significance and their regional and local representation.

1.4.5.1. Fauna Habitats of the Kimberley

The North Kimberley is highly diverse and supports a variety of rare fauna habitat types including mound springs, swamp rainforests and the Airfield Swamp; a large wetland and paperbark forest. Fauna habitat values of the Kimberley region are listed below:

- The presence of four internationally recognised Ramsar listed wetlands and an additional 21 wetlands that are considered to be of national importance (DEC, 2009a). Such areas are important nesting and foraging habitat for aquatic and migratory bird species, including species listed under international conventions such as JAMBA, CAMBA, ROKAMBA and the Bonn Convention.
- The presence of some of the largest patches of mangroves in Australia, totalling an area of approximately 140,000ha (DEC, 2009a).
- The exhibition of a high degree of invertebrate endemism, particularly within groups such as camaenid land snails and earthworms, within the sandstone uplands and rainforest patches of the high-rainfall north Kimberley, and from within the limestone ranges in the south-western Kimberley and the Victoria-Bonaparte Bioregion (DEC, 2009a).
- The presence of rainforest ecosystems that exhibit high levels of invertebrate endemism and contain fruit producing plants which are an essential food resource for much of the region's fauna. While Kimberley rainforest is relatively limited in extent compared to savannah habitats, 45% of terrestrial bird fauna in the Kimberley has been recorded within rainforest communities (DEC, 2009a).
- The presence of troglobitic and stygofauna habitats, particularly within the limestone ranges of the east and west Kimberley.

1.4.5.2. Fauna Habitats of the Dampier Peninsula

There have been very few comprehensive fauna surveys of the Dampier Peninsula. More recent targeted fauna surveys as part of Beagle Bay Tropical Timber Plantation Project to the north east of the James Price Point coastal area (Ecologia, 2004) and wet and dry season surveys conducted as part of this project (ENV, 2008c; **Appendix C-16**, Biota, 2009b; **Appendix C-17** and AECOM, 2010b; **Appendix C-20**) have helped to improve the understanding of the fauna habitats that occur and their value.

Known fauna values of the Dampier Peninsula include the following:

- coastal areas that provide a foraging resource for migratory and aquatic bird species;
- fragmented patches of monsoon vine thicket communities at the landward edge of coastal dunes; and
- Pindan and woodland communities that provide habitat for listed State and Federal fauna species.

ENV (2008c; **Appendix C-16**) described 10 fauna habitat types within the Dampier Peninsula and at a nearby location, Gourdon Bay. Described habitat types include:

- Pindan woodland;
- monsoon vine thickets;
- semi-permanent freshwater lakes;
- ephemeral clay pans;
- supratidal mudflat;
- mangroves;
- tidal creeks, stream beds and springs;
- saltwater lagoons and inlets;
- dunes and headland; and
- beaches and intertidal flats.

The dominant habitat type on the Dampier Peninsula is Pindan woodland. This habitat type typically consists of open eucalypt woodland with a sparse canopy of *Corymbia* and *Eucalyptus* species and a mid-layer of *Melaleuca, Hakea* and *Acacia* species. The ground cover usually consists of a moderate to dense cover of *Triodia* species, or a dense cover of *Acacia* in regenerating Pindan habitats. Pindan habitats sustain high species richness and is potentially utilised by a large number of conservation-significant fauna, such as the Bilby (*Macrotis. lagotis*), the Dampierland Burrowing Snake (*Simoselaps minimus*), the Bush Stone-curlew (*Burhinus grallarius*), the Australian Bustard (*Ardeotis australis*), the Pictorella Mannikin (*Heteromunia pectoralis*) and the Gouldian Finch (*Erythrura gouldiae*) (ENV, 2008c; **Appendix C-16**).

Another important habitat type found on the Dampier Peninsula is monsoon vine thickets, which are recognised by the DEC as a TEC. Monsoon vine thickets are a restricted habitat type in the region that supports unique flora and fauna (including many at the southern extent of their range). Monsoon vine thicket communities have very high biodiversity (ENV, 2008a; **Appendix C-14**) and support endemic species, such as the Rose-crowned Fruit Dove (*Ptilinopus regina*), Little Shrike Thrush (*Colluricincla megarhyncha*) and Rainbow Pitta (*Pitta iris*) (World Wildlife Foundation, (**WWF**) 2008).

1.4.5.3. Fauna Habitats of the James Price Point Coastal Area

Seven main habitat units were identified within the James Price Point coastal area, based on differences in substrate, vegetation and landform (Biota, 2009b; **Appendix C-17**):

- Pindan woodland and shrubland;
- coastal communities;
- coastal heath;
- open forest;
- monsoon vine thicket;
- tall closed shrub; and
- drainage basin.

The dominant habitat type within the James Price Point coastal area is Pindan woodland and shrubland, located immediately inland of a narrow coastal strip composed of coastal heath, coastal communities and monsoon vine thickets. The condition of this habitat varies, primarily as a result of differences in historical fire frequency and intensity, but is generally in very good or good condition.

The coastal habitats have local importance in providing foraging resources for migratory and aquatic bird species, but primarily it is the monsoon vine thicket that is of local and regional conservation significance. It represents a distinct and restricted faunal assemblage and habitat type in the James Price Point coastal area and is a listed TEC by the DEC. Monsoon vine thickets are likely to represent a significant feeding resource for particular bird species given the presence of fruit producing plants (Biota, 2009b; **Appendix C-17**) and may provide localised shelter for mammals, reptiles, and short-range endemic (**SRE**) fauna with specific habitat requirements not exhibited by surrounding Pindan woodland.

The remaining habitats of the James Price Point coastal area are considered to be well-represented within and typical of the Dampier Peninsula and do not have particular conservation value for fauna (Biota, 2009b; **Appendix C-17**).

1.4.5.4. Fauna of the James Price Point Coastal Area

Dry season fauna surveys undertaken by ENV (2008c; **Appendix C-16**) and wet season surveys completed by Biota (2009b; **Appendix C-17**) represent systematic fauna survey work been carried out in the James Price Point coastal area. AECOM (2010b; **Appendix C-20**) also compiled a list of fauna species observed within the area during a supplementary fauna survey which more specifically targeted EPBC Act-listed fauna species. Biota (2009b; **Appendix C-17**) conducted a search of the WA Museum's Nature Map program and compiled a checklist of species that have been recorded within the James Price Point coastal area. The list comprised of 297 species and contained 30 mammals, 70 reptiles, nine amphibians and 188 bird species. Wet season surveys (Biota, 2009b; **Appendix C-17**) and dry season surveys (ENV, 2008c; **Appendix C-16** and AECOM, 2010b; **Appendix C-20**) found direct or indirect evidence of 194 vertebrate species at James Price Point, comprising 21 mammals, 51 reptiles, four amphibians and 118 bird species.

Table 1-9 provides a summary of the number of species recorded from the major vertebrate fauna groups with avifauna species representing the most common group. The results of ENV (2008c; **Appendix C-16**) surveys within the broader

Dampierland region (Gourdon Bay, Perpendicular Head/North Head and Packer Island) are also provided to give an indication of the number of fauna species that potentially occur within the James Price Point coastal area, given that similar habitat types occur within the region. Lists of species recorded can be found in the reports by ENV (2008c; **Appendix C-16**), Biota (2009b; **Appendix C-17**) and AECOM (2010b; **Appendix C-20**) respectively.

- **Table 1-9 Wet and Dry Season Fauna Results Summary.**

Fauna Group	Number of Species Recorded (indirectly recorded)			
	James Price Point (Biota, 2009b)	**James Price Point (ENV, 2008c)**	**James Price Point (AECOM, 2009b)**	**Dampierland (ENV, 2008c)**
Amphibians	4	0	0	7
Reptiles	39	19	20	56
Native Volant Mammals (Bats)	4	9	0	18
Native Non-volant Mammals	3	3	3 (2)	11
Introduced Fauna	2	3	3	7
Avifauna	68	0*	85	181
Total	120	34*	111	278
*Avifauna surveys were not conducted within the area due to time constraints.				

1.4.5.5. Fauna of Conservation Significance in the James Price Point Coastal Area

The following discussion of fauna of conservation significance deals primarily with threatened fauna listed under the EPBC Act, International Union for Conservation of Nature (**IUCN**) listed-fauna, fauna protected under the WC Act and DEC-listed Priority Fauna. Migratory birds, i.e. those listed as 'Migratory' under the EPBC Act are specifically dealt with in **Section 1.4.8**. An explanation of the Commonwealth and State conservation status indicated above against these species and a summary of the statutory framework for considering conservation significance is provided in **Appendix C-17**.

A desktop review of regional fauna records for threatened species indicated a potential for 31 conservation significant species in the James Price Point coastal area (**Table 1-10**). Of these species, eight were recorded within the James Price Point coastal area (Biota, 2009b; **Appendix C-17**, ENV, 2008c; **Appendix C-16** and AECOM, 2010b; **Appendix C-20**) and a further 11 species were determined to possibly occur within the area based on the presence of suitable habitat. Key habitat attributes, such as large hollow-bearing trees or permanent freshwater, are generally absent from the James Price Point coastal area and, as such, preclude the potential presence of a number of species of conservation significance.

Fauna species of conservation significance recorded in the James Price Point coastal area include:

- Peregrine Falcon (*Falco peregrinus*) - Schedule 4 (WC Act);
- Dampierland Burrowing Snake (*Simoselaps minimus*) - Priority 2 (DEC);
- Dampierland Plain Slider (*Lerista separanda*) - Priority 2 (DEC);
- Bush Stone-curlew (*Burhinus grallarius*) - Priority 4 (DEC);
- Chestnut-backed Button-quail (*Turnix castanota magnifica*) - Priority 4 (DEC);
- Little Northwestern Mastiff Bat (*Mormopterus loriae cobourgiana*) - Priority 1 (DEC);
- Eastern Curlew (*Numenius madagascariensis*) - Priority 4 (DEC), Migratory (EPBC Act); and
- Dingo (*Canis lupus dingo*) Vulnerable (IUCN).

Fauna species of conservation significance which possibly occur include:

- Australian Painted Snipe (*Rostratula australis*) – Vulnerable, Migratory (EPBC Act);
- Greater Bilby (*Macrotis lagotis*) – Vulnerable (EPBC Act), Schedule 1 (WC Act);
- Golden Bandicoot (*Isodoon auratus*) - Vulnerable (EPBC Act), Schedule 1 (WC Act);
- Masked Owl (northern) (*Tyto novaehollandiae kimberli*) - Vulnerable (EPBC Act);
- Golden-backed Tree-rat (*Mesembriomys macrurus*) - Vulnerable (EPBC Act), Priority 4 (DEC);
- Flock Bronzewing (*Phaps histrionica*) - Priority 4 (DEC);
- Water-rat (*Hydromys chrysogaster*) - Priority 4 (DEC);
- Pictorella Mannikin (*Heteromunia pectoralis*) - Priority 4 (DEC);
- Australian Bustard (*Ardeotis australis*) - Priority 4 (DEC);
- Grey Falcon (*Falco hypoleucos*) - Priority 4 (DEC); and
- Lakeland Downs Mouse (*Leggadina lakedownensis*) - Priority 4 (DEC).

The consideration of habitat availability and likely presence of conservation significant species presented in **Table 1-10** found that the majority of conservation significant fauna species under consideration have broad habitat requirements, and are likely to occur elsewhere on the Dampier Peninsula where woodland or shrubland habitats occur.

- **Table 1-10 Consideration of Conservation Significant Species Presence.**

Species	**Status**	**Known Habitat Requirements**	**Habitat Potential of the James Price Point Coastal Area**	**Likelihood of Occurrence**
Gouldian Finch (*Erythrura gouldiae*)	Endangered, Migratory (EPBC Act), Vulnerable (IUCN), Schedule 1 (WC Act).	May occur in low densities across the Dampier Peninsula, wherever suitable grasslands occur (ENV, 2008c; **Appendix C-16**). Known breeding habitats occur in association with rocky hills, hollow bearing eucalypts and permanent fresh water. Gouldians nest in tree hollows or in termite mounds. This species usually feeds on a range of seeding grasses. They are partly migratory, following grass seeding patterns.	Species has been recorded in the northern Dampier Peninsula (Galaxia, 2010; **Appendix C-1**), however it is unlikely that the James Price Point coastal area would represent an area of habitat owing to the absence of breeding habitat and permanent freshwater for much of the dry season.	Unlikely
Australian Painted Snipe (*Rostratula australis*)	Vulnerable, Migratory (EPBC Act).	The Australian painted snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans.	Species was recorded from the Dampier Peninsula near the James Price Point coastal area.	Possible
Princess parrot (*Polytelis alexandrae*)	Vulnerable (EPBC Act), Priority 4 (DEC).	The princess parrot generally inhabits arid areas and lightly wooded country. The species core range appears to be within the Great Sandy Desert.	Species may periodically occur within the James Price Point coastal area; however, the area is unlikely to represent important habitat.	Unlikely
Brush-tailed Rabbit- rat (*Conilurus penicillatus*)	Vulnerable (EPBC Act).	In WA, this species is restricted to the northern Kimberley where its distribution is both patchy and large, with several known populations. Most records are from the Mitchell Plateau and nearby Prince Regent Nature Reserve (DEWHA, 2008c). The	Based on the species known range within WA it is considered unlikely that the species would occur within the James Price Point coastal area. Further to this it areas	Unlikely

Species	Status	Known Habitat Requirements	Habitat Potential of the James Price Point Coastal Area	Likelihood of Occurrence
		species is identified as preferring eucalypt woodland where it nests in tree hollows (NRETA, 2007).	of preferred habitat are absent in the James Price Point coastal area.	
Northern Quoll (*Dasyurus hallucatus*)	Endangered (EPBC Act)	The Northern Quoll occurs in tropical savannahs of northern Australia, where it mostly occurs in rocky areas and eucalypt forests rests in caves, hollow logs and rock crevices (WWF, 2008).	The James Price Point coastal area does not contain suitable habitat for this species.	Unlikely
Greater Bilby (*Macrotis lagotis*)	Vulnerable(EPBC Act) Schedule 1 (WC Act)	Pindan woodland and shrubland habitats form suitable habitat for this species. It is believed that individuals of the Greater Bilby are regularly spotted by locals in the Gourdon Bay area, south of Broome, while there is a population known to exist in the Beagle Bay area, to the north of the James Price Point coastal area (ENV, 2008c; **Appendix C-16**).	Indirect evidence of potential presence in the form of foraging holes was recorded within the vicinity of the BLNG Precinct and south towards Quondong Point. Suitable habitat occurs within the Precinct area.	Possible
Golden Bandicoot (*Isodoon auratus*)	Vulnerable (EPBC Act) Schedule 1 (WC Act)	Once widespread in arid and semi arid habitats of central and north western WA, the Golden Bandicoot is now confined to grasslands, grassy woodlands and monsoon vine thickets of the Kimberley (Menkhorst and Knight, 2004). The last DEC record was in 1971 from the Coulomb Point Nature Reserve (Biota, 2009b; **Appendix C-17**) and currently there are no known populations of the species on the Dampier Peninsula. All known populations on the Kimberley mainland are further north at Yampi Peninsula, Prince Regent Nature Reserve and Mitchell Plateau (DEWHA, 2010g).	While there are no recent records of the species, woodland, grassland and monsoon vine thicket communities may provide some potential habitat for this species, should a local population occur.	Possible
Masked Owl (northern) (*Tyto novaehollandiae kimberli*)	Vulnerable (EPBC Act)	This subspecies typically occurs in the north and north western Kimberley coast where they usually occur in heavier forested eucalypt country, roosting in large tree hollows or crevices in cliffs and occasionally caves (Biota, 2009b; **Appendix C-17**).	While roosting habitat is unlikely to occur it is possible that the James Price Point coastal area may represent part of the home range of a local population of this species.	Possible
Golden-backed Tree-rat (*Mesembriomys macrurus*)	Vulnerable (EPBC Act), Priority 4 (DEC)	The Golden-backed Tree-rat is semi arboreal, inhabiting tropical woodland and adjacent monsoon vine thickets, rainforest and beaches. It roosts in tree hollows and less commonly in loosely woven nests under Pandanus crowns (Biota, 2009b; **Appendix C-17**). Most records of the species are from the north-west Kimberley, however, there are records from the Dampier Peninsula and	Suitable habitat is present, however, it is considered to be uncommon on the Dampier Peninsula. Recent information suggests that the Golden-backed Tree-rat may be regionally extinct from the Dampier Peninsula (AWC, 2010).	Possible

Species	Status	Known Habitat Requirements	Habitat Potential of the James Price Point Coastal Area	Likelihood of Occurrence
		Broome.		
Crest-tailed Mulgara (*Dasycercus cristicauda*)	Vulnerable (EPBC Act), Schedule 1 (WC Act)	Found principally in mature hummock grasslands (spinifex). Available information suggests that colonies coincide with better watered areas such as palaeo-drainage systems or drainage lines in sandplain or sand dune habitats (Wildlife Australia, 1996).	Based on current habitat descriptions it is considered unlikely that the species would occur within the James Price Point coastal area.	Unlikely
Brush-tailed Mulgara (*Dasycercus blythi*)	Vulnerable (EPBC Act), Priority 4 (DEC)	This species was previously confused with *Dasycercus cristicauda* until recent taxonomic studies (see Woolley, 2005 and Woolley, 2006). As the EPBC Act Threatened Fauna list has yet to be updated with this taxonomic change, the status of *Dasycercus blythi* is treated as 'Vulnerable', as per the status of *D. cristicauda.* Once common throughout the central deserts region of Australia the species is now known from at least the western and central deserts.	It is considered unlikely that the species would occur within the James Price Point coastal area based on species preferred habitat range.	Unlikely
Airlie Island Ctenotus (*Ctenotus angusticeps*)	Vulnerable (EPBC Act)	Occurs on Airlie Island, 35km north-north-east of Onslow, north-western WA (Species Profile and Threats (**SPRAT**) database). There are also records from south of Roebuck Bay.	The species known range does not extend to the James Price Point coastal area.	Unlikely
Great Desert Skink (*Egernia kintorei*)	Vulnerable (EPBC Act)	The species generally occurs on red sandplains and sand ridges in the eastern interior of WA (Environment Australia, 2000). There are no records of the species from the James Price Point coastal area and the species' preferred desert habitats were not recorded.	Preferred desert habitats are not present.	Unlikely
Little Northwestern Mastiff Bat (*Mormopterus loriae cobourgiana*)	Priority 1 (DEC)	Inhabits mangroves along the northern coast of WA (and elsewhere), it has also been recorded primarily from open forests, and is known to forage over open water: it requires clear areas because of its rapid flight (ENV, 2008c; **Appendix C-16**).	The species was recorded during the Coulomb – Quondong Point Survey (ENV, 2008c; **Appendix C-16**). While the preferred mangrove habitats are not present within the site, areas of monsoon vine thicket may provide potential roosting habitat. Open forest areas are also likely to provide foraging habitats.	Possible roosting and foraging habitat
Dampierland Burrowing Snake (*Simoselaps*	Priority 2 (DEC)	The species is likely to occur within a variety of habitat types on the Dampier peninsula including	Biota (2009b; **Appendix C-17**) recorded the species	Occurs

Species	Status	Known Habitat Requirements	Habitat Potential of the James Price Point Coastal Area	Likelihood of Occurrence
minimus)		monsoon vine thickets, coastal communities and Pindan woodland.	within monsoon vine thicket. Potential habitats are likely to include monsoon vine thickets, coastal communities and areas of Pindan woodland (ENV, 2008c; **Appendix C-16**).	
Dampierland Plain Slider (*Lerista separanda*)	Priority 2 (DEC)	This species known from the south west Kimberley coast where it occurs in association with sandy soils.	This species was recorded at a single location within in open forest on sandy soil (Biota, 2009b; **Appendix C-17**).	Occurs
Peregrine Falcon (*Falco peregrinus*)	Schedule 4 (WC Act)	This species occupies a diverse range of habitats which would include most areas of the Dampier Peninsula and James Price Point coastal area.	This species was recorded within drainage basin habitat (Biota, 2009b; **Appendix C-17**). All vegetation types within the site and construction camp are likely to provide potential habitat for this species.	Occurs
Bush Stone-curlew (*Burhinus grallarius*)	Priority 4 (DEC)	The Bush Stone-curlew is nocturnal and inhabits sparsely grassed, lightly timbered forest or woodland. It is likely that most woodland and coastal communities within the James Price Point coastal area and similar habitat types on the Dampier Peninsula would support habitats for this species.	The species was recorded in Pindan bushland habitat (Biota, 2009b; **Appendix C-17**). Coastal communities and woodland vegetation likely to provide suitable habitat.	Occurs
Australian Bustard (*Ardeotis australis*)	Priority 4 (DEC)	Within the Kimberley the Australian Bustard is still relatively widespread but commonly sparse occurring in grassy woodland and grassland habitats (Biota, 2009b; **Appendix C-17**). Species has been recorded at Gourdon Bay (ENV, 2008c; **Appendix C-16**).	Woodland and grassland habitats may provide potential habitat for this species.	Possible
Grey Falcon (*Falco hypoleucos*)	Priority 4 (DEC)	This species is known to inhabit a variety of woodland and aquatic habitats and is known from records on the Dampier Peninsula.	It is likely that the species would periodically inhabit the James Price Point coastal area as part of the species broader habitat requirements.	Possible
Flock Bronzewing (*Phaps histrionica*)	Priority 4 (DEC)	This species has a broad distribution which includes the Dampier Peninsula and is likely to include the James Price Point coastal area.	It is likely that the species would periodically inhabit the James Price Point coastal area as part of the species' broader habitat requirements.	Likely

Species	Status	Known Habitat Requirements	Habitat Potential of the James Price Point Coastal Area	Likelihood of Occurrence
Water-rat (*Hydromys chrysogaster*)	Priority 4 (DEC)	This species is distributed around much of coastal Australia where it generally occurs in permanent fresh or brackish water, but can also be found in marine environments.	This species may occur along the coastal parts of the James Price Point coastal area.	Possible
Chestnut-backed Button-quail (*Turnix castanota magnifica*)	Priority 4 (DEC)	This species is known to occur on the Dampier Peninsula with core habitat consisting of savannah woodlands.	Two individuals were recorded during AECOM (2010b; **Appendix C-20**) survey, however core habitat is absent.	Occurs
Pictorella Mannikin (*Heteromunia pectoralis*)	Priority 4 (DEC)	The Pictorella Mannikin occurs through northern Australia, from Broome east to the Gulf of Carpenteria where it generally occurs in acacia-dotted savannahs, ranging into spinifex country (Biota, 2009b; **Appendix C-17**).	Suitable habitat is considered to occur however, should the species occur it is considered likely to be uncommon (Biota, 2009b; **Appendix C-17**).	Possible
Lakeland Down's Mouse (*Leggadina lakedownensis*)	Priority 4 (DEC)	The Lakeland Down's Mouse occurs across northern Australia, from Cape York to the Pilbara (WA). Known to occur on sandy soils and cracking clays in WA. Species has been recorded at Gourdon Bay (ENV, 2008c; **Appendix C-16**).	Based on the known species distribution and presence of sandy soils it is possible that habitat for this species may occur.	Possible
Eastern Curlew (*Numenius madagascariensis*)	Migratory (EPBC Act) Priority 4 (DEC)	This species occurs along the coastal waters of WA where its preferred habitat includes tidal mudflats and sandy beaches.	The species may periodically occur along coastal beaches. A small number (<10) of the species were observed during the high tide aerial survey.	Occurs
Dingo (*Canis lupus dingo*)	Vulnerable (IUCN)	This species exists throughout WA (ENV, 2008c; **Appendix C-16**) and is likely to occur over much of the Dampier Peninsula.	Recorded during Biota (2009b; **Appendix C-17**) and ENV (2008c; **Appendix C-16**) surveys. Habitat likely to comprise all vegetation types within the James Price Point coastal area.	Occurs
Little Bittern (*Ixobrychus minutes*)	Priority 4 (DEC)	This species is known from the Dampier Peninsula and occurs in swampy habitats including reed beds.	Suitable habitat was not identified within the James Price Point coastal area.	Unlikely
Black Bittern (*Ixobrychus flavicollis australis*)	Priority 3 (DEC)	This species is known from the Dampier Peninsula and occurs in freshwater pools, swamps and lagoons.	Suitable habitat was not identified within the James Price Point coastal area.	Unlikely
Scaly-tailed Possum (*Wyulda squamicaudata*)	Priority 3 (DEC)	This medium-sized possum appears to shelter deep within rockpiles from which it emerges at night to feed.	Suitable habitat was not identified within the James Price Point coastal area	Unlikely

1.4.5.6. Migratory Birds in the James Price Point Coastal Area

The coastal region in the vicinity of Broome is extremely important for migratory shorebirds, particularly waders and terns which breed in the northern hemisphere during the austral winter. Roebuck Bay, which lies immediately east of Broome, is an internationally important non-breeding area for migratory shorebirds and supports over 190,000 migratory waders of at least 35 species (Watkins, 1993). As James Price Point coastal area is relatively close to this internationally important shorebird site, it is important to understand its significance for migratory birds.

The James Price Point coastal area comprises a suite of species that are widespread and well-represented on the Dampier Peninsula (Galaxia, 2010; **Appendix C-1**). A total of 39 migratory bird species listed as 'Migratory' under the EPBC Act have been recorded within the James Price Point costal area (Galaxia, 2010; **Appendix C-1**). All of these species are also listed as 'Marine' birds under the EPBC Act, however, none are listed 'Threatened' species. With the exception of the Osprey, all of the migratory bird species recorded in the James Price Point coastal area are protected under the WA *Wildlife Conservation Act 1950*.

The ten most common migratory bird species (from combined data sources; Galaxia, 2010; **Appendix C-1**) recorded within the James Price Point coastal area were:

- Common Tern (*Sterna hirundo*);
- Greater Sand Plover (*Charadrius leschenaultia*);
- Lesser Crested Tern (*Sterna benghalensis*);
- Red-necked Stint (*Calidris ruficollis*);
- Rainbow Bee-eater (*Merops ornatus*);
- Little Tern (*Sterna albifrons*);
- Grey-tailed Tattler (*Tringa brevipes*);
- Red Knot (*Calidris canutus*);
- Sanderling (*Calidris* alba); and
- Lesser Frigatebird (*Fregata ariel*).

In addition to the 39 species known to occur, there are an additional 28 species of migratory bird that could potentially occur within the James Price Point coastal area. Of these, two species are listed Threatened species under the EPBC Act – the painted snipe (Vulnerable), and the Gouldian Finch (Endangered).

Regionally, the James Price Point coastal area is considered to be relatively insignificant as a summer feeding site for migratory shorebirds compared to Eighty Mile Beach and Roebuck Bay, two locations of international significance given the numbers of birds that feed in these areas (Watkins, 1993). December 2008 counts of the five most common migratory shorebirds were in the order of hundreds of individuals at James Price Point in comparison to the tens of thousands of individuals at Eighty Mile Beach and Roebuck Bay (Rogers *et al*., 2009).

The habitats suitable for roosting and feeding by migratory birds at the James Price Point coastal area include (Galaxia, 2010; **Appendix C-1**):

- inshore seas, intertidal sand and reef flats, rocky outcrops and cliffs which may support a variety of migratory bird species during periods of high spring tides;
- Pindan woodland which may support nomads, breeding and non-breeding migratory birds; and
- several small drainage basins with ephemeral wetlands may provide habitat for some migratory bird species on a seasonal basis.

These habitat types are well represented at other locations on the Dampier Peninsula and as such, it is unlikely that the James Price Point coastal area (including Coulomb Point) includes any regionally significant habitat for migratory bird species (Galaxia, 2010; **Appendix C-1**). Hence, the area is unlikely to host any regionally significant populations of migratory birds showing a preference for these habitats.

1.4.6. Introduced Fauna

Terrestrial introduced fauna species are of concern within the Kimberley region. Introduced fauna can impact on native faunal communities both directly, through predation and competition for food, water and shelter; and indirectly, through processes such as habitat degradation and spread of disease.

1.4.6.1. Introduced Fauna of the Kimberley

Several species of introduced fauna are known to occur in the Kimberley including species such as (DAFWA, 2009):

- Wild Dog (*Canis familiaris*);
- Feral Donkey (*Equus asinus*);
- Feral Camel (*Camelus dromedarius*);
- Feral Pig (*Sus scrofa*);
- Feral Cat (*Felis catus*);
- Little Corella (*Cacatua sanguinea*);
- Galah (*Cacatua roseicapilla*);
- European Red Fox (*Vulpes vulpes*); and
- European Rabbit (*Oryctolagus cuniculus*).

With exception of the Feral Cat, all of the above listed introduced fauna species are listed as 'Declared' animals under the *Agriculture and Related Resources Protection Act 1976* (**ARRP Act**). The Feral Cat and European Red Fox are listed as 'key threatening processes' to Australia's biodiversity under the EPBC Act.

1.4.6.2. Introduced Fauna of the Dampier Peninsula

ENV (2008c; **Appendix C-16**) identified seven species of introduced fauna during fauna surveys on the Dampier Peninsula:

- Black Rat (*Rattus rattus*);
- Domestic House Mouse (*Mus musculus*);
- Feral Donkey (*Equus asinus*);
- Feral Cat (*Felis catus*);
- Little Corella (*Cacatua sanguinea*);
- Galah (*Cacatua roseicapilla*); and
- European Red Fox (*Vulpes vulpes*).

Of the above listed introduced fauna species, the Feral Donkey, Galah, Little Corella and Red Fox are listed as 'Declared' animals under the ARRP Act.

1.4.6.3. James Price Point Coastal Area

ENV (2008b; **Appendix C-15**), Biota (2009b; **Appendix C-17**) and AECOM (2009b; **Appendix C-20**) recorded four species of introduced fauna in the James Price Point coastal area, including:

- Feral Cat (*Felis catus*) ;
- Domestic House Mouse (*Mus musculus*);
- Black Rat (*Rattus rattus*); and
- Domestic Cattle (*Bos tarus*).

None of the above listed introduced fauna species are listed as 'Declared' animals under the ARRP Act. The Feral Cat and European Red Fox are listed as 'key threatening processes' to Australia's biodiversity under the EPBC Act.

1.4.7. Matters of National Environmental Significance

Matters of National Environmental Significance (**NES**) are matters which are protected under national environmental law by the EPBC Act 1999. Terrestrial matters of NES relevant to the James Price Point coastal area include:

- **Listed threatened species (flora)**: No flora species listed on the EPBC Act Threatened Flora List have been recorded in the James Price Point coastal area. Habitat suitable for one threatened flora species, *Keraudrenia exastia*, does exist within the James Price Point coastal area in the form of red sand in Pindan and coastal sites. Intensive targeted searches for this species in 2009 (AECOM, 2010a; **Appendix C-19**) did not record this species.
- **Listed threatened species (fauna)**: No species listed on the EPBC Act Threatened Fauna List have been recorded in the James Price Point coastal area, although five species may possibly occur. These species include:
    - Australian Painted Snipe (*Rostratula australis*) - Vulnerable, Migratory (EPBC Act);
    - Greater Bilby (*Macrotis lagotis*) - Vulnerable (EPBC Act), Schedule 1 (WC Act);
    - Golden Bandicoot (*Isodoon auratus*) - Vulnerable (EPBC Act), Schedule 1 (WC Act);
    - Masked Owl (northern) (*Tyto novaehollandiae kimberli*) - Vulnerable (EPBC Act); and
    - Golden-backed Tree-rat (*Mesembriomys macrurus*) (EPBC Act), Priority 4 (DEC).

The above listed species are discussed in **Section 1.4.5.5** and **Table 1-10**.

Migratory species protected under international agreements: Thirty-nine species of birds listed as 'Migratory' under the EPBC Act and various international agreements have been recorded in James Price Point coastal area and a further 28 species may potentially occur (Galaxia, 2010; **Appendix C-1**). Migratory birds are discussed in **Section 1.4.5.6.**

1.4.8. Subterranean Fauna

Two broad categories of fauna generally comprise subterranean fauna: stygofauna and troglofauna (Biota, 2009b; **Appendix C-17**). Stygofauna are aquatic subterranean animals, found in a variety of groundwater systems occurring close to the surface (Biota, 2009b; **Appendix C-17**). Troglofauna occur in air chambers in underground caves or other smaller voids historically been collected primarily from karstic limestone systems in WA (Biota, 2009b; **Appendix C-17**).

1.4.8.1. Regional Setting

The Kimberley region is known to contain troglobiotic and stygofauna habitat. EPA Guidance Statement 54A - Sampling Methods and Survey Considerations for Subterranean Fauna in WA (EPA, 2003b) describes the Kimberley region as having a high probability of stygofauna values, occurring in association with karst, limestone and sandstone formations. There is no published work on subterranean fauna surveys within the Dampier Peninsula (Biota, 2009b; **Appendix C-17**).

1.4.8.2. James Price Point Coastal Area

The James Price Point coastal area may contain subterranean fauna habitats, based on the known sandstone geology of the area. Biota (2009b; **Appendix C-17**) completed an initial risk assessment for presence of stygofauna and troglofauna in accordance with the requirements as described in EPA Guidance Statement No. 20 (EPA, 2009b).

The Biota (2009b; **Appendix C-17**) assessment found that the majority of the James Price Point coastal area is dominated by clays and sands strata in Pindan sandplain, meaning there may be limited saturated habitat space beneath the watertable. Based on this, Biota (2009b; **Appendix C-17**) concluded that it is unlikely that there will be significant stygofauna values associated with the James Price Point coastal due to the absence of supporting habitat; in this case, appropriate geological formations. It is possible that some stygal taxa, particularly smaller and vermiform types like oligochaetes and copepods, may still occur in sand aquifers, but in these habitat settings individual species are usually not restricted at small spatial scales.

Biota (2009b; **Appendix C-17**) concluded that it appears unlikely that there will be significant troglofauna values associated with the James Price Point coastal area based on:

- the study area is dominated by Pindan sandplain, mudflats and dunes; units which has little or no cavernous or vuggy habitat space; and
- the area is relatively low-lying and of flat topography, and may therefore have been subject to historical marine transgressions and eustatic changes.

However, some of the more coastal and southern areas may have calcrete or limestone strata and these could possibly support troglobitic animals.

1.4.9. Short Range Endemic Fauna

Short Range Endemic fauna are defined as terrestrial and freshwater invertebrates that have naturally small distributions of less than 10,000km^2 (EPA, 2009b). Examples of taxonomic groups that show high levels of short-range endemism in this respect include mygalomorph spiders, millipedes, pseudoscorpions and freshwater and terrestrial molluscs.

1.4.9.1. Short Range Endemic Fauna of the Kimberley

SRE taxa such as land snails, earthworms and spiders are known to occur in monsoon vine thicket communities in the Kimberley Region. Of the land snail fauna known from the Kimberley, it is the family Camaenidae that are considered most likely to support SREs, with some taxa exhibiting highly restricted distributions (Biota, 2009b; **Appendix C-17**). There are at least 69 SRE taxa in the Kimberley and it is highly likely that further survey work will increase this number (Ecologia, 2005).

1.4.9.2. Short Rang Endemic Fauna of the James Price Point Coastal Area

Biota (2009b; **Appendix C-17**) undertook a targeted survey and habitat assessment for SRE species as part of the wet season fauna survey. The aim of this was to search for evidence of SRE species and to determine the likelihood of SRE species occurring.

Two species of land snail belonging to the family Camaenidae were collected from within the James Price Point coastal area. *Quistrachia leptogramma* and *Rhagada bulgana* were recorded from several locations within the James Price Point coastal area and are also known from outside the James Price Point coastal area. Specimens were collected from monsoon vine thicket, open forest and Pindan shrubland and at this stage it is considered unlikely that these would represent SRE taxa. A third species, *Rhagada reinga*, was collected opportunistically from Broome but was not recorded within the Biota (2009b; **Appendix C-17**) survey area.

Some *Rhagada* shells collected from the monsoon vine thickets within James Price Point coastal area did not properly match the description for *R. bulgana*, being notably smaller in size. The shells are most similar in shape and size to the other Dampierland vine thicket snails (such as *R. cygna*, *R. reinga* and the undescribed *Rhagada* sp. from Cape Leveque). There is some uncertainty as to whether these shells are representative of a new taxon that is similarly highly restricted, given the restricted distributions shown by *R. cygna*, *R. reinga* and *Rhagada* sp. on the Dampier Peninsula. A plausible explanation is also that the naturally fragmented monsoon vine thickets of the James Price Point coastal area and Dampier Peninsula support an additional, similarly fragmented, species (Biota, 2009a; **Appendix C-17**). No live specimens of this of this particular *Rhagada* were collected and it is also considered possible that these specimens may represent a now extinct population

The specimens of *Quistracha leptogramma* collected from the study area fell into two clear groups based on size; large specimens collected from woodland and Pindan habitats and smaller specimens collected from the coastal monsoon vine thickets. Biota (2009b; **Appendix C-17**) observed that specimens from Broome and Coulomb Point are distinctly smaller than those from the northern part of the Dampierland bioregion. However, the recent collections suggest that large specimens also occur in the southern part of Dampierland bioregion, but only in the woodland and Pindan habitats. This larger taxon appears to be replaced by small-shelled populations in the monsoon vine thickets. It is unclear whether there are underlying taxonomic differences between the large and small-shelled populations. Based on the known presence of these large and small shelled *Q. leptogramma* it is considered unlikely that they would be restricted to James Price Point or represent an SRE landsnail.

Several spirobolid millipedes similar to the genus *Austrostrophus* were collected from monsoon vine thicket within the James Price Point coastal area. They appear to represent an un described taxon and have been lodged with the WA Museum to contribute to ongoing taxonomic work. The taxonomy of this group is poorly resolved and there is insufficient information to make further comment on their regional representation (Biota, 2009b; **Appendix C-17**). Six mygalomorph spider taxa and two species of scorpion have been collected from the James Price Point coastal area (Biota 2010, pers. comm., June 2010). Based on the locations and habitats from which these specimens were recorded, these may occur within the BLNG Precinct however, none are restricted to this area (Biota pers comm. 2010). No further information is available to assess the SRE status of these specimens.

1.4.10. Species of Ethno-biological Significance

Plants and animals have been utilised by Aboriginal people for many thousands of years. A wide range of species have been utilised and are still utilised for food, medicine, shelter and cultural activities including art. More recently, Indigenous people in the Kimberly region have responded to a broader interest in 'bush tucker' products, and have begun to harvest particular species for the commercial market.

The following information utilises lists of terrestrial plant and animal species recorded from ENV (2008b; **Appendix C-15** and ENV, 2008c; **Appendix C-16**) and Biota (2009c; **Appendix C-18**), as well as published information on Indigenous use of these species. The information presented has not been verified with Traditional Owners.

1.4.10.1. Regional Ethnobiology

The Kimberley region is a rich resource for species with ethno-biological significance, especially plants. Many Kimberley plant species are utilised as food products by Indigenous people, as well as being harvested for a variety of other uses.

A report on the plants and people of the Dampier Peninsula was undertaken by Kenneally *et al*. (1996). The report defined six categories of Aboriginal plant uses, including:

- food;
- medicinal;
- shelter;
- hunting and gathering;
- artefacts; and
- miscellaneous.

In the Dampier Peninsula, underground dugouts (mirdibalang) were traditionally used to provide shelter during the wet season from cyclones, monsoonal rain and mosquitoes. Species such as *Acacia colei*, *Grevillea refracta*, *Lysiphyllum cunninghamii* and *Terminalia canescens* were used to create windbreaks; while durable, framed huts were built from a variety of plant species. Fishing was undertaken using boomerangs made from mangrove wood and, in the northern part of the peninsula, rafts were built from kapok mangrove (*Camptostemon schultzii*). Plants were used for a variety of medicinal purposes, such as rubbing *Distichostemon hispidulus* or *Gardenia pyriformis* on bare feet to prevent against coral cuts and stonefish stings (Kenneally *et al*., 2006).

1.4.10.2. James Price Point Coastal Area Ethnobiology

The James Price Point coastal area supports few animals of ethnobiological significance, probably because of a lack of permanent water sources. The site, however, supports almost 80 plant species documented as having some type of use for Aboriginal people. Indigenous use of these plants covers all six Aboriginal plant uses defined by Kenneally *et al.* (1996).

A number of families from the native title claimant group participate in commercial harvesting of gubinge (bush plum) on the Dampier Peninsula as part of the Kullaria Australia Co-Operative. While the bush plum (*Terminalia ferdinandiana)* is known to occur within the James Price Point coastal area, the importance of this area as a harvest resource for Traditional Owner groups is uncertain.

Indigenous use of plants is not restricted to native species. For example, a significantly invasive species found in the James Price Point coastal area, *Passiflora foetida*, is used by local people for its edible fruit and for medicinal purposes.

Animal groups and plant species from the James Price Point coastal area documented as having traditional use are presented in **Table 1-11** and **Table 1-12**, respectively; however, it is likely that other ethno-biological species are present at the site. Anecdotal evidence suggests that fleshy fruited plants may be of importance to traditional people as a food resource and will be utilised depending on the season. Monsoon vine thickets may therefore be of particular ethnobiological significance within the James Price Point coastal area given the propensity for fleshy fruited plants to occur within this vegetation type.

- **Table 1-11 Possible Faunal Groups of Ethnobiological Significance within the James Price Point Coastal Area.**

Fauna Group	Number of Species Within the James Price Point Coastal Area	Aboriginal Uses for Species Recorded Within the James Price Point Coastal Area
Amphibians	4	None known.
Reptiles	39	Larger species (monitors and pythons) used as a food source.
Native volant mammals (bats)	4	None known.
Native non-volant mammals	3	Agile wallaby is used as a food source and provides fibre for tools etc.
Introduced mammals	2	Cats have been used as a food source.
Avifauna	68 *	Pigeons and doves are the most common species utilised.
Invertebrates	Not assessed	Ant eggs, witchetty grubs, termites, honey and pollen are food sources. Wax from bee hives is also utilised.

Source: Biota, 2009b; **Appendix C-17**.

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- **Table 1-12 Possible Flora Species of Ethnobiological Significance within the James Price Point Coastal Area.**

Category	Attribute and Uses	Plant Species
Food	Edible fruits Edible leaves Edible seeds and nuts Edible roots Edible galls Edible lerps Edible grubs Edible gum Edible nectar Edible flowers Bush honey Bush tobacco	*Acacia adoxa* var. *subglabra* *A. colei* var *colei* *A. colei* var *ileocarpa* *A. tumida* *Boerhavia gardneri* *Brachychiton diversifolius* subsp. *diversifolius* *Bridelia tomentosa* *Calandrinia strophiolata* *Capparis lasiantha* *Carissa lanceolata* *Cassytha filiformis* *Celtis philippensis* *Cleome viscosa* *Corymbia polycarpa* *Crotalaria cunninghamii* *Cymbidium canaliculatum* *Cyperus bulbosus* *Ehretia saligna* var. *saligna* *Eucalyptus miniata* *Exocarpos latifoliu* *Ficus virens* *Fleuggea virosa* subsp. *melanthesoides* *Gardenia pyriformis* subsp. *keartlandii* *Grewia breviflora* *G. retusifolia* *Ipomoea pes-caprae* subsp. *brasiliensis* *Ipomoea polymorpha* *Lysiana spathulata* subsp. *spathulata* *Marsdenia viridiflora* subsp. *tropica* *Pandanus spiralis* var. *convexus* *Passiflora foetida* var. *hispida* *Pavetta kimberleyana* *Persoonia falcata* *Planchonia careya* *Pterocaulon sphacelatum* *Santalum lanceolatum* *Terminalia ferdinandiana* *Terminalia petiolaris* *Ventilago viminalis*
Medicinal	Medicines Smoking ritual Fly repellent Mosquito repellent	*Acacia monticola* *Canavalia rosea* *Capparis lasiantha* *Carissa lanceolata* *Cleome viscosa*

Category	Attribute and Uses	Plant Species
		Corymbia dampieri *C. polycarpa* *Distichostemon hispidulus var. aridus* *Exocarpos latifolius* *Fleuggea virosa* subsp. *melanthesoides* *Gardenia pyriformis* subsp. *keartlandii* *Gymnanthera oblonga* *Gyrocarpus americanus* subsp. *pachyphyllus* *Planchonia careya* *Santalum lanceolatum* *Tephrosia crocea* *Terminalia ferdinandiana* *Tinospora smilacina* *Ventilago viminalis*
Shelter	Windbreaks Hut frames Hut roofing	*Acacia colei* *Grevillea refracta* subsp. *refracta* *Eucalyptus miniata* *Melaleuca dealbata* *Spinifex longifolius*
Hunting and Gathering	Sea going rafts Raft pegs Harpoons Fishing boomerangs Fish poisons Fishing torches Spears Spearheads Boomerangs Axe handles Coolamons Water containers Digging sticks	*Acacia colei* *A. eriopoda* *A. monticola* *A. platycarpa* *A. tumida* *Eucalyptus miniata* *Exocarpos latifolius* *Ficus virens* *Grewia breviflora* *Gyrocarpus americanus* subsp. *pachyphyllus* *Hakea arborescens* *H. macrocarpa* *Planchonia careya* *Premna acuminata* *Tephrosia crocea* *T. rosea* var. *rosea* *Ventilago viminalis*
Artefacts	Clapping sticks Shields Fighting sticks Walking sticks Sandpaper	*Acacia monticola* *Erythrophleum chlorostachys* *Eucalyptus miniata* *Ficus virens* *Gyrocarpus americanus* subsp. *pachyphyllus*
Miscellaneous	Firesticks Firewood Smoking pipes String and cord Footwear	*Abrus precatorius* *Acacia colei* *A. tumida* *Brachychiton diversifolius* subsp. *diversifolius* *Caesalpinia major*

Category	Attribute and Uses	Plant Species
	Marbles Ornamentation Body paint Dyes Soap	*Cassytha filiformis* *Corymbia dampieri* *Croton habrophyllus* *Ehretia saligna* var. *saligna* *Ficus virens* *Fleuggea virosa* subsp. *melanthesoides* *Grevillea pyramidalis subsp. pyramidalis* *Grewia breviflora* *Gymnanthera oblonga* *Pandanus spiralis* var. *convexus* *Planchonia careya* *Premna acuminata* *Tinospora smilacina*
Other	Unknown	*Bauhinia (Lysiphyllum) cunninghamii* *Calytrix exstipulata* *Clerodendrum floribundum* var. *ovatum* *Corymbia bella* *Cymbopogon procerus* *Cyperus conicus* *Dolichandrone heterophylla* *Lophostemon grandiflorus* subsp. *grandiflorus* *Operculina aequisepala* *Operculina brownii* *Portulaca napiformis* *Solanum diversiflorum* *Terminalia petiolaris* x *ferdinandiana* *Triodia schinzii* *T. stenostachya* *Wrightia saligna*

Source: Adapted from Kenneally *et al.,* 1996.

1.4.11. Threatening Processes

A threatening process in natural ecosystems is a process that threatens, or has potential to threaten, the conservation of native species and/or ecological communities (Lindenmayer and Burgman, 2005). Identifying threatening processes is an essential first step for undertaking conservation management.

Currently, there are 19 Key Threatening Processes listed under the EPBC Act. Two of these are relevant to the BLNG Precinct:

- predation by the European Red Fox (*Vulpes vulpes*); and
- predation by Feral Cats (*Felis catus*).

Also relevant to the project are a number of key threatening processes identified by DEC. These processes are listed as impacting on riparian zone vegetation, threatened ecological communities, other communities at risk, and/or flora and fauna species at risk within the Pindanland subregion of the Dampierland bioregion (CALM, 2003). Threatening processes identified by DEC and relevant to the James Price Point coastal area are discussed below.

1.4.11.1. Grazing Pressure

Impacts of grazing relate primarily to associated changes in soil structure and weed invasion (DEC, 2002), that, when combined with other threatening processes such as fire, can have a devastating impact on native species.

Pastoralism has been the predominant land use in the Kimberley region and many areas have been subject to heavy grazing pressure as a result. Grazing is recognised as a major threatening process in the Kimberley region.

Recent reports have indicated that grazing may not be as threatening to species and communities on the Dampier Peninsula as in other parts of the Kimberley (DEC, 2009a) because the Dampier Peninsula is typically less developed for pastoral use. Historically, approximately half the total area of the Dampier Peninsula formed the Waterbank Station, during which time it was subject to high stocking rates and heavy grazing pressure. Although the vegetation on the Peninsula is now largely regenerated, feral cattle (*Bos taurus*) and other introduced herbivores continue to have an impact on the area. Such impacts include an increased spread of weeds, such as Kapok bush and Buffel grass (Biota, 2009c; **Appendix C-18**), and indirect impacts on threatened species, such as the Chestnut-backed Button-quail (*Turnix castanota magnifica*) (AECOM, 2010b; **Appendix C-20**).

As part of the Waterbank Station, the James Price Point coastal area was historically subjected to heavy grazing pressure which led to associated changes in vegetation. For example, trampling by stock has led to the formation of grassy trails throughout monsoon vine thicket areas on the site (Biota; 2009c; **Appendix C-18**). While stray cattle have been observed near James Price Point, considering the closure of cattle stations, signalled by the State Government purchase of the Waterbank Station, near James Price Point in 1996 (Environs Kimberley, 2002), current impacts from grazing are considered to be low.

1.4.11.2. Weeds

Weeds are recognised as one of the most significant threats to species and communities within northern Australia (Smith, 2002), including in the Kimberley region. Weeds can degrade ecosystems via the following mechanisms:

- displacement of individual species and entire communities over time;
- changes to fire regimes;
- loss of habitat and resources for native species;
- changes to nutrient cycles; and
- provision of refuge for invasive species.

1.4.11.3. Species of Concern in Kimberley/Dampier Peninsula

Two hundred and thirty six weeds have been recorded in the Kimberley (Ellison, 2009). Weeds of particular concern in the Kimberley include Passion Vine (Passiflora foetida), Noogoora Burr (*Xanthium strumarium*), Rubber Vine (*Cryptostegia grandiflora*), Parkinsonia (*Parkinsonia aculeata*) and Leucaena (*Leucaena leucocephala*) (Ellison, 2009).

Weeds typically thrive in disturbed areas (DEC, 2009a). Although riparian areas are especially vulnerable to weed invasion due to high moisture levels, many weed species such as Buffel grass are able to tolerate dryer conditions and therefore threaten the broader landscape (DEC, 2009a).

1.4.11.4. Species of Threat in the James Price Point Coastal Area

Twenty two weed species have been identified at the James Price Point coastal area and include the weed *Sida acuta*, which is a Declared Plant under the ARRP Act, as well as nine species considered serious environmental weeds as they are highly aggressive and can have significant impacts on vegetation (Biota, 2009c; **Appendix C-18**). *Sida acuta* was found within a single location south of the James Price Point coastal area and is a prolific seed setter which favours degraded land and competes with native species (Smith, 2002).

Although the majority of weeds that occur within the James Price Point coastal area are scattered throughout the site, there are a number of significant weed infestations. The most noticeable weed infestation is Buffel grass, which has replaced native dune-binding vegetation along the James Price Point coastline (AECOM, 2010a; **Appendix C-19**).

Kapok bush (*Aerva javanica*) is another widespread weed that has expanded into native dune vegetation at the site (Biota, 2009c; **Appendix C-18**).

Wild passionfruit, Hairy merremia, Siratro and Leucana all represent a threat to monsoon vine thicket vegetation. However, while their presence reduces the condition, these weeds may not substantially diminish the overall conservation value of the vegetation type of the area (Biota, 2009c; **Appendix C-18**).

A large number of ornamental species are present on an abandoned tenement north of Quondong Point, some of which have the potential to become weeds. Some of the species are not currently known as weeds in the region, but are persisting, and sometimes spreading from original plantings.

1.4.11.5. Changed Fire Regimes

Inappropriate fire regimes are considered to greatly threaten biodiversity values, impacting on both ecosystem and species-scale biodiversity assets. Altered fire regimes can reduce biodiversity by reducing habitat quality and diversity. Late dry-season fires, which are characteristically more intense, can result in the death of numerous plant species and cause extensive damage to cultural and sacred sites. Although the interactions between current fire regimes in the Kimberley ecosystems are complex and not fully understood, the implications of frequent, large, and intense dry season fires are known to be serious (EPA, 2006a). Suppression of fire-sensitive species and increased weed invasion from altered fire regimes can alter both floristic and vegetation structure at a site (Biota, 2009c; **Appendix C-18**). Studies on native Kimberley biota have shown a number of flora and fauna species to be detrimentally impacted by fire, with some fire sensitive species and communities (for example, rainforest) facing local and possibly even regional extinction.

Fire and the Kimberley

Although fire is a natural ecological process and an essential part of the Kimberley environment, recent decades have seen a dramatic change in Kimberley fire regimes, with greater frequencies and intensities of fires occurring in the mid-late dry season. Evidence from the Kimberley Region suggests that there has been a significant increase in the extent, intensity and frequency of fire over the past 30 years (EPA, 2006a). Although the interactions between current fire regimes in Kimberley ecosystems are complex and not fully understood, the implications of frequent, large, and intense dry season fires are known to be serious and to be impacting on the ecology of the Kimberley environment (EPA, 2006a). The current fire regime in the Kimberley is believed to be a major factor in biodiversity loss with some plants, particularly fire-sensitive ones, being unable to recover (EPA, 2006a).

Suppression of fire-sensitive species and increased weed invasion from altered fire regimes can alter both floristics and vegetation structure at a site (Biota, 2009c; **Appendix C-18**). Studies on native Kimberley biota have shown a number of flora and fauna species to be detrimentally impacted by fire, with some fire sensitive species and communities (for example, rainforest) facing local and possibly even regional extinction. An inappropriate fire regime is considered a major biophysical threat against broad biodiversity conservation values of landscape, the protected area system, ecosystem and species-scale biodiversity assets.

Table 1-13 lists the size of areas burnt each year in the Kimberley region between 1996 and 2004. This table demonstrates that significantly large areas of land are regularly burnt, with between 13 per cent and 39 percent of the entire region being burnt each year. Despite this, fires are largely unmanaged in the Kimberley due to a lack of resources (EPA, 2006a).

- **Table 1-13 Areas Burnt in the Kimberley, 1996 to 2004.**

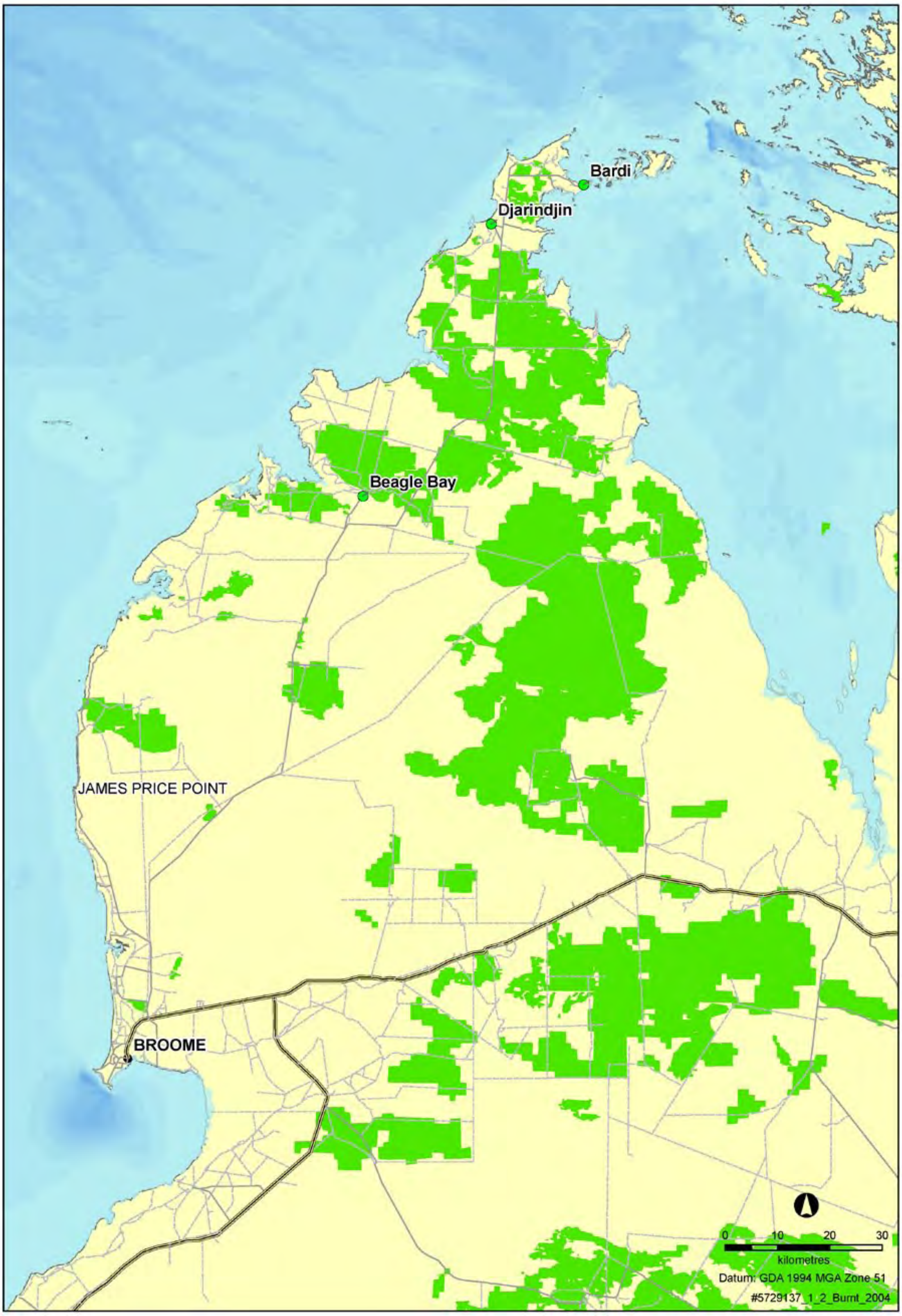
Year	Area Burned (km^2)	Land Area Burned (%)
1996	92,440	39
1997	30,724	13
1998	64,415	27
1999	91,329	38
2000	85,858	36
2001	91,647	38
2002	57,155	24
2003	68,129	29
2004	82,200	34

Table 1-13 uses firescar data obtained from the Firewatch project, which is part of the Remote Sensing Services Division of Landgate (EPA, 2006a).

Fire Regimes on the Dampier Peninsula

Fire is well documented on the Dampier Peninsula and is recognised as an important process for maintaining vegetation structure, as it aids regeneration of some species (ENV, 2008a; **Appendix C-14**). However, changed fire regimes have detrimentally impacted on biodiversity throughout the Peninsula, primarily because of the reduction in area and condition of fire sensitive vegetation and the reduction in vegetation heterogeneity as fires become more extensive. The current frequent fire regime on the Dampier Peninsula is considered to be having a negative impact on all vegetation types (McKenzie *et al.,* 2003). In recent decades, fire regimes on the Dampier Peninsula have been more frequent and often occur in the mid to late dry season with high intensity. There is some evidence that altered fire regimes result in habitat simplification and degradation and, together with increased predators and herbivores, are implicated in the decline and extinction of medium-sized mammals in the semi-arid and arid zones of the Kimberley region (EPA, 2006a). Altered fire regimes can also intensify the impacts of other threatening processes such as increasing the biomass of Buffel grass (*Cenchrus ciliaris*) which reduces the condition of native ecosystems and increases the flammability of native vegetation.

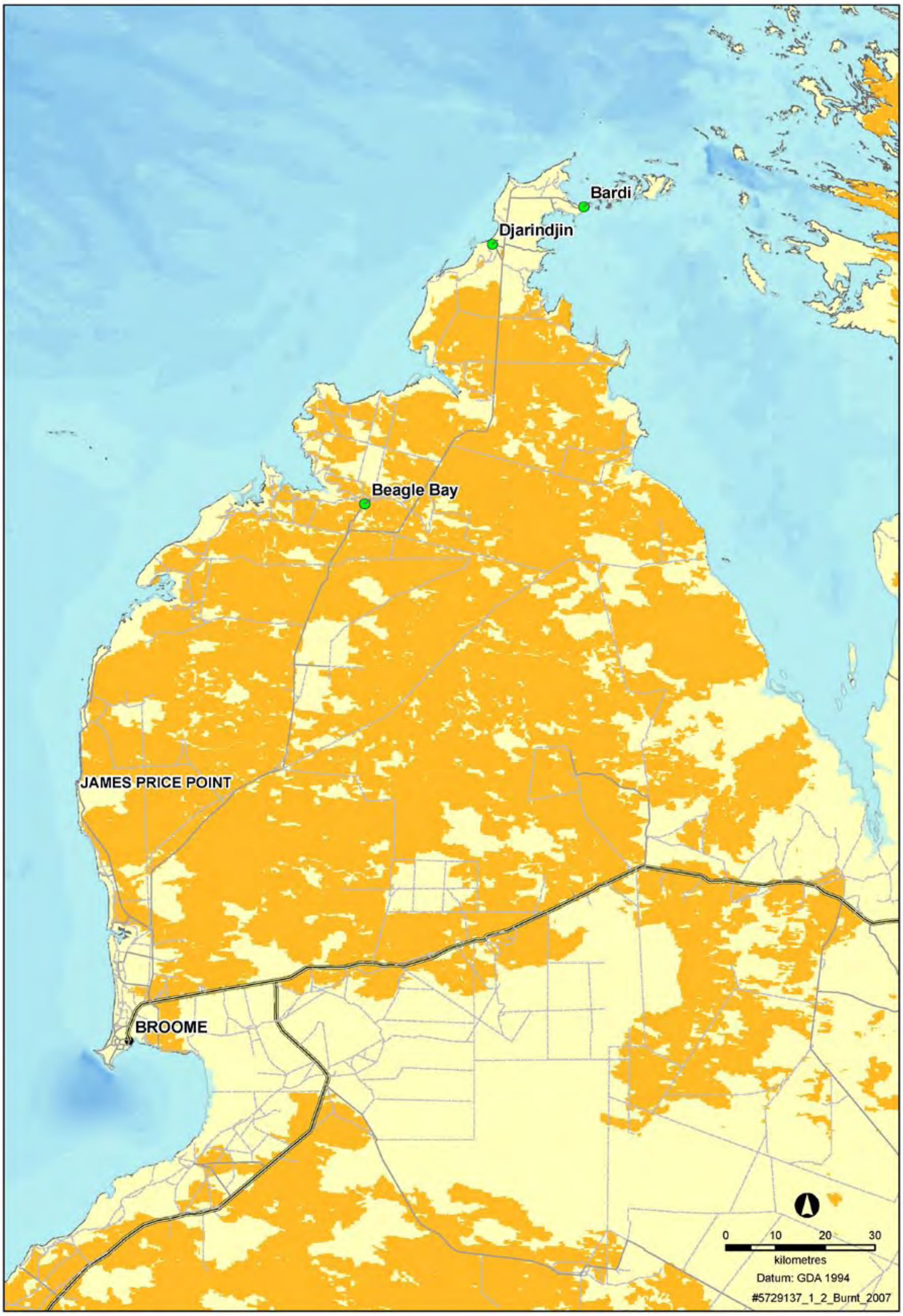
Figure 1-16 and **Figure 1-17** show the extent of fires on the Dampier Peninsula in 2004 and 2007, respectively.



Source: Landgate Firewatch Project database.

- **Figure 1-16 Burnt Areas on the Dampier Peninsula during 2004.**

Note: Burnt areas shown in green.



Source: Landgate Firewatch Project database.

- **Figure 1-17 Burnt Areas on the Dampier Peninsula during 2007.**

Note: Burnt areas shown in orange.

Figure 1-18 and **Figure 1-19** show examples of habitat degradation in Pindan woodland as a result of fire. Excessive fire frequency is having a devastating effect on the long-term survival of the Pindan on the Dampier Peninsula; maintaining this vegetation community in an early successional state (Biota, 2009a).

Source: Biota, 2009a.

- **Figure 1-18 Open Woodland (*Eucalyptus miniata*) with Dead 'Broomstick' Wattle, Showing Regeneration Post Fire.**

Source: DEC, 2009a.

- **Figure 1-19 Degraded Pindan Shrubland in the Dampierland Bioregion Impacted by Frequent Burning.**

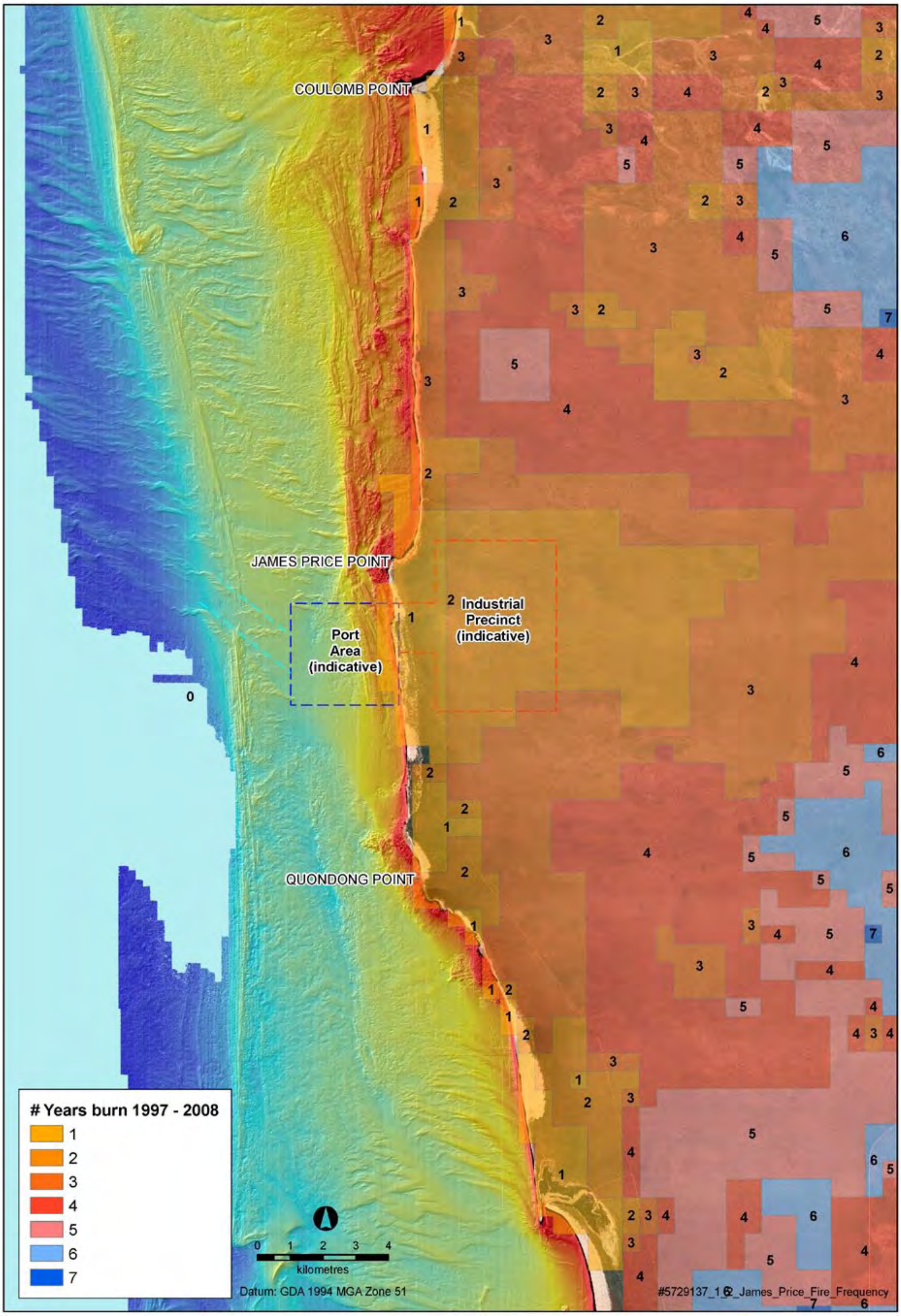
Fire History of James Price Point Coastal Area

Many of the negative impacts within the Kimberley region attributed to frequent, high intensity fires have also been observed to occur within the James Price Point coastal area. The bushland condition survey undertaken by AECOM (2010a; **Appendix C-19**) found that fire was the main factor influencing bushland condition at the site. Resources available to manage fire in this area are limited, and improving fire management in this area is likely to have positive ecological outcomes.

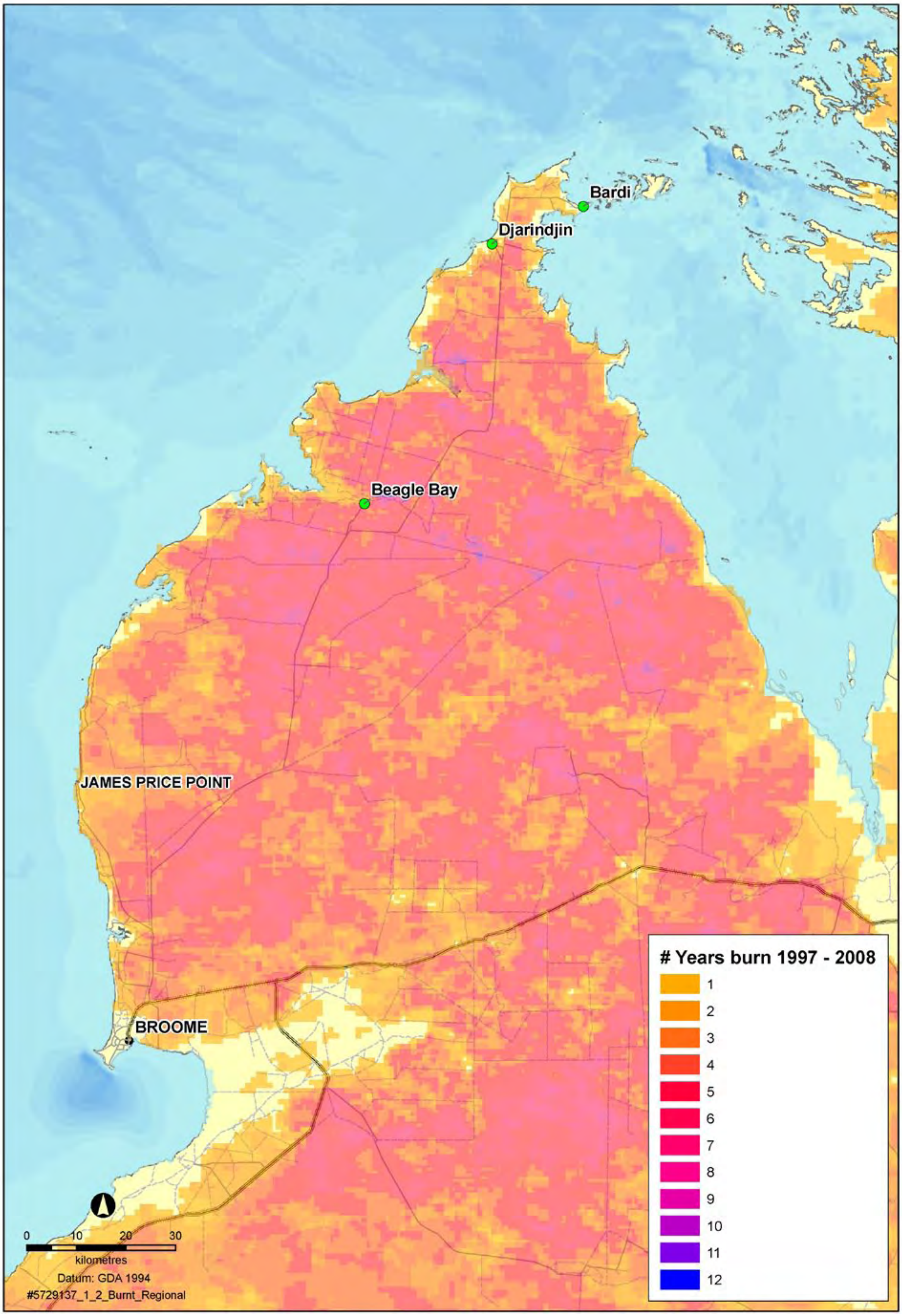
Fire frequency for the James Price Point coastal area is shown in **Figure 1-20** and the number of times fires have occurred between 1997 and 2009 is labelled for each patch. The majority of the study area has been burnt three to four times within this 12-year period, which is more frequent than is optimum for the majority of vegetation types in this area. Coastal areas generally have a lower fire frequency, with the coastal margin being burnt once or twice in the period. Of note is a large area of relatively low fire frequency associated with the James Price Point coastal area. This may be due to the wetter, low-lying nature of this area and associated fire-sensitive vegetation. When compared with the fire frequency for the peninsula (**Figure 1-21**), the study area appears to show a slightly lower fire frequency than the majority of the Peninsula, particularly when compared with areas on the northern and eastern parts of the Peninsula. The relatively large patch of low fire frequency on the study area is unusual and is one of approximately 10 patches of similar size on the peninsula.

Late-dry season fires are thought to generally be more intensive and extensive than fires that occur earlier in the dry season. **Figure 1-22** shows the frequency of late-dry season fires in the study area. The James Price Point coastal area and a large area to the immediate east and south have not experienced a late-dry season fire between 1997 and 2008, which is very rare for the peninsula. Areas to the north of the precinct have experienced numerous (up to five) late-dry season fires during the period.

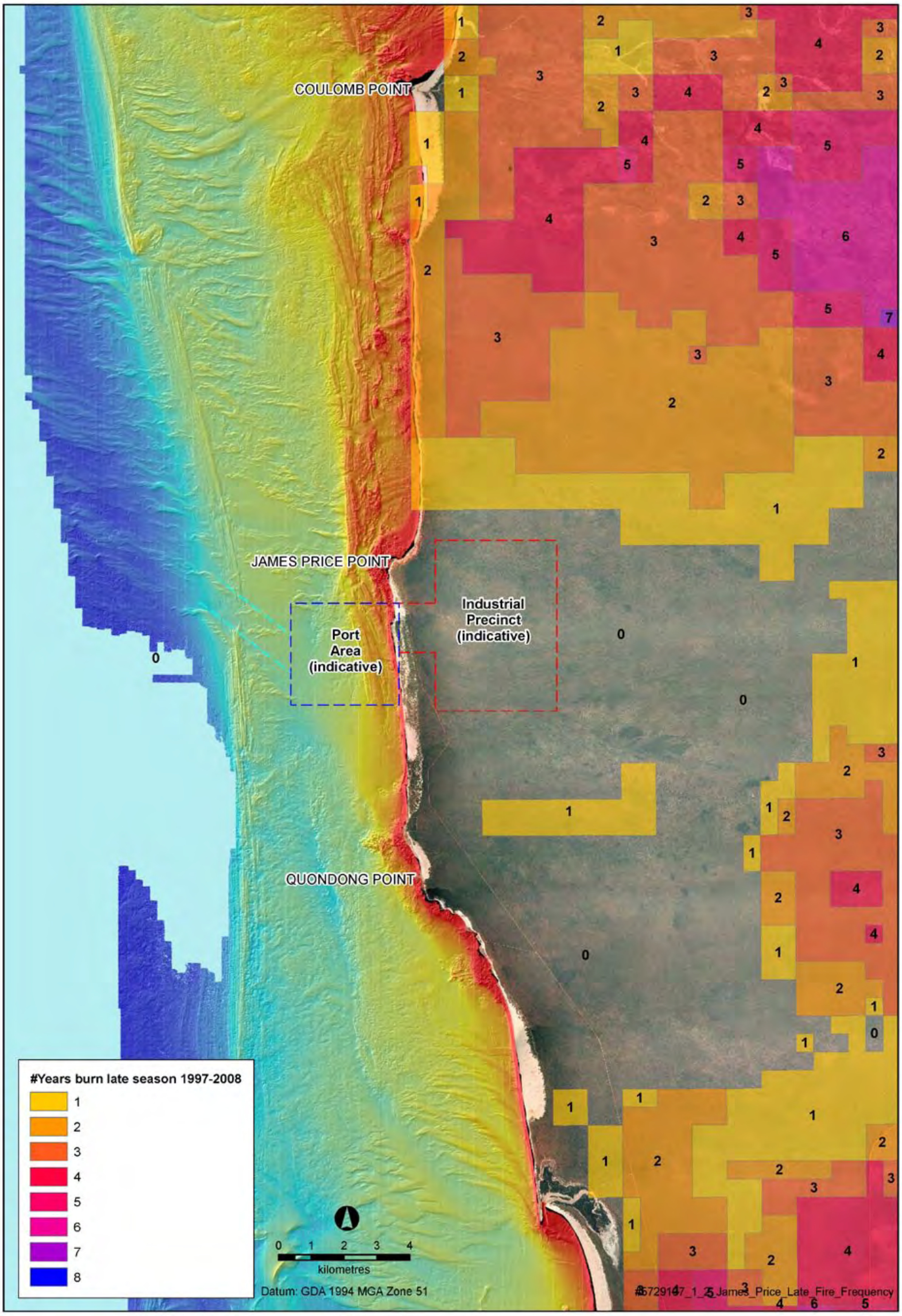
The time elapsed since the last fire can also have an influence on vegetation and habitat condition, as the short-term effects of recent fires (for example, weed invasion and vegetation cover) may be more pronounced. **Figure 1-23** shows the number of years since the most recent fire between 1997 and 2008. For the majority of the study area, this is two years; however, a large patch in the proposed development area has not been burnt for 4 to 8 years and many coastal areas in the southern portion of the study area have not been burnt for 8 to 10 years. It should be noted that an extensive fire was experienced in the study area in 2009 which was not incorporated into this analysis.



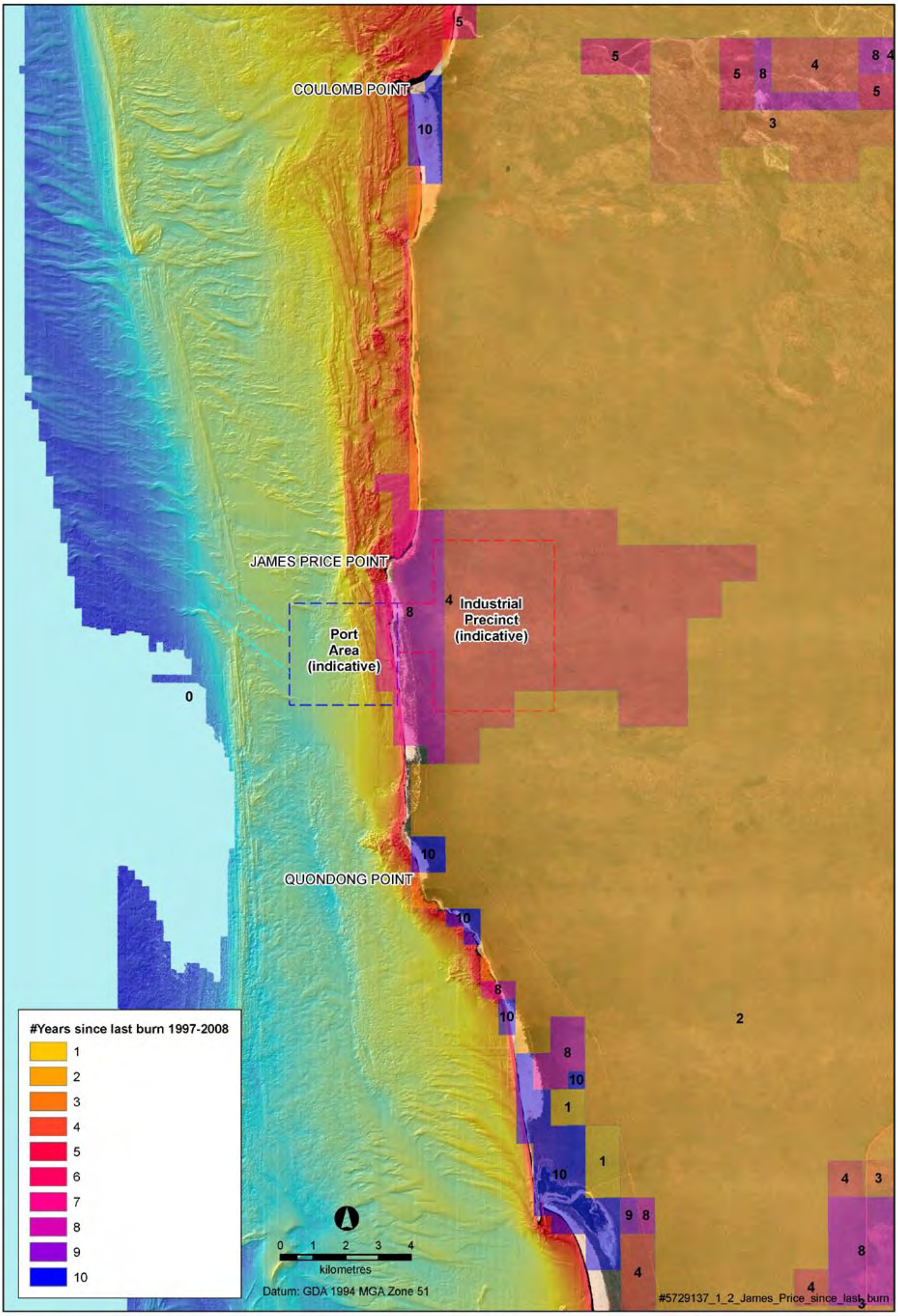
▪ **Figure 1-20 Fire Frequency over the James Price Point Coastal Area (1997 to 2008).**



- **Figure 1-21 Regional (Dampier Peninsula) Fire Frequency (1997 to 2008).**



■ **Figure 1-22 Late Season Fire Frequency in the Vicinity of the James Price Point Coastal Area (1997 to 2008).**



- **Figure 1-23 Number of Years since Last Fire in the Vicinity of the James Price Point Coastal Area (1997 to 2008).**

1.4.11.6. Terrestrial Invasive Species (Feral Pests)

Terrestrial invasive species can impact on native species both directly, through predation and competition for food, water and shelter; and indirectly, through processes such as habitat degradation and spread of disease. Invasive species impacts are also potentially linked to the following changes in ecosystem structure (DEC, 2009a):

- simplified vegetation structures dominated by annual grasslands and with fewer perennial trees;
- shrubs and grasses and loss of obligate seeders;
- increased soil erosion including the loss of leaf litter, organic-A and mineral-A soil horizons;
- greater runoff volumes and velocities, with increased alluvial deposition on foot slopes, floodplains and in estuaries, and as bed load in rivers, and more severe flood events in drainage lines with high flow velocities that strip riparian zone vegetation; and
- enhanced weed invasion (associated with invasive pest animal movements).

Species of Concern for the Kimberley

Terrestrial invasive species are of serious concern within the Kimberley region. Within the Northern Rangelands (incorporating the Kimberley and Pilbara regions) DAFWA (2009) identified a number of declared species to be of regional significance. These species include wild dogs (*Canis familiaris*), feral donkeys (*Equus asinus*), feral camels (*Camelus dromedarius*), feral pigs (*Sus scrofa*), feral cats (*Felis catus*), Little Corellas (*Cacatua sanguinea*) and Galahs (*Cacatua roseicapilla*). European Red foxes (*Vulpes vulpes*) and European rabbits (*Oryctolagus cuniculus*) were reported to be uncommon in the region. Perhaps the most formidable of these species are feral cats, which pose a serious threat by predating on Australian native fauna and as such, are listed as a Key Threatening Process under the EPBC Act (DEWHA, 2008b).

Species of Concern on Dampier Peninsula

Terrestrial invasive species recorded on the Dampier Peninsula include feral cats, feral cattle, wild dogs, feral donkeys, Black rats (*Rattus rattus*), the House Mouse (*Mus musculus*) (ENV, 2008c; **Appendix C-16**) and feral horses (*Equus caballus*). Although the Dampier Peninsula is not mapped within the European Red fox's distribution area (DEWHA, 2008c), the species has been observed on occasions by locals at Gourdon Bay (ENV, 2008c; **Appendix C-16**). Foxes are of concern as they pose a formidable threat to Australian native fauna, particularly having an impact on mammal species within the critical weight range of 35 to 5,500gm. It is unlikely that foxes occur in high densities on the Dampier Peninsula.

Species of Threat in James Price Point Coastal Area

Feral cats, wild dogs, feral cattle, feral horses, Black rats and the House Mouse have all been recorded in the James Price Point coastal area. Other species that have been identified on the Dampier Peninsula, such as foxes and feral donkeys, are also likely to occur on the site. These pest species are likely to have a large impact on native flora and fauna species at the site.

The Bureau of Rural Sciences (2006) presents a priority system in which introduced vertebrate species have been assigned a pest status based on their impact to agriculture and the environment within Australia. Of the pest species listed above, feral pigs, foxes, wild dogs, feral cats and the house mouse are listed to be serious pests, whilst feral horses, feral donkeys, feral cattle and the black rat are listed as being moderate pests. Assigning a similar prioritisation system from a biodiversity impact perspective for the James Price Point coastal area would be useful, but is complicated due to the lack of information currently available.

1.5. Atmospheric Environment

This section includes the existing atmospheric environment with respect to noise, meteorology and air quality, greenhouse gas emissions and ambient light. These factors can affect, directly or indirectly, the health, amenity and behaviour of sensitive receptors in the area to be developed.

1.5.1. Terrestrial Ambient Noise

This section describes the potential sensitive receptors that currently exist and the background noise expected at the site.

There are no current permanent populations within the James Price Point coastal area; the nearest permanent residential receptor is at Willie Creek some 30km south of James Price Point. However, there are temporary or transient residents that use the area for recreational four-wheel driving, camping, fishing and other outdoor pursuits.

Areas around the coastal margin of the Dampier Peninsula are utilised as informal camping areas. The four sites identified by DEC and the Shire (Barred Creek, Quondong Point, James Price Point, Coulomb Point) are the most commonly used areas for recreational camping. Despite being common use camping areas, none of these locations are recognised by the Shire as official designated camping sites, as the land is not currently vested to the Shire. Popular areas utilised in the region are Cable Beach (adjacent to Broome), Willie Creek (30km south), and Coulomb Point Nature Reserve 15km to the north of James Price Point.

As there are no existing industrial sources of noise in the area, the background noise levels at James Price Point are generally attributed to non-anthropogenic sources, for example, coastal wave action on the beach or faunal calls. Some minor contribution comes from passing and visiting tourists and recreational users along the coastal area; however, these noise levels are generally transient and will not be consistent in level.

Noise levels for human impact are defined under the Environmental Protection (Noise) Regulations 1997. The assigned noise level not to be exceeded for noise impact from a noise source at night is 35 A-weighted decibels (**dB(A)**) with the L_{10} (10 minute average) statistic. L_{90} (background noise level) could reasonably be expected to be 5dB lower than the L_{10} depending on the nature of the noise source. From surveys of background noise levels at comparable sites along the north-west WA coast (**Table 1-14**). It can be anticipated that the background noise levels at James Price Point are in the order of 25–30dB(A) over a typical 24 hour period.

- **Table 1-14 Indicative Background Noise Levels at Comparable Sites along North-west WA Coastal Locations.**

Measurement Site	L_{90} Sound Pressure Level (dB(A))		
	Day	**Evening**	**Night**
Northern Carnarvon Basin – 190 kilometres north of Karratha[1]	24	32.5[(2)]	29
Barrow Island	30	24.5	30.5
Burrup Peninsula	25 - 30	25 - 30	25 - 30

Notes: 1 Sound Pressure Levels – L90 of the LA90
2 Noise levels influenced by people on beach

The expected existing background noise level at the site is considered to be 'quiet', as per the comparisons in the following table (**Table 1-15**).

- **Table 1-15 Typical Sound Pressure Levels for a Range of Noise Sources.**

Sound Pressure Level (dB)	Typical Environment	Average Subjective Description
140	30m from jet aircraft	Intolerable
130	Pneumatic chipping and riveting (operator's position)	
120	Boiler shop (maximum levels)	
110	Chainsaw	Very noisy
100	Disco	
90	Heavy trucks at 6m	
80	Kerbside of busy road	Noisy
70	Loud radio	
60	Restaurant	
50	Conversational speech at 1 metre	Quiet
40	Residential area at night	
30	Quiet bedroom at night	
20	Background in TV and recording studios	Very quiet
10	N/A	
0	Threshold of hearing	

1.5.2. Meteorology and Air Quality

The following sections outline the characteristics of the meteorology and the existing ambient air quality at a local and regional level.

1.5.2.1. Meteorology

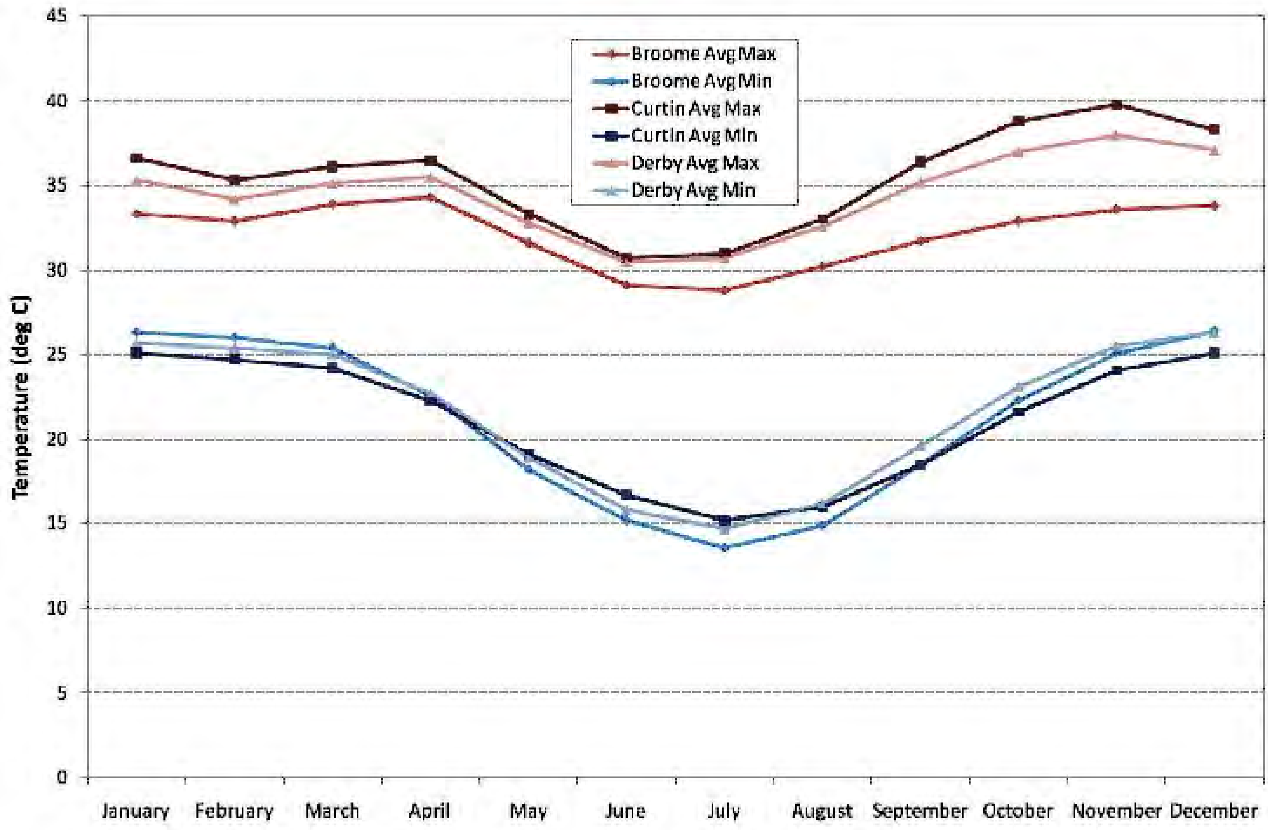
Two major atmospheric pressure systems affect the Kimberley region; a subtropical ridge of high pressure cells and a broad tropical low pressure region called the Monsoon Trough. Seasons are characterised by the Bureau of Meteorology (**BoM**) as a hot 'wet' season (usually December to March) and a cooler 'dry' season for the rest of the year (BoM, 2010a).

Local and regional air quality dispersion conditions are dependent upon the meteorology in the region. The BoM currently operates several meteorological monitoring sites in the vicinity of James Price Point and the following three were used for analysis: Broome (approximately 55km south of James Price Point), Derby (approximately 165km east-north-east of James Price Point) and Curtin (approximately 180km east-south-east of James Price Point).

Due to the proximity and regional aspect (west coast of the Dampier Peninsula) of the BLNG Precinct and the Broome BoM site location, the meteorological conditions experienced at both sites are expected to be similar. An instrumented tower has recently been installed to provide specific meteorological data for the James Price Point coastal area. The recorded data will be incorporated into future reporting.

Temperature

Temperature trends recorded around the Dampier Peninsula are shown in **Figure 1-24**. The mean maximum monthly temperature fluctuates between 29°C in July and 40°C in November. The mean minimum monthly temperature ranges between 14°C in July and 26°C in December. There is a larger temperature variation during the dry season than during the wet season.



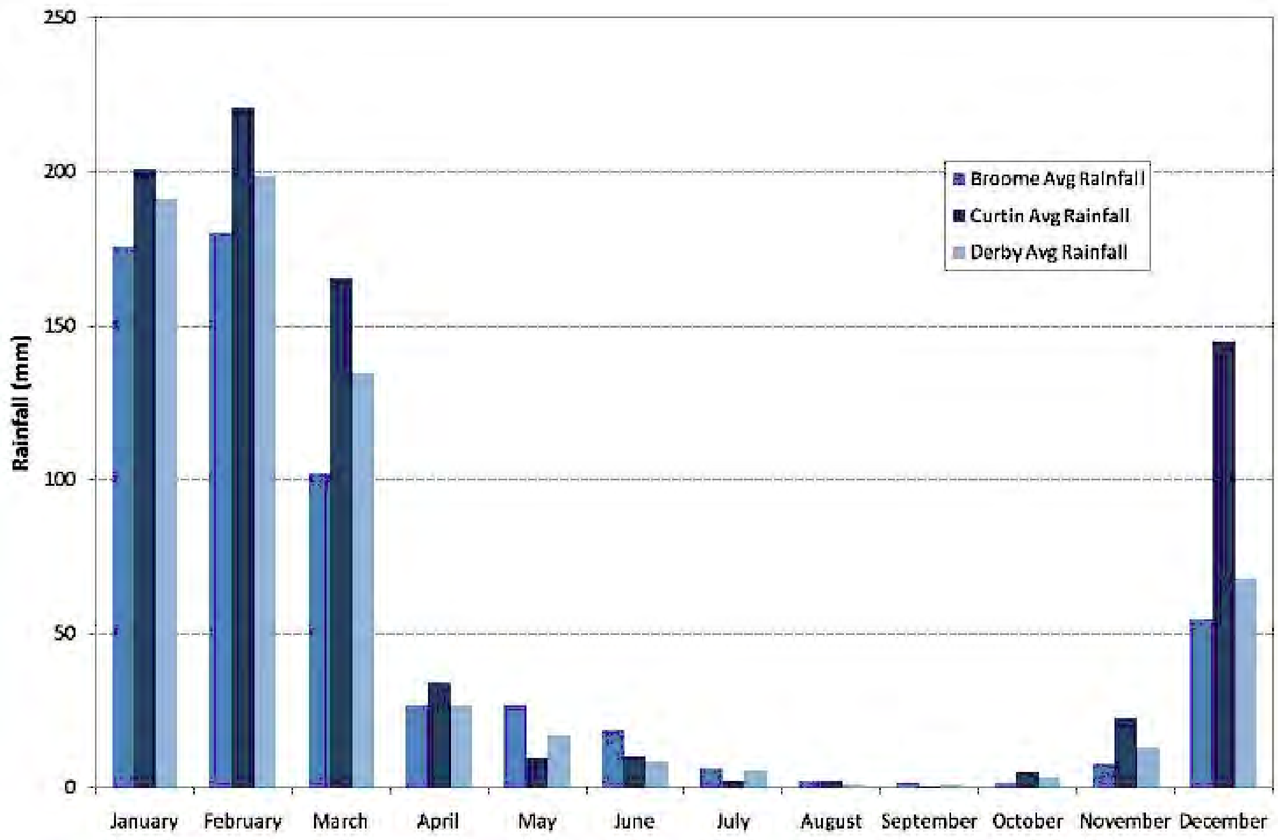
Source: BoM, 2010a.

- **Figure 1-24 Maximum and Minimum Monthly Temperatures for the Dampier Peninsula (°C).**

Rainfall

The average monthly rainfall for the Dampier Peninsula region is presented in **Figure 1-25**. This figure shows that the rainfall in this region is seasonal, with the majority occurring between December and March, with April and November being transitional months. Over 75% of the average annual rainfall falls between January and March, associated with thunderstorms and tropical cyclones (BoM, 2010a). Heavy rains over short periods have been known to provide significant proportions of the annual total rainfall over a period of a few days (BoM, 2010a). Very little rainfall occurs during the dry season months from May to October, with the median rainfall for July to October being zero (BoM, 2010a).

Rainfall patterns measured at each of the three BoM stations are similar in trend, indicating that rainfall in the area is relatively consistent, although rainfall at Curtin is typically higher than at the other two locations, particularly in December.

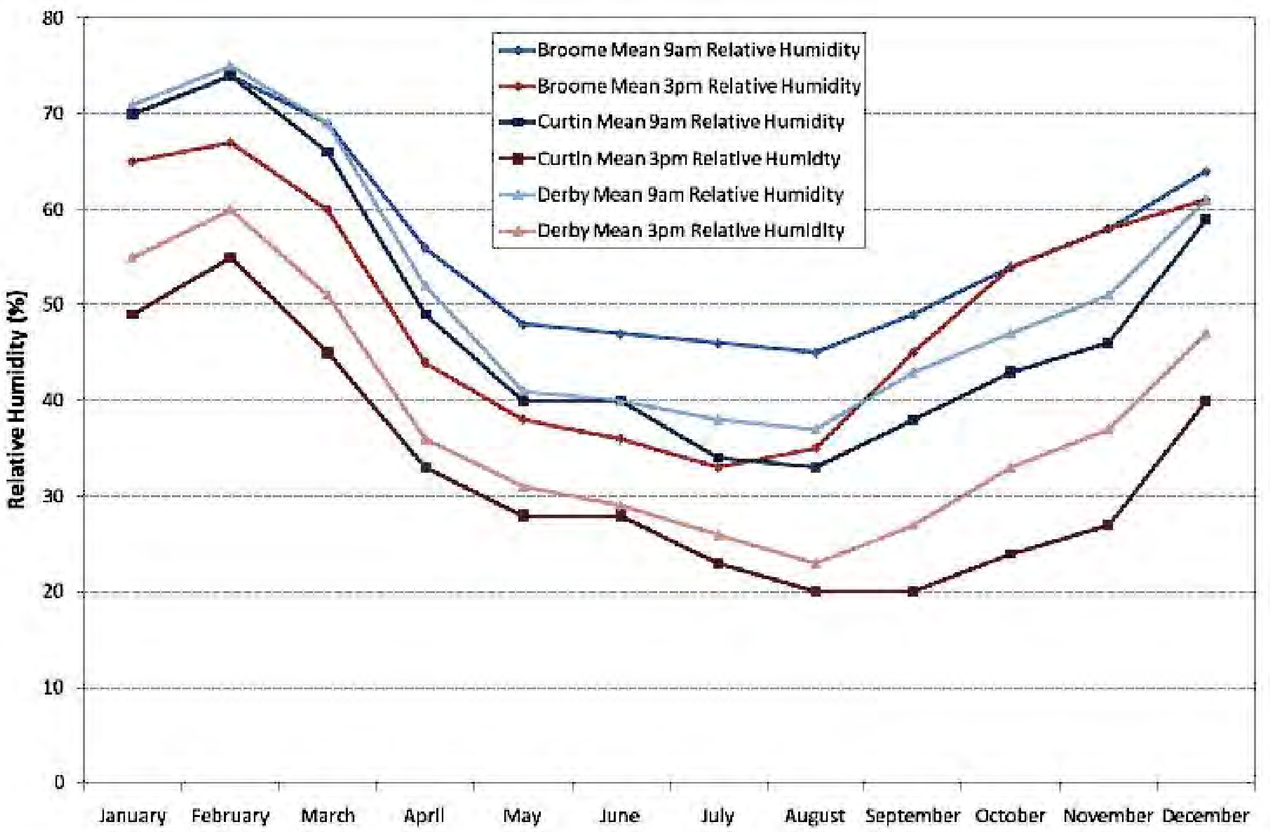


Source: BoM, 2010a.

- **Figure 1-25 Average Monthly Rainfall for the Dampier Peninsula (millimetres).**

Relative Humidity

The relative humidity of the Dampier Peninsula is illustrated in **Figure 1-26**. This figure presents the mean 9 A.M. and 3 P.M. relative humidity recorded at Broome, Derby and Curtin. The figure shows that humidity is generally higher in the morning than the afternoon and the average humidity is higher during the wet season than in the dry season, mirroring rainfall patterns. Again, humidity at the site is expected to be comparable to that occurring at Broome.



Source: BoM, 2010a.

- **Figure 1-26 Relative Humidity for Broome, Curtin and Derby (%).**

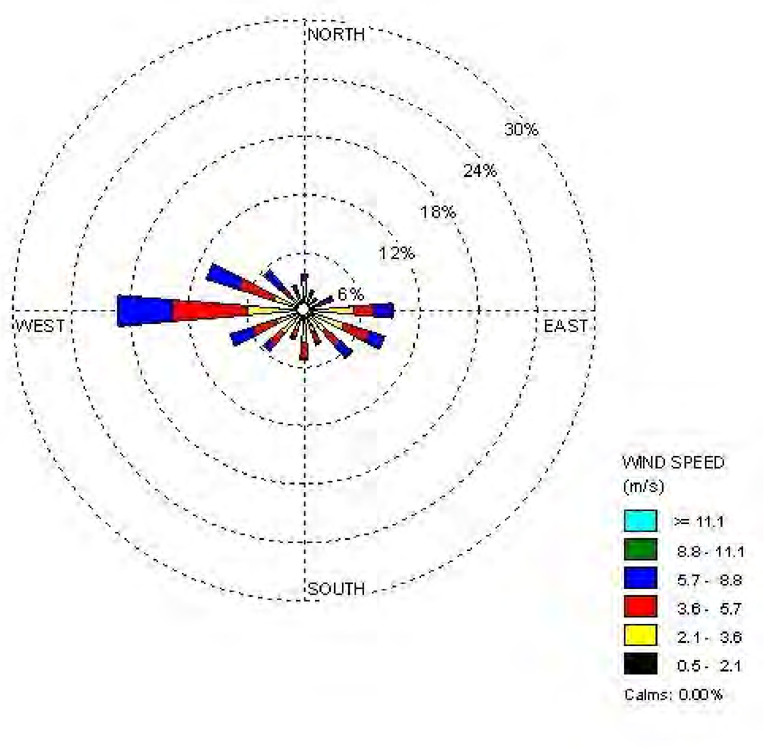
The winds experienced around the Dampier Peninsula were compared using annual wind roses for Broome, Derby and Curtin for 9 A.M. and 3 P.M. measurements. The comparison of the annual wind roses indicated a typical coastal diurnal on-shore and off-shore pattern with similar wind distribution for all three sites. As the Broome site is the closest BoM monitoring station, monitoring data for the ten most recent years was obtained for further analysis. This analysis included comparing individual calendar years with long term wind characteristics.

The year 2007 was selected for more detailed analysis as it was both the most recently available data and was considered to be representative of conditions at the site (when compared with long term average wind characteristics for Broome).

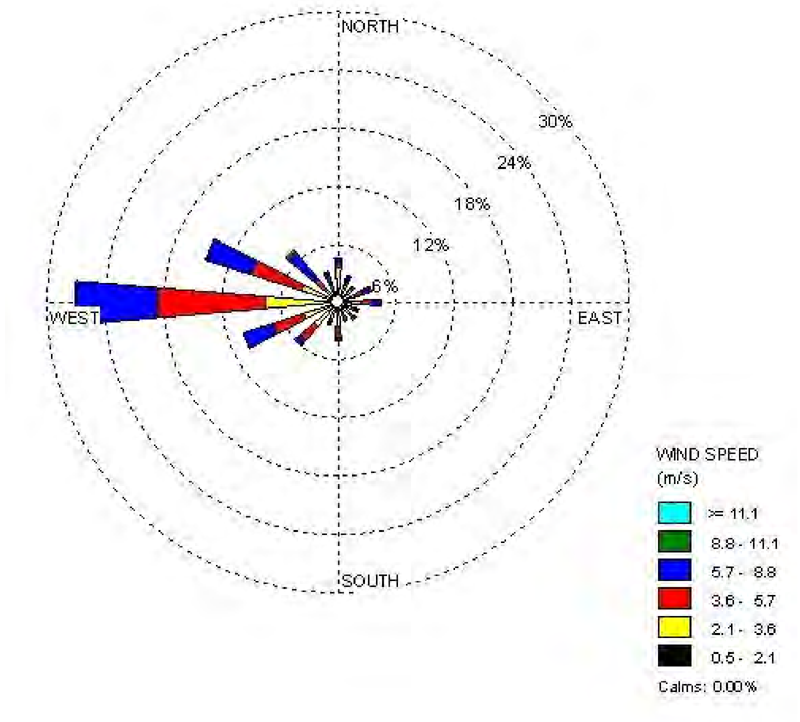
The 2007 annual wind rose for Broome is displayed in **Figure 1-27**. The wet season (including the adjoining months of November and April) wind rose for Broome during the 2007 period is presented **Figure 1-28**. The wind rose for the dry season (May to October) is presented in **Figure 1-29**. From these figures it can be seen that:

- the overall pattern for the year is dominated by westerly winds (blowing approximately 19% of the year at speeds typically between 3.5 and 8.8 metres per second (**m/s**);
- there is very little wind from the north or south in the region;
- during the wet season, almost all winds are westerly (blowing approximately 27% of the season at speeds typically between 3.5 and 8.8m/s); and
- during the dry season, an east-south-easterly breeze prevails (blowing approximately 15% of the season at speeds typically between 3.5 and 8.8m/s).

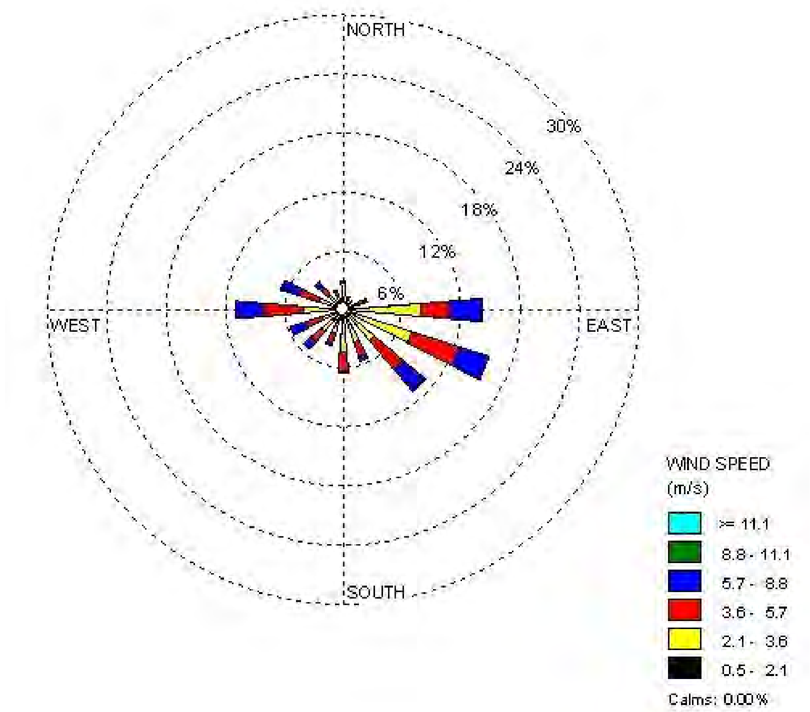
The Air Quality Assessment undertaken to inform the strategic assessment also provides an analysis of existing air quality and meteorology. Refer to Air Assessments 2010 (**Appendix C-25**).



- **Figure 1-27 Annual Wind Rose for Broome.**



- **Figure 1-28 Wind Rose for Broome, Wet Season (November to April).**



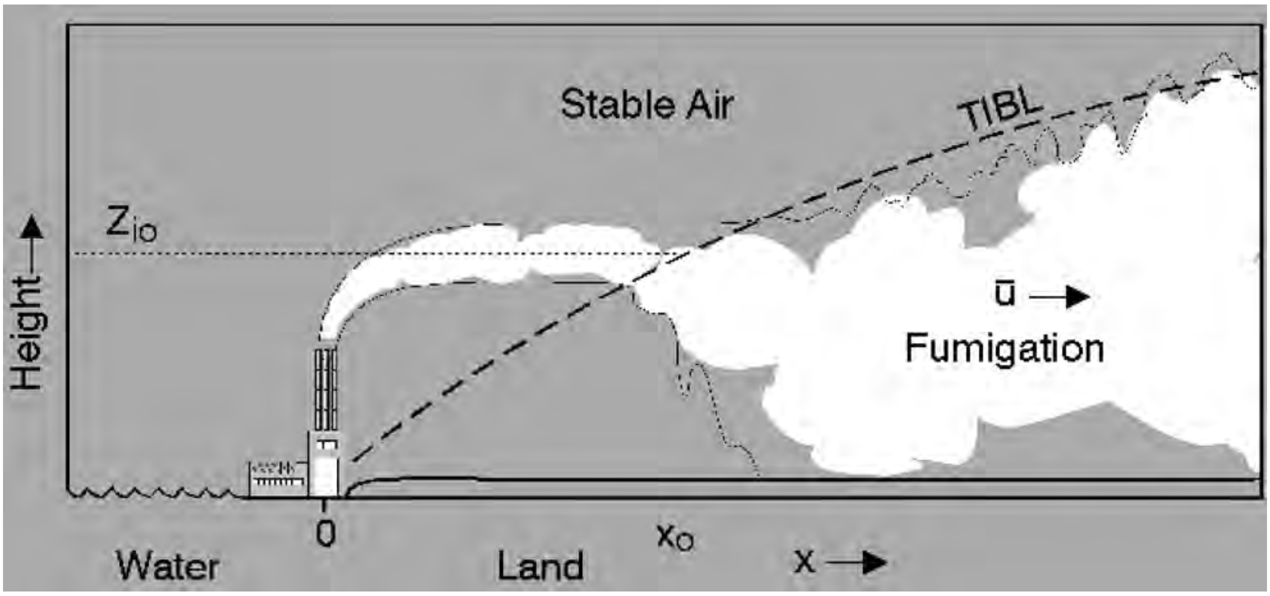
- **Figure 1-29 Wind Rose for Broome, Dry Season (May to October).**

Atmospheric Stability

An important aspect of plume dispersion is the atmospheric turbulence level in the region of the plume. Turbulence acts to increase the cross-sectional area of the plume due to random motions of the air, thus diluting or diffusing a plume. For traditional dispersion modelling using Gaussian plume models, categories of atmospheric stability are used in conjunction with other meteorological data to describe atmospheric conditions and, thus, dispersion.

The most well-known stability classification is the Pasquill-Gifford scheme, which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions, plumes can remain relatively undiluted for considerable distances downwind. Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small.

As the site is to be situated adjacent to the coastline, the effect of coastline stability on pollutant dispersion needs to be considered. Atmospheric stability close to the coast is often affected by a phenomenon known as coastal fumigation. This occurs when a layer of air, in which convective mixing is occurring, increases in depth the further inland a stable air mass travels (**Figure 1-30**). As this layer, known as a thermal internal boundary layer, grows and if it intersects a plume which originates close to the coastline, the plume can be bought down to ground sooner than would be normally expected, increasing ground level concentrations. This phenomenon has been observed in WA as part of studies into the Kwinana industrial area air quality impacts undertaken by CSIRO (1997).



Source: CSIRO, 1997.

- **Figure 1-30 Illustration of Coastal Fumigation.**

The existing meteorological conditions would have the following air quality implications for the operation of the BLNG Precinct:

- air quality impacts would be greatest to the east of the BLNG Precinct due to the dominant westerly winds;
- sea breeze fumigation would combine with the consistent, steady westerly winds to result in greater air quality impacts to the east of the BLNG Precinct; and
- air quality impacts on areas to the south of the BLNG Precinct (for example, Broome) would be least due to the low frequency of northerly winds.

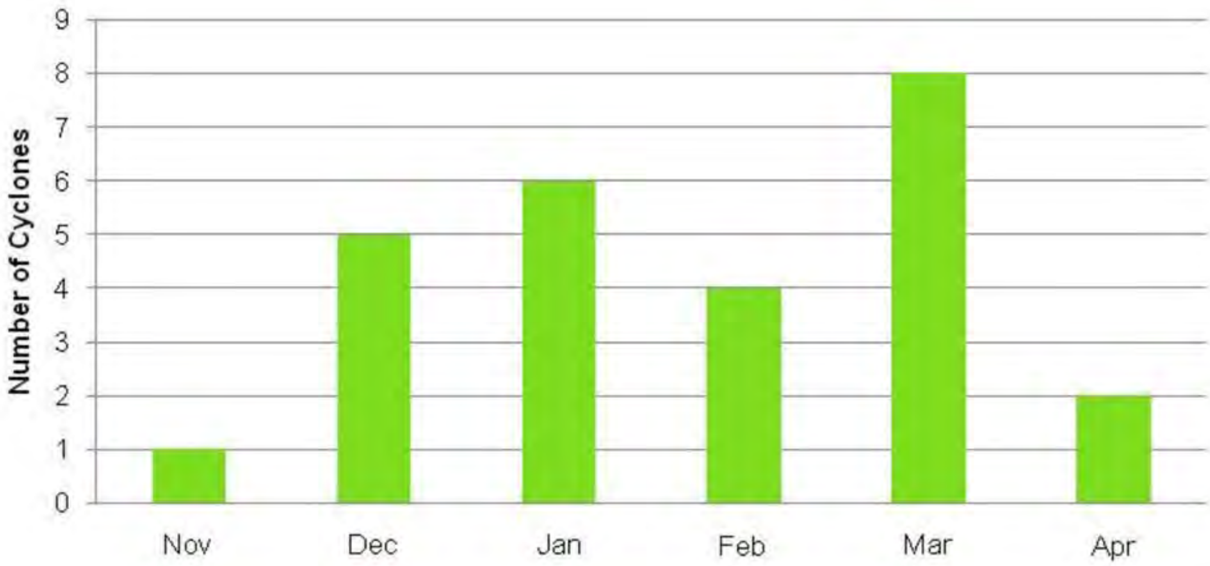
Cyclones

Cyclones are intense low-pressure systems that produce sustained gale-force winds. The cyclone season in Australia starts in November and continues through to April, with the most severe storms usually occurring later in the season. Most Australian cyclones affect the WA coastline between Broome and Exmouth.

Tropical cyclones are associated with very strong winds, heavy rainfall, and high seas. Gust speeds during cyclones at Broome Airport have been measured at 153km/hr. While severe cyclones (those with wind gusts of at least 170km/hr) have not been officially recorded in Broome, gusts have been estimated to be in excess of 250km/hr at the centre of some cyclones (BoM, 2010b).

Additionally, cyclones can generate heavy rainfall. Total rainfall during cyclone events in Broome commonly exceeds 100mm and several cyclones have produced accumulated rainfall exceeding 400mm (BoM, 2010b). Exposed coastline areas, such as James Price Point, are considered to be vulnerable to storm surge (BoM, 2010b) which can cause coastal erosion and inundation of low-lying areas with seawater. As such, cyclones can significantly affect populated areas, both in terms of losses of life and damage to property and infrastructure.

On average, Broome is affected by a cyclone causing gale-force winds approximately every four years, although the frequency appears to be decreasing. Only two cyclones affected the region between 1990 and 2004. The frequency of cyclones over approximately the last 100 years for each month of the cyclone season is shown in, **Figure 1-31**, which indicates that the most cyclones occur in March.



Source: BoM, 2010b.

- **Figure 1-31 Monthly Cyclone Frequency in the Broome Area, 1910 to 2004.**

1.5.2.2. Existing Local and Regional Air Quality

A combination of bushfires, dust storms and remote industrial activities are currently the major causes of reduced air quality in the Kimberley. The most significant existing source is bushfires, which contribute to seasonal smoke haze conditions across the Kimberley region. The EPA recognises that smoke haze is persistent during the dry season, raising the potential for increased asthma symptoms (EPA, 2006a). Burning (including wildfires) produced the largest proportion of pollutants in the Broome area in 2007-08 with an estimated 28.2% contribution to the total reported emissions of National Pollutant Inventory (**NPI**) substances. Pollutants emitted as a result of bushfires in the region consist of oxides of nitrogen (**NO_X**), volatile organic compounds (**VOC**), carbon monoxide (**CO**), particulate matter (**PM**) as PM_{10} and benzene, toluene, ethylbenzene and xylenes (**BTEX**). Besides fires contributing to high particulate, there is occasional dust from distant dust storms that can create high dust/haze levels in the region.

There are no major man-made atmospheric emission sources in the vicinity of James Price Point coastal area. Broome with the power station, fuel depots and motor vehicle use, is the main source of atmospheric emissions in the region. Potential emissions include NO_X, VOCs, CO, particulate matter and BTEX, as well as sulphur dioxide (**SO_2**) and

polycyclic aromatic hydrocarbons (**PAH**). A review of the National Pollutant Inventory database for the 2007-08 reporting year shows the nearest facilities reporting to NPI are located in Broome, approximately 53km south of James Price Point coastal area, and in Derby, approximately 167 km to the east. Industrial activities in these areas include electricity generation, iron ore mining, quarrying, and other non-metalliferous mining activities.

To date, there has been little monitoring of air pollutants in the Kimberley region. The remoteness of the location has generally dictated that the few studies that have been undertaken have used monitoring methods that do not enable direct comparison to the short-term air quality standards of most interest for human health and amenity. Taking into account all available information, including on-site measurements, measurements from other locations in the region and modelling undertaken for this assessment, indicates that:

- the pollutant of most concern is particulate matter ($PM_{2.5}$ and PM_{10}) which is associated with smoke during the fire season from September to November and can generate levels likely to be above the Ambient Air Quality National Environmental Protection Measures (**NEPM**) standards. Similarly, the standard can potentially be exceeded during dust storms, principally over the months from June to August;
- ozone is the pollutant of next most concern, with smoke plumes from fires leading to ground-level concentrations at or just below the 4-hour NEPM standard;
- NO_2 is also generated from fires, however maximum concentrations are around 50 to 67% of the NEPM standard; and
- ambient concentrations of other pollutants such as CO and BTEX are well below relevant criteria.

In summary, the existing state of knowledge of local and regional air quality is that:

- Fires, which have the potential to generate high concentrations of air-borne particulate matter and ozone, are the dominant source of pollutants in the region. The high levels are due to the very large area of land burned, and the potential for pollutants to accumulate as the fires burn for several days.
- Although there are industrial and other development activities in the Kimberley region, there are no major anthropogenic emission sources in the Precinct area or generally within the Dampier Peninsula.
- Current information indicates that for the pollutants of most concern at a regional level (particulates, ozone and NO_2), concentrations may occasionally approach or exceed ambient air NEPM standards.

1.5.3. Greenhouse Gases

Greenhouse gases (**GHG**) are a group of gases that are known to contribute to an increase in the natural warming of the Earth. A range of GHGs are recognised internationally by the Intergovernmental Panel on Climate Change (**IPCC**), and include water vapour, carbon dioxide (**CO_2**), methane, nitrous oxide and a number of artificial gases including Montreal Protocol gases, hydrofluorocarbons, perfluorocarbonated compounds and fluorinated ethers.

The IPCC has developed a standard set of Global Warming Potential (**GWP**) factors which considers the potential warming capacity of GHGs relative to CO_2, the most abundant anthropogenic GHG. These factors provide a means of standardising the relative impacts of various GHGs by translating all GHG emissions into CO_2 equivalents (**CO_2-e**). As an example, the impact of releasing one tonne of methane (**CH_4**), with a GWP of 21, is the equivalent of releasing 21 tonnes of CO_2 into the atmosphere; hence, 1t CH_4 = 21t CO_2-e.

In Australia, the six Kyoto gases regulated under the Kyoto Protocol are recognised in the national greenhouse accounts by the Federal Department of Climate Change (**DCC**). These gases and their GWP factors are outlined in **Table 1-16**. These GWP factors are published as part of the National Greenhouse Accounts (**NGA**) Factors workbook based on the GWP determined by the IPCC (DCC, 2009a).

Table 1-16 Global Warming Potentials of Different Gases Relative to CO_2.

Gas	Global Warming Potential
CO_2	1
CH_4	21
Nitrous Oxide (**N_2O**)	310
Hydrofluorocarbons	140 - 11,700
Perfluorocarbons	6,500 - 9,200
Sulphur hexafluoride	23,900

There are no major anthropogenic GHG emission sources in the James Price Point coastal area. Emissions associated with prescribed burning of the savannahs are likely to be the only significant source of GHGs around the James Price Point coastal area. Prescribed burning of savannahs in WA is estimated to release 4.5 million tonnes of CO_2 equivalents (**Mt CO_2-e**) into the atmosphere, which is equivalent to 5.9% of total annual WA GHG emissions. However, the regional contribution of these sectoral emissions for the Kimberley is not currently defined and is dependent upon the extent of burning which occurs annually.

Recent National and State greenhouse accounts (DCC, 2009b) reports WA GHG emissions, excluding emissions and removals from Land Use, Land Use Change and Forestry were 77.5MtCO_2-e in 2007. When emissions and removals from Land Use, Land Use Change and Forestry are included the total is estimated to be 76.3MtCO_2-e.

1.5.4. Ambient Light

No permanent artificial light sources exist at the James Price Point coastal area as the site is located on a relatively undeveloped stretch of coastline. Consequently, light would be expected from non-anthropogenic sources such as the moon. Occasional and low level light emissions could occur from short-term fishing, vessel mooring, aquaculture activities or recreational camping at the site.

The nearest significant sources of light to the James Price Point coastal area are the port and residential developments at Broome (approximately 55km south), which would provide a distant but limited skyglow along the southern portion of the Dampier Peninsula and surrounding areas. The nearest minor light source is from residential communities and aquaculture activities at Willie Creek (approximately 30km to the south) and Beagle Bay (approximately 80km north).

Lighting from the town of Broome is the largest source of existing light at very close proximity to the Roebuck Bay wetlands and there are no recorded impacts of artificial lighting at Broome on migratory or resident birds.

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2. Terrestrial Factors

The following chapter provides an assessment of the impacts to the terrestrial factors pertinent to the construction and operation of the BLNG Precinct. The factors have been identified and their potential impacts assessed by providing an overview and objectives for each factor, identifying the potential impacts, consideration of the sensitivity and resilience of the factor, describing the proposed management and mitigation actions and assessing the significance of the residual impacts following implementation of management and mitigation actions.

The key terrestrial factors identified through the assessment process described in **Part 2**, **Section 8** are:

- terrestrial flora and vegetation;
- terrestrial fauna; and
- greenhouse gases.

A detailed impact assessment is presented for each of these key environmental factors.

Other terrestrial factors identified as being relevant to the assessment are:

- soils and geomorphology;
- surface water;
- groundwater;
- species of ethno-biological significance;
- terrestrial ecosystem integrity; and
- air quality.

Although relevant to the assessment, these factors were determined as not requiring detailed assessment or management measures beyond standard practice. As such, only a brief description of the potential impacts and proposed management measures are presented for these factors.

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2.1. Relevant Factor: Soils and Geomorphology

This section describes the predicted impacts on soils and landforms resulting from the construction and operation of facilities proposed for the development of the BLNG Precinct (Category A) and the potential for cumulative impacts from activities that may indirectly arise as a result of the BLNG Precinct development (Category B) and other related resource activities in the region (Category C). The term geomorphology refers broadly to the study of landforms and processes that shape them. This section primarily considers impacts to local landforms as a result of the construction and operation of the BLNG Precinct while impacts to processes such as surface water runoff or coastal process are addressed elsewhere within the SAR (**Part 4**, **Section 2.3** (Surface Water) and **Part 3**, **Section 2.1** (Tidal Regimes, Wave Climate, Currents and Hydrodynamics)).

The soils and landforms underlying the BLNG Precinct form a dynamic system of interrelated environments that provide unique challenges for construction of the proposed infrastructure. The following information is provided to form a basis for understanding the impacts and potential mitigation measures that would be required to safely integrate large scale infrastructure into the existing James Price Point coastal area environment.

2.1.1. Current Knowledge

The following sub-sections describe regulatory expectations with respect to surface water, and provide a summary of key site features relevant to potential impacts.

2.1.1.1. Key Statutory Requirements, Environmental Policy and Guidance

There are a number of key statutory requirements, environmental policy and guidance that apply to the Strategic Assessment in relation to soils and geomorphology.

State Guidance and Policy

The EPA sets objectives and has a number of position and guidance statements relevant to soils and geomorphology.

In most circumstances, the EPA applies the following objective to the assessment of proposals that may involve soils and geomorphology:

"To maintain the integrity, ecological functions, and environmental values of the soil and landform."

Other Acts and Regulations that are relevant to the impact assessment for soils and geomorphology include:

- The pollution control provisions of Part V of the *EP Act 1986.*
- *Conservation and Land Management Act 1984.*
- Environmental Protection (Liquid) Waste Regulations 1996.
- Environmental Protection (Controlled Waste) Regulations 2004.
- Environmental Protection (Unauthorised Discharges) Regulations 2004.
- Environmental Protection (NEPM-NPI) Regulations 1998.
- *Soil and Land Conservation Act 1945.*
- *Contaminated Sites Act 2003* and associated Contaminated Sites Regulations 2006.
- Dangerous Goods Safety (General) Regulations 2007.
- WAPC State Planning Policy No. 2.6 - State Coastal Planning 2003.
- WAPC Planning Bulletin No. 64 - Acid Sulphate Soils.

2.1.1.2. Description of Factor

Soils and geomorphology, both within the potential BLNG Precinct site and in the general James Price Point coastal area are described in **Part 4**, **Section 1** (Environmental Overview). Relevant key findings include:

- Pindan sand plains dominate the area around the James Price Point coastal area (NDT, 2008a). Pindan soils form widespread undulating plains and have poor surface drainage, resulting in a tendency for sheet runoff and subsequent sheet erosion. Pindan sands of the Dampier Peninsula are predominantly to a depth of 5 to 20m

(Rockwater, 2009; **Appendix C-22**), however depths at the James Price Point coastal area will be confirmed as part of proposed geotechnical investigations.

- Potential acid sulphate soils (**PASS**) may be associated with the shallow sedimentary basins that form at the intersection of the coastal dune sands with some of the ephemeral streams within or adjacent to the BLNG Precinct. The presence or absence and areal extent of PASS soils will be determined as part of the geotechnical investigations by the Foundation Proponent.
- The topography of the James Price Point coastal area is relatively flat with elevation rising gradually towards the east. An elevated coastal dune system, approximately 20m in height, occurs between James Price Point and Quondong Point (approximately 10km from James Price Point).
- The landforms of the James Price Point coastal area form a very simple environment of gently sloping surfaces with few incised drainage lines. The James Price Point coastal area is characterised by narrow beaches with an intermittent rocky shoreline and platforms of lithified coastal sediments adjoining low lying cliffs and sand dunes to the landward side (Atteris, 2010a).

2.1.2. Identification of Key Aspects

2.1.2.1. Definition of Relevant Aspects

Aspects associated with the development and operation of the BLNG Precinct and associated infrastructure that may have an environmental impact on soils and landforms were identified in the Scope of the Strategic Assessment and considered in this assessment. These aspects are:

- site disturbance and excavation;
- terrestrial waste and discharges; and
- altered fire regime.

In addition to the above, the following aspect was considered to be applicable to this factor and has been considered in this section:

- physical presence of facilities and associated infrastructure (including permanent buildings and shore crossing infrastructure).

2.1.2.2. Sources of Potential Impact

2.1.2.2.1. Site Disturbance and Excavation

Site disturbance and excavation have the potential to cause increased surface runoff and erosion as a result of the disturbance of large volumes of Pindan soils and other material.

Table 2.1-1 provides details on site disturbance and excavation activities likely to occur within the BLNG Precinct, including the onshore pipeline corridors (including shore crossings), workers accommodation camp and LIA.

Initial earthworks would include stripping top soil and contouring sites for future construction. This would require the removal of Pindan soils to a nominal depth of 5–20m with excess material stockpiled for re-use in other construction activities. While considered unlikely, blasting and drilling may be required during site preparation. Once the sites have been levelled, they would be graded to contain runoff and direct it to appropriately constructed drains. Sediment/silt fences would be erected where there is potential for storm water run-off to occur.

Table 2.1-1 Scope of Potential Site Disturbance and Excavation Activities within the BLNG Precinct and Associated Infrastructure.

Activity	Potential site disturbance and excavation activities
Earthworks (site levelling)	• Removal of Pindan sand plain soils to a nominal depth (between 5 to 20 m) and stockpiling excess, where practicable, for potential reuse. • Limited controlled blasting (if required) for excavation of sandstone bedrock where levelling is required. • Site contouring, removal and stabilisation of dunes within the area linking the BLNG Precinct to the Marine Port Area. • Installation of site drainage, sediment and erosion control measures.
Foundation preparation earthworks	• Foundation construction methodology dependent on pending geotechnical assessment. Options include the following, in combination with ground stabilisation techniques: 1. Installation of spread foundations or pad footings (commercial grade concrete based with reinforced steel). 2. Installation of raft foundations (deep reinforced concrete slab) where soil integrity is weaker and stabilisation is required. 3. Installation of piled foundations where soil conditions are not suitable by concrete foundations. Typically concrete plate with steel piles driven into bedrock. • Use of ground improvement or stabilisation techniques (e.g. soil compaction and/or treatment). • Dredge spoil removed from excavation activities in the marine environment may be used for backfill requirements for construction of the onshore foundations. The composition and suitability of dredge spoil for material use is subject to confirmation of geotechnical information.
Permanent transport corridors (road construction)	• Road construction would be required within the BLNG Precinct as defined in **Part 2**, **Section 5**. • Haul road connecting the Marine Facility (including materials offloading facility) to the BLNG Precinct for module transport. • Access roads and site drainage would be installed following site clearance, levelling and compaction works within the BLNG Precinct site. • Road construction would include a combination of bitumen surfaces for main access roads and crushed rock for minor roads. Minor roads would be constructed using road base material from locally sourced aggregate (including sand, gravel and potentially rock) from site clearing works, and/or sourced from a commercial supplier.
Pipeline construction (shore crossing and onshore pipeline corridors)	• Excavation of soil material at shore crossing from trench/tunnel or drill void by use of machinery dependent on type of construction methodology (see **Part 2**, **Section 5**). Trench spoil would be stockpiled where practicable for potential reuse. • Removal of top soil (to be stockpiled, where practicable) for potential re-use within the designated onshore pipeline corridors. • Back filling of pipeline trench with trench spoil material (if suitable) or clean fill and compacted. • Site clean-up and rehabilitation to restore the site to its original condition using either stockpiled top soil or clean fill.

Terrestrial Wastes and Discharges

Non-routine discharges of waste or inappropriate storage and disposal of hydrocarbons, solid wastes and hazardous wastes, have the potential to result in the contamination of local soils.

Terrestrial waste would consist of both routine, controlled discharges from the BLNG Precinct facilities (including support and supply vessels) and non-routine, unplanned events such hydrocarbon or chemical spills. The potential hazardous and non-hazardous solid and liquid terrestrial waste streams that would be generated or disposed of during the construction, commissioning and operation of the BLNG Precinct are identified in **Part 2**, **Section 5**. Key construction and operational waste sources are discussed in further detail below.

Construction

During construction, wastes would comprise spoil (e.g. soil, rock and green waste from site clearing and preparation activities), glass, scrap metal, concrete and construction rubble, pallets, cardboard, plastic, aluminium cans, empty drums, personal protective equipment, and office materials. Food wastes would also be generated from the accommodation and associated facilities.

Hazardous/controlled wastes would include chemicals, oils, and waste water streams from the waste water treatment plant.

Dredge spoil material would be generated during construction of the marine facilities and from maintenance dredging operations. The ultimate use of the spoil material would depend on the outcome of geotechnical investigations. In the interim, the material would be managed to prevent any potential impact upon sensitive environments such as subsurface aquifers. Impacts on local groundwater conditions are addressed separately in **Part 4, Section 2.3** (Groundwater).

Operations

Key waste streams generated during operations would include general domestic waste, and hazardous/controlled wastes from LNG processing such as slop oils; spent MEG; mercury; and treated wastewater from the waste water treatment plant (including sewage, grey water, produced water and associated liquid effluents from processing and stormwater runoff from process areas). Once treated at the WWTP, wastewater would be disposed of via a marine outfall. Potential impacts associated with marine discharges are discussed separately in **Part 3**, **Section 2.3** (Marine Water Quality).

The majority of the solid, semi-liquid and liquid waste streams generated by activities within the BLNG Precinct will be separated where practicable, and stored prior to transfer to an offsite DEC approved waste management and/or recycling facility. Industry standard waste treatment and disposal methods would be adopted for all discharge and waste types, as part of BLNG Precinct construction and operation.

Altered Fire Regimes

Fire is a natural process which plays an important role in the regeneration of vegetation. Altering the frequency, timing or intensity of fires can have a detrimental effect on vegetation exposing large areas of soil to wind and water erosion. The effect of current fire regimes on Kimberley ecosystems is not fully understood, however, the frequent, large, and intense dry season fires are known to have serious consequences (EPA, 2006a). Evidence indicates that altered fire regimes can result in habitat simplification and degradation, which together with increased predators and herbivores, contributes to the decline and extinction of medium size mammals in the semi-arid and arid zones (EPA, 2006a).

Although altered fire regimes are impacting vegetation and habitats within the James Price Point coastal area, it is currently uncertain if this process is significantly contributing to loss of top soil and exacerbating the affects of wind and water erosion.

Physical Presence

The BLNG Precinct development description has been provided in **Part 2**, **Section 5**. Key components of the BLNG Precinct will include LNG processing and storage facilities, shore crossing and onshore pipeline installation, workers accommodation, LIA and ancillary infrastructure such as access roads. The presence of these facilities and infrastructure may alter natural airflow rates and direction resulting in localised and irregular patterns of erosion and deposition, particularly surrounding coastal dunes.

2.1.2.3. Sensitivity and Resilience

The absence of large scale excavation activities has resulted in the local soils in James Price Point coastal area being relatively undisturbed. The only exceptions are Manari Road and minor tracks.

Some gully erosion is evident north of James Price Point where drainage lines discharge to the nearshore environment.

The poor stability and high erosion potential of Pindan sands is an important feature of the soil conditions within the BLNG Precinct. This may result in serious erosion during site excavations if not appropriately managed.

The coastal dune system which occurs between James Price Point and Quondong Point may be particularly vulnerable to wind and water erosion during construction. Increased erosion may also have the potential to impact monsoon vine thicket which occurs in association with the coastal dunes.

2.1.3. Predicted Impacts

Potential impacts on soils and geomorphology from the construction and operation of the BLNG Precinct are discussed in detail in the following sub-sections and summarised in **Table 2.1-5**. Both direct and indirect impacts are considered within these sections. For the purpose of this assessment it is considered that direct impacts would largely be confined to areas of direct disturbance within the BLNG Precinct, and other locations where development activities are proposed to occur.

2.1.3.1. Potential Impacts to Soils and Geomorphology due to Site Disturbance and Excavation

Earthworks (site levelling)

As described at **Table 2.1-1,** site levelling will require the contouring of all construction areas and excavation of Pindan sands, to depths of up to 20m.

Disturbance of the Pindan sands during construction could make the sands susceptible to erosion by both wind and water, particularly during high intensity wet season rainfall events. Erosion can cause loss of topsoil, land degradation and siltation and the deterioration of drainage lines. Erosion and sedimentation of local drainage lines is likely to occur naturally during high intensity rainfall events, however, clearing and the excavation of Pindan sands during earthworks has the potential to exacerbate the impact. Where practicable, site disturbance and excavation activities are proposed to occur during the dry season, reducing sedimentation associated with heavy rainfall events. Site runoff and soil management activities would be adopted as part of all excavation activities so that impacts are primarily contained within each of the site disturbance and excavation locations. This would include runoff and erosion control to avoid impacts to nearby watercourses or vegetation communities. The extent of cleared areas and exposed soil would be minimised as far as practicable to reduce potential impacts. In addition, dust suppression will be adopted during earthworks.

Local landforms would be altered by the initial excavations and site levelling, with the potential to impact local drainage patterns.

Excavation below the water table in an area with potential acid sulphate soils may affect soil and water quality. PASS which have been dewatered and subsequently exposed to the atmosphere can be oxidised causing acidification and release of naturally occurring heavy metals. As the groundwater level in the BLNG Precinct is estimated to be approximately 2m AHD (Rockwater, 2009; **Appendix C-22**) and the majority of the Precinct is above 10m AHD, it is unlikely that significant volumes of dewatering would be required. Furthermore, a preliminary hydrogeological assessment (Rockwater, 2009; **Appendix C-22**) found that there was a minimal risk of encountering Acid Sulphate Soils (**ASS**). While the possible presence of ASS is considered to be low, detailed acid sulphate soils investigations would be undertaken prior to construction to confirm the presence or absence of acid sulphate spoils within the proposed disturbance envelope. The potential disturbance of acid sulphate soils would be managed in accordance with the proponent of derived proposals Construction Environmental Management Plan, to be informed by the results of acid sulphate soils investigations.

The impacts to surface water flows and groundwater conditions have been addressed in **Part 4**, **Section 2.2** (Surface Water) and **Part 4, Section 2.3** (Groundwater).

Foundation Preparation Earthworks

The Pindan sands may become locally saturated during the wet season (which could weaken foundations prepared from this material) and therefore to reach suitable foundation layers, the excavation and removal of large volumes of Pindan soils are likely to be required. The volume of material removed will be dependent on a number of geotechnical parameters and foundation design. It is possible that excavations to a depth of 20m or greater may be required to reach suitable foundation layers. Ground improvement methods such as compaction or stabilisation, would be investigated to identify the most appropriate ground preparation techniques.

Foundation preparation would flatten the local landscape, particularly in areas where the LNG processing facilities are located, consequently impacting local drainage patterns. The impacts to surface water flows and groundwater conditions are addressed at **Part 4**, **Section 2.2** (Surface Water) and **Part 4**, **Section 2.3** (Groundwater) of this report. Foundation preparation is also likely to cause localised compaction of the soil profile affecting areas of potential subterranean habitat as well as drainage flows. However, in a local context, such impacts are unlikely to be significant. In relation to the entire BLNG Precinct, areas requiring specific ground preparation techniques are likely to be minimal.

Sites for the disposal of spoil from onshore earthworks and the use of such soils within the BLNG Precinct for applications that are not sensitive to variability or loss of soil strength, will be determined by the proponents of derived proposals during detailed design. The use of dredge spoil for backfill requirements and foundation preparation during onshore construction is under consideration. Impacts on local soil conditions would be restricted to locations in close proximity to areas of spoil use and are unlikely to significantly impact soil conditions within the broader James Price Point coastal area.

Permanent Transport Corridors (roads)

Compaction required for the construction of permanent transport corridors has the potential to change local soil profiles. Road construction will also require the movement and storage of large volumes of soil. The impacts of these activities are likely to be similar to those described for Earthworks above. Impacts resulting from changes to local drainage patterns are addressed in **Part 4**, **Section 2.2** (Surface Water).

Pipeline Construction (shore crossing and onshore pipeline corridor)

Installation of nearshore pipelines connecting the upstream facilities to the downstream BLNG Precinct and the BLNG shore crossing approach connecting the BLNG Precinct to the Port Facility has the potential to affect the local coastal geomorphology. Changes to coastal process and beach environments as a result of nearshore construction activities are addressed in **Part 3**, **Section 2.1** (Tidal regimes, wave climate, currents and hydrodynamics). Although the final construction method has not been identified, preliminary design indicates that the excavation and contouring of a 110m section of dune would be required for the southern pipelines and a corridor of between 1 and 1.5km for the shore crossing approach.

Localised alteration to the pattern of dune movements as a result of dune destabilisation, is likely to be the primary impact on local geomorphology. Potentially, wind and water-driven dune movements will be affected to the north and south of the shore crossing and pipeline corridor. However, the coastal dunes at James Price Point coastal area are well vegetated and relatively stable and it is considered unlikely that significant dune movement would occur.

Exposure of the dune sands during and after construction has the potential to cause increased erosion and changes to dune movement patterns. In addition, strong winds or heavy rainfall occurring during construction may lead to increased localised erosion surrounding the shore crossing and southern LNG pipeline corridor.

The potential impacts to soils and landforms resulting from site disturbance and excavation activities are considered to be of low residual significance as the majority of impacts may be minimised or avoided through the management measures proposed or involve short-term (i.e. construction) or localised (i.e. within Precinct) effects. Erosion, the generation of ASS and changes in landform were all identified as potential impacts to local soils geomorphology, occurring as a result of site disturbance and excavation during construction of the BLNG Precinct. Erosion control features to be incorporated in the proponents' design will be used to manage erosion and sedimentation, topsoil and soil quality (e.g. slope stabilisation, temporary erosion control berms). Detailed acid sulphate soils investigation would be undertaken prior to construction to confirm the presence or absence of acid sulphate soils within the BLNG Precinct. The potential disturbance of acid sulphate soils would be managed in accordance with the proponents of derived proposals Construction Environmental Management Plan.

The integrity, ecological functions and environmental values of the soils and landform will be maintained by managing impact through the application of standard measures and the management measures such as slope stabilisation and erosion control. A more detailed description of proposed mitigation measures is outlined in **Section 2.1.4**. The significance of residual impact is assessed as low because impacts will be localised and it is considered by the proponent that, based on industry experience, design, management and rehabilitation measures can reasonably be expected to be successful.

2.1.3.2. Potential Impacts to Soils and Geomorphology due to Terrestrial Wastes and Discharges

Construction activities will require the storage of hydrocarbons such as fuels and lubricants as well as hazardous chemical materials in both dry and liquid forms. The local Pindan sands are transmissive and would convey contamination arising from spills of hydrocarbons, wastes and hazardous chemicals, therefore storage and transfer facilities would be contained within impermeable bunded areas designed to capture discharges and prevent release to the surrounding environment. Potential impacts to groundwater are addressed in **Part 4**, **Section 2.3** (Groundwater). Should a spill occur during construction, the implementation of standard containment and response procedures would

likely confine soil contamination to the immediate vicinity of the BLNG Precinct and would not significantly affect local environmental values.

Spills or leaks of liquid production waste, by-products such as produced formation water (containing hydrocarbons), and process chemicals have the potential to cause contamination on contact with the soil. Leaks from buried pipelines conveying hydrocarbons can cause significant contamination if they are not detected in a timely manner. The potential for soil contamination from leaks and spills of chemicals or hydrocarbons and incorrect solid and liquid waste disposal will be minimised through the proposed proponent management plans and the implementation of Emergency Response Procedures. Any soil contamination which does occur will be expected to be readily remediated.

It is expected that potential impacts to soils and landform can be successfully mitigated, by the application of management and mitigation measures such as impermeable bunding and the capture of emergency discharge. A more detailed description of proposed mitigation measures is presented in **Section 2.1.4**. The significance of the residual environmental impact from terrestrial wastes and discharges, including non-routine events, is assessed as low as it is highly likely that, with the application of the proposed mitigation measures, soil contamination would be confined to the immediate vicinity of the BLNG Precinct.

2.1.3.3. Potential Impacts to Soils and Geomorphology due to Altered Fire Regimes

The frequent and high intensity fires which occur within the James Price Point coastal area are likely to lead to the exposure of large areas of Pindan sand plains to the affects of both wind and water erosion. Safety would require the ongoing fire management in areas surrounding the BLNG Precinct. As a result of these activities it is likely that the frequency and intensity of fires will be reduced. Ongoing fire management surrounding the BLNG Precinct would focus on reducing fuel loads, rather than a complete burn of all surrounding vegetation. As such, it is likely that some vegetation structure would be retained, helping to reduce the affects of both wind and water erosion. It is possible that the implementation of a managed fire regime would reduce the severity of both wind and water erosion on Pindan soils surrounding the BLNG Precinct site. Accordingly it is likely that a changed fire regime established as part of the BLNG Precinct, would result in negligible impacts to soil characteristics and therefore would have an insignificant impact on local soil conditions.

It is expected that potential impacts to soils and landform can be successfully mitigated by the implementation of management and mitigation measures such as the implementation of a managed fire regime. A more detailed description of proposed mitigation measures is presented in **Section 2.1.4**. The significance of the residual environmental impact on soils from altered fire regimes is assessed to be very low, as it is likely that with the application of the proposed management measures, there will be a reduction in fire intensity which is likely to result in less soil being directly exposed to wind and rain over time.

2.1.3.4. Potential Impacts to Soils and Geomorphology due to Physical Presence of Infrastructure

Installation of large scale infrastructure would have the potential to affect wind flow, resulting in localised changes to air flow and the generation of turbulent flow. Turbulent air flow associated with large structures has the potential to impact soils and landforms through localised irregular patterns of increased erosion and deposition. Should alterations to airflow occur these are likely to be restricted to the BLNG Precinct and it is considered unlikely that changes would affect soils and geomorphology within the James Price Point coastal area. While some changes in local patterns of soil erosion and deposition are possible this is likely to be restricted to the BLNG Precinct only and have negligible impact beyond the Precinct.

It is expected that potential impacts to soils and landform can be successfully mitigated by the implementation of management and mitigation measures such as barriers and hard surfacing will be required to control and manage erosion. A more detailed description of proposed mitigation measures is presented in **Section 2.1.4**. The significance of the residual environmental impact on soils from the physical presence of infrastructure is assessed to be very low, as it is likely that with the application of the proposed management measures, the impacts will be very localised and minor.

2.1.4. Management Measures

Mitigation measures and safeguards that have been identified to manage potential impacts of the BLNG Precinct and are relevant to impacts to soils and geomorphology are outlined below in **Table 2.1-2**, **Table 2.1-3** and **Table 2.1-4**.

- **Table 2.1-2 State Government Measures for Soils and Geomorphology.**

State Government measure	Lead Responsibility	Timing
Prepare and implement a closure and decommissioning strategy for the Browse LNG Precinct and related activities for the purpose of providing a timely and consistent approach to removal or retention of plant and infrastructure, rehabilitation of disturbed areas and identification of contaminated areas.	DSD through its involvement in the BLNG Precinct Control Group.	5 years prior to decommissioning of BLNG Precinct infrastructure.
Prepare an overarching Emergency Response Plan that addresses: • risk assessment of potential emergencies (including bushfires, introduction of foreign pests, flooding and spills); • emergency response equipment and training; • emergency response procedures; • responsibilities during emergency response; and • reporting, review and improvement as required.	DSD through its involvement in the BLNG Precinct Control Group, with advice from FESA.	Prior to commencement of construction of an LNG plant.

- **Table 2.1-3 Proposed Environmental Conditions for the Strategic Proposal that may affect Soils and Geomorphology.**

Condition No.	Proposed Environmental Conditions for the Strategic Proposal
T1.1	Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address: • detailed measures to be implemented for final closure; • the schedule and timing of final closure activities; • completion criteria for closure; and • closure monitoring requirements.
T1.2	Proponents of derived proposals shall implement the Final Closure Plan required by condition 1.2 until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.

Table 2.1-4 Requirements to be Addressed via Development of a Management Plan to Support a Derived Proposal Relevant to Soils and Geomorphology.

Derived Proposal Requirements	Timing
Prepare and implement a Construction Environmental Management Plan (**CEMP**) to the satisfaction of the Western Australian Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets; • environmental management; • environmental training and inductions; and • environmental monitoring, contingencies and reporting, and stakeholder consultation. *In order to address the potential impacts to soils and geomorphology identified within this Section, the CEMP may include environmental management measures such as:* • *site levelling and preparation activities staged to avoid exposing large areas of soil to wind and water erosion;* • *cut and fill excavation shaped to maintain slope stability;* • *temporary erosion control berms, drains and sediment barriers installed as necessary and maintained until final construction clean-up is completed;* • *ground stabilisation techniques established in more vulnerable cleared areas such as unstable sections of dunes and areas of excessive sheet flow;* • *runoff control measures adopted around potential onshore dredge spoil storage areas;* • *presence or absence of acid sulphate soils to be determined; and* • *dust suppression techniques adopted during construction such as water or surface stabilisation.*	Prior to commencement of associated construction activities.
Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan, to the satisfaction of the Western Australian Minister for Environment, for each activity, which addresses the following: • effective and timely management of spills; • roles and responsibilities of response personnel; • procedures for incident response; • objectives, targets and associated monitoring; and • alignment and compliance with the State Government Precinct Emergency Response Plan. *In order to address the potential impacts to soils and geomorphology identified within this Section, the Plan may include the following environmental management measures:* • *contaminated wastewater to be contained (e.g. in sumps) and treated prior to discharge to the environment;* • *a risk assessment of construction and operation activities that have the potential to result in a non-routine discharge event; and* • *hazardous wastes stored and disposed of in accordance with regulatory requirements.*	Prior to commencement of associated construction activities.
Prepare and implement a Waste Management Plan which includes the following: • measures to reduce, reuse and recycle wastes from the construction and operational BLNG Precinct activities; • arrangements for any transportation of waste streams on public roads, or marine based transportation; and • disposal or treatment options for various waste streams associated with BLNG Precinct activities.	Prior to commencement of relevant activity.
Prepare and implement a Rehabilitation Plan, to the satisfaction of the Western Australian Minister for Environment, which includes the following: • objectives, targets and associated monitoring; • rehabilitation of areas not required post-construction; • stabilisation of disturbed landforms; • use of local native species in revegetation activities; • rehabilitation techniques (such as relocation of topsoil, translocation of particular trees); and • reporting on inspections and monitoring.	Prior to commencement of associated construction activities.

2.1.5. Environmental Outcome of the BLNG Proposal

Local soils and geomorphology are likely to be affected as a result of site excavation activities and the physical presence of onshore processing facilities and service corridors. Terrestrial wastes and discharges and altered fire regimes may also affect local soils.

Impacts related to these aspects are likely to be localised, and in most cases, restricted to the direct clearing and construction footprints of the BLNG Precinct facilities and service corridors. Important considerations in assessing the potential impact to soils and geomorphology include the high erosion potential of Pindan soils, potentially large areas of clearing and excavation and the known occurrence of high intensity wet season rainfall events. Following assessment of likely impacts and consideration of potential mitigation measures the BLNG Development is likely to result in the following direct and indirect impacts to local soils and geomorphology.

Direct Impacts to Soils and Geomorphology

- Site excavation activities would result in the excavation and disposal of large volumes of Pindan soils. If appropriate runoff and erosion control structures are not established prior to excavation, increased wind and water erosion and impacts to surrounding vegetation and drainage systems would result. The establishment of soil containment and erosion control structures are proven techniques capable of managing increased soil erosion.
- The local dune system would be affected by excavation for the shore crossing and southern pipeline. While it would be possible to stabilise disturbed areas following construction, sand movement patterns to dune areas north and south of the disturbance areas would be affected.
- Site excavations would alter the local landform in areas where BLNG Precinct processing facilities are located and at the shore crossing and southern LNG pipeline corridor. Changes to the local landform at these locations have the potential to affect groundwater and surface water systems within the BLNG Precinct area. Impacts to these environmental factors are addressed in **Part 4**, **Section 2.2** (Surface Water) and **Part 4**, **Section 2.3** (Groundwater).

Indirect Impacts to Soils and Geomorphology

- Soil contamination could occur during construction and operation of the BLNG precinct. Hydrocarbons and hazardous liquid chemicals would be contained within bunded, impervious hardstand areas with drainage systems designed to capture discharges and prevent release to the surrounding environment. In the event of any uncontrolled release to the natural environment emergency response procedures would be established to contain spills and facilitate clean-up activities.
- Frequent high intensity fires occur naturally within and surrounding the James Price Point coastal area and the broader Dampier Peninsula, resulting in land degradation. The establishment of a managed fire regime is likely to reduce the frequency and intensity of fire. A managed fire regime is likely to result in the retention of some vegetative cover, potentially reducing extent of soil and water erosion in some areas.

2.1.6. Cumulative Impacts of the Proposal and Associated Activities and Projects

Many of the Category B and C activities would impact soils and landforms, however, these impacts would be confined to the immediate vicinity of the proposed activity. In addition, standard construction and operational mitigation measures such as site drainage and runoff control would be implemented. Given that these impacts are local and would be controlled, it is unlikely that they would combine to produce cumulative effects when considered with Category A activities.

2.1.6.1. Category B Impacts

The following potential Category B activities may result in impacts to local soils and landforms:

- site excavations and construction of additional housing and associated infrastructure in Broome;
- site excavations and construction for industrial areas in or near Broome;
- site excavations and construction of a solid waste facility in Broome;
- site excavations and clearing for service corridors;
- site excavations and construction for any expansion or relocation of the Broome International Airport;
- site excavations and construction of gas pipelines from the BLNG Precinct to Broome; and
- site excavations and construction of quarries for breakwaters and reclamation.

Similar to impacts considered for Category A activities detailed within this section, the following aspects are particularly relevant to Category B activities.

- site disturbance and excavation; and
- terrestrial wastes and discharges.

Site disturbance and excavation would occur for each of the Category B activities identified above. The extent of excavations and earthworks will depend on the chosen construction locations and the activity proposed. While locations of Category B activities are yet to be determined it is expected that larger scale excavations would be required for the potential construction of quarries and gas pipelines, while the future establishment of housing and industrial areas would most likely involve more minor excavation works.

As discussed for Category A activities, disturbance of the Pindan sands during construction could make these soils susceptible to erosion by both wind and water, particularly during high intensity wet season rainfall events. Erosion can cause loss of topsoil, land degradation and siltation and the deterioration of drainage lines. Erosion and sedimentation of local drainage lines is likely to occur naturally during high intensity rainfall events, however, clearing and the excavation of Pindan sands during earthworks has the potential to exacerbate the impact.

Compaction required for the construction of permanent transport corridors, industrial areas, housing and future relocation or expansion of the Broome airport has the potential to change local soil profiles. Road construction will also require the movement and storage of large volumes of soil. The impacts of soil movement and storage activities are likely to be similar to those described for earthworks above.

Terrestrial wastes and discharges during construction have the potential to result in localised soil contamination. Construction activities associated with Category B activities are likely to require the storage of hydrocarbons such as fuels and lubricants. The local Pindan sands are transmissive and would convey contamination arising from spills of hydrocarbons, wastes and hazardous chemicals, therefore appropriate storage and transport systems would need to be established.

The design, construction and management of a future solid waste facility will need to consider impacts associated with soil contamination.

2.1.6.2. Category C Impacts

The construction of a future supply base within the Broome area (if required) to support the Browse upstream development would result in future impacts to soils within the vicinity of the chosen construction location. Similar to Category A impacts described within this section the construction of a future supply base may result in the following potential impacts:

- Soil erosion and sedimentation during construction; and
- Localised soil contamination as a result of hydrocarbon and chemical spills during construction and operation.

While the need or location is not currently defined, it is anticipated that impacts could be managed through the implementation of standard mitigation measures and procedures during construction and operation.

- **Table 2.1-5 Impact Assessment Summary for Soils and Geomorphology.**

Environmental Aspect (Stressor)	Potential Impacts	Mitigation Measures			Significance of Residual Impact
		State Government Measures	Proposed Environmental Conditions	Future Proponent Management Plans	
Site Disturbance and Excavation (construction)	Generation of ASS Construction activities along the coastal dune system have the potential to affect sand movements patterns and dune stability Increased erosion and deposition of exposed soils Construction activities along the coastal dune system have the potential to affect sand movement patterns and dune stability	Prepare and implement a closure and decommissioning strategy for the Browse LNG Precinct and related activities for the purpose of providing a timely and consistent approach to removal or retention of plant and infrastructure, rehabilitation of disturbed areas and identification of contaminated areas. Prepare an overarching Emergency Response Plan that addresses: • risk assessment of potential emergencies (including bushfires, introduction of foreign pests, flooding and spills); • emergency response equipment and training; • emergency response procedures; • responsibilities during emergency response; and • reporting, review and improvement as required.	Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address: • detailed measures to be implemented for final closure; • the schedule and timing of final closure activities; and • completion criteria for closure • closure monitoring requirements. Proponents of derived proposals shall implement the Final Closure Plan until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.	Prepare and implement a CEMP to the satisfaction of the Western Australian Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets; • environmental management; • environmental training and inductions; and • environmental monitoring, contingencies and reporting, and stakeholder consultation. In order to address the potential impacts to soils and geomorphology, the CEMP would include environmental management measures such as: • site levelling and preparation activities staged to avoid exposing large areas of soil to wind and water erosion; • cut and fill excavation shaped to maintain slope stability; • temporary erosion control berms, drains and sediment barriers installed as necessary and maintained until final construction clean-up is completed; • ground stabilisation techniques established in more vulnerable cleared areas such as	Low

Environmental Aspect (Stressor)	Potential Impacts	Mitigation Measures			Significance of Residual Impact
		State Government Measures	**Proposed Environmental Conditions**	**Future Proponent Management Plans**	
Altered Fire Regimes	The frequent and high intensity fires which occur within the James Price Point coastal area are likely to lead to the exposure of large areas of Pindan sand plains to the effects of both wind and water erosion.			unstable sections of dunes and areas of excessive sheet flow; • runoff control measures adopted around potential onshore dredge spoil storage areas; and • dust suppression techniques adopted during construction such as water or surface stabilisation. Prepare and implement a Rehabilitation Plan, to the satisfaction of the Minister for Environment, which includes the following: • objectives, targets and associated monitoring; • rehabilitation of areas not required post-construction; • stabilisation of disturbed landforms; • use of local native species in revegetation activities; • rehabilitation techniques (such as relocation of topsoil, translocation of particular trees); and • reporting on inspections and monitoring. Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan, to the satisfaction of the Minister for Environment, for each activity, which addresses the following: • effective and timely management of spills; • roles and responsibilities of response personnel; • procedures for incident response; • objectives, targets and associated monitoring; and • alignment and compliance with the State Government Precinct Emergency Response	Very Low
Physical Presence	Installation of large scale infrastructure would have the potential to affect wind flow, resulting in localised changes to air flow and the generation of turbulent flow				Low
Terrestrial Discharges, Including Non-routine Discharges	Non-routine discharges or inappropriate storage and disposal of hydrocarbons, solid wastes and hazardous wastes, have the potential to result in the contamination of local soils.				Low

<table>
<tr><th rowspan="2">Environmental Aspect (Stressor)</th><th rowspan="2">Potential Impacts</th><th colspan="3">Mitigation Measures</th><th rowspan="2">Significance of Residual Impact</th></tr>
<tr><th>State Government Measures</th><th>Proposed Environmental Conditions</th><th>Future Proponent Management Plans</th></tr>
<tr><td></td><td></td><td></td><td></td><td>Plan.

In order to address the potential impacts to soils and geomorphology, the Plan may include the following environmental management measures:
• contaminated wastewater to be contained (e.g. in sumps) and treated prior to discharge to the environment;
• a risk assessment of construction and operation activities that have the potential to result in a non-routine discharge event; and
• hazardous wastes stored and disposed of in accordance with regulatory requirements.

Prepare and implement a Waste Management Plan which includes the following:
• measures to reduce, reuse and recycle wastes from the construction and operational BLNG Precinct activities;
• arrangements for any transportation of waste streams on public roads, or marine based transportation; and
• disposal or treatment options for various waste streams associated with BLNG Precinct activities.</td><td></td></tr>
</table>

2.2. Relevant Factor: Surface Water

This section describes the predicted impacts on surface water resulting from activities, facilities and other components to be implemented under the Plan for the BLNG Precinct and the potential for cumulative impacts from activities that may indirectly arise as a result of Precinct development (Category B) and other related resource activities in the region (Category C). The section also sets out the controls to be implemented to mitigate these impacts.

The assessment also considers the possible occurrence of vegetation communities in the James Price Point area which appear to be maintained by both surface water and groundwater inflow. This is discussed in detail in SAR **Part 4**, **Section 2.4** (Terrestrial Flora and Vegetation).

2.2.1. Current Knowledge

The following sections present the current knowledge of surface water within the James Price Point coastal area. Reflecting the significance of this factor, key surface water features relating to the BLNG Precinct have been inferred from desktop reviews of available regional and local information sources. Baseline site-specific hydrological investigations are planned to inform detailed design. Further discussion on surface water and hydrology on the Dampier Peninsula and the James Price Point coastal area is provided in **Part 4**, **Section 1** (Environmental Overview).

The Department of Water is currently developing a regional water plan which includes consideration of an LNG facility in the Kimberley, as part of a framework for water management in the Kimberley region. The Kimberley Regional Water Plan will identify a 10 year strategy to meet the commitment made by the Department of Water to address water management issues and enhance water resource management in the area.

2.2.1.1. Key Statutory Requirements, Environmental Policy and Guidance

There are a number of key statutory requirements, environmental policy and guidance that apply to the Strategic Assessment in relation to surface water protection.

State Guidance and Policy

The relevant EPA objectives for surface water are:

- *to maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected; and*
- *to ensure that emissions do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.*

The following State guidelines and regulatory frameworks are applicable to surface water management associated with the James Price Point coastal area:

- Pollution control provisions of Part V of the *Environmental Protection Act 1986.*
- Stormwater Management Manual for WA, February 2004 (DoW, 2004).
- Main Roads WA, Design Standards and Guidelines, 2009.
- Guidelines for Design and Construction of Stormwater Drainage Systems, September 2009 (Shire of Broome, Engineering Services Department, 2009).
- Environmental Protection (Unauthorised Discharges) Regulations 2004.
- Environmental Protection (Controlled Waste) Regulations 2001.
- *Contaminated Sites Act 2003* and associated Contaminated Sites Regulations 2006.

At a Commonwealth level, the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000) are applicable to this factor.

2.2.1.2. Description of Factor

Surface water flows, both within the potential BLNG Precinct site and in the general James Price Point coastal area are described in **Part 4**, **Section 1**. Relevant key findings include:

- The BLNG Precinct is situated on a low lying drainage area.
- Rivers generally flow from east to west, with discharges either direct to the ocean north of James Price Point, or to natural drainage basins to the south of James Price Point (Rockwater, 2009; **Appendix C-22**).
- No permanent surface water features are located within the James Price Point coastal area, however, several minor catchments and ephemeral drainage channels are present. Of the three sub-catchments located within the BLNG Precinct area:
    - One small sub-catchment (5.3km^2) discharges directly to the coast north of James Price Point.
    - One sub-catchment has an existing defined channel of 10.2km in length flowing east to west through the centre of the BLNG Precinct, and discharging immediately east of the dune sands in the vicinity of monsoon vine thicket vegetation. The majority of the lower part of this catchment lies within the BLNG Precinct boundary.
    - The southern half of the BLNG Precinct overlies a large portion of the downstream part of the third sub-catchment, and has a main channel flowing adjacent to the southern boundary of the BLNG Precinct. This channel discharges immediately east of the coastal dunes in the vicinity of monsoon vine thicket vegetation.
- The monsoon vine thicket TEC in the James Price Point area appears to be maintained by both surface water and groundwater inflow (Ray Froend, 2010, pers. comm. Edith Cowan University, 25 June 2010). The surface water input pathways are directly through run-on into the area during the wet season, and indirectly via recharge of the local superficial aquifer.

2.2.2. Identification of Key Aspects

2.2.2.1. Definition of Relevant Aspects

Aspects associated with the development and operation of the BLNG Precinct and associated infrastructure that may have an environmental impact on surface water were identified in the Scope of the Strategic Assessment and considered in this assessment. These aspects include:

- terrestrial wastes and discharges;
- site disturbance and excavation; and
- physical presence of infrastructure.

2.2.2.2. Sources of Potential Impact

Terrestrial Wastes and Discharges

Routine (planned) wastes and discharges from the construction, commissioning and operation of the BLNG Precinct are not considered to pose a significant impact on the surface water environment. It is only unplanned (non-routine) wastes and discharges that are considered of concern due to their potential to contaminate surface water. Sources of unplanned terrestrial wastes and discharges during the construction, commissioning and operational phases are summarised as follows:

- wastewater treatment;
- desalination;
- cooling, process, product water and hydrotest (commissioning only) water;
- stormwater;
- hydrocarbon fuels, oils and chemical leaks/spills;
- domestic, hazardous and green wastes; and
- any wastes treated at the BLNG Precinct which are associated with shipping or support vessels.

Site Disturbance and Excavation

Site disturbance and/or excavations activities required for the construction and operation of the Precinct which have the potential to change hydrological regimes include:

- earthworks (site levelling);
- foundation construction;
- road construction; and
- pipeline construction (shore crossing and onshore).

Physical Presence

The physical presence of the BLNG Precinct and associated infrastructure will alter the characteristics of the catchments within the BLNG Precinct. The source of potential impacts associated with the physical presence of the BLNG Precinct and associated infrastructure include:

- hardstand areas, roads and buildings;
- modified topography; and
- drainage systems.

2.2.2.3. Sensitivity and Resilience

Little is known regarding the surface hydrology of the area within and adjacent to the BLNG Precinct. Although rainfall data is available from neighbouring meteorological stations, no flow data exists for the ephemeral streams within the identified sub catchments. Predicted peak flows within these catchments are therefore the best estimate of ephemeral flows that may be impacted by the construction, commissioning and operation of the Precinct. Consequently, the sensitivity of the surface water hydrology to the BLNG Precinct is unknown, but likely to be high taking into account the existing hydrological processes towards the coastal zone.

2.2.3. Predicted Impacts

Potential impacts on surface water from the construction and operation of the BLNG Precinct are discussed below and summarised in **Table 2.2-4**. Both direct and indirect impacts are considered within these sections. For the purpose of this assessment it is considered that direct impacts would largely be confined to areas of direct disturbance within the BLNG Precinct, and other locations where development activities are proposed to occur.

Detailed hydrological investigations and modelling will be undertaken as engineering details for specific facilities within the LNG Precinct are progressed at the design phase to confirm the magnitude, frequency and duration of the potential impacts assessed at this Strategic Assessment stage.

2.2.3.1. Potential Impacts to Surface Water Quality due to Terrestrial Wastes and Discharges

All waste water produced by the construction, commissioning and operation of the BLNG Precinct are anticipated to be treated prior to discharge to the marine environment and consequently are unlikely to impact surface water (non-marine). Onsite stormwater and drainage infrastructure will be designed taking into account potential pollution, erosion, sediment transport and increased runoff. Therefore, planned discharges are unlikely to result in contamination of surface water

Unplanned discharges from stormwater drainage, hydrocarbon/chemical storage and waste sites are considered to potentially impact the surface water quality. The construction and operation of the BLNG Precinct has the potential to result in unplanned discharges such as spills and leaks from the:

- wastewater treatment plant;
- stormwater system (contaminated run off);
- hydrocarbon fuels, oils and chemical storage; and
- domestic, hazardous and green wastes.

Any accidental spills of hydrocarbons and other chemicals on site may be intercepted by the stormwater drainage system and therefore a potential for these discharges to be contaminated is present. Examples of such discharges include:

- general contamination of runoff from hardstand surfaces such as roads and car parks; and/or
- specific contamination of runoff as a result of unplanned site operations.

Given the absence of permanent surface water features within and surrounding the BLNG Precinct it is unlikely that unplanned discharges would be transported to the marine environment or drainage basins, except during high intensity rainfall events when surface water flows may occur. Discharges to the marine environment have been addressed in **Part 3**, **Section 2.3** (Marine Water Quality).

Should contaminants reach local surface water flows this runoff is most likely to result in contamination of the underlying groundwater, as the surface water runoff is likely to ultimately reach the underlying water table. Prevention of groundwater contamination will consequently be highly dependent on the ability to limit and manage surface water contamination. The impact of groundwater contamination has been addressed in detail in **Part 4**, **Section 2.3**.

Although no permanent surface water features are located within the James Price Point coastal area, several minor catchments and ephemeral drainage channels are present. The construction and operation of the BLNG Precinct may impact on surface waters by contamination of surface water runoff associated with routine (controlled) wastes and discharges and non-routine (unplanned events) discharges. It is likely that surface water management would direct runoff from process areas and areas of potential contamination sources for appropriate storage and treatment. It is expected that stormwater and hydrocarbon handling and spill procedures would prevent significant impacts to local surface water systems.

It is expected that contamination of surface water due to terrestrial wastes and discharges will be managed through the implementation of appropriate prevention and response controls, including the storage of chemicals and hydrocarbons in bunded areas, contaminated surface water run-off capture and treatment prior to discharge to the environment, and the implementation of the actions specified in an Emergency Response Plan. A more detailed description of proposed mitigation measures is presented in **Section 2.2.4**. The significance of residual impacts associated with terrestrial wastes and discharges is assessed to be low because the majority of the impacts will be minimised or avoided through the management measures proposed and only minor changes to local water resources are likely to occur, resulting in local short term and small reduction in water quality with no exceedence of applicable ANZECC water quality guidelines.

2.2.3.2. Potential Impacts to Surface Water Quality due to Site Disturbance and Excavation

Terrestrial site disturbance and excavation associated with the BLNG Precinct is likely to be associated with temporary and/or permanent alterations to catchment characteristics. Such potential impacts include:

- alteration of erosion/deposition characteristics stream by diversions required for construction activities;
- alteration of minor drainage channels; and
- unplanned sediment discharge from excavation/site clearance areas.

Increased erosion and sedimentation caused by construction activities may lead to geomorphologic changes, in addition to the potential for pollution as a result of increased turbidity and transport of pollutants trapped within sediments, such as heavy metals.

Land development and construction sites are a potential major source of stormwater pollution, including litter, hydrocarbons, sediment and harmful pollutants absorbed to sediment particles (for example heavy metals, nutrients and pesticides).

Site preparation will require diversion of some of the ephemeral drainage channels and also has the potential to result in increased erosion and sediment deposition following high intensity rainfall events. As a result the deposition/erosion characteristics of the existing catchments with the BLNG Precinct are likely to be permanently altered and would include changes in surface water flows within some catchments.

Changes in catchment flows and patterns of erosion and deposition due to site disturbance and excavation will be managed through the implementation of appropriate stormwater controls, such as the construction of stormwater control

and management structures to capture runoff and sediment (e.g. rock armouring, use of settlement ponds), and maintaining natural surface water flows where possible. A more detailed description of proposed mitigation measures is presented in **Section 2.2.4**. The significance of residual impacts associated with site disturbance and excavation are assessed to be low because the majority of the impacts would be minimised or avoided through the proposed management measures, and the design of infrastructure to manage surface water flows. Any impacts will be localised and only a minor change in sub-catchment surface water hydrology and flow regimes within the BLNG Precinct is expected.

2.2.3.3. Potential Impacts to Surface Water Quality due to the Physical Presence of Facilities and Infrastructure

The construction and operation of the BLNG Precinct will cause changes to the existing catchment hydrology through a combination of the obstruction, removal and diversion of existing watercourses.

The potential impacts associated with these activities include:

- changes in discharge of existing catchments caused by the stormwater drainage system;
- reduced recharge/baseflow due to the presence of impervious surfaces;
- ponding of surface water run off;
- flooding from existing natural surface water runoff and increased runoff within the BLNG Precinct; and
- permanent alterations to erosion/deposition characteristics of existing surface water catchments.

Surface water runoff (i.e. discharges from existing catchments) would be maintained to the coastal dunes and drainage basin following Precinct construction although flows will be managed to reduce flood risk within the BLNG Precinct. This may mean that runoff to the dune system could be increased or reduced in some circumstances. It is also possible that discharge to the ocean will be required under extreme rainfall events, however, this will be determined as BLNG Precinct design continues. By maintaining surface water flows to the dunes and drainage basin community, as far as practicable, it is unlikely that alterations to the current drainage systems would significantly impact the vegetation composition of this area.

A recent hydrology study (BG&E, 2010b; **Appendix C-24**) assumed an average annual rainfall of 929mm for predicted peak flows for catchments associated with the BLNG Precinct. Assuming that the calculations for storm water run off generation are directly proportional to average annual rainfall, process areas within the BLNG Precinct are likely to produce 2.8GL per year for a 15Mtpa development and 9.7GL per year for a 50Mtpa development. It should be noted however, that storm water run off estimates are highly variable, especially given the rainfall characteristics of northern WA. Any use of these estimates should therefore assume a large element of uncertainty and also anticipate possible increases in annual rainfall.

Any construction of impervious surfaces has the potential to impact infiltration to the soil and consequently baseflow (groundwater contribution to streams) to surface water streams. If infiltration rates are not maintained, then this may have a long term impact on stream flows. However, the streams within the immediate vicinity of the BLNG Precinct are ephemeral and consequently not likely to be reliant on baseflow.

Impervious surfaces constructed for the BLNG Precinct and its associated infrastructure will also potentially lead to ponding of surface water in some areas and shadowing of natural flow paths. The presence of standing water, either in existing wetlands or artificially created water bodies associated with the BLNG Precinct development, may provide an environment for mosquitoes to breed. A high level of mosquito numbers in proximity to human habitation is a significant health risk in addition to impacting on amenity (EPA, 2000b). This issue is discussed further in **Part 5**, **Section 4.9**.

The deposition/erosion characteristics of the existing catchments are likely to be permanently altered by the presence of the BLNG Precinct. The storm water drainage system has the potential for increased erosion, increased flooding behind bunded structures and changing the hydrological regime of potential surface water dependent areas between the Precinct infrastructure and the dune. There is also potential for the artificial creation of new habitats through the introduction of permanent surface water features, such as sediment traps and drainage retention basins.

Changes in catchment flows and patterns of erosion and deposition due to the physical presence of the BLNG Precinct will be managed through the implementation of appropriate stormwater controls, such as the construction of stormwater

control and management structures to maintain natural surface water flows and volumes where possible. A more detailed description of proposed mitigation measures is presented in **Section 2.2.4**. The significance of residual impacts associated with the physical presence of the BLNG Precinct is assessed to be low because the majority of the impacts will be minimised or avoided through the management measures proposed, and the design of infrastructure to manage surface water flows. Any impacts will be localised and only a minor change in sub-catchment surface water hydrology and flow regimes is expected.

2.2.4. Management Measures

Mitigation measures and safeguards that have been identified to manage potential impacts to surface water are outlined below in **Table 2.2-1**, **Table 2.2-2** and **Table 2.2-3**.

- **Table 2.2-1 State Government Measures for Surface Water.**

State Government Measure	Responsibility	Timing
Prepare an overarching Emergency Response Plan that addresses: • risk assessment of potential emergencies (including bushfires, introduction of foreign pests, flooding and spills); • emergency response equipment and training; • emergency response procedures; • responsibilities during emergency response; and • reporting, review and improvement as required.	DSD through its involvement in the BLNG Precinct Control Group, with advice from FESA.	Prior to commencement of construction of an LNG plant.
Develop and implement a Management and Monitoring Strategy for Vegetation of Medium to High Conservation Significance, with particular reference to remnant monsoon vine thicket and drainage basin vegetation. The Strategy will inform all future proponents of derived proposals of requirements for detailed management plans specific to individual activities and will include a framework in which the following Plans will be implemented: • Fire Management Plan; • Terrestrial Fauna Management Plan; • Terrestrial Weed Management Plan; and • Appropriate management of hydrology (both surface water and groundwater). The effectiveness of the Strategy is to be measured via condition and health monitoring for a defined area within and surrounding the BLNG Precinct area and associated buffer zones. Annual reporting on success of the program is to be made publicly available.	DSD through its involvement in the BLNG Precinct Control Group, with advice from DEC.	Prior to construction.

- **Table 2.2-2 Proposed Environmental Conditions for the Strategic Proposal Potentially Affecting Surface Water.**

Condition No.	Proposed Environmental Conditions for the Strategic Proposal
T2.1	Prior to the commencement of construction activities, proponents of derived proposals shall prepare and implement an Ecological Surface Water Requirements Management Plan, to the satisfaction of the Minister for Environment on advice from DEC, which shall address the following: • Drainage measures to manage surface water flows and minimise environmental impacts as far as practicable on monsoon vine thicket and drainage basin vegetation communities within the affected catchments. • A vegetation composition, health and condition monitoring program for areas of vegetation determined likely to be dependent on surface water flows, including the superficial aquifer, for seasonal water requirements. • Process to be implemented if monitoring indicates declining vegetation condition or changing composition as a result of changes in surface water flows.
T1.2	Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address: • detailed measures to be implemented for final closure; • the schedule and timing of final closure activities; • completion criteria for closure; and • closure monitoring requirements.
T1.3	Proponents of derived proposals shall implement the Final Closure Plan required by condition 1.2 until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.

- **Table 2.2-3 Requirements to be Addressed via Development of a Management Plan to Support a Derived Proposal Potentially Affecting Surface Water.**

Derived Proposal Requirements	Timing
Prepare a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets; • environmental management; • environmental training and inductions; and • environmental monitoring, contingencies and reporting, and stakeholder consultation. *In order to address the potential impacts to surface water identified within this Section, the Plan may include environmental management measures such as the following:* • *Water quality control for management of potential water quality impacts resulting from construction or operational activities.* • *Bunding or other means of containment (such as impervious berms) of hydrocarbon and chemical storages and areas likely to present a contamination hazard.* • *Techniques to be used for management of sediment loads and erosion such as revegetation, sediment basins, erosion berms and maintenance programs.* • *Collection and treatment of first flush water from paved process areas.* • *Discharge of surface water collected from potential contamination areas to minimise surface water quality impacts.* • *Minimise the amount of constructed impervious areas as far as practicable (with reference to DoW stormwater manual 2004).*	Prior to commencement of associated construction activities
Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan for construction and operation activities. See **Part 4**, **Section 2.1**.	Prior to commencement of associated construction activities

2.2.5. Environmental Outcome

After management and mitigation measures have been applied, it is expected that the BLNG Precinct will result in the following outcomes in relation to surface water:

2.2.5.1. Direct Impacts

- Decreased peak flows from catchments CA3, CA4 and CA5 (see **Part 4**, **Figure 1-8**) as a result of the alteration to catchment characteristics.
- Changes in surface water flows as a result of the physical presence of the BLNG and excavations and removal of part of the dune system during BLNG shore crossing and pipeline shore crossing works. These impacts will be managed through the implementation of the Ecological Surface Water Requirements Management Plan.
- The requirement to maintain surface water flows as far as is practicable to identified high risk areas of conservation significant vegetation (monsoon vine thicket and drainage basin) will minimise the impacts of an altered surface water regime on these potentially water dependent vegetation types.
- The deposition/erosion characteristics of the existing catchments are likely to be permanently altered by the presence of the BLNG Precinct.
- The construction and operation of the BLNG Precinct has the potential to result in unplanned spills or leaks of hydrocarbons or other chemicals which have the potential to cause contamination to surface water. Design of facilities and infrastructure within the BLNG Precinct will incorporate standard industry practices and conform to regulations. All LNG processing facilities will be required to have Works Approvals under Part V of the EP Act, which will ensure that the appropriate standards are being met. Proponents of derived proposals will also be required to provide a Hydrocarbon and Chemical Spill Contingency Plan as part of their derived proposal application that will detail the measures used to reduce the risk of leaks and spills, and the response procedures should they occur.

2.2.5.2. Indirect Impacts

The requirement for proponents of derived proposals to prepare an Ecological Surface Water Requirements Management Plan and Construction Environmental Management Plan as part of their derived proposal application will ensure controls are in place to minimise the risks to surface water flows.

Assuming all relevant environmental policies, regulations and guidelines are adhered to, and control measures implemented as proposed, the environmental impact of surface water from Category A activities is expected to be low.

2.2.6. Cumulative Impacts of the Proposal and Associated Activities

The impacts of the BLNG Precinct on surface water are also to be considered in context of additional impacts from indirectly facilitated or related projects in the region, and their cumulative impacts.

2.2.6.1. Category B Impacts

Potential Category B activities that may affect surface water include:

- additional housing and associated infrastructure in Broome;
- additional industrial areas in or near Broome;
- establishment of a new solid waste facility in Broome;
- establishment of service corridors;
- expansion or relocation of the Broome International Airport;
- establishment of offsite quarries for breakwaters and reclamation; and
- disturbance and affects associated with increased recreational use of the Dampier Peninsula due to improved access.

Similar to impacts considered for Category A activities, the following impacts to surface water systems may occur as a result of Category B activities:

- contamination of surface water, as a result of terrestrial wastes and discharges;
- changes to existing hydrological regimes, as a result of physical presence of the Category B facilities; and
- alteration of catchment flows, as a result of site disturbance and changes to landforms.

The extent of impacts will be somewhat dependent on the proximity of Category B activities to local watercourses and drainage systems. While locations of Category B facilities are to be confirmed, appropriate siting of facilities and the establishment of site drainage and runoff systems during construction and as part of ongoing surface water management is expected to manage impacts. In addition the adoption of appropriate hydrocarbon and chemical handling procedures is also likely to prevent contamination of local watercourses.

The potential for surface water runoff from new residential or industrial land in or near Broome to affect Roebuck Bay (approximately 60–70km south of James Price Point), a Ramsar site, is addressed in **Part 6**, **Section 2** (Matters of National Environmental Significance).

2.2.6.2. Category C Impacts

The Main Access Road from Cape Leveque Road to the BLNG Precinct will be formally assessed by both State and Commonwealth separately from the Strategic Assessment. There is potential for changes in hydrological regimes or alteration of catchment flows to result from additional linear infrastructure for the road corridor. The proponent for this new development will be expected to undertake studies to inform the assessment and management of surface water hydrological impacts from the proposed road, and to ensure impacts are acceptable.

The construction and operation of supply base to service the Browse upstream development has the potential to impact surface water flows and runoff surrounding a chosen supply base site. Construction and operation of a supply base is likely to result in some alterations to natural drainage flows. Site selection and appropriate runoff management during construction and operation is expected to manage impacts.

Table 2.2-4 Impact Assessment Summary for Surface Water.

Environmental Aspect (Stressor)	Potential Impacts	Mitigation Measures			Significance of Residual Impact
		State Government Measures	**Proposed Environmental Conditions**	**Future Proponent Management Plans**	
Terrestrial discharges, including non-routine discharges	The construction and operation of the BLNG Precinct may impact on surface waters by contamination of surface water runoff associated with routine (controlled) wastes and discharges and non-routine (unplanned events) discharges.	Develop and implement a Management and Monitoring Strategy for Vegetation of Medium to High Conservation Significance, with particular reference to remnant monsoon vine thicket and drainage basin vegetation. The Strategy will inform all proponents of derived proposals of requirements for detailed management plans specific to individual activities and will include a framework in which the following Plans will be implemented: • Fire Management Plan; • Terrestrial Fauna Management Plan; • Terrestrial Weed Management Plan; and • Appropriate management of hydrology (both surface water and groundwater). The effectiveness of the Strategy is to be measured via condition and health monitoring for a defined area within and surrounding the BLNG Precinct area and associated buffer zones. Annual reporting on success of the program is to be made publicly available. Prepare an overarching Emergency Response Plan that addresses: • risk assessment of potential emergencies (including bushfires, introduction of	Prior to the commencement of construction activities, the proponents of derived proposals shall prepare and implement an Ecological Surface Water Requirements Management Plan, to the satisfaction of the Minister for Environment on advice from DEC, which shall address the following: • Drainage measures to manage surface water flows and minimise environmental impacts as far as practicable on monsoon vine thicket and drainage basin vegetation communities within the affected catchments. • A vegetation composition, health and condition monitoring program for areas of vegetation determined likely to be dependent on surface water flows, including the superficial aquifer, for seasonal water requirements. • Process to be implemented if monitoring indicates declining vegetation condition or changing composition as a result of changes in surface water flows. Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the	Prepare a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets; • environmental management; • environmental training and inductions; and • environmental monitoring, contingencies and reporting, and stakeholder consultation. In order to address the potential impacts to surface water identified within this section, the Plan may include environmental management measures such as the following: • Water quality control for management of potential water quality impacts resulting from construction or operational activities. • Bunding or other means of containment (such as impervious berms) of hydrocarbon and chemical storages and areas likely to present a contamination hazard. • Techniques to be used for management of sediment loads and erosion such as revegetation,	Very low
Site disturbance/ excavation (Construction)	Disturbance and/or modification of natural drainage systems				Low
Physical presence	Disturbance and/or modification of natural drainage systems				Low

<table>
<tr><th rowspan="2">Environmental Aspect (Stressor)</th><th rowspan="2">Potential Impacts</th><th colspan="3">Mitigation Measures</th><th rowspan="2">Significance of Residual Impact</th></tr>
<tr><th>State Government Measures</th><th>Proposed Environmental Conditions</th><th>Future Proponent Management Plans</th></tr>
<tr><td></td><td></td><td>foreign pests, flooding and spills);
• emergency response equipment and training;
• emergency response procedures;
• responsibilities during emergency response
• reporting, review; and improvement as required.</td><td>Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address:
• detailed measures to be implemented for final closure;
• the schedule and timing of final closure activities;
• completion criteria for closure; and
• closure monitoring requirements.

Proponents of derived proposals shall implement the Final Closure Plan until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the Proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.</td><td>sediment basins, erosion berms and maintenance programs.
• Collection and treatment of first flush water from paved process areas.
• Discharge of surface water collected from potential contamination areas to minimise surface water quality impacts.
• Minimise the amount of constructed impervious areas as far as practicable (with reference to DoW stormwater manual 2004).

Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan for construction and operation activities.</td><td></td></tr>
</table>

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2.3. Relevant Factor: Groundwater

The following section describes the predicted impacts on groundwater from activities, facilities and other components to be approved under the Plan for the BLNG Precinct (Category A) and the potential for cumulative impacts from activities that may indirectly arise as a result of the BLNG Precinct development (Category B) and other related resource activities in the region (Category C). The section also sets out the controls to be implemented to mitigate the impacts.

2.3.1. Current Knowledge

The following sub-sections describe regulatory expectations with respect to groundwater, and provide a summary of key site features relevant to potential impacts.

2.3.1.1. Key Statutory Requirements, Environmental Policy and Guidance

There are a number of key statutory requirements, environmental policy and guidance that apply to the Strategic Assessment in relation to groundwater protection.

State Guidance and Policy

The relevant EPA objectives for groundwater are:

- *to maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected; and*
- *to ensure that emissions do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.*

The following guidelines and regulatory frameworks are applicable to groundwater:

- Licensing requirements of the WA *Rights in Water Irrigation Act 1914* (**RIWI Act**).
- Pollution control provisions of Part V of the *EP Act 1986.*
- Water and Rivers Commission. Statewide 19 Operational Policy No. 5.12: Hydrogeological reporting associated with a groundwater licence application.
- Department of Water. Operational Policy 5.08: Use of operating strategies in the water licensing process.
- Water and Rivers Commission. Statewide Policy No. 16: Policy on water conservation/efficiency plans: achieving water use efficiency gains through water licensing.
- Water and Rivers Commission. Environmental Water Provisions Policy for WA: Statewide Policy No. 5.
- Environmental Protection (Unauthorised Discharges) Regulations 2004.
- Environmental Protection (Controlled Waste) Regulations 2001.
- *Water Services Licensing Act 1995.*
- *Contaminated Sites Act 2003* and associated Contaminated Sites Regulations 2006.

At a Commonwealth level, the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) are applicable to this factor.

2.3.1.2. Description of Factor

Groundwater flows, both within the potential BLNG Precinct site and in the general James Price Point coastal area are described in **Part 4**, **Section 1**. Relevant key findings include:

- Shallow perched aquifers may occur within quaternary Sand Plain deposits, which directly underlie the BLNG Precinct (e.g. Pindan sands) and the Beach Dune Complex which is found along the coast.
- Possible occurrence of vegetation communities in the James Price Point area which appear to be maintained by both surface water and groundwater inflow.

- Aquifer systems which are potential water supply sources and/or potentially affected by development of the BLNG Precinct include the Quaternary Superficial aquifer(s), Broome Sandstone aquifer, Wallal aquifer and possibly the Grant Group (including the Poole Sandstone).

2.3.2. Identification of Key Aspects

2.3.2.1. Definition of Relevant Aspects

Aspects associated with the development and operation of the BLNG Precinct and associated infrastructure that may have an environmental impact on groundwater were identified in the Scope of the Strategic Assessment and considered in this assessment. These aspects include:

- terrestrial wastes and discharges;
- physical presence;
- site disturbance and excavation; and
- groundwater abstraction.

2.3.2.2. Sources of Potential Impact

Terrestrial Wastes and Discharges

Activities from routine (planned) management of the construction, commissioning and operation of the BLNG Precinct are not considered to pose a significant impact on the groundwater environment. It is only unplanned (non-routine) wastes and discharges that are considered of concern as they can cause contamination of groundwater. The source of the potential impacts associated with unplanned terrestrial wastes and discharges during the construction, commissioning and operational phases and are summarised as follows:

- wastewater treatment;
- desalination;
- cooling, process, product and hydrotest (commissioning only) water;
- stormwater;
- hydrocarbon fuels, oils and chemical storage/spills;
- domestic, hazardous and green wastes; and
- any wastes treated on the BLNG Precinct which are associated with shipping or support vessels.

All waters produced by the construction, commissioning and operation of the BLNG Precinct will be treated as necessary prior to discharge to the marine environment and consequently are unlikely to impact groundwater. Unplanned discharges from stormwater drainage, hydrocarbon/chemical storage and waste sites are considered to potentially impact groundwater quality.

Physical Presence

The source of potential impacts associated with the physical presence of the BLNG Precinct and associated infrastructure are summarised as follows:

- hard stand areas, roads and buildings;
- modified topography; and
- drainage systems.

The physical presence of facilities and infrastructure may result in a reduction in groundwater recharge.

Site Disturbance and Excavation

The source of potential impacts associated with any site disturbance and/or excavation required for the construction and operation of the BLNG Precinct are summarised as follows:

- earthworks (site levelling);
- temporary dewatering;
- foundation construction;
- road construction; and
- pipeline construction (shore crossing and onshore).

Terrestrial site disturbance and excavation may result in drawdown of superficial aquifers.

Groundwater Abstraction

A number of options are currently under investigation to ensure a permanent supply of water during construction and operation of the BLNG Precinct, including:

- desalination of seawater;
- desalination of water extracted from a deep aquifer abstraction of low salinity e.g. Wallal/Grant aquifer; and
- shallow aquifer abstraction of fresh water e.g. Broome Sandstone.

The options for groundwater abstraction are not yet finalised as further investigation is required to fully inform this process.

Groundwater abstraction for construction and operation of the BLNG Precinct may result in mid to long term groundwater drawdown.

2.3.2.3. Sensitivity and Resilience

There is little information regarding the local hydrogeological regime of the area within or adjacent to the BLNG Precinct, particularly in relation to the likely presence of superficial aquifers. Whilst potential changes in groundwater recharge may not have a significant impact on the regional groundwater flow regime, local variations induced by the construction and operation of the BLNG Precinct may be significant and alter the potentially delicate hydrological cycle upon which vegetation communities, such as the monsoon vine thicket and drainage basin, may depend. Consequently, the sensitivity of the groundwater regime of the Superficial and Broome Sandstone aquifers is unknown, but likely to be high.

It is known that the groundwater quality within the Broome Sandstone aquifer is sensitive to movements of the seawater/groundwater interface. Consequently, the water quality associated with the Broome Sandstone aquifer is considered to be sensitive to alterations in the hydrogeological regime.

2.3.3. Predicted Impacts

Potential impacts on groundwater from the construction and operation of the BLNG Precinct are discussed below and summarised in **Table 2.3-4**. Both direct and indirect impacts are considered within these sections. For the purpose of this assessment it is considered that direct impacts would largely be confined to areas of direct disturbance within the BLNG Precinct, and other locations where development activities are proposed to occur.

Detailed hydrogeological investigations and modelling will be undertaken at the design phase to determine the magnitude, frequency and duration of the potential impacts. These will be provided to the Department of Water as part of the necessary groundwater licensing process.

2.3.3.1. Potential Impacts to Groundwater due to Site Disturbance and Excavation

Potential impacts to groundwater occurring as a result of site disturbance and excavation are the generation of acid sulphate soils, groundwater drawdown and a subsequent decline in health of groundwater dependant vegetation (where

groundwater drawdown occurs). The impact of drawdown on groundwater dependant vegetation is discussed in detail in **Part 4**, **Section 2.4**.

Excavations may directly impact any perched aquifers within the coastal dune system leading to temporary / permanent removal of the aquifer or increase the drainage from these aquifers, potentially impacting vegetation such as monsoon vine thicket. These impacts are likely to be associated with the following activities:

- site preparation (including site clearing and levelling);
- onshore construction (foundation construction); and
- pipeline construction (shore crossing excavation and reinstatement).

Construction activities are likely to have direct and indirect impacts on groundwater and shallow aquifers, where present. Pipeline construction may directly impact any perched aquifers within the coastal dune system leading to temporary/permanent removal of the aquifer and increase the drainage of any perched aquifers if present. The shore crossing works will incorporate some reinstatement and therefore any removal of the dune system may be temporary. An appropriate assessment would be undertaken once the detailed design of the shore crossing is known. This assessment would consider localised impacts to adjacent monsoon vine thicket communities as a result of drawdown of the superficial aquifer. Construction activities on the BLNG Precinct are likely to have less direct impact on groundwater; nevertheless, indirect impacts are may occur.

Indirect impacts to groundwater quality may result from excavation below the water table in areas with potential acid sulphate soils. If PASS are dewatered and exposed to the atmosphere, the material can be oxidised which causes acidification and subsequent release of naturally occurring heavy metals. While the possible presence of ASS is considered to be low, areas of PASS would be identified during geotechnical investigations. If identified, the excavation and management of ASS material would be addressed through a CEMP and this is likely to be effective in managing potential impacts to the surrounding environment. If excavation below the water table of PASS materials is required, then proponents of derived proposals would need to demonstrate that any acid generating potential would be neutralised. This information would be provided in the Construction Environment Management Plan as part of the derived proposal process.

To reach the required surface levels and geotechnical stability, it may be necessary to import fill material for the Precinct. All material used as fill will be required to meet geotechnical criteria and qualify as 'clean fill' with no potential for contamination of groundwater. On-site materials will be utilised for fill as much as possible. The potential for use of dredge spoil as fill will be investigated but will only be used if it meets the geotechnical and 'clean fill' criteria.

Ongoing management may result in improvements to the condition of vegetation such as monsoon vine thicket as a result of fire and weed management as well as strategies aimed specifically at the long term management and improvement of communities of conservation significance.

Changes resulting from site excavation arising from PASS will be managed through the appropriate technical practices available to neutralise any acid generating potential. A more detailed description of proposed mitigation measures is presented in **Section 2.3.4**. The significance of the residual impact from contamination of the groundwater as a result of site disturbance and excavation is assessed to be very low because of the low likelihood for the presence of Potential Acid Sulphate Soils and the localised and minor nature of any changes in groundwater recharge patterns due to construction activities.

Impacts to groundwater dependant vegetation are addressed in **Part 4**, **Section 2.4**.

2.3.3.2. Potential Impacts to Groundwater due to Physical Presence of Infrastructure

The potential impacts associated with the physical presence of the BLNG Precinct, include:

- reduction in recharge to the superficial/Broome Sandstone aquifer;
- reduction in baseflow to surface water streams/basins; and
- reduction in shallow groundwater reserves.

Hard stand areas and drainage structures proposed to be constructed within the BLNG Precinct are likely to alter the distribution of recharge (rainfall which is not converted to surface water flow, evapotranspiration, or evaporation) to aquifers beneath the site. It is possible that groundwater from either the superficial aquifer and/or the Broome Sandstone aquifer provides baseflow to surface water features such as the drainage basin near the coast. If recharge is significantly reduced, groundwater levels may become lower as a result of the construction of impervious surfaces.

The Superficial aquifer is likely to comprise mainly sand and is therefore likely to have a porosity of between 25% and 40% (Driscoll, 1986). If an effective porosity (that portion of the soil/strata which is able to transmit water) of 25% is assumed, the groundwater level would increase up to 0.1m for every 25mm of recharge. Conversely, if recharge is reduced by 25mm, then it is reasonable to assume that groundwater levels may fall by up to 0.1m. These estimates are preliminary and will need to be reviewed once more information is obtained regarding the groundwater environment. Groundwater level responses to variations in recharge will be buffered by evapotranspiration and groundwater flux up gradient and down gradient of the BLNG Precinct.

Groundwater conditions within the James Price Point coastal area and the presence of groundwater dependant vegetation communities will be determined as part of future hydrological studies and modelling. While the impacts of physical presence on groundwater levels within the Broome sandstone aquifer and superficial aquifers are uncertain, a groundwater abstraction licence will be required by the Department of Water and this will need to demonstrate that impacts to groundwater as a result of abstraction and other impacts such as a reduction in recharge will not result in unacceptable environmental impacts.

The impacts on groundwater as a consequence of the physical presence of the BLNG Precinct are likely to be localised and permanent. Whilst this may not be significant in a regional context, localised reductions in recharge to the Broome and superficial aquifers may impact sensitive vegetation communities, such as monsoon vine thicket and drainage basin vegetation and/or any springs of ecological/cultural significance. Groundwater conditions within the James Price Point coastal area and the presence of groundwater dependant vegetation communities will be further investigated as part of future hydrogeological studies and modelling.

There is the potential that the physical presence of facilities and infrastructure may result in changes in water infiltration and re-charge rates. The impact of this will be managed through the implementation of appropriate management and mitigation measures such as the design and location of borefield and abstraction regimes to minimise groundwater drawdown and saltwater intrusion, and potential impacts on stygofauna, groundwater dependent ecosystems and other user; and a groundwater monitoring program designed to monitor for potential impacts on the resource (e.g. water quality and drawdown), saltwater interfaces, groundwater dependent ecosystems (if applicable) and other users (if applicable). A more detailed description of proposed mitigation measures is presented in **Section 2.3.4**, The significance of the residual impact on groundwater flows resulting from the physical presence of infrastructure associated with the BLNG Precinct is assessed to be medium because any changes in groundwater recharge patterns would be local (confined to the BLNG Precinct), although long term in nature.

2.3.3.3. Potential Impacts to Groundwater due to Terrestrial Wastes and Discharges

The construction and operation of the BLNG Precinct has the potential to result in unplanned discharges such as spills and leaks, which could cause a pollution event, the severity of which may affect groundwater quality within the local area, potentially degrade vegetation which may be reliant on groundwater, affect subterranean habitat, or potentially pose a human health risk.

During construction and operation of the LNG facilities and other supporting infrastructure, hydrocarbon and chemicals will be stored on site in tanks within designated storage areas with impervious berms or appropriate bunds for spill management. The types of chemicals and hydrocarbons for storage, including raw materials include:

- liquefied natural gas (**LNG**);
- liquefied petroleum gas (**LPG**) and mixed refrigerants;
- LNG condensate;
- hydrate inhibitors (e.g. MEG);
- corrosion inhibitors;
- oxygen scavenger;

- solvents for CO_2 removal;
- diesel fuel;
- hydraulic oils and fluids;
- water demineralisation treatment chemicals (e.g. sulphuric acid); and
- seawater and freshwater system treatment chemicals (e.g. biocides).

In addition to these chemicals the storage of dredge spoil, if necessary, may result in the discharge of saline waste water and subsequent infiltration to the superficial aquifer. This option is still subject to investigation and dredged materials would be stored within appropriately bunded areas, however some saline runoff would still be likely.

The Superficial aquifer and Broome Sandstone aquifer are the primary considerations for contamination from discharge events due to the unconfined nature and shallow watertable which is likely to underlie the BLNG Precinct. The Broome Sandstone aquifer is used for water supply purposes and both aquifers may potentially support monsoon vine thicket and drainage basin vegetation communities. Thus, contamination of these systems may be significant, depending on the severity of a discharge event. The Wallal aquifer is unlikely to be affected by potential contamination from discharge events as it occurs at depths in excess of 400m and is confined or semi-confined by the relatively low permeability Jarlemai Siltstone.

The extent and magnitude of a potential contamination plume in either the superficial aquifer or Broome Sandstone aquifer would be a function of:

- the duration of the discharge event;
- concentrations of the contaminant and the degree of dispersion; and
- diffusion, retardation and decay that the contaminant undergoes in the groundwater system.

Single, short duration and low concentration discharge events are likely to result in small (site based) plumes. Discharge events of longer duration and higher concentration may result in plumes beyond the BLNG Precinct. Such plumes would extend westwards from the BLNG Precinct in the direction of groundwater flow and would either discharge directly to surface water features, such as the drainage basin or stream beds, or gradually discharge to the marine environment.

Groundwater users to the north, east and south of the BLNG Precinct are considered to be hydraulically up gradient or cross gradient and are therefore unlikely to be impacted from any unplanned discharges that come into contact with the underlying ground water. Groundwater users include the BLNG Precinct proponents and the Broome Water Reserve which is 15km to the south of the BLNG Precinct area.

If groundwater contamination occurred, this would ultimately discharge to the marine environment and/or surface water features within the vicinity of the BLNG Precinct. If groundwater does not discharge to surface water features, the potential for humans to be exposed to any contaminated groundwater is considered to be low.

During construction and operation of the LNG facilities and other supporting infrastructure, hydrocarbon and chemicals will be stored on site in tanks within designated storage areas with impervious berms or appropriate bunds for spill management. Through the adoption of appropriate hydrocarbon and chemical handling and disposal practices during construction and operation of the BLNG Precinct it is likely that spill events capable of reaching local groundwater would be avoided. Emergency response procedures would be developed and are likely to be effective in containing spills in the unlikely event that a non routine discharge occurs.

It is expected that potential impacts on groundwater from terrestrial wastes and discharges will be minor following the implementation of appropriate management and mitigation measures such as the storage of chemicals and hydrocarbons in bunded areas, contaminated surface water run-off capture and treatment prior to discharge to the environment, and the implementation of the actions specified in an Emergency Response Plan. A more detailed description of proposed mitigation measures is presented in **Section 2.3.4**. The significance of the residual impact from terrestrial discharges, including non-routine events on groundwater is assessed to be very low as there is a low likelihood of uncontained spills and comprehensive emergency response measures will be in place to minimise impacts.

2.3.3.4. Potential Impacts to Groundwater due to Groundwater Abstraction

Potential impacts to groundwater occurring as a result of groundwater abstraction are a decline in health of groundwater dependant vegetation (where groundwater drawdown occurs), the potential reduction in stygofauna habitat suitability and impacts to local groundwater availability. Potential impacts to stygofauna and groundwater dependant vegetation are addressed in detail in **Part 4**, **Section 2.4** and **Part 4**, **Section 2.6**.

The use of groundwater is controlled under the RIWI Act, administered by the Department of Water. The James Price Point coastal area lies within a proclaimed groundwater area. Hence, it will be necessary for proponents of derived proposals to make an application for licences to construct bores and to take and use groundwater. The Department of Water determines the level of groundwater abstraction that may occur without unacceptable environmental or social impacts on other water users, and this limit is defined as the sustainable yield of the aquifer. This licence process provides certainty that the environmental impacts of the proposed groundwater licence application will be assessed by the Department of Water and that no unacceptable environmental or social impacts will be approved. The Department of Water will not approve licence applications for groundwater abstraction beyond the sustainable yield.

Department of Water will assess the application to take and use water under Clause 7(2) of Schedule 1 of the RIWI Act, including considering whether the taking and use of groundwater:

- is in the public interest;
- is ecologically sustainable;
- is environmentally acceptable;
- may prejudice other current and future needs for water;
- would have a detrimental effect on another person, and/or; and
- could be provided for by another source.

Detailed hydrogeological field investigations, analysis and interpretation including the installation and testing of investigation bores and wells, and development and calibration of a numerical groundwater model will be undertaken by each proponent of derived proposals applying to take and use groundwater. The numerical groundwater model(s) will also be used to optimise the production borefield layout, including spacing and depths and hence, borefield and ancillary infrastructure design. Borefield design will address mitigation of the potential for interference with bores of other groundwater users, impacts on potential groundwater dependent ecosystems, and unacceptable saltwater intrusion.

An operating strategy detailing how potential impacts on groundwater will be managed and monitored, and containing a water conservation and efficiency plan, will also be required to be prepared by the proponents of derived proposals and submitted as part of the groundwater licence applications.

The potential drawdown of groundwater within the Broome Sandstone/ Wallal Aquifers is shown in conceptual site models (**Figure 2.3-1** and **Figure 2.3-2**).

The potential Foundation Proponent estimates that fresh water demand for the BLNG Precinct will range from 2GL/yr for a 12Mtpa LNG processing development up to 8GL/yr for a 50Mtpa development. The water source options include groundwater abstraction, desalination of saline groundwater and desalination of seawater, or a combination of these options. It is proposed to use groundwater to supply construction water requirements and to also use groundwater as the preferred primary water supply for operation water requirements. This proposal will be subject to hydrogeological investigations to identify whether there is likely to be sufficient sustainable yield and to support the groundwater licence application(s) to Department of Water. Groundwater demand will likely be influenced by the reuse of stormwater and/or treated water. Stormwater stored in holding basins may be reused (for dust suppression etc.) and there is also potential for treated wastewater to be reused for construction and operation purposes.

Groundwater abstraction scenarios (volumes and rates) are currently being investigated by the potential Foundation Proponent and may include abstraction from the Broome Sandstone aquifer, the Wallal aquifer and Grant Group aquifer or a combination of all three. If present, the Superficial aquifer is highly unlikely to have enough storage to meet the abstraction rate required and is therefore not considered as a potential groundwater source. The Broome Sandstone aquifer, being shallow and fresh, is the most accessible for the size of resource required, however, it is also likely to have

the highest potential for environmental impacts as it is a shallow aquifer. Utilisation of the deeper aquifers are likely to have less environmental impacts (including less saltwater intrusion) and are therefore also being investigated.

Groundwater abstraction has the potential to lower groundwater levels either directly if the abstraction is from an unconfined surface aquifer or indirectly if the abstraction is from a semi-confined lower aquifer where the abstraction would cause leakage from the upper aquifer(s). The extent and magnitude of any groundwater level drawdown will depend on the aquifer, borefield layouts, groundwater pumping rates and duration.

The potential impacts of groundwater abstraction will be investigated and assessed in future groundwater licence applications under the RIWI Act and will include those associated with saltwater intrusion, impacts on other groundwater users, inter-aquifer contamination, groundwater level drawdown, impacts on groundwater dependent ecosystems and possible reductions in baseflow to surface water features (e.g. the coastal drainage basin). Groundwater abstraction may reverse horizontal and/or vertical groundwater flow gradients. This reversal may result in groundwater being drawn in from other parts of the same aquifer, inter-aquifer leakage, and alteration of the natural freshwater/saltwater interface near the coast. The implications of these changes can be summarised as follows:

- reduction in baseflows to surface water features;
- migration of the freshwater/saltwater interface landward (saltwater intrusion) resulting in higher groundwater salinity concentrations; and
- deterioration of the groundwater quality of the resource if overlying or underlying aquifers and/or groundwater in other parts of the same aquifer contain poorer quality groundwater.

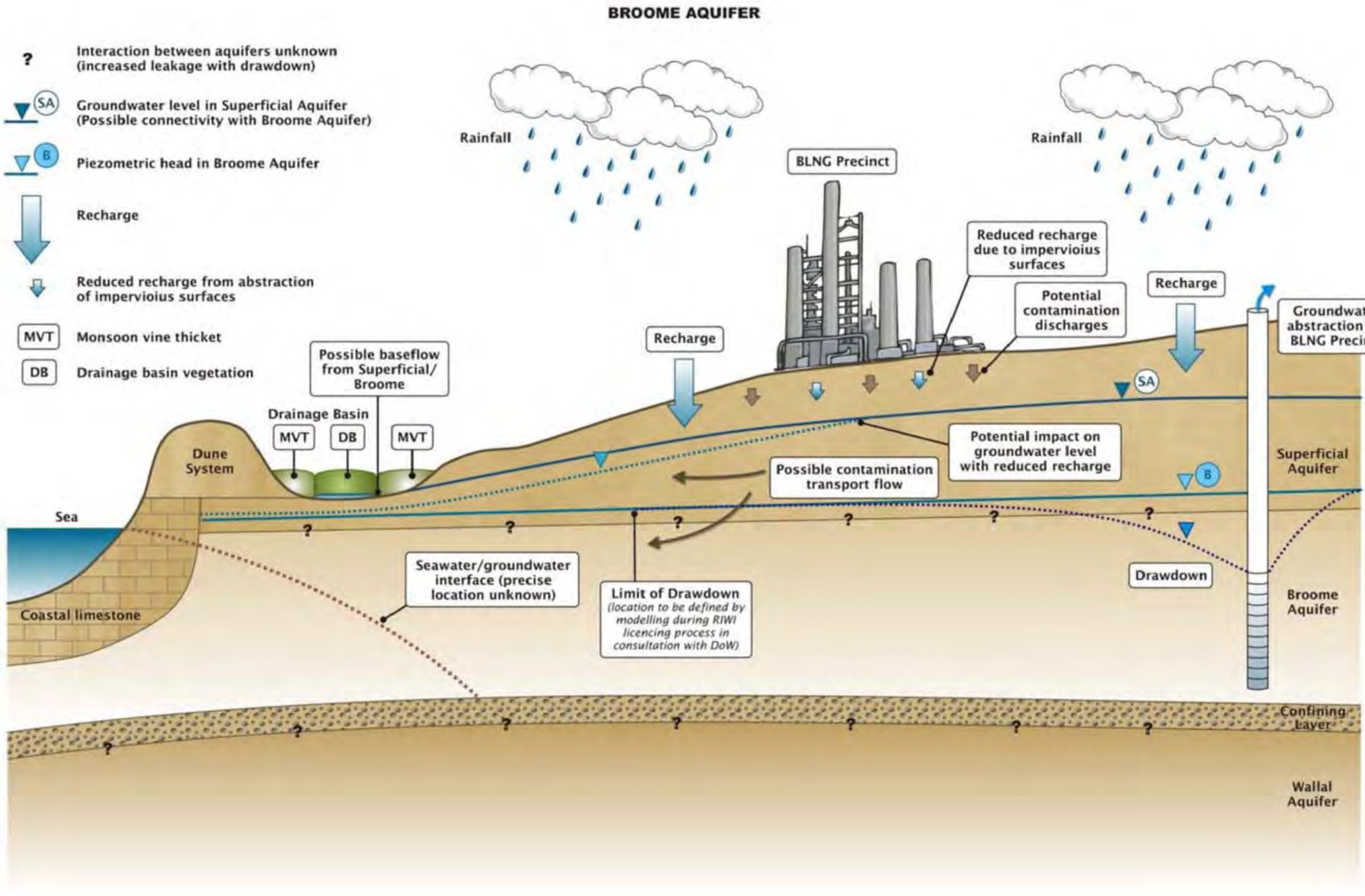
Groundwater levels in shallow aquifers (e.g. the superficial aquifer and the Broome Sandstone aquifer) in near-coastal areas are likely to be controlled by the hydraulic head of the ocean and the potential for abstraction to affect water levels in this area will be limited. It is already known that the Broome Sandstone aquifer is sensitive to movements in the sea water/groundwater interface. If groundwater users, including surface water systems and ecosystems which may rely on groundwater, are located within the zone of groundwater level drawdown caused by groundwater abstraction, the following potential impacts may occur:

- Reduced yields and quality in groundwater bores, including the Broome town water supply production bores.
- Altered characteristics or loss of vegetation communities of ecological significance, such as monsoon vine thicket or drainage basin vegetation (potential impacts are detailed in **Part 4**, **Section 2.4**). The dependency on groundwater of monsoon vine thicket TEC is unknown, although there is a high likelihood of some use of groundwater by this vegetation community. Hydrogeological assessment of proposed abstraction scenarios will include consideration of potential impacts on the monsoon vine thicket TEC as part of the Department of Water licence application under the RIWI *Act*.
- Altered characteristics or loss of stygofauna habitat (potential impacts are detailed in **Part 4**, **Section 2.6**). At present it is considered unlikely that the James Price Point coastal area contains significant subterranean fauna values however this would be confirmed as part of future investigations. The proposed groundwater source for the BLNG Precinct and extraction volumes are subject to the outcome of hydrogeological studies. Based on current information it is considered unlikely drawdown as a result of groundwater abstraction would impact stygofauna values at both a local or regional scale.

Bore spacing within the Broome town water supply borefield (as presented in WRC, 2001) indicates that the drawdown interference zone of bores in the Broome Sandstone aquifer is relatively small (less than one kilometre). Thus, the 15km separation distance between the BLNG Precinct and the Broome Water Reserve and associated town water supply borefield is likely to be sufficient to ensure that no interference with the Broome town water supply bores occurs as a result of groundwater abstraction for the BLNG Precinct. The extent and magnitude of any groundwater level drawdown will depend on the aquifer, borefield layouts, groundwater pumping rates and duration. Groundwater modelling as part of the hydrogeological investigations required for a groundwater licence application under the RIWI Act will be used to assess any possible interference drawdown that may occur. The potential impacts of groundwater abstraction will be investigated and assessed in future groundwater licence applications under the RIWI Act.

The hydrogeological assessment for future licensing under the RIWI ACT and the implementation of a groundwater monitoring program designed to monitor for potential impacts on the resource (e.g. water quality and drawdown), saltwater interfaces, groundwater dependent ecosystems (if applicable) and other users (if applicable), will provide a high

level of assurance that impacts on groundwater from abstraction will not result in significant environmental or social impacts. A more detailed description of proposed mitigation measures is presented in **Section 2.3.4**. The significance of the residual impact of a possible decline in groundwater availability as a result of groundwater abstraction is assessed to be low as this will be appropriately controlled under licence requirements set and monitored by the Department of Water.



■ **Figure 2.3-1 Conceptual BLNG Precinct Groundwater Model: Drawdown from the Broome Aquifer.**

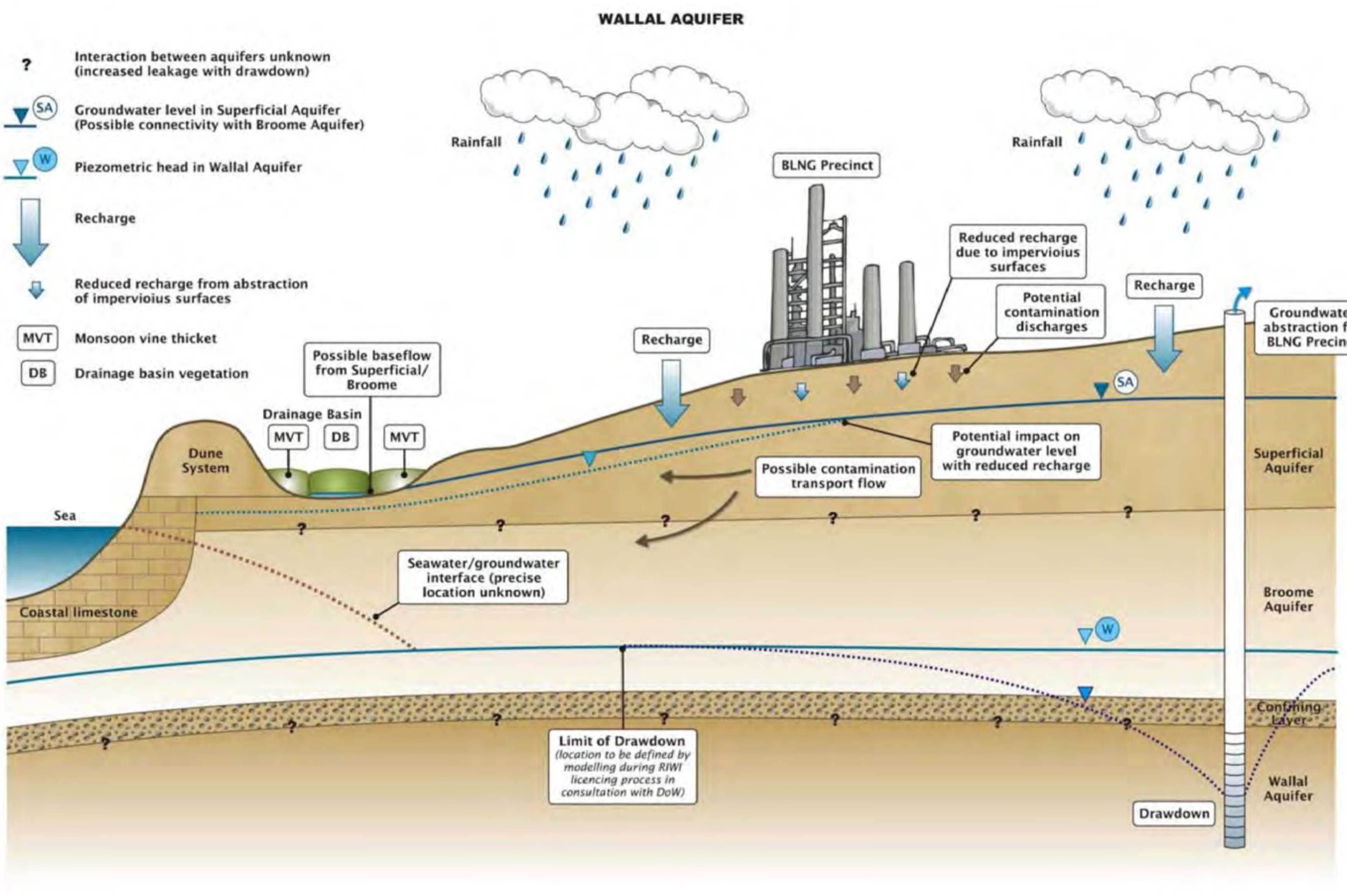


Figure 2.3-2 Conceptual BLNG Precinct Groundwater Model: Drawdown from the Wallal Aquifer.

2.3.4. Management Measures

The key safeguard that exists for potential impacts associated with groundwater abstraction is that all proposals to abstract groundwater will be assessed by Department of Water under the *Rights in Water and Irrigation Act 1914* and approved only if they meet environmental and social criteria (**Section 2.3.4**). Proponents of derived proposals will be required to undertake hydrogeological investigations and modelling to support their licence applications. If a groundwater abstraction licence application is not approved by Department of Water, the contingency water supply option of seawater or groundwater desalination will be pursued. This contingency has been assessed as part of the SA.

Mitigation measures and safeguards that have been identified to manage potential impacts to groundwater are outlined below in **Table 2.3-1**, **Table 2.3-2** and **Table 2.3-3**.

- **Table 2.3-1 State Government Measures for Groundwater.**

State Government measure	Responsibility	Timing
Prepare an overarching Emergency Response Plan that addresses: • risk assessment of potential emergencies (including bushfires, introduction of foreign pests, flooding and spills); • emergency response equipment and training; • emergency response procedures; • responsibilities during emergency response; and • reporting, review and improvement as required.	DSD through its involvement in the BLNG Precinct Control Group, with advice from FESA.	Prior to commencement of construction of an LNG plant.
Develop and implement a Management and Monitoring Strategy for Vegetation of Medium to High Conservation Significance, with particular reference to remnant monsoon vine thicket and drainage basin vegetation. The Strategy will inform all proponents of derived proposals of requirements for detailed management plans specific to individual activities and will include a framework in which the following Plans will be implemented: • Fire Management Plan; • Terrestrial Fauna Management Plan; • Terrestrial Weed Management Plan; and • Appropriate management of hydrology (both surface water and groundwater). Refer also the commitment for Ecological Surface Water Requirements Management Plan and surface water management commitments in **Part 4**, **Section 2.2**. The effectiveness of the Strategy is to be measured via condition and health monitoring for a defined area within and surrounding the BLNG Precinct area and associated buffer zones. Annual reporting on success of the program is to be made publicly available.	DSD through its involvement in the BLNG Precinct Control Group, with advice from DEC.	Prior to construction.

Table 2.3-2 Proposed Environmental Conditions for the Strategic Proposal that may affect Groundwater.

Condition No.	Proposed Environmental Conditions for the Strategic Proposal
T3.1	Proponents of derived proposals shall not cause the loss of vegetation, including monsoon vine thicket, in excess of the limits of cumulative loss prescribed in **Part 4**, **Section 2.4** for the BLNG Precinct.
T1.2	Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address: • detailed measures to be implemented for final closure; • the schedule and timing of final closure activities; • completion criteria for closure; and • closure monitoring requirements.
T1.3	Proponents of derived proposals shall implement the Final Closure Plan required by condition 1.2 until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.

Table 2.3-3 Requirements to be Addressed via Development of a Management Plan to Support a Derived Proposal Potentially Affecting Groundwater.

Derived Proponent Requirements	Timing
Prepare and implement a Groundwater Abstraction Management Plan to address the following: • The scope and studies to be completed as part of the Hydrogeological Assessment for future licensing under the *Rights in Water and Irrigation Act 1914*. • Groundwater sources to be utilised and proposed volumes to be abstracted. • Design and location of borefield and abstraction regimes to minimise groundwater drawdown and saltwater intrusion, and potential impacts on stygofauna, groundwater dependent ecosystems and other users. • A groundwater monitoring program designed to monitor for potential impacts on the resource (e.g. water quality and drawdown), saltwater interfaces, groundwater dependent ecosystems (if applicable) and other users (if applicable). • Reporting requirements. • Water efficiency methods employed. The above measures will be considered and addressed in consultation with the Department of Water.	Prior to groundwater abstraction activities
Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan for construction and operation activities. See **Part 4**, **Section 2.2**.	Prior to commencement of associated construction activities
Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets; • environmental management; • environmental training and inductions; and • environmental monitoring, contingencies and reporting, and stakeholder consultation.	Prior to commencement of associated construction activities

2.3.5. Environmental Outcome of Category A Activities

The construction and operation of the BLNG Precinct has the potential to result in spills or leaks of hydrocarbons or other chemicals. The Broome Sandstone aquifer and the Superficial aquifer (if present) are at most risk of contamination from discharge events due to their unconfined nature and shallow watertables.

Design of facilities and infrastructure within the BLNG Precinct will incorporate standard industry practices and conform to regulations including the use of bunding and leakage detection devices. All LNG processing facilities will be required to have Works Approvals under Part V of the EP Act, which will ensure that the appropriate standards are being met. Proponents of derived proposals will also be required to provide a Hydrocarbon and Chemical Spill Contingency Plan as part of their derived proposal application that will detail the measures used to reduce the risk of leaks and spills and the response procedures when they occur.

Excavations and removal of part of the dune system during pipeline shore crossing works may have localised impacts on shallow/perched water tables. If confining layers are removed and the impacted perched aquifers need to be reinstated, this will need to be engineered to ensure no permanent drainage of these shallow aquifers occur. Mitigation measures will need to be finalised once the groundwater regime of the near coastal areas is determined from further site investigation.

Terrestrial site disturbance and excavation could result in groundwater contamination if excavation occurred below the water table in areas with PASS. As the groundwater level in the Precinct is estimated to be approximately 2m AHD (Rockwater, 2009; **Appendix C-22**) and the majority of the Precinct is above 10m AHD, it is unlikely that significant dewatering would be required and that any areas with PASS would be able to be avoided. Other potential contamination from imported fill will be managed through the requirement for all fill to meet geotechnical criteria and quality as 'clean fill' before being used.

The physical presence of the BLNG Precinct will incorporate the construction of impervious surfaces and will consequently have the potential to reduce recharge to any underlying shallow/unconfined aquifers which may be present. The severity of this impact will depend on the sensitivity of groundwater levels to the reduction of recharge and the areal extent of the impervious surfaces to be constructed. Possible mitigation measures include the creation of hard stand surfaces which permit infiltration from rainfall, or soak away systems which are fed by a drainage system. However, whilst the creation of permeable surfaces and soak aways may mitigate reductions in recharge, it may also promote contamination of aquifers from contaminated surface water run-off.

Groundwater abstraction for water supply may cause drawdown effects in the Broome Sandstone aquifer, but these effects may be minimised if the Wallal aquifer is targeted as an alternative source for water supply. However, all groundwater abstraction in the area would require a licence from Department of Water under the RIWI Act. In assessing licence applications, Department of Water is required to consider the potential for environmental and social impacts on other users and require detailed hydrogeological investigations and modelling to be undertaken to demonstrate that the sustainable yield of the aquifer was not exceeded. This licence process provides certainty that the environmental impacts of the proposed groundwater licence application will be assessed by the Department of Water and that no unacceptable environmental or social impacts will be allowed.

As part of groundwater abstraction licence applications submitted to the Department of Water, should an assessment not support the issue of a licence, then the contingency water supply option is seawater desalination. Depending on the volume of water determined to be available from local groundwater, and the overall economics, the groundwater supply may be supplemented by seawater desalination to make up any shortfall in supply. This contingency has been included in the assessment of marine impacts.

In summary, with the relevant environmental policies, regulations and guidelines that will be applied, and control measures implemented as proposed, the environmental outcome for groundwater from Category A activities would be expected to be acceptable.

2.3.6. Cumulative Impacts of the Proposal and Associated Activities

2.3.6.1. Category B Activities

The impacts of the BLNG Precinct proposal to groundwater are also to be considered in the context of additional impacts from indirectly facilitated or related projects in the region, and their cumulative impacts.

Of Category B activities, the following may apply to cumulative impacts on groundwater:

- Housing and associated infrastructure: The BLNG Precinct is expected to accelerate demand for the Broome North development which is likely to increase demand for groundwater supplies.
- Industrial areas: The BLNG Precinct will increase demand for water associated with some industrial activities.
- Solid waste: The BLNG Precinct will facilitate the need for a new facility sooner than previously expected. No location is yet proposed however this may pose potential risks to groundwater.

Potential impacts on groundwater from Category B activities associated with increased urban and industrial development in Broome would be similar to those identified for Category A activities. As Category B development and water supply impacts are likely to be concentrated around Broome and the Water Supply Reserve, it is unlikely that there would be any cumulative effect on groundwater levels or quality in the aquifers.

The current Broome town water supply borefield is located in the southern quarter of the Broome Water Reserve. Future expansion of the borefield to meet growth in demand at Broome will extend in a northerly direction, within the Water Reserve, ultimately extending to approximately 15km south of the BLNG Precinct. Bore spacing within the Broome town water supply borefield (as presented in WRC, 2001) indicates that the drawdown interference zone of bores in the Broome Sandstone aquifer is relatively small (less than one kilometre). Thus, the separation distance between the BLNG Precinct and the Broome Water Reserve should be sufficient to avoid interference with expansion of the Broome town borefield.

Groundwater on the Dampier Peninsula is not considered a matter of national environmental significance. Hence, it is appropriate to apply state regulatory framework policies and guidelines as protection measures to mitigate or avoid potential impacts. The relevant policies and guidelines are:

- WA Rights in Water Irrigation Act 1914.
- Water Authority of WA (1994). Broome Groundwater Management Plan.

Department of Water is currently developing a regional water management framework for the Kimberley region, which includes the Dampier Peninsula. As part of this regional water management framework, Department of Water is undertaking a review of the 1994 Broome groundwater management plan. Future regional water plans developed under the Kimberley regional water management frameworks will provide guidance for proponents of Category B activities.

The ANZECC/ARMCANZ (2000) Australian and New Zealand Water Quality Guidelines should be adopted as a protection measure to mitigate and/or avoid potential groundwater contamination associated with the growth of Broome.

2.3.6.2. Category C Activities

A future supply base to service the Browse Upstream development may be established in the vicinity of Broome. The water supply requirements for this development are yet to be determined however it is most likely that this would be sourced from the Broome sandstone aquifer, either as part of the current Broome town water supply or the establishment of a supply bore.

Appropriate licences and approvals would be sought for the water supply requirements of a supply base. In assessing both category A and B activities it is considered unlikely that this would contribute to significant cumulative impacts to groundwater conditions within the Broome area.

Table 2.3-4 Impact Assessment Summary for Groundwater.

<table>
<tr><th rowspan="2">Environmental Aspect</th><th rowspan="2">Potential Impacts</th><th colspan="3">Mitigation Measures</th><th rowspan="2">Significance of Residual Impact</th></tr>
<tr><th>State Government Measures</th><th>Proposed Environmental Conditions</th><th>Future Proponent Management Plans</th></tr>
<tr><td rowspan="3">Site Disturbance and Excavation</td><td>Generation of acid sulphate soils</td>
<td rowspan="8">Develop and implement a Management and Monitoring Strategy for Vegetation of Medium to High Conservation Significance, with particular reference to remnant monsoon vine thicket and drainage basin vegetation. The Strategy will inform all proponents of derived proposals of requirements for detailed management plans specific to individual activities and will include a framework in which the following Plans will be implemented:
Fire Management Plan;
Terrestrial Fauna Management Plan;
Terrestrial Weed Management Plan; and
Appropriate management of hydrology (both surface water and groundwater).
The effectiveness of the Strategy is to be measured via condition and health monitoring for a defined area within and surrounding the BLNG Precinct area and associated buffer zones. Annual reporting on success of the program is to be made publicly available.

Prepare an overarching Emergency Response Plan that addresses:
risk assessment of potential emergencies (including bushfires, introduction of</td>
<td rowspan="8">Proponents of derived proposals shall not cause the loss of vegetation, including monsoon vine thicket, in excess of the limits of cumulative loss prescribed in Part 4, Section 2.4 (Terrestrial Flora and Vegetation) for the BLNG Precinct.

Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address:
detailed measures to be implemented for final closure;
the schedule and timing of final closure activities;
completion criteria for closure; and
closure monitoring requirements.
Proponents of derived proposals shall implement the Final Closure Plan until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.</td>
<td rowspan="8">Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following:
schedule of construction activities;
details of the construction methods to be used;
objectives and targets;
environmental management;
environmental training and inductions; and
environmental monitoring, contingencies and reporting, and stakeholder consultation.
Prepare and implement a Groundwater Abstraction Management Plan to address the following:
The scope and studies to be completed as part of the Hydrogeological Assessment for future licensing under the Rights in Water and Irrigation Act 1914.
Groundwater sources to be utilised and proposed volumes to be abstracted.
Design and location of borefield and abstraction regimes to minimise groundwater drawdown and potential impacts on stygofauna, groundwater</td>
<td>Very Low</td></tr>
<tr><td>Groundwater drawdown</td><td>Low</td></tr>
<tr><td>Decline in health of groundwater dependant vegetation (where groundwater drawdown occurs)</td><td>Low</td></tr>
<tr><td>Terrestrial discharges, including non - routine discharges</td><td>Groundwater contamination</td><td>Very Low</td></tr>
<tr><td>Physical Presence</td><td>Change in water infiltration of recharge rates</td><td>Medium</td></tr>
<tr><td rowspan="3">Groundwater Abstraction</td><td>Reduction in stygofauna habitat suitability</td><td>Very Low</td></tr>
<tr><td>Impacts to local groundwater availability</td><td>Low</td></tr>
<tr><td>Decline in health of groundwater dependant vegetation (where groundwater drawdown occurs)</td><td>Very Low</td></tr>
</table>

Environmental Aspect	Potential Impacts	Mitigation Measures			Significance of Residual Impact
		State Government Measures	Proposed Environmental Conditions	Future Proponent Management Plans	
		foreign pests, flooding and spills); • emergency response equipment and training; • emergency response procedures; • responsibilities during emergency response; and • reporting, review and improvement as required.		dependent ecosystems and other users. • A groundwater monitoring program designed to monitor for potential impacts on the resource (e.g. water quality and drawdown), groundwater dependent ecosystems (if applicable) and other users (if applicable). • Reporting requirements. • Water efficiency methods employed. The above measures will be considered and addressed in consultation with the Department of Water. Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan for construction and operation activities.	

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2.4. Key Factor: Terrestrial Flora and Vegetation

The following section describes the predicted impacts on terrestrial flora and vegetation from activities, facilities and other requirements to be approved under the Plan for the BLNG Precinct (Category A) and the potential for cumulative impacts from activities that may indirectly arise as a result of the BLNG Precinct development (Category B) and other related resource activities in the region (Category C). The section also sets out the controls to be implemented to mitigate these impacts.

2.4.1. Current Knowledge

The following sub-sections describe the regulatory expectations with respect to flora and vegetation protection, and provide a summary of the key flora and vegetation values present in the James Price Point coastal area. This assessment of terrestrial flora and vegetation has focussed on the 'key receptors' that are species of conservation significance that are known to occur in the vicinity of the BLNG Precinct, as outlined in **Table 2.4-1**.

- **Table 2.4-1 Key Receptors Considered in the Impact Assessment.**

Key Receptor	Rationale for Selection as a key receptor
Significant ecological communities	Significant ecological communities are those listed as Threatened Ecological Communities (**TEC**) or Priority Ecological Communities (**PEC**) in WA, or those identified as having restricted distributions within the James Price Point coastal area.
Priority flora	While no threatened flora species listed under the EPBC Act or DRF have been recorded in the James Price Point coastal area, five current Priority listed flora species listed by the DEC have been recorded within or near the James Price Point coastal area. An additional five Priority Flora species may potentially occur within the area based on suitable habitat being present.
Surface and groundwater dependent vegetation	Possible occurrence of vegetation communities in the James Price Point area which appear to be maintained by both surface water and groundwater inflow.

2.4.1.1. Key Statutory Requirements, Environmental Policy and Guidance

There are a number of key statutory requirements, environmental policy and guidance that apply to the Strategic Assessment in relation to flora and vegetation protection as discussed below.

Commonwealth Protection

The State and Commonwealth governments have endorsed the National Strategy for the Conservation of Australia's Biological Diversity (Australian and New Zealand Environment and Conservation Council and Australian Department of the Environment, Sport and Territories (now SEWPAC) 1996), and the National Strategy for Ecologically Sustainable Development (Australian Ecologically Sustainable Development Steering Committee 1992). The strategies address the conservation of Australia's biological diversity by defining several guiding principles.

The principles of the National Strategy for the Conservation of Australia's Biological Diversity are based on establishing a cooperative approach between governments, non-government and Aboriginal people to anticipate, prevent and target the causes of reduction or loss of biodiversity. It recognises that international activities affect Australia's biodiversity and that central to conservation of biodiversity is the establishment of viable protected areas.

The National Strategy for Ecologically Sustainable Development provides broad strategic directions and framework for governments to direct policy and decision-making. The Strategy's aim at facilitating a coordinated and co-operative approach to ecologically sustainable development and encourages long-term benefits for Australia over short-term gains.

Under the EPBC Act, protection of Australia's native species and ecological communities provides for identification and listing of species and ecological communities as threatened, development of conservation advice and recovery plans for listed species and ecological communities, recognition of key threatening processes and, where appropriate, reducing the impacts of these processes through threat abatement plans. The Commonwealth Minister for Environment acts consistent with advice provided in species recovery plans.

State Guidance and Policy

The relevant EPA objective for terrestrial flora and vegetation is:

"to maintain the abundance, species diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge."

The following EPA objective addressing biodiversity is also relevant to this factor:

"to maintain biological diversity that represents the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form, at the levels of genetic diversity, species diversity and ecosystem diversity."

In WA the legislation for the preservation and conservation of flora and vegetation communities is covered primarily by the *Wildlife Conservation Act* 1950. This Act provides for taxa (species, subspecies and varieties) of native flora to be specially protected because they are under identifiable threat of extinction, are rare, or otherwise in need of special protection. Such specially protected flora are considered to be "threatened". The Minister may also list ecological communities which are at risk of becoming destroyed.

The DEC (Nature Conservation Division) Priority Flora List also nominates conservation species from Priority One to Priority Four, however there is no formal legislative protection. It is expected that the potential impacts of a proposal to these priority listed species should be managed such that the species do not meet the IUCN criteria for threatened species.

The EPA sets objectives and has a number of position and guidance statements relating to their expectations in regards to impacts to vegetation and flora.

EPA Position Statement No. 2 (EPA, 2000a) provides an overview of the EPA position on the clearing of native vegetation in WA. In assessing a proposal, the EPA will include the following basic elements in consideration of biological diversity:

- Comparison of development scenarios, or options, to evaluate protection of biodiversity at the species and ecosystems levels, and demonstration that all reasonable steps have been taken to avoid disturbing native vegetation.
- No known species of plant or animal is caused to become extinct as a consequence of the development and the risks to threatened species are considered to be acceptable.
- No association or community of Indigenous plants or animals ceases to exist as a result of the proposal.

  There is a comprehensive, adequate and secure representation of scarce or endangered habitats within and/or in areas biologically comparable to the proposal area, protected in secure reserves.
- If the proposal is large (in the order of 10–100 ha or more, depending on location in the State) the proposal area itself should include a comprehensive and adequate network of conservation areas and linking corridors whose integrity and biodiversity are secure and protected.
- The on-site and off-site impacts of the proposal are identified and the proponents of derived proposals demonstrates that these impacts can be managed.

EPA Position Statement No. 3 (EPA, 2002a) discusses the principles the EPA would apply when assessing proposals that may have an effect on biodiversity values in WA. The outcomes sought by this Position Statement are intended to:

- promote and encourage all proponents of derived proposals and their consultants to focus their attention on the significance of biodiversity and, therefore, the need to develop and implement best practice in terrestrial biological surveys; and
- enable greater certainty for proponents of derived proposals in the environmental impact assessment process by defining the principles the EPA will use when assessing proposals that may have an effect on biodiversity values.

EPA Position Statement No. 9 (EPA, 2006b) recognises environmental offsets as one tool that can provide alternative beneficial environmental outcomes in situations where social and economic growth is sought at some detriment to the environment. The EPA stresses that offsets are not intended to make otherwise unacceptable environmental impacts acceptable but rather to achieve a net environmental benefit to counterbalance acceptable environmental impacts only. The EPA does not consider it appropriate to validate or endorse the use of environmental offsets where proposals are

predicted to have significant adverse impacts to critical assets[1]. The position statement recognises native vegetation (with some further clarification) as a critical asset and usually considers adverse impacts to this asset to be significant where they are seriously at variance to the principles to protect native vegetation listed under Schedule 5 of the EP Act or associated Regulations and/or they would result in a 30 percent or less representation of the pre-clearing extent of that vegetation complex in a bioregion.

The EPA also recognises aspects of biodiversity as critical assets and in relation to this, will have regard to the significance of any potential impacts to Priority flora and DRF.

2.4.1.2. Description of Factor

Existing terrestrial flora and vegetation, both within the potential BLNG Precinct site and in the general James Price Point coastal area and in a regional context, are described in **Part 4**, **Section 1** (Environmental Overview). Relevant key findings include:

Vegetation Communities and Condition

- The Dampier Peninsula lies on the western side of the Dampierland IBRA bioregion, within the Pindanland subregion. The vegetation is typically Pindan sandplains, more or less densely wooded according to rainfall; tall-grass savanna with or without scattered trees on clay plains; spinifex steppe on sandstone and limestone outcrops (Biota, 2009c; **Appendix C-18**).
- Biota (2009c; **Appendix C-18**) identified 12 vegetation communities within the James Price Point coastal area, with Pindan shrubland and woodland communities being the dominant vegetation type occupying the landward areas of the James Price Point coastal area, east of the monsoon vine thicket and drainage basin communities. The Pindan community contained areas of open forest and woodland communities, as well as variability in shrub species dominance. Additional vegetation types that occur only in narrow bands along the coast include coastal heath and beach communities, and sub-coastal monsoon vine thickets.
- Significant ecological communities, which include monsoon vine thicket TEC, are primarily restricted to the coastal fringe. The remaining Pindan and woodland vegetation types occurring east of the coastal vegetation are considered to be relatively homogenous and are well represented within the local and regional area.
- Listed PECs, TECs and other vegetation communities identified within the James Price Point coastal area that are considered to be of conservation significance are described in **Table 2.4-2**. Drainage basin vegetation and coastal communities were considered to be important based on their restricted distribution on the Dampier Peninsula, and/or likelihood to be impacted by fragmentation, weed invasion, changed fire regimes and changes to hydrological and hydrogeological regimes.
- Overall, the vegetation of the James Price Point coastal area was considered to be in good to very good condition; however, specific areas were found to be subject to disturbance as a result of weed invasion and altered fire regimes. On the Dampier Peninsula, frequent burning is deemed to be having a detrimental effect on the wildlife and long-term survival of the Pindan (Biota, 2009c; **Appendix C-18**). Vegetation communities, where there was no road access or were otherwise difficult to penetrate, showed little evidence of weed invasion or physical disturbance as a result of human activities.

[1] Critical assets represent the most important environmental assets in the State that must be fully protected and conserved.

- **Table 2.4-2 Vegetation Communities of Conservation Significance in the James Price Point Coastal Area.**

Vegetation community	Description/distribution	Conservation significance*	DEC Listing	Significant Flora
Monsoon vine thickets	Represent the southern-most occurrence of vine thicket ecosystems of the broader Kimberley region, and are noted for their unique structure. They occur in discontinuous patches behind the primary dune system along the coastal stretch north of Broome, around James Price Point coastal area, and further north.	High regional significance.	TEC - currently ranked as Vulnerable.	Priority 4 species *Pittosporum moluccanum.*
Drainage basin vegetation	Representative of the community described as permanent/ephemeral wetlands, damplands, and riparian habitat of the Dampierland bioregion (ENV, 2008a; **Appendix C-14**). Within the James Price Point coastal area this community is located in areas behind coastal dunes which are subject to seasonal inundation and is categorised by the presence of species such as *Melaleuca dealbata* and *Lophostemon grandiflorus.*	High local significance.	Considered by the DEC to be at risk (Biota, 2009c; **Appendix C-18**).	
Coastal heaths	Restricted within the James Price Point coastal area to discontinuous, narrow, linear bands, occurring on exposed Pindan coastal cliffs north from James Price Point to Flat Rock. It appears to be common along the coast of the Dampier Peninsula; however, it is relatively restricted in distribution to the narrow coastal fringe.	Moderate regional significance.	PEC - Corresponds with dwarf pindan heath community of the Broome coast (Priority 1).	
Coastal communities	These communities are likely to be widespread along the coastline of the Dampier Peninsula, but have only a minor area of representation given the restricted position of this habitat type in the landscape.	Moderate regional significance.	Not listed by DEC.	Priority 2 species *Gomphrena pusilla.*

Note: * Significance ranking was signed by Biota (2009c; **Appendix C-18**) according to listed status, and restricted distributions on the Dampier Peninsula.

Flora

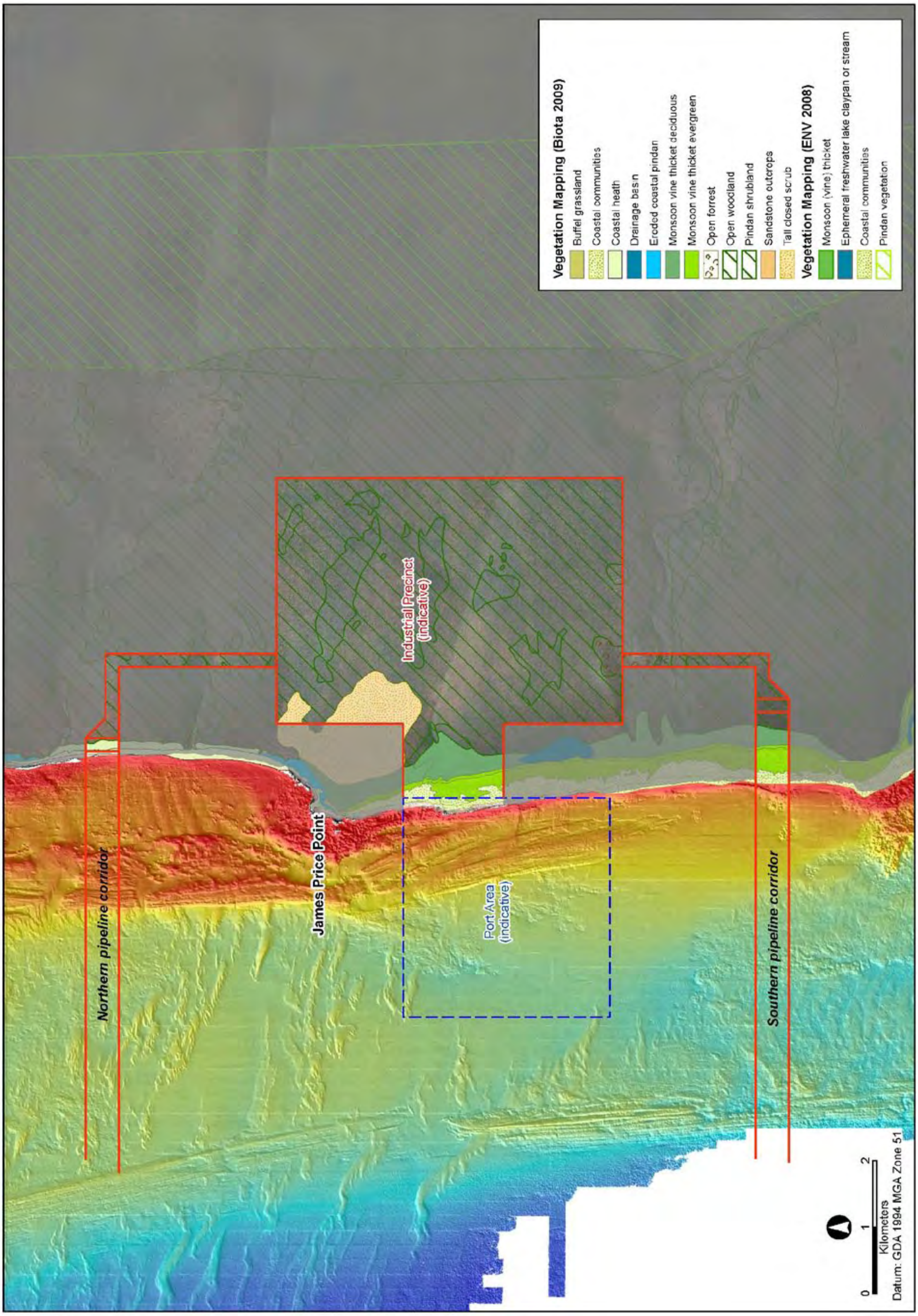
- No threatened flora species listed under the EPBC Act or DRF were recorded in the James Price Point coastal area from all surveys to date (ENV, 2008a; **Appendix C-14**, Biota, 2009c; **Appendix C-18** and AECOM, 2010a; **Appendix C-19**).
- Five current Priority listed flora species have been recorded within or near the James Price Point coastal area, with an additional species nominated to be given a priority status. An additional five species of potential conservation significance have been recorded south of the James Price Point coastal area; these additional five flora species are being assessed further as suitable habitat may occur within the James Price Point coastal area (AECOM, 2010a; **Appendix C-19**).
- Twenty two weed species were recorded in the James Price Point area with one being a Declared Plant under the ARRP Act and nine being serious environmental weeds as they are highly aggressive and can have significant impacts on vegetation (Biota, 2009c; **Appendix C-18**). Weeds were generally localised along the coastal strip being in close proximity to existing disturbed areas and Manari Road.

Site Selection at James Price Point

Following the decision by the Western Australian Government to locate the BLNG Precinct at James Price Point, two sites were assessed; a northern and a southern option.

Clearing of an area of the monsoon vine thicket in the southern option represented the main sensitive terrestrial impact for the two options. Monsoon vine thicket is absent from the northern option, with the southern option impacting on a significant area of this DEC listed (Vulnerable) TEC. The monsoon vine thicket in the James Price Point area has been assessed as ranging in condition from excellent to good, with some thickets subject to weed invasions.

Following assessment of all marine and terrestrial factors during site selection, it was considered that the southern James Price Point location represented a better overall environmental outcome in terms of reducing the impact to the moderate to highly sensitive marine environment. Whilst this option has a greater impact on the terrestrial monsoon vine thicket, it was considered that this could be more effectively mitigated and managed taking into account impacts from dredging, drilling and blasting on the marine environment. As part of this option selection, the location of the BLNG Precinct was moved a minimum of 1km inland of James Price Point to reduce impacts on monsoon vine thickets and avoid the drainage basin community. It is estimated that this set back reduced potential disturbance to monsoon vine thicket by approximately 118ha. Direct impacts on this TEC are limited to the required shore crossing area of the BLNG Precinct and southern pipeline shore crossing only (**Figure 2.4-1**). The southern option was also favoured following assessment of the area by the traditional owners for heritage protection.



■ **Figure 2.4-1 Estimated Required Clearing of Conservation Significant Vegetation Communities.**

2.4.2. Identification of Key Aspects

2.4.2.1. Definition of Relevant Aspects

Aspects associated with the development and operation of the BLNG Precinct and associated infrastructure that may have an environmental impact on terrestrial flora and vegetation were identified in the Scope of the Strategic Assessment and considered in this assessment. These aspects are:

- vegetation and habitat clearing;
- groundwater abstraction;
- introduced weeds; and
- altered fire regime.

In addition to the above, the following aspects were considered to be applicable to this factor and have been considered in this section:

- physical presence of facilities and associated infrastructure;
- site disturbance and excavation; and
- terrestrial discharges and spills.

2.4.2.2. Sources of Potential Impact

The sources of potential impact on terrestrial ecosystem integrity are summarised under the aspect from which they were derived.

Vegetation and Habitat Clearing

Vegetation clearing, earthworks and vehicle movements would be required to facilitate construction and development of the BLNG Precinct and associated infrastructure. The extent of vegetation clearing for the BLNG Precinct, pipeline corridors, workers accommodation, light industrial area and ancillary infrastructure is expected to be up to a maximum of 3,037ha (**Table 2.4-3**). In the context of the ancillary infrastructure (including minor access roads and service corridors, Manari Road diversion and possible groundwater abstraction borefield) the total extent of vegetation loss cannot be accurately quantified at this early stage of BLNG Precinct layout definition. However, the extent of clearing will be within that defined in **Table 2.4-3**. A description of disturbance requirements for ancillary infrastructure and for fire management purposes is presented in **Table 2.4-4**. Siting of the light industrial area, workers accommodation and ancillary infrastructure outlined in **Table 2.4-4** will avoid areas of high habitat value where possible.

- **Table 2.4-3 Extent of Terrestrial Vegetation Clearing.**

Proposal component	Extent of vegetation disturbance (ha)
BLNG Precinct Project Area	Up to 2,090
Pipeline corridors	Up to 250
Workers accommodation	Up to 200
Light industrial area	Up to 200
Ancillary infrastructure	Up to 297
Total	**Up to 3,037ha***

Note: * Fuel reduction activities and clearing for fire access will be as described in the Fire Management Strategy, utilising the above infrastructure where practicable.

Table 2.4-4 Additional Infrastructure and Fire Management Vegetation Loss Details.

Activity	Additional information
Ancillary infrastructure including: • minor access roads; • service corridors; • Manari Road Diversion; and • borefield.	Clearing for minor access roads and service corridors will be required to link the Light Industrial Area and Workers Accommodation to the Main Access Road and Services Corridor. This will include: • road from Main Access Road to Workers Accommodation (100m corridor) and associated services corridor (60m); • road from Main Access Road to Light Industrial Area (100m corridor) and associated services corridor (60m); and • clearing required for other infrastructure such as the Manari Road diversion and borefield is subject to final design and layout. This total includes a nominal alignment for Manari Road diversion (1) and up to 22 groundwater bores, supported by an approximate 70m x 70m compound.
Fuel reduction activities and clearing for fire access within the Plan area in accordance with Fire Management Strategy.	As described in the Fire Management Strategy.

Note: [1] Clearing associated with Manari Road diversion may necessitate the loss of areas of high habitat value.
[2] A borefield in Broome sandstone may necessitate additional bores, however, the borefield source and location will be subject to further hydrogeological, cultural and ecological investigations. The size of the borefields will be dependent upon the selection of the water source for the BLNG Precinct and the total water demand for the BLNG Precinct development.

Vegetation and habitat clearing will result in the removal of vegetation which will affect significant ecological communities and may affect conservation significant flora (including Priority flora).

Groundwater Abstraction

Groundwater abstraction may be required for construction and operation of the BLNG Precinct. A number of options are currently under investigation to ensure permanent supply of water during construction and operation of the BLNG Precinct.

Groundwater abstraction may result in mid to long term groundwater drawdown. This could impact vegetation, that has some level of groundwater dependence as a result of groundwater drawdown such as monsoon vine thicket and drainage basin vegetation.

Introduced Flora Pests (Weeds)

Weeds can be introduced or spread during construction, operation or decommissioning activities. The main potential source for the introduction of weeds is in association with vehicles and machinery brought into the BLNG Precinct. The movement of vehicles, such as light and heavy machinery, is required to facilitate construction and development and operation of the BLNG Precinct and associated facilities and activities.

Weeds can result in additional competition to native flora species and may impact the quality of any significant ecological communities present in the area if not adequately managed.

Altered Fire Regime

The fire regime of the James Price Point coastal area has already been altered to the extent that the Pindan vegetation is considered in advanced long term decline (AECOM, 2010a; **Appendix C -19**). Vegetation clearing, construction activities, vehicles, and the BLNG plant and other equipment will introduce new ignition sources that could result in an increase in late (or dry) season fires if not properly managed. However, the reduction in informal access will reduce the incidence of wildfires caused as a result of human activity and potentially counteract the additional ignition sources. In addition, the presence of a large workforce in the area will enable fire management activities to be initiated prior to fires becoming uncontrolled.

An altered fire regime may result in altered vegetation structure and composition in areas surrounding the BLNG Precinct and may affect conservation significant flora or significant ecological communities.

Physical Presence of Facilities and Associated Infrastructure

Physical presence of facilities and associated infrastructure (including drainage measures) in the BLNG Precinct may alter the flow paths and volumes of surface water and subsequently the amount of surface water received by adjacent vegetation communities. Recharge of the local superficial aquifer of the dune system interface may also be altered as a consequence of changes to surface water flows and volumes.

Site Disturbance and Excavation

Site disturbance and earthworks for excavation and construction activities associated with the BLNG Precinct are likely to change the hydrology of the BLNG Precinct, such as surface water flows and recharge of the superficial aquifer. These activities may detrimentally affect flora of conservation significance and vegetation communities.

Terrestrial Discharges and Spills

The construction and operation of the BLNG Precinct and supporting infrastructure has the potential to result in unplanned discharges such as spills and leaks. Terrestrial discharges and spills, particularly non-routine discharges, may detrimentally affect flora and vegetation communities if not contained or managed properly.

2.4.2.3. Sensitivity and Resilience

Conservation Significant Vegetation

Monsoon vine thicket vegetation is listed as a Vulnerable TEC by the State with further classification into 'Criteria C', meaning that while this ecosystem is still widespread it is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes (DEC, 2009c), such as clearing for development, inappropriate fire regimes and weed invasion (DEC, 2009c). The Dampier Peninsula monsoon vine thicket TEC is considered the highest priority for monitoring in the Kimberley region due to the aforementioned threats (DEC, 2009e). The total area of the Dampier Peninsula monsoon vine thicket TEC is thought to have declined by approximately 40 percent since European settlement (DEC, 2009e).

Monsoon vine thicket vegetation has a wide distribution on the Dampier Peninsula, occurring from Broome in the south and up to the eastern Dampier Peninsula coastline. Monsoon vine thicket vegetation forms discrete narrow linear patches along the coast and are confined to the landward edge of coastal dunes. These characteristics mean that the community occupies a small area of extent within its known distribution and is highly vulnerable to disturbance through fragmentation and edge effects. Monsoon vine thickets are also at threat from degrading factors such as changes in fire regimes, impacts of recreational activities such as off-road driving and camping, and weed invasion (Black, 2001). Clearing of vegetation within the dune areas can also alter dunal movement, causing dunal blowouts, and potentially result in sand deposition on monsoon vine thicket vegetation.

Monsoon vine thicket and drainage basin vegetation in the James Price Point area appears to be maintained by both surface water and groundwater inflow (Ray Froend, 2010, pers. comm. Edith Cowan University, 25 June 2010). The surface water input pathways are directly through run-on into the area during the wet season, and indirectly via recharge of the local superficial aquifer. The removal of the dune system for the shore crossing and the physical presence of facilities and infrastructure associated with the BLNG Precinct may alter surface water flow paths and groundwater conditions and thus indirectly impact on the monsoon vine thicket.

Coastal heath vegetation appears to correspond with the Priority 1 PEC described as the "dwarf pindan heath community". The full extent of this community outside of the Broome townsite area is poorly known with apparently few, small occurrences, all or most not actively managed for conservation. The coastal heath vegetation forms discontinuous, narrow linear patches along the coast and, as with the monsoon vine thickets, are highly susceptible to fragmentation and edge effects. These communities are likely to be widespread along the coastline of the Dampier Peninsula, but have only a minor area of representation given the restricted position of this habitat type in the landscape (Biota, 2009c; **Appendix C-18**).

Conservation Significant Flora

Existing weed infestations within the monsoon vine thicket are likely to be having some impact on *Pittosporum moluccanum*, *Eriachne semiciliata* and *Polymeria distigma* are currently unlikely to be significantly impacted by weeds, as they appear to be widespread in occurrence, with specimens recorded in relatively undisturbed areas in pindan

woodland. *Gomphrena pusilla* (P2), associated with coastal community vegetation south of Quondong Point, was found to be growing in association with Buffel grass (Biota, 2009a).

Pittosporum moluccanum (P4) is restricted to the monsoon vine thicket community, which is known to be sensitive to fire. The population of *Gomphrena pusilla* located in the survey area during the wet season survey (Biota, 2009c; **Appendix C-18**) has since been burnt (AECOM, 2010a; **Appendix C-19**). Its sensitivity to fire is not currently known, however Biota (2010, pers. comm.) re-surveyed the area after the fire to determine if any recruitment had occurred in the burnt areas. Additional locations of *Gomphrena pusilla* were recorded during the survey. The sensitivity and resilience to fire of the remaining Priority flora known to occur and potentially occur is not currently known.

2.4.3. Predicted Impacts

Potential impacts on vegetation and flora from the construction and operation of the BLNG Precinct are discussed in detail in the following sub-sections and summarised in **Table 2.4-10**. Both direct and indirect impacts are considered within these sections. For the purpose of this assessment it is considered that direct impacts would largely be confined to areas of direct disturbance within the BLNG Precinct, and other locations where development activities are proposed to occur.

2.4.3.1. Potential Impacts to Terrestrial Flora and Vegetation due to Vegetation and Habitat Clearing

Vegetation and habitat clearing will occur as a result of site preparation in association with the BLNG Precinct, light industrial area, workers accommodation, pipeline corridors and ancillary infrastructure. The total land area required for the proposal is expected to be up to 3,037ha (**Table 2.4-2**). Additional to this, some fire management activities are proposed in areas surrounding the BLNG Precinct and associated project components to manage fuel loads and reduce the likelihood of fire. Fire management activities aim to manage and reduce the likelihood of fire and involve measures such as hazard reduction burns and vegetation thinning to reduce fuel loads. At this point vegetation disturbance as a result of fire management cannot be accurately quantified. A Fire Management Plan would be implemented during the construction, commissioning and operation phases.

The exact location of the clearing footprint within the BLNG Precinct area would be finalised as part of detailed planning and engineering studies. All infrastructure would be located within the BLNG Precinct with the exception of pipeline corridors, access road corridors, light industrial area and workers accommodation. Vegetation disturbance for the BLNG Precinct and associated infrastructure will not exceed those areas indicated in **Table 2.4-3**.

While the exact location and route of the northern and southern pipelines are to be confirmed, the routes shown in **Figure 2.4-1** have been used as the basis of this assessment. The final area (and location) of clearing associated with other ancillary infrastructure is currently uncertain. A framework for considering the potential impact of ancillary infrastructure has been proposed as part of the BLNG Precinct management measures.

Impacts on Significant Vegetation Communities

For the purpose of enabling a quantitative impact assessment on a local and regional scale, the local area has been defined as the combined mapped area provided by ENV (2008a; **Appendix C-14**) and Biota (2009c; **Appendix C-18**), representing the most reliable combined dataset of vegetation mapping in the James Price Point coastal area. The regional area is the portion of the Dampier Peninsula, comprising a large section of the IBRA Pindanland subregion, of known vegetation community extent surveyed to date during development of this Strategic Assessment Report. It does not include all areas of monsoon vine thicket surveyed by DEC as part of the MVT Recovery Plan (currently in draft), although this information is provided for reference in regional context.

The majority of vegetation types within the proposal area are of low conservation significance (Biota, 2009c; **Appendix C-18**) and are likely to be widely distributed and well represented in the wider region. The BLNG Precinct would have a localised impact to these vegetation types but is generally unlikely to have any regional implications due to their broad distribution. Four vegetation communities have been identified in the James Price Point coastal area that Biota (2009c; **Appendix C-18**) considered to have moderate to high conservation significance, for which there is varying regional significance associated with their disturbance. Their extent and the impacts on these vegetation types locally and regionally are outlined in **Section 2.4.1.2** and discussed below.

Monsoon Vine Thickets

Some clearing of the TEC monsoon vine thickets, which are of high conservation significance, will be necessary to construct the shore crossing between the BLNG Precinct and the Port Facility, and the southern pipeline (**Figure 2.4-1**). Clearing of this vegetation community is unavoidable as it runs parallel to the shore line at the BLNG Precinct location behind the foredunes. The setback of the BLNG Precinct area inland from the coast, as defined in the Master Plan, has minimised the area of coastal monsoon vine thicket at the selected site to be potentially disturbed by an estimated 118ha. Direct impacts to monsoon vine thickets could have been further reduced if the northern option was selected as the BLNG Precinct location, however, analysis indicated that the northern location would have likely resulted in greater costs, visual impact and marine environmental impacts (for example more blasting and dredging would have a greater impact on seagrass, corals and EPBC Act listed marine species) than the chosen southern option, and hence was considered less appropriate. In addition the location of listed cultural heritage locations south of James Price Point was a key consideration in selecting a preferred shore crossing location.

A total of 572ha of monsoon vine thicket vegetation is found in the James Price Point coastal area. Of this area up to 132.4ha of monsoon vine thicket will be removed as part of the proposal. This loss equates to the removal of up to 23.2% of this community's distribution within the James Price Point coastal area (**Table 2.4-5**).

Based on the results of the CSIRO spatial analysis, the total area of monsoon vine thicket on the Dampier Peninsula is at least 1,479ha (refer **Part 4, Section 1** (Environmental Overview)). With reference to this data, the removal of the monsoon vine thicket associated with the Proposal will be up to 9% of regional extent (**Table 2.4-5**).

Recent DEC mapping has indicated that up to 2,710ha of monsoon vine thicket TEC may occur on the Dampier Peninsula (V. English, 2010, pers. comm. DEC, 20 July 2010). Using this data, the removal of the monsoon vine thicket associated with the Proposal will be up to 4.9%.

The clearing of up to 9% (or 4.9% using DEC estimates) of the known extent of the monsoon vine thickets on the Dampier Peninsula, would not represent a significant impact or detrimentally affect the viability and representation of this community on the Dampier Peninsula as more than 90% of the known extent of monsoon vine thickets will remain. In addition, at a local scale 439ha of monsoon vine thicket would remain within the James Price Point coastal area. It is noted that the monsoon vine thickets vary in structure and species across the Peninsula with vine thickets increasing in species diversity and structural composition progressively towards the northern end of the Peninsula (McGilvray, 2008).

Non-metric Multi Dimensional Scaling (**MDS**) was undertaken to further quantify similarities in patches of monsoon vine thicket vegetation across the Dampier Peninsula (Biota, 2009c; **Appendix C-18**). An analysis of quadrat data collected from Perpendicular Head-North Head (approximately 92km north of James Price Point), Packer Island (approximately 126km north east of James Price Point) and Quondong Point and James Price Point was undertaken by Biota (2009c; **Appendix C-18**). Ordination using the results of the ENV and Biota surveys showed that the monsoon vine thicket at James Price Point formed a loose aggregation with the five sites of monsoon vine thicket vegetation from the Packer Island study area. The results of this analysis indicate that monsoon vine thicket from James Price Point is similar in floristic composition to that occurring 110km north east. This is important as it provides an indication that monsoon vine thicket communities mapped at James Price Point are floristically similar to those occurring elsewhere on the Dampier Peninsula. While monsoon vine thicket at James Price Point represents a large area of this community's extent, the MDS analysis suggests that this community is unlikely to be floristically distinct from monsoon vine thicket associations occurring in areas elsewhere in the region.

Ongoing weed and fire management of the 439ha of monsoon vine thicket retained within the vicinity of the BLNG Precinct may result in improved quality of the remnants and will help to manage some of the issues known to be affecting monsoon vine thicket quality on the Dampier Peninsula.

Vegetation clearing and its replacement with the physical presence of the BLNG Precinct have the potential to indirectly impact on the remaining monsoon vine thicket community through altering of surface water flows. As previously mentioned monsoon vine thicket vegetation appears to be maintained by both surface water and groundwater inflow.

Drainage Basin Communities

Two drainage basin vegetation communities were mapped in the James Price Point coastal area totalling 395ha (refer **Part 4**, **Section 1** (Environmental Overview). This vegetation type had two species (*Lophostemon grandiflorus* and

Melaleuca dealbata) not recorded elsewhere in the James Price Point coastal area and was therefore deemed to have a high conservation significance by Biota (2009c; **Appendix C-18**) due to its local scarcity. No direct impact on these communities is expected as a result of clearing activities associated with the BLNG Precinct.

Vegetation clearing and its replacement with the physical presence of the BLNG Precinct have the potential to indirectly impact on the drainage basin community through altering of surface water flows. As with the monsoon vine thicket vegetation, drainage basin vegetation appears to be maintained by both surface water and groundwater inflow.

Coastal Heath

The 114ha of coastal heath mapped in the James Price Point coastal area (refer **Part 4**, **Section 1** (Environmental Overview)) may correspond to the PEC (Priority 1) described as the dwarf pindan heath community and hence is considered to be of moderate conservation significance (Biota, 2009c; **Appendix C-18**). Up to 8.9ha of this vegetation may be cleared for construction of the northern pipeline representing a local loss of approximately 7.8% of the coastal heath (**Table 2.4-5**). Regionally, 705ha of coastal heath has been mapped at four sites on the Dampier Peninsula (ENV, 2008a; **Appendix C-14**) and the 8.9ha of clearing proposed represents only 1.3% of the mapped extent of this vegetation type on the Dampier Peninsula. It is noted that the unit identified by Biota (2009c; **Appendix C-18**) as eroded coastal Pindan, which contains no vegetation, was mapped as coastal heath by ENV (2008a; **Appendix C-14**) in their survey of James Price Point and is included in the total regional estimation for coastal heath (Biota, 2009c; **Appendix C-18**). In the James Price Point coastal area, 51.5ha of eroded coastal Pindan was mapped and therefore the coastal heath mapped by ENV (2008a; **Appendix C-14**) in the wider region may potentially include unvegetated areas and as such a larger percentage of regional coastal heath may be cleared for the proposal. The known regional extent of coastal heath on the Dampier Peninsula (705ha) is likely to be an underestimate as mapping has only been conducted at four sites.

Coastal Communities

Coastal communities are likely to be widespread along the coastline of the Dampier Peninsula, but due to the restricted position of this habitat type in the landscape, they only have a minor area of representation. Biota (2009c; **Appendix C-18**) considered these communities to be of moderate conservation significance based on their restricted location. Clearing of this vegetation community for the BLNG Precinct is unavoidable as it occurs along the majority of the coastline in the James Price Point coastal area (refer **Part 4**, **Section 1** (Environmental Overview)). Up to 34.5ha of coastal community vegetation may be removed for the shore crossing between the BLNG Precinct and Port Facility, and construction of the southern pipeline. This represents a 5.9% loss of this vegetation type in the James Price Point coastal area, taking into account the total estimated area of 583ha. Based on the small area of habitat to be removed, clearing will not result in significant local impacts of the community's distribution and abundance. On a regional scale, this amount of clearing represents only 0.9% of the mapped extent of this vegetation type on the Dampier Peninsula (3,712ha, refer **Table 2.4-5**). In addition, the known regional extent of coastal communities on the Dampier Peninsula (3,712ha) is likely to be an underestimate as mapping has only been conducted at four sites.

- **Table 2.4-5 Estimated Disturbance of Conservation Significant Vegetation Communities in a Local and Regional Context.**

Vegetation community	Preliminary estimate of area to be cleared (ha)	Approximate area mapped in the James Price Point coastal area (ha)*	Disturbance within the James Price Point coastal area (%)	Known community extent mapped on Dampier Peninsula (ha)*	Disturbance within the Dampier Peninsula (%)
High conservation significance (as determined by Biota 2009a)					
Monsoon vine thickets (TEC)	132.4	572	23.2	1,479[1] (2,710[2])	9.0[1] (4.9[2])
Drainage basins	0	395	0	1,018	0
Moderate conservation significance (as determined by Biota 2009a)					
Coastal heath (PEC)	8.9	114	7.8	705	1.3
Coastal communities	34.5	583	5.9	3,712	0.9

Note Vegetation clearing takes into account the total land area requirements for the BLNG Precinct and ancillary infrastructure. Vegetation clearing associated with the pipeline corridors has been presented as the maximum extent of required area within the corridor buffers.

* Estimates based on the combined mapping by Biota (2009c; **Appendix C-18**), ENV (2008a; **Appendix C-14**) and CSIRO (2010; **Appendix C-21**)

1 Based on results of monsoon vine thicket TM spatial analysis conducted by CSIRO (2010; **Appendix C-21**).

2 Based on recent mapping studies of monsoon vine thicket conducted by the DEC.

The establishment of conservation areas, in alignment with the State Government's commitments as part of the Kimberley Science and Conservation Strategy, will offer greater protection to conservation significant vegetation communities. Protection of areas of conservation significant communities in the Dampier Peninsula is a key criterion for establishing the location and boundaries of proposed or potential reserves. Currently large areas of these vegetation communities remain in the region; however, little is within conservation reserves. Currently, only one conservation reserve exists on the Dampier Peninsula, Coulomb Point Nature Reserve, and it does not include a good representation of coastal communities, drainage basins or monsoon vine thickets (Burbidge *et al.* 1991). Refer to **Section 2.4.4** and **Part 6**, for State commitments specific to this conservation objective.

Impacts on Flora of Conservation Significance

No Declared Rare Flora will be affected by the proposed BLNG Precinct as none have been recorded or are expected to occur within the BLNG Precinct boundary.

A number of species of Priority flora have been recorded within and adjacent to the James Price Point coastal area (**Part 4**, **Section 1** (Environmental Overview)). Avoidance of all known occurrences of Priority flora will not be possible and some impacts are anticipated.

***Gomphrena pusilla* (Priority 2)**

Gomphrena pusilla was recorded from ten locations in the James Price Point coastal area occurring on or immediately behind coastal dunes in the coastal communities and evergreen monsoon vine thicket vegetation units (Biota, 2009c; **Appendix C-18**, Biota 2010 pers. comm.). Although up to 34.5ha of potentially suitable coastal community habitat will be disturbed as a result of the proposal, this vegetation type is widespread on the Dampier Peninsula. Furthermore, more than 90% of the known extent of monsoon vine thickets will remain, taking into account the proposed clearing envelope. This flora species is known from the Dampier Peninsula and from the northern Pilbara coast (Biota; 2009b; **Appendix C-17**). This amount of clearing is unlikely to affect the long-term survival and distribution of the species. Within the BLNG Precinct, this species has been recorded within the shore crossing area.

***Eriachne semiciliata* (Priority 3)**

Eriachne semiciliata was recorded from numerous locations in the James Price Point coastal area and was widespread. The majority of the occurrences were within the Pindan shrubland vegetation type (57% of occurrences), with additional occurrences within deciduous vine thicket vegetation (33%), coastal heath (10%) and tall closed scrub vegetation (10%). Therefore this species may be more widely distributed throughout the Proposal area and Dampier Peninsula. As such long term impacts to the local population are considered unlikely. Within the BLNG Precinct this species was recorded in both the 2009 and 2010 Biota studies, with the 2010 study recording this species in the deciduous monsoon vine thicket in addition to the Pindan vegetation (Biota, 2010, pers. comm., June 2010).

***Polymeria distigma* (Priority 3)**

There were four occurrences of *Polymeria distigma* within the James Price Point coastal area from three locations in the south of Quondong Point and one location approximately 8km to the northeast of the proposed BLNG Precinct (Biota, 2009c; **Appendix C-18**). These populations will not be affected by the BLNG Precinct. All occurrences were located within Pindan shrubland vegetation. Some Pindan shrubland which may support this species will be disturbed for the Proposal. However Pindan shrubland is widely distributed throughout the James Price Point coastal area outside the potential disturbance areas and the wider region and therefore there remains sufficient habitat to support this species locally and regionally.

***Pittosporum moluccanum* (Priority 4)**

Two occurrences of this species have been recorded in the James Price Point coastal area, with both of these occurrences close to the potential disturbance area (Biota, 2009c; **Appendix C-18**). Both of these records occur within evergreen monsoon vine thickets. Searches were carried out in suitable habitat adjacent to these individuals, however no additional plants were located. Up to 132.4ha of monsoon vine thickets, including both evergreen and deciduous, will be disturbed as part of the BLNG Precinct development, hence some potential habitat for this priority species may be affected. However, it is estimated that at least 1,479ha of monsoon vine thickets exist throughout the Dampier Peninsula and therefore sufficient habitat will remain to support this species locally and regionally. Furthermore, *Pittosporum moluccanum* is known in Australia from a few scattered locations along the WA coast in the Dampier land and North Kimberley bioregions, extending east into the Northern Territory (Biota, 2009c; **Appendix C-18**). The closest known populations are on the Maret Islands and Berthier Island, in the northern Bonaparte Archipelago, some 700km north of the survey area (AECOM, 2010a; **Appendix C-19**). Therefore the populations within the James Point coastal area may be significant, representing range extensions for this species. However, this may be a reflection of the lack of survey effort in the Dampier Peninsula and the species may be more widely distributed. Further targeted surveys will be undertaken in the monsoon vine thicket to characterise the distribution of this species in the James Price Point coastal area.

***Pterocaulon* sp. A Kimberley Flora (Priority 2)**

Two populations of this species were recorded south of the James Price Point coastal area, close to Barred Creek (Biota, 2009c; **Appendix C-18**). These occurrences will not be affected by the Proposal. While DEC records show that this species has been identified to the south and north of James Price Point, surveys undertaken by Biota (2009c; **Appendix C-18**) in the drainage basin did not identify any specimens. It is therefore unlikely that the species exists in the footprint area. It should be noted that drainage basin communities are unlikely to be directly affected by the BLNG Precinct. Further surveys in areas where the species has the potential to occur (within *Melaleuca* vegetation in drainage lines) will be undertaken prior to development.

***Lophostemon grandiflorus subsp. grandiflorus* (nominated as Priority 3)**

The nominated Priority flora species *Lophostemon grandiflorus* subsp. *grandiflorus* (recommended to be listed as Priority 3) was recorded at two locations within the James Price Point coastal area and at two additional locations to the north of James Price Point near Flat Rock. This species is likely to occur in association with areas of poor drainage such as the drainage basin communities mapped at James Price Point and Coulomb Point to the north. Additional populations of this species were found on the north side of the Great Northern Highway adjacent Taylors Lagoon during previous work by R. Barrett, T. Willing and K. Kenneally (AECOM, 2010a; **Appendix C-19**) and at Coulomb Point, indicating that the species is not restricted to the local area. Populations of *Lophostemon grandiflorus* subsp. g*randiflorus* were also recorded near the Edgar Range and near Wyndham, however these have not been relocated and both may have been burnt out. The Dampier Peninsula populations may be the only ones extant in WA and they represent a significant disjunction from the

nearest populations in the NT. This species is likely to be restricted to drainage basin communities to be retained within James Price Point.

Prior to development, further searches for Priority flora will be undertaken of the proposed light industrial area, pipeline and infrastructure corridors, and workers accommodation area to avoid populations as far as practicable in finalisation of location, layouts and routes.

Other Flora

Other flora species recorded outside of the BLNG Precinct area (AECOM, 2010a; **Appendix C-19**) that have some conservation significance include:

- *Merremia davenportii* – currently unlisted in WA but may be nominated as Priority 3, recorded on coastal strip north of proposed BLNG Precinct location;
- *Cleome* sp. Dampier Peninsula (R.L. Barrett and A. Sleep RLB 5962) – new species that may be nominated as Priority 3 as it requires further survey to determine its conservation status, recorded at Barred Creek;
- *Pandanus spiralis* var. *convexus* – southernmost population, recorded at Barred Creek; and
- *Nothocastoreum* sp. nov. aff. *cretaceum* (Lloyd) G.W. Beaton – poorly known taxon, third record of this genus in WA, recorded in northeast of BLNG Precinct.

The locations of these species are unlikely to be directly affected by the proposal as they are either considerably south or north of the proposed BLNG Precinct location. The *M. davenportii* record may be affected by the northern pipeline but its location has not been finalised. Potential habitat for all of these species is likely to be affected by the proposal.

There are some areas within the James Price Point Coastal area, such as drainage lines, that still require survey to determine the status of conservation species that are likely to occur in these areas, such as the Priority 1 taxon *Aphyllodium parvifolium*. To date access to these areas have been limited given the sensitive heritage values present. Prior to development, further searches for significant flora will be undertaken in these areas such that populations can be avoided as far as practicable during finalisation of location, layouts and routes.

The construction and operation of the BLNG Precinct would result in the clearing of terrestrial vegetation, as discussed in previous sections. This impact most notably includes the removal of up to 9% of monsoon vine thicket community within the Dampier Peninsula and limited loss of drainage basin vegetation, and coastal communities. Recent DEC mapping has indicated that up to 2,710ha of monsoon vine thicket TEC may occur on the Dampier Peninsula. Using this data, the removal of the monsoon vine thicket associated with the Proposal will be up to 4.9%. In addition, vegetation clearing is highly likely to remove populations of priority flora occurring in the Precinct footprint.

It is expected that potential impacts to terrestrial flora and vegetation can be minimised through measures such as the implementation of a management and monitoring strategy for vegetation of medium to high conservation significance and measures to limit the extent of areas to be cleared. A more detailed description of proposed mitigation measures is presented in **Section 2.4.4**. The significance of residual impacts on terrestrial flora and vegetation due to vegetation clearing resulting from site disturbance and excavation activities is assessed to be high as local site clearing cannot be further avoided.

Vegetation and habitat clearing also has the potential to create air emissions (dust) and this is addressed in **Part 4**, **Section 2.8**.

2.4.3.2. Potential Impacts to Terrestrial Flora and Vegetation due to Groundwater Abstraction

Groundwater abstraction has the potential to lower groundwater levels either directly if the abstraction is from an unconfined surface aquifer or indirectly if the abstraction is from a semi-confined lower aquifer where the abstraction would cause leakage from the upper aquifer(s). The extent and magnitude of any groundwater level drawdown will depend on the aquifer, borefield layouts, groundwater pumping rates and duration. At present it is assumed that groundwater abstraction would occur from underlying aquifers and not from superficial aquifers on which monsoon vine thicket TEC and drainage basin are potentially reliant.

Groundwater Dependant Ecosystems (**GDE**) are regarded as ecosystems supporting plant species which require groundwater for survival. Key indicators of GDEs are generally species known to rely on groundwater for survival. It is

unlikely that the species within the James Price Point coastal area are wholly dependent on groundwater for survival. These species are referred to as phreatophytes and are highly linked to permanent water sources for water uptake.

Due to a lack of physiological and/or morphological adaptations to drought, phreatophytic vegetation often shows a low tolerance to water stress for extended periods of time (Graham, 2001). Phreatophytes respond to significant and/or rapid groundwater drawdown by a decline in health and eventual death. Proposed groundwater abstraction will cause localised drawdown of the water table, which could affect phreatophytic vegetation if it occurs in proximity to abstraction bores. Long term abstraction may have a resulting impact on the long-term viability of any GDEs within the James Price Point coastal area, if not appropriately managed. If the rate and extent of drawdown is beyond the natural tolerance of the phreatophytic species present, it may cause a decline in the condition and a ‘retreat’ in the extent of this vegetation. A gradual drop in groundwater levels within the tolerance of the plants may allow dependent species time to adapt to the altered conditions. Such adaptations would include extension of roots into the lowered water table.

Areas within the project area that are considered potentially to support phreatophytic vegetation are those in areas less than 10m above sea level close to the coast where the groundwater is likely to be within 10m of the ground surface (Ray Froend, 2010, pers. comm. Edith Cowan University, 25 June 2010). This assumption is based on groundwater discharging at the coast high tide level and that vegetation growing in areas of less than 10m depth to groundwater may have some level of groundwater dependence. In particular, some areas along the coast are at or below 10m above sea level including areas of vine thicket and drainage basin vegetation communities adjacent to the dunes.

Monsoon vine thicket vegetation in the James Price Point area appears to be maintained by both surface water and groundwater inflow. It is also likely that the drainage basin community is supported in the same way. The surface water input pathways are directly through run-on into the area during the wet season, and indirectly via recharge of the local superficial aquifer. Given the depth to the superficial aquifer surface and knowledge of the lithology in the monsoon vine thicket habitat, it is likely that some of the dominant species are utilising groundwater reserves. However the degree of groundwater used is likely to vary spatially and temporally and soil water in the vadose zone (zone between the land surface and water table within which the soil is unsaturated) could be the dominant source of water in places where the depth to the water table is greater than 10m.

Further evaluation of the likely level of groundwater dependence of monsoon vine thickets and drainage basin vegetation communities together with detailed ground water mapping following field investigations, will be undertaken to inform a groundwater operating strategy for construction and operations. The operating strategy would be designed such that the extent and rate of groundwater drawdown beneath retained vegetation communities, found to have some level of groundwater dependence, does not exceed that determined to likely be tolerable of these vegetation communities. This may include locating bores as far away as possible from vegetation likely to have some level of groundwater dependence and/or changing the rates of abstraction and period over which water is drawn to alter the extent of drawdown experienced under these areas. The groundwater operating strategy would be prepared to support an application for licence to abstract water under the RIWI Act. If the groundwater licence application(s) is considered unacceptable by Department of Water the use of desalination as a contingency water supply has been assessed in this strategic assessment.

The potential impacts of groundwater abstraction will be investigated and assessed in future groundwater licence applications under the RIWI Act and will include those associated with saltwater intrusion, impacts on other groundwater users, inter-aquifer contamination, groundwater level drawdown, impacts on groundwater dependent ecosystems and possible reductions in baseflow to surface water features. This licensing process provides a high degree of confidence that the environmental impacts of the proposed groundwater abstraction will be assessed by the Department of Water and that no unacceptable environmental or social impacts will be approved.

It is expected that the potential Impacts to terrestrial flora and vegetation due to groundwater abstraction can be successfully mitigated by the application of management and mitigation measures such as appropriate design and location of borefields and monitoring potential impacts. A more detailed description of proposed mitigation measures is presented in **Section 2.4.4**. The significance of the residual impact on terrestrial flora and vegetation due to groundwater abstraction is assessed as being very low, as this will be appropriately controlled under licence requirements set and monitored by the Department of Water who will not issue a licence unless it is demonstrated that significant impacts are manageable.

2.4.3.3. Potential Impacts to Terrestrial Flora and Vegetation due to Introduced Flora Pests

Clearing of vegetation for the BLNG Precinct and associated infrastructure, and the increased volume of vehicle and machinery movements, have the potential to result in the introduction or further spread of existing weed species into significant ecological communities and vegetation that supports Priority Flora within the James Price Point coastal area. Native flora and vegetation within the project area may be indirectly impacted by the introduction and spread of weeds through increased rates of competition for light, nutrients, water and space, which may ultimately reduce biodiversity. It is considered likely that the implementation of weed control measures, quarantine procedures and a management and monitoring strategy for vegetation of medium to high conservation significance would reduce the incidence of weed species and potentially improve the quality of vegetation communities, including monsoon vine thicket within the James Price Point coastal area. It is unlikely that new introductions of weeds will occur from terrestrial pathways (vehicles and excavation activities) as there is already uncontrolled access and weeds established in the area.

It is unlikely that construction and operation of the BLNG Precinct, with implementation of appropriate mitigation measures, will significantly increase the impact of weed invasion on significant communities as disturbance will be localised.

While there is the potential for introduced flora pests to indirectly impact native flora and vegetation within the James Price Point area it is expected that they can be successfully mitigated by the application of management and mitigation measures such as the implementation of ongoing weed control, quarantine procedures and a management and monitoring strategy for vegetation of medium to high conservation significance. A more detailed description of proposed mitigation measures is presented in **Section 2.4.4**. The significance of the residual impacts to native flora and vegetation from introduced flora pests is assessed as to be low as it is likely that, with the application of the proposed mitigation measures, there will reductions in the incidence of weed species and improvements in the quality of vegetation communities.

The assessment of impacts to vegetation communities from weed invasion is discussed in detail in **Part 4**, **Section 2.7**.

2.4.3.4. Potential Impacts to Terrestrial Flora and Vegetation due to Altered Fire Regime

The current frequent fire regime on the Dampier Peninsula is considered to be having a negative impact on all vegetation types (Graham, 2001). In the monsoon vine thickets, frequent fire threatens the many species that require long periods between fires in order to flourish and is likely that each burn is causing a retreat in their extent. Priority species found within these habitats may be similarly affected. Vegetation clearing, construction activities, vehicles, and the BLNG plant and other equipment will introduce new ignition sources that could result in an increase in late (or dry) season fires. However, this is likely to be offset by the reduction in informal access which will reduce the incidence of wildfires caused as a result of human activity. In addition, the presence of a large workforce in the area will enable fire management activities to be initiated prior to fires becoming uncontrolled.

The introduction of a fire management plan as well as other strategies designed to monitor and manage threats to conservation significant vegetation communities, is likely to result in a reduction of frequent high intensity fires and has the potential to result in improvements to the condition of vegetation communities such as monsoon vine thicket.

It is expected that altered fire regimes arising from development activities that may impact terrestrial flora and vegetation in the vicinity of the BLNG Precinct can be mitigated by the application of mitigation measures such as the implementation of a managed fire regime in areas around the precinct including the application of low intensity prescribed burning. A more detailed description of proposed mitigation measures is presented in **Section 2.4.4**. The significance of the residual impact is assessed as low as it is likely that the implementation of a managed fire regime will result in reduced fire intensity and improvements to vegetation condition.

2.4.3.5. Potential Impacts to Terrestrial Flora and Vegetation due to Physical Presence of Infrastructure

The physical presence of the BLNG Precinct and subsequent alterations to natural surface water flow regimes have the potential to degrade vegetation communities which are sensitive to surface water flows due to the creation of drainage shadow effects and localised flooding or ponding. Vegetation communities within the James Price Point which may be sensitive to surface water flows include the drainage basin habitat, as suggested by the presence of the flora species *Melaleuca dealbata* and *Lophostemon grandiflorus*, and the monsoon vine thicket habitat, based upon the data

presented by the Department of Water (**DoW**) discussion papers (Dow, 2009b), and information summarised in **Part 4**, **Section 1** (Environmental Overview).

Vegetation and flora in James Price Point coastal area may be affected by the following potential alterations to the existing surface water regime:

- alteration of minor drainage channels;
- shadowing of natural downstream catchments;
- ponding and flooding of surface water runoff from the BLNG Precinct; and
- contamination of surface water from the BLNG Precinct.

Surface hydrology has been inferred largely from a desktop study review of regional information available and as described in the aspect impact assessment modules prepared for the BLNG site. Baseline site specific hydrological investigations are currently being undertaken.

With the large dune system currently acting as a barrier, it is unlikely that the two drainage lines present in the James Price Point coastal area drain into the ocean. Instead, it is understood that when runoff volumes exceed the infiltration capacity of the dunes, runoff drains into the local landscape, particularly in the area where the drainage basin community has been identified. It is possible that the monsoon vine thicket and drainage basin communities may be supported by the interaction of this drainage system and the groundwater system, but this is subject to further investigation.

The physical presence of the BLNG Precinct also has the potential to affect surface and groundwater flows to superficial aquifers which may occur in association with the coastal dune and, along with seasonal surface water flows, may be responsible for supporting monsoon vine thicket and drainage basin communities. Groundwater levels within the superficial aquifers are unknown, but given the likely connectivity between these deposits and the underlying Broome Sandstone, a shallow depth to the water table near the coast may be present. Groundwater conditions within this area and interrelationships with vegetation communities such as monsoon vine thickets will be examined as part of further groundwater investigations and modelling.

As described in **Section 2.4.4**, it is proposed that an Ecological Surface Water Requirements Management Plan be developed to prevent, as far as practicable, impacts to surface water dependant vegetation and habitat types. Following completion of hydrological studies it will be possible to gain a detailed understanding of the relationship between vegetation communities and surface water flow requirements. It is likely that this information will be used to identify opportunities to manage flows to sensitive vegetation types such as monsoon vine thicket and the drainage basin community.

It is expected that alterations to natural surface water flow regimes that may result from the physical presence of infrastructure within the BLNG Precinct can be mitigated by the application of mitigation measures which will be detailed in an Ecological Surface Water Requirements Management Plan such as engineering to maintain surface flows to areas where flows are obstructed where practicable. A more detailed description of proposed mitigation measures is presented in **Section 2.4.4**. Given the localised nature and scale of such impacts and implementation of the management and mitigation measures it is assessed that the significance of the residual impacts is low.

Assessment of the impacts associated with altered surface water flows is discussed in detail in **Part 4**, **Section 2.2**.

2.4.3.6. Potential Impacts to Terrestrial Flora and Vegetation due to Site Disturbance and Excavation

Site disturbance and excavation activities associated with the construction of the BLNG Precinct have the potential to indirectly impact flora and fauna due to:

- localised drawdown; and
- dust deposition.

The monsoon vine thicket and drainage basin communities are likely to be reliant on a combination of surface water flows, groundwater and superficial aquifers present within coastal dune systems. Groundwater levels are currently unknown however, it is considered possible that excavation of the coastal dune for the shore crossing may intercept this superficial aquifer or localised aquifers. Monsoon vine thicket vegetation will be removed as a result of the shore

crossing, however, should any superficial aquifers supporting monsoon vine thicket vegetation be intercepted during excavations this may have the potential to result in draw down and impact adjacent areas of monsoon vine thicket. Draw down will also have the potential to indirectly impact on the drainage basin communities. If the rate and extent of drawdown is beyond the natural tolerance of the dependant species and communities present, it may cause a decline in the condition and a 'retreat' in the extent of this vegetation. A gradual drop in groundwater levels within the tolerance of the plants may allow dependent species time to adapt to the altered conditions. Such adaptations would include extension of roots into the lowered water table. Impacts to groundwater levels associated with site disturbance and excavation activities would be considered as part of future groundwater licence applications under the RIWI Act. This licence application would be supported by detailed hydrogeological studies and modelling so that an accurate assessment of likely impacts can be conducted.

Construction activities such as vegetation clearing and earthworks, traffic movements on unsealed roads, trenching and loading may potentially result in carriage of dust onto nearby vegetation and into ephemeral drainage lines. Dust generation is likely to be more pronounced during construction rather than during the BLNG Precinct's operational phase.

Dust deposition on vegetation surrounding site clearing and construction areas has the potential to affect vegetation surrounding these locations. Impacts of dust deposition on plant species include reduced plant health and stunted growth. Such impacts are likely to be restricted to the immediate area surrounding clearing and earth work locations. Experience with past projects has shown that dust control methods such as water spraying and ground restoration are effective in reducing the area of potential impact. Assessment of the impacts associated with dust emissions is discussed in detail in **Part 4**, **Section 2.8**.

Dust emissions will be controlled through the application of standard measures to minimise off-site effects, which will be defined in construction environment management plans for the works in accordance with industry practice.

It is expected that the impact on flora and vegetation from dust deposition and localised draw down of groundwater due to site disturbance and excavation can be mitigated by measures such as the requirement for qroundwater licences and industry practice dust control measures. A more detailed description of proposed mitigation measures is presented in **Section 2.4.4**. Given the localised and temporary nature of such impacts, and the implementation of the appropriate management and mitigation measures it is assessed that the significance of the residual impact is medium.

Site disturbance and excavation activities also have the potential to create acid sulphate soils and the impacts are discussed in detail in **Part 4**, **Section 2.1**.

2.4.3.7. Potential Impacts to Terrestrial Flora and Vegetation due to Terrestrial Wastes and Discharges

Leaks, spills or the incorrect disposal of chemicals, hydrocarbons or wastes have the potential to cause deterioration in plant health due to toxic effects. Such non-routine discharges could occur during construction and operational phases, however, spill response procedures will be implemented to contain and rectify any spills and minimise adverse impacts to flora and vegetation.

It is expected that potential impacts on flora and vegetation from terrestrial wastes and discharges will be minor following the implementation of appropriate management and mitigation measures such as the storage of chemicals and hydrocarbons in bunded areas, contaminated surface water run-off capture and treatment prior to discharge to the environment, and the implementation of the actions specified in an Emergency Response Plan. A more detailed description of proposed mitigation measures is presented in **Section 2.4.4**. The significance of the residual impact from terrestrial discharges, including non-routine events on flora and vegetation is assessed to be very low as there is a low likelihood of uncontained spills and comprehensive emergency response measures will be in place to minimise impacts.

2.4.4. Management Measures

Mitigation measures and safeguards that have been identified to manage potential impacts to terrestrial flora and vegetation are outlined below in **Table 2.4-6**, **Table 2.4-7**, **Table 2.4-8** and **Table 2.4-9**.

The Proponent recognises the conservation significance and key environmental asset of the monsoon vine thicket vegetation community and is committed to making ongoing engineering refinements to minimise and mitigate the direct and indirect impacts of the BLNG Precinct on the community. The management measures will be developed in consultation with DEC.

- **Table 2.4-6 State Government Measures for Flora and Vegetation.**

State Government measure	Responsibility	Timing
The State Government commits, through the implementation of the Dampier Peninsula Land Use and Infrastructure Plan, to facilitate the establishment of additional nature reserves and/or National Parks within the Dampier Peninsula to secure representative vegetation of the Peninsula in reserves, protect fauna habitat of rare and specially protected fauna and to protect Aboriginal culture and heritage. The establishment of a National Park and its location will be in accordance with agreements with Traditional Owners.	DSD through its involvement in the BLNG Precinct Control Group, with advice from State Planning Commission, DEC and Traditional Owners.	Throughout the life of the Plan.
Mitigation measures to avoid impacts on terrestrial conservation areas from indirect activities associated with the implementation of the Plan include: • assist with fire and weed management in and around Coulomb Point Nature Reserve and any other nature reserves established in the vicinity of the Precinct in collaboration with the DEC; • DEC to monitor visitor numbers to Coulomb Point Reserve camping area; and • DEC to develop a management plan for the Coulomb Point Reserve.	DSD through its involvement in the BLNG Precinct Control Group, with advice from DEC.	Throughout the life of the Plan.
Prepare and implement a Fire Management Strategy for the Dampier Peninsula to align with existing fire management strategies to reduce the frequency of fires and the occurrence of late dry season burns on the Peninsula.	DSD through its involvement in the BLNG Precinct Control Group, with advice from DEC and Indigenous ranger groups.	Prior to commencement of construction of an LNG plant.
Prepare an overarching Emergency Response Plan that addresses: • risk assessment of potential emergencies (including bushfires, introduction of foreign pests, flooding and spills); • emergency response equipment and training; • emergency response procedures; • responsibilities during emergency response; and • reporting, review and improvement as required.	DSD through its involvement in the BLNG Precinct Control Group, with advice from FESA.	Prior to commencement of construction of an LNG plant.
Prepare and implement a closure and decommissioning strategy for the Browse LNG Precinct and related activities for the purpose of providing a timely and consistent approach to removal or retention of plant and infrastructure, rehabilitation of disturbed areas and identification of contaminated areas.	DSD through its involvement in the BLNG Precinct Control Group.	5 years prior to decommissioning of BLNG Precinct infrastructure.
Prepare and implement an engagement plan to manage all interactions with public users of the marine and terrestrial environment in and around James Price Point, including recreational users and tourism operators.	DSD through its involvement in the BLNG Precinct Control Group, with advice from Broome Port Authority and LandCorp.	Prior to the commencement of construction.
Develop and implement a Management and Monitoring Strategy for Vegetation of Medium to High Conservation Significance, with particular reference to remnant monsoon vine thicket and drainage basin vegetation. The Strategy will inform all proponents of derived proposals of requirements for detailed management plans specific to individual activities and will include a framework in which the following Plans will be implemented: • Fire Management Plan; • Terrestrial Fauna Management Plan; • Terrestrial Weed Management Plan; and • appropriate management of hydrology (both surface water and groundwater). Refer also the commitment for Ecological Surface Water Requirements Management Plan and surface water and groundwater management commitments in **Part 4**, **Section 2.2** and **Section 2.3**. The effectiveness of the Strategy is to be measured via condition and health monitoring for a defined area within and surrounding the BLNG Precinct area and associated buffer zones. Annual reporting on success of the program is to be made publicly available.	DSD through its involvement in the BLNG Precinct Control Group, with advice from DEC.	Throughout the life of the Plan.

- **Table 2.4-7 Proposed Environmental Conditions for the Strategic Proposal that may affect Flora and Vegetation.**

Condition No.	Proposed Environmental Conditions for the Strategic Proposal
T3.1	Proponents of derived proposals shall not cause the loss of vegetation including monsoon vine thicket in excess of the limits of cumulative loss prescribed in **Table 2.4-8** for the BLNG Precinct.
T1.2	Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address: • detailed measures to be implemented for final closure; • the schedule and timing of final closure activities; • completion criteria for closure; and • closure monitoring requirements.
T1.3	Proponents of derived proposals shall implement the Final Closure Plan required by condition 1.2 until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.
T2.1	Prior to the commencement of construction activities, the proponents of derived proposals shall prepare and implement an Ecological Surface Water Requirements Management Plan, to the satisfaction of the Western Australian Minister for Environment on advice from DEC, which shall address the following: • Drainage measures to manage surface water flows and minimise environmental impacts as far as practicable on monsoon vine thicket and drainage basin vegetation communities within the affected catchments. • A vegetation composition, health and condition monitoring program for areas of vegetation determined likely to be dependent on surface water flows, including the superficial aquifer, for seasonal water requirements. • Process to be implemented if monitoring indicates declining vegetation condition or changing composition as a result of changes in surface water flows.

- **Table 2.4-8 Extent of Terrestrial Vegetation Clearing with Potential Disturbance to Monsoon Vine Thicket.**

Activity	Total terrestrial vegetation loss (ha)	Monsoon vine thicket community (ha)
Construction and operation of BLNG Precinct	2,090	96
Construction and operation of pipeline corridors	250	35
Construction and operation of light industrial area	200	0
Construction and operation of workers accommodation area	200	0
Construction and operation of ancillary infrastructure (for example, minor roads and service corridors, Manari Road diversion and groundwater borefield)	297	1.4
Fuel reduction activities and clearing for fire access within the Plan area in accordance with fire management strategy	As described in Fire Management Strategy	As described in Fire Management Strategy

- **Table 2.4-9 Requirements to be Addressed via Development of a Management Plan to Support a Derived Proposal in regards to Flora and Vegetation.**

Derived Proposal Requirements	Timing
Prepare a Rehabilitation Plan, to the satisfaction of the Western Australian Minister for Environment, which includes the following: • objectives, targets and associated monitoring; • rehabilitation of areas not required post-construction; • stabilisation of disturbed landforms; • use of local native species in revegetation activities; • rehabilitation techniques (such as relocation of topsoil, translocation of particular trees); and • reporting on inspections and monitoring.	Prior to commencement of associated construction activities
Prepare and implement a BLNG Precinct Fire Management Plan for construction and operation. See **Part 4**, **Section 2.7**.	Prior to construction and updated for ongoing operational requirements
Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan for construction and operation activities. See **Part 4**, **Section 2.1**.	Prior to commencement of associated construction activities
Prepare and implement a Quarantine Management Plan for construction and operation. See **Part 4**, **Section 2.7**.	Prior to construction and updated for ongoing operational requirements
Prepare and implement a Terrestrial Weed Management Plan for a defined area within and immediately adjacent to the BLNG Precinct to manage the indirect impacts. The Plan will address the issues around management of fragmentation and edge effects. Annual reporting on success of the control program is to be made publicly available.	Prior to construction and updated for ongoing operational requirements
Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets;	Prior to commencement of associated construction activities

Derived Proposal Requirements	Timing
• environmental management; • environmental training and inductions; and • environmental monitoring, contingencies and reporting, and stakeholder consultation. *In order to address the potential impacts to terrestrial flora and vegetation identified within this Section the CEMP may include environmental management measures such as:* • *the cumulative direct loss of vegetation is not to exceed that detailed in Table 2.4-8 and should be minimised as far as practicable;* • *areas of vegetation and habitat to be cleared within the Industrial Precinct to be marked on construction plans;* • *areas of sensitive vegetation to be cleared to be clearly marked in the field;* • *clearing to be undertaken to minimise disturbance and maintain linkages where possible;* • *an environmental specialist to be on site during vegetation clearing to supervise the clearing activities;* • *the progress (measured by area) of clearing activities to be monitored and recorded in a clearing register;* • *vegetation and habitat clearing for activities not detailed in the Plan and SAR to be subject to normal flora and vegetation assessment requirements provided for under the WA EP Act;* • *activities should minimise disturbance and avoid clearing in sensitive areas (e.g. significant ecological communities, species of ethno-biological significance and priority flora species as far as practicable; and* • *implement land management practices to manage threatening processes impacting on significant ecological communities and terrestrial biodiversity (encompassing both flora and fauna species) within the Industrial Precinct and surrounding buffer zones.*	

The implementation of the aforementioned mitigation measures and safeguards will be effective in mitigating the impact of the BLNG Precinct. Management plans will be developed in consultation with DEC and other relevant agencies.

2.4.5. Environmental Outcome

After management and mitigation measures have been applied, it is expected that the BLNG Precinct will result in the following outcomes in relation to the flora and vegetation:

2.4.5.1. Direct Impacts

- The disturbance of up to 3,037ha of vegetation during construction of the BLNG Precinct. This does not include fire management activities, which cannot be quantified at this Strategic Assessment stage.
- Substantial loss in local representation of three vegetation communities (monsoon vine thickets, coastal communities and coastal heath), but no significant effect in a regional context.
- The TEC monsoon vine thickets will be affected by the BLNG Precinct (specifically the shore crossing and southern onshore pipeline), resulting in the removal up to 9% of the known regional extent of this TEC.
- No declared rare flora species are expected to be affected by the BLNG Precinct, as none have been recorded within the BLNG Precinct nor are they expected to occur.
- Several specimens of Priority flora and other significant species will be disturbed but these are generally well represented and widely distributed locally and regionally and the BLNG Precinct will not affect the conservation status of any species.
- The occurrence of weeds will be controlled through a Terrestrial Weed Management Plan and Rehabilitation Plan which is discussed in detail in **Part 4**, **Section 2.7**.

2.4.5.2. Indirect Impacts

- The requirement to maintain surface water flows as far as is practicable to identified high risk areas of conservation significant vegetation (monsoon vine thicket and drainage basin) will minimise the impacts of an altered surface water regime on these potentially water dependent vegetation types.

- The requirement for proponents of derived proposals to prepare a construction environmental management plan as part of their derived proposal application will ensure controls are in place to minimise the potential impact to vegetation outside the clearing areas.
- The potential impacts on groundwater dependent ecosystems from groundwater abstraction will be assessed through the groundwater licence application process.
- Potential impacts to monsoon vine thicket as a result of fragmentation and 'edge effects' from clearing activities for the BLNG Precinct, and pipeline crossings.
- Indirect impacts on vegetation resulting from fragmentation and edge effects, further considered in **Part 4**, **Section 2.7**. While the cumulative impacts may be greater than 3,037ha, the implementation of detailed management measures will minimise the potential impact to vegetation outside the clearing areas.
- Implementation of a fire management plan, together with a reduction in informal access within the James Price Point coastal area is likely to reduce the incidence of late hot, dry season wildfires, which are known to be particularly damaging to vegetation communities. As such, it is considered likely that vegetation may improve over time. Where vegetation types are restricted and currently determined to be under threat, such as the monsoon vine thicket, it is considered that an improvement in vegetation condition is likely to improve habitat availability and local ecosystem function. In the absence of fire it is possible that occurrences of monsoon vine thicket may increase in size (V. English, 2010, pers. comm. DEC, 20 July 2010).

Consistent with EPA objectives, the abundance, species diversity, geographic distribution and productivity of flora at species and ecosystem levels will be maintained, thereby conserving regional biological diversity.

2.4.6. Cumulative Impacts of the Proposal and Associated Activities

2.4.6.1. Category B Impacts

The following potential Category B activities that may affect vegetation and flora include:

- clearing for additional housing and associated infrastructure in Broome;
- clearing for industrial areas in or near Broome;
- clearing for a new solid waste facility in Broome;
- clearing for service corridors;
- clearing for any expansion or relocation of the Broome International Airport;
- clearing for a gas pipeline infrastructure from the BLNG Precinct to Broome;
- clearing for any expansion or development of new port facilities;
- clearing for offsite quarries for breakwaters and reclamation; and
- disturbance and affects associated with increased recreational use of the Dampier Peninsula due to improved access.

The remaining Category B activities within and near Broome will most likely be developed on Pindan vegetation. Over 4,000,000ha of Pindan shrubland exists within Dampierland subregion (Graham, 2001). Impacts on ecosystem integrity will largely relate to fragmentation and edge effects from clearing.

The potential relocation of the Broome airport has already been assessed, whereby the EPA concluded that the proposal could be managed in an environmentally acceptable manner (EPA Report 1017, EPA 2001). Should the airport be relocated sometime soon in the future, it is likely that the current airport site will be redeveloped for additional housing and thereby reduce the need for housing expansion projects in remnant vegetation areas. Impacts from the relocation of the airport would also be related to, but will edge effects into surrounding vegetation.

LandCorp's 695ha Broome North development for housing may impact on nearby monsoon vine thickets through edge effects.

Future industrial land may be developed in the Broome port area or in areas north of Broome. Locations of industrial areas and the solid waste facility have not been determined and therefore vegetation and flora surveys have not been conducted.

Of the above Category B activities, only the housing development has progressed to a stage where a location has been identified and vegetation and flora investigations completed. The BLNG Precinct is expected to facilitate the demand for LandCorp's Broome North development which is proposed for an area of land north of Broome. The development comprises up to 695ha of mixed Acacia low woodland (pindan shrubland/woodland) in good to very good condition, similar to the majority of vegetation within the James Price Point coastal area. Clearing of this area will not result in any additional direct impacts on the significant ecological communities identified in the James Price Point coastal area. However, the proposed development is within the buffer area of an area of monsoon vine thickets and may be impacted by indirect impacts from edge effects, changes in surface water regime and increases in human activity in that area. With appropriate management, impacts on vine thickets should be avoided; therefore, the additional impact on vine thicket communities in the region from this development is expected to be insignificant. Mangrove communities also occur near the proposed housing development; however, there are no anticipated impacts to this community. No DRF or Priority flora were identified in the development area, therefore cumulative impacts on the Priority flora identified in the BLNG Precinct is unlikely.

Demand for additional industrial areas and a new solid waste facility in Broome may result in sites for these being required and subsequent clearing. Future industrial land may be developed in the Broome port area or in areas north of Broome. Locations of industrial areas and the solid waste facility have not been determined and therefore vegetation and flora surveys have not been conducted. It is likely that vegetation north of Broome will be similar to that surveyed in the Broome North development (pindan shrubland/woodland); however, the presence of DRF or Priority flora in these northern areas is not known. Within the Port of Broome, seven subpopulations of the DRF *Keraudrenia exastia* have been identified (TSSC, 2009) therefore any clearing of vegetation for industrial areas at the Port would need to consider this species. In regards to cumulative impact, there will be no cumulative impact on this species as it has not been identified in the James Price Point Coastal area.

The international airport relocation is proposed approximately 12km northeast of the Broome townsite and would require the clearing of approximately 200ha of Pindan shrubland/woodland. The EPA assessed the relocation of the airport to this site (EPA Bulletin 1017, EPA 2001) and concluded that the proposal could be managed in an environmentally acceptable manner.

Broome is also the most likely location for the required supply base; therefore additional Pindan vegetation may be cleared. Avoidance of conservation significant vegetation around Broome, such as monsoon vine thickets and mangrove communities is possible.

It is likely that most Category B activities within and near Broome will be developed on Pindan vegetation. Over 4,000,000ha of Pindan shrubland exists within Dampierland subregion (Graham, 2001). Cumulatively, clearing of Pindan shrubland for Category A, B and C activities is unlikely to have a significant impact on its abundance and diversity. However, as Pindan vegetation in the Dampier Peninsula is currently in advanced decline due to excessive fire frequency over most of its range (AECOM, 2010b; **Appendix C-20**), it is important to ensure good examples of this vegetation type are avoided. Priority flora identified in the James Price Point Coastal area that may occur in Pindan shrubland near Broome include *Polymeria distigma* and *Eriachne semiciliata*.

Changes to the surface water regime may also occur as a result of any of the above developments, which may affect adjacent vegetation. This may include the monsoon vine thickets that are located on the west coast of Broome or the mangrove communities surrounding Roebuck Bay (approximately 66km south of James Price Point). Impacts from changes to surface water regime can be minimised through effective stormwater drainage systems designed to maintain natural flow regimes. It is anticipated that maintenance of existing flows to significant vegetation areas and prevention of impacts from contaminated runoff to Roebuck Bay will be a key focus for management of these developments.

The locations of the potential offsite quarries have not been finalised. However, quarries can be located in areas away from conservation significant flora and vegetation and clearing for these should not result in significant cumulative impacts on the distribution and diversity of vegetation in the Dampier Peninsula.

Increased recreational use of the Dampier Peninsula due to improved access may result in further spread of weeds. This is discussed in more detail in **Part 4**, **Section 2.7**.

2.4.6.2. Category C Impacts

Clearing and related impacts associated with the Main Access Road from Cape Leveque Road to the BLNG Precinct will be formally assessed by both State and Commonwealth separately from the Strategic Assessment. The estimated clearing required for the road is 191 ha with an additional 172ha part of possible future requirements for services such as electricity and gas alongside the Main Access Road. The principal impact from this activity is the clearing of Pindan vegetation which, given its very common occurrence of the Dampier Peninsula, is not considered to have a significant cumulative environmental impact.

Another potential Category C impact in relation to flora and vegetation is clearing for the development of a supply base (if proposed) to service upstream development. Impact assessment is dependent on the location of the proposed supply base and will be defined as the development progresses.

- **Table 2.4-10 Impact Assessment Summary for Terrestrial Flora and Vegetation.**

<table>
<tr><th rowspan="2">Factor/Sub-Factor</th><th rowspan="2">Environmental Aspect</th><th rowspan="2">Potential Impacts</th><th colspan="3">Mitigation Measures</th><th rowspan="2">Significance of Residual Impact</th></tr>
<tr><th>State Government Measures</th><th>Proposed E nvironmental Conditions</th><th>Future Proponent Management Plans</th></tr>
<tr><td>Terrestrial Flora - Significant Ecological Communities</td><td>Site disturbance / excavation (Construction)</td><td>Decline in health of groundwater dependent vegetation (where groundwater drawdown occurs).</td><td rowspan="3">Develop and implement a Management and Monitoring Strategy for Vegetation of Medium to High Conservation Significance, with particular reference to remnant monsoon vine thicket and drainage basin vegetation. The Strategy will inform all proponents of derived proposals of requirements for detailed management plans specific to individual activities and will include a framework in which the following Plans will be implemented:
• Fire Management Plan;
• Terrestrial Fauna Management Plan;
• Terrestrial Weed Management Plan; and
• appropriate management of hydrology (both surface water and groundwater). Refer also the commitment for Ecological Surface Water Requirements Management Plan and surface water and groundwater management commitments in Part 4, Section 2.2 and Section 2.3.

The effectiveness of the Strategy is to be measured via condition and health monitoring</td><td rowspan="3">Proponents of derived proposals shall not cause the loss of vegetation including monsoon vine thicket in excess of the limits of cumulative loss prescribed in Table 2.4-8 for the BLNG Precinct.

Prior to the commencement of construction activities, the proponents of derived proposals shall prepare and implement an Ecological Surface Water Requirements Management Plan, to the satisfaction of the Western Australian Minister for Environment on advice from DEC, which shall address the following:
• Drainage measures to manage surface water flows and minimise environmental impacts as far as practicable on monsoon vine thicket and drainage basin vegetation communities within the affected catchments.
• A vegetation composition, health and condition monitoring program for</td><td rowspan="3">Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following:
• schedule of construction activities;
• details of the construction methods to be used;
• objectives and targets;
• environmental management;
• environmental training and inductions;
• environmental monitoring, contingencies and reporting; and
• stakeholder consultation.

In order to address the potential impacts to terrestrial flora and vegetation identified within this section the CEMP may include environmental management measures such as:
• The cumulative direct loss of vegetation is not to exceed that detailed in Table 2.4-8 and should be minimised as far as practicable.
• Areas of vegetation and habitat to be cleared within the Industrial Precinct to be marked on construction plans.
• Areas of sensitive vegetation to be cleared to be clearly marked in the field.
• Clearing to be undertaken to minimise disturbance and maintain linkages where possible.
• An environmental specialist to be on site during vegetation clearing to</td><td>Medium</td></tr>
<tr><td>Terrestrial Flora - Significant Ecological Communities</td><td>Dust emissions</td><td>Disturbance of general flora species and vegetation communities</td><td>Very Low</td></tr>
<tr><td>Terrestrial Flora - Other flora including Priority flora</td><td>Vegetation / habitat clearing (Construction)</td><td>Disturbance of conservation significant flora</td><td>Medium</td></tr>
</table>

Factor/Sub-Factor	Environmental Aspect	Potential Impacts	Mitigation Measures			Significance of Residual Impact
			State Government Measures	Proposed Environmental Conditions	Future Proponent Management Plans	
			for a defined area within and surrounding the BLNG Precinct area and associated buffer zones. Annual reporting on success of the program is to be made publicly available. The State Government commits, through the implementation of the Dampier Peninsula Land Use and Infrastructure Plan, to facilitate the establishment of additional nature reserves and/or National Parks within the Dampier Peninsula to secure representative vegetation of the Peninsula in reserves, protect fauna habitat of rare and specially protected fauna and to protect Aboriginal culture and heritage. The establishment of a National Park and its location will be in accordance with agreements with Traditional Owners. Mitigation measures to avoid impacts on terrestrial conservation areas from indirect activities associated with the implementation of the Plan include: • assist with fire and weed management in and around Coulomb Point Nature Reserve and any other nature reserves established in the vicinity of the Precinct in collaboration with the	areas of vegetation determined likely to be dependent on surface water flows, including the superficial aquifer, for seasonal water requirements. • Process to be implemented if monitoring indicates declining vegetation condition or changing composition as a result of changes in surface water flows. Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address: • detailed measures to be implemented for final closure; • the schedule and timing of final closure activities; • completion criteria for closure; and • closure monitoring requirements. Proponents of derived	supervise the clearing activities. • The progress (measured by area) of clearing activities to be monitored and recorded in a clearing register. • Vegetation and habitat clearing for activities not detailed in the Plan and SAR to be subject to normal flora and vegetation assessment requirements provided for under the WA EP Act. • Activities should minimise disturbance and avoid clearing in sensitive areas (e.g. significant ecological communities, species of ethno-biological significance and priority flora species as far as practicable. • Implement land management practices to manage threatening processes impacting on significant ecological communities and terrestrial biodiversity (encompassing both flora and fauna species) within the Industrial Precinct and surrounding buffer zone. Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address: • detailed measures to be implemented for final closure; • the schedule and timing of final closure activities; • completion criteria for closure; and • closure monitoring requirements.	
Terrestrial Flora - Significant Ecological Communities	Vegetation / habitat clearing (Construction)	Disturbance of conservation significant vegetation communities				High
Terrestrial Flora - Groundwater Dependent Ecosystems	Groundwater abstraction	Decline in health of groundwater dependent vegetation (where groundwater drawdown occurs)				Very Low
Terrestrial Flora - Significant	Physical presence	Decline in vegetation health due to				Low

<table>
<tr><th rowspan="2">Factor/Sub-Factor</th><th rowspan="2">Environmental Aspect</th><th rowspan="2">Potential Impacts</th><th colspan="3">Mitigation Measures</th><th rowspan="2">Significance of Residual Impact</th></tr>
<tr><th>State Government Measures</th><th>Proposed E nvironmental Conditions</th><th>Future Proponent Management Plans</th></tr>
<tr><td>Ecological Communities</td><td></td><td>reduction of surface water flows.</td><td rowspan="4">DEC;
• DEC to monitor visitor numbers to Coulomb Point Reserve camping area; and
• DEC to develop a management plan for the Coulomb Point Reserve.

Prepare and implement a closure and decommissioning strategy for the Browse LNG Precinct and related activities for the purpose of providing a timely and consistent approach to removal or retention of plant and infrastructure, rehabilitation of disturbed areas and identification of contaminated areas.

Prepare an overarching Emergency Response Plan that addresses:
• risk assessment of potential emergencies (including bushfires, introduction of foreign pests, flooding and spills);
• emergency response equipment and training;
• emergency response procedures;
• responsibilities during emergency response; and
• reporting, review and improvement as required.

Prepare and implement an</td><td rowspan="4">proposals shall implement the Final Closure Plan until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.</td><td rowspan="4">Proponents of derived proposals shall implement the Final Closure Plan until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.

Prepare a Rehabilitation Plan, to the satisfaction of the Minister for Environment, which includes the following:
• objectives, targets and associated monitoring;
• rehabilitation of areas not required post-construction;
• stabilisation of disturbed landforms;
• use of local native species in revegetation activities;
• rehabilitation techniques (such as relocation of topsoil, translocation of particular trees); and
• reporting on inspections and monitoring.

Prepare and implement a Quarantine Management Plan for construction and operation. See Part 4, Section 2.7.

Prepare and implement a Terrestrial Weed Management Plan for a defined area within and immediately adjacent to the BLNG Precinct to manage the indirect impacts. The Plan will address the issues around management of fragmentation and edge effects. Annual reporting on success of the control program is to be made publicly available.</td><td></td></tr>
<tr><td>Terrestrial Flora - Significant Ecological Communities</td><td>Introduced pests</td><td>Disturbance of general flora species and vegetation communities</td><td>Low</td></tr>
<tr><td>Terrestrial Flora - Significant Ecological Communities</td><td>Altered fire regime</td><td>Disturbance of conservation significant vegetation communities.</td><td>Low</td></tr>
<tr><td>Terrestrial Flora</td><td>Altered fire regime</td><td>Disturbance of conservation significant flora</td><td>Low</td></tr>
</table>

Factor/Sub-Factor	Environmental Aspect	Potential Impacts	Mitigation Measures			Significance of Residual Impact
			State Government Measures	Proposed E nvironmental Conditions	Future Proponent Management Plans	
			engagement plan to manage all interactions with public users of the marine and terrestrial environment in and around James Price Point, including recreational users and tourism operators.		Prepare a nd i mplement a B LNG P recinct Fire Management Plan for construction and operation. See **Part 4**, **Section 2.7**.	
Terrestrial Flora	Terrestrial discharges, including non-routine discharges	Disturbance of general flora species and vegetation communities.	Prepare and implement a Fire Management Strategy for the Dampier Peninsula to align with existing fire management strategies to reduce the frequency of fires and the occurrence of late dry season burns on the Peninsula.			Very Low

2.5. Relevant Factor: Species of Ethno-biological Significance

Plants and animals have been utilised by Aboriginal people for many thousands of years. A wide range of species are still utilised for food, medicine, shelter and cultural activities including art. More recently, Aboriginal people in the Kimberly region have responded to a broader interest in 'bush tucker' products, and have begun to harvest particular species for the commercial market.

2.5.1. Current Knowledge

The James Price Point coastal area supports 77 plant species documented as having some type of use for Aboriginal people such as for food, medicine, shelter, hunting and gathering or as artefacts (Margetts and Grabasch, 2010a, **Appendix E-6**). In addition some 27 terrestrial fauna species with ethno-biological uses have been identified as occurring within the area (Margetts and Grabasch, 2010a; **Appendix E-6**).

Currently, one species, the gubinge or bush plum (*Terminalia ferdinandiana*), is targeted for bush tucker commercial sales. A number of families from the Traditional Owner claimant group participate in commercial harvesting of this plant on the Dampier Peninsula as part of the Kullari Australia Co-operative. The harvest area stretches along a 350km coastal band from One Arm Point in the north to Bidyadanga in the south. DEC manages the annual harvest through the issue of a small number (5 to 6) of community licences allowing family members to collect gubinge in areas determined by family groups. The annual harvest ranges between 4 and 6 tonnes per annum depending on seasonal conditions but has the potential for higher production through improved management practices and enrichment plantings. The economic value (farm gate) of the harvest is approximately $90,000 - $100,000 per annum (Q. Blades, 2010, pers. comm. Cooradgi, June 2010). Further research and a management plan for gubinge is required to determine the potential to develop a larger industry and set sustainable harvest levels for the Dampier Peninsula (K. Miller, pers. comm. DEC, June 2010). The highest occurrence of gubinge, on a percentage cover basis was in coastal communities, Pindan shrubland and in the monsoon vine thickets (Biota, 2009a). Other species of ethno-biological significance are known to occur in most of the vegetation types within the James Price Point coastal area

Information on the presence of flora of ethno-biological significance is based primarily on survey data from Biota Environmental Sciences (Biota, 2009c; **Appendix C-18**) and ENV Australia (ENV, 2008a; **Appendix C-14** and ENV, 2008b; **Appendix C-15**). A limited assessment of the utilisation of the area by Traditional Owners for the collection of these plant species and the importance of particular species in addition to gubinge was also undertaken (Margetts and Grabasch, 2010a; **Appendix E-6**).

The site also supports fauna of known ethno-biological significance including lizards, snakes, wallabies and birds. The use of fauna is primarily for food however skins, fur and bone are used to make hunting and gathering tools, utensils, implements, clothing and ornaments (Margetts and Grabasch, 2010a; **Appendix E-6**).

A combined total of 202 direct ethno-biological uses of terrestrial flora and fauna were identified based on existing public sources and limited Traditional Owner oral recoding undertaken to support this assessment (Margetts and Grabasch, 2010a; **Appendix E-6**). Of the vegetation types at the James Price Point coastal area, the monsoon vine thicket behind coastal sand dunes was identified as being of particular significance as a location providing water and shelter from harsh weather as well as being rich in ethno-biological values.

2.5.2. Sources of Potential Impact

Activities or aspects of the Proposal that may potentially affect species of ethno-biological significance, not considering mitigation measures, include:

- Vegetation and habitat clearing, affecting:
    - plant species of ethno-biological significance – clearing at the site will result in the removal of vegetation that could have ethno-biological significance; and
    - animal species of ethno-biological significance – clearing will reduce the available habitat (food sources and/or refugia) for animals of ethno-biological significance and clearing activities may cause animal deaths.

- Altered fire regime, affecting:
  - plant species of ethno-biological significance – more frequent fire and/or late season fires from an increase in ignition sources could impact on plant species of ethno-biological significance, if not appropriately managed, by reducing the capacity of fire sensitive species to successfully re-establish. Conversely, improvements in fire management compared to current conditions may have a significant benefit to such species; and
  - animal species of ethno-biological significance – more frequent fire and/or late season fires are likely to impact animal species of ethno-biological significance by limiting the amount of available habitat for food and refugia.
- Altered surface water regime, affecting:
  - plant species of ethno-biological significance – a change in the surface water regime of the area may have an impact on plant species of ethno-biological significance that are located adjacent to the construction and operation area.

2.5.3. Predicted Impacts

Potential impacts on species of ethno-biological significance from the construction and operation of the BLNG Precinct are discussed below and summarised in **Table 2.5-5**. Both direct and indirect impacts are considered within these sections. For the purpose of this assessment it is considered that direct impacts would largely be confined to areas of direct disturbance within the BLNG Precinct, and other locations where development activities are proposed to occur.

The highest local impact to species of ethno-biological significance will result from the initial vegetation and habitat clearing associated with construction of LNG facilities and associated infrastructure. The vegetation types on the site are well represented outside of the area to be cleared and vegetation likely to contain gubinge and large areas of habitat will continue to persist within the local area. Therefore, it is likely that species of ethno-biological significance will continue to be available outside of the immediate clearing area; however, it is possible that harvest pressures of the Traditional Owners on the remaining vegetation communities will be higher.

Considering that gubinge is located across the James Price Point Coastal area, important harvest locations will be identified with the Traditional Owners prior to clearing. The importance of the James Price Point coastal area as a source of indigenous food products will be further investigated as social baseline studies are completed and would likely to be linked to access and locations of roads.

Traditional Owners will be consulted to determine the significance of the areas to be cleared and to support the development of appropriate responses.

Indirect sources as altered surface water or groundwater flows have the potential to impact upon vegetation that could support species of ethno-biological significance, outside the site. For example, a stormwater drainage management system which diverts drainage and uncontaminated runoff to natural drainage areas would be implemented to minimise potential impacts to surface water flows.

The introduction of new ignition sources into the area during construction operational has the potential to increase the number of fires in the area, which has the potential to be detrimental to the vegetation in the area. Frequent and high intensity fires are known to reduce ecosystem quality and could reduce the availability of species of ethno-biological significance within the James Price Point coastal area. The vegetation does regenerate after a fire event; however, frequent fire events, particularly late season hot fires, can have a detrimental cumulative effect preventing the establishment of late successional species. Compared with much of the inland areas on the Dampier Peninsula, the James Price Point coastal area has not been subject to a large number of fires in the last 12 years (see **Part 4**, **Section 1** (Environmental Overview)), although this is less so for areas of the BLNG Precinct surround further inland and east from the coast. Also, in mid-late 2009, a large fire burnt much of the James Price Point coastal area. With implementation of the BLNG Precinct, it is expected that the existing fire regime of the area can not only be maintained but potentially also improved, particularly for those areas further from the coast but subject to the BLNG Precinct fire management program.

It is expected that potential impacts to species of ethno-biological significance can be minimised through measures such as working with Traditional Owners to identify important ethno-biological species (including gubinge) harvest areas within the BLNG Precinct, and ensuring Traditional Owners are involved in the management of areas containing ethno-

biologically significant species. A more detailed description of proposed mitigation measures is presented in **Section 2.5.4**. The significance of residual impacts on species of ethno-biological significance due to vegetation clearing, altered fire regimes and surface water flows is assessed to be low as the impacts will be very localised in respect of clearing and changed surface water flows and in respect of fire should result in improved vegetation condition through improved fire management measures.

2.5.4. Mitigation Measures and Safeguards

Mitigation measures and safeguards that have been identified to manage potential impacts to ethno-biological significance are outlined below in **Table 2.5-1**, **Table 2.5-2**, **Table 2.5-3** and **Table 2.5-4**.

Table 2.5-1 State Government Measures for Species of Ethno-biological Significance.

State Government Measure	Responsibility	Timing
In cooperation with Traditional Owners, identify important ethno-biological species (including gubinge) harvest areas within the BLNG Precinct.	DSD through its involvement in the BLNG Precinct Control Group, in consultation with Traditional Owners.	Prior to any clearing commencing.
If ethno-biologically important harvest areas are identified, a management plan will be prepared to develop measures to maintain these resources in the surrounding areas and provide for access for Traditional Owners.	DSD through its involvement in the BLNG Precinct Control Group, in consultation with Traditional Owners.	Prior to any clearing commencing.
The Traditional Owners by agreement are to be involved in aspects relating to management of areas containing ethno-biologically significant species.	DSD through its involvement in the BLNG Precinct Control Group, in consultation with Traditional Owners.	Throughout the life of the Plan.
Prepare and implement a Fire Management Strategy for the Dampier Peninsula to align with existing fire management strategies to reduce the frequency of fires and the occurrence of late dry season burns on the Peninsula.	DSD through its involvement in the BLNG Precinct Control Group, with advice from DEC and Indigenous ranger groups.	Prior to commencement of construction of an LNG plant.
Prepare an overarching Emergency Response Plan that addresses: • risk assessment of potential emergencies (including bushfires, introduction of foreign pathogen or pest, flooding and spills); • emergency response equipment and training; • emergency response procedures; • responsibilities during emergency response; and • reporting, review and improvement as required.	DSD through its involvement in the BLNG Precinct Control Group, with advice from FESA.	Prior to commencement of construction of an LNG plant.

- **Table 2.5-2 Proposed Environmental Conditions for the Strategic Proposal that may affect Species of Ethno-biological Significance.**

Condition No.	Proposed Environmental Conditions for the Strategic Proposal
Environmental Footprint	
1-1	Proponents of derived proposals shall not cause the loss of vegetation including monsoon vine thicket in excess of the limits of cumulative loss prescribed in **Table 2.5-3** for the BLNG Precinct.
Surface Water	
3-1	Prepare an Ecological Surface Water Requirements Management Plan in consultation with DEC and DoW. See **Part 4**, **Section 2.2** (Surface Water).

- **Table 2.5-3 Extent of Terrestrial Vegetation Clearing with Respect to Species of Ethno-biological Significance.**

Activity	Total terrestrial vegetation loss (ha)	Monsoon vine thicket community (ha)
Construction and operation of BLNG Precinct.	2,090	96
Construction and operation of pipeline corridors.	250	35
Construction and operation of light industrial area.	200	0
Construction and operation of workers accommodation area.	200	0
Construction and operation of ancillary infrastructure (for example, minor roads and service corridors, Manari Road diversion and groundwater borefield).	297	1.4
Fuel reduction activities and clearing for fire access within the Plan area in accordance with fire management strategy.	As described in Fire Management Strategy.	As described in Fire Management Strategy.

- **Table 2.5-4 Requirements to be Addressed via Development of a Management Plan to Support a Derived Proposal in regards to Species of Ethno-biological Significance.**

Derived Proposal Requirements	Timing
Prepare and implement a Fire Management Plan for construction and operation activities, which addresses the following: • objectives, targets and associated monitoring; • roles and responsibilities of response personnel; • risk assessment of proposed activities ; • fire response equipment that will be available; • alignment and compliance with the State Government Fire Management Strategy for the Dampier Peninsula; and • fire risk reduction and management measures, which may include vegetation thinning to reduce fuel load and installation of firebreaks around the perimeter fence, within the areas surrounding the BLNG Precinct.	Prior to construction and updated for ongoing operational requirements.
Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan for construction and operation activities. See **Part 4**, **Section 2.1.**	Prior to commencement of associated construction activities.
Prepare and implement a Quarantine Management Plan, to the satisfaction of the Western Australian Minister for Environment, for construction and operation activities, which addresses the following: • baseline information regarding non-indigenous species; • objectives, targets and associated monitoring; • profile of potential quarantine risks based on where the equipment is sourced (locally, interstate, overseas); • species-specific or generic response plans to minimise and manage any incursions or spread; • on-site management measures (including investigation of the requirements for establishing an on-site fumigation facility, wash-down facility and Quarantine Approved Premise); • process for earth moving machinery, vehicles, plant and equipment to be free of soil and vegetation prior to entering and exiting the BLNG Precinct; • management and control of Declared Plants (as defined by the Agriculture and Related Resources Protection Act 1976); • monitoring program during and after the activity has been completed; • reporting on inspections and monitoring; • consultation with AQIS, DAFWA and DEC; and • integration with the State Government Emergency Response Plan.	Prior to construction and updated for ongoing operational requirements.
Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets; • environmental management; • environmental training and inductions; and • environmental monitoring, contingencies and reporting, and stakeholder consultation.	Prior to commencement of associated construction activities.

2.5.5. Environmental Outcome of Category A Activities

After management and mitigation measures have been applied, it is expected that the BLNG Precinct will result in the following outcomes in relation to the species of ethno-biological significance:

1) The disturbance of up to 3,037ha of vegetation, some of which has potential to support species of ethno-biological significance, during construction of the BLNG Precinct and associated infrastructure.
2) Loss of vegetation which can support species of ethno-biological significance as a result of the BLNG Precinct is expected to have some impact on the local representation of the vegetation communities which contain species of ethno-biological significance, but no significant effect at the local or regional level.
3) The proposed BLNG Precinct Fire Management Strategy will maintain and possibly improve fire regimes for flora species and habitat of ethno-biological significance susceptible to fire.
4) The requirement to prepare an Ecological Surface Water Requirements Management Plan that will include consideration of requirements for drainage basin vegetation and the monsoon vine thickets will minimise the impacts of an altered surface water regime on these potentially water dependent vegetation types which can support species of ethno-biological significance.
5) The requirement for proponents of derived proposals to prepare a construction environmental management plan as part of their derived proposal application will ensure controls are in place to minimise the risks to species of ethno-biological significance outside the clearing areas.
6) The potential impacts on Groundwater Dependent Ecosystems from groundwater abstraction will be managed through the groundwater licence application process.

Consistent with EPA objectives, the abundance, species diversity, geographic distribution and productivity of flora at species and ecosystem levels will be maintained, thereby conserving regional biological diversity.

2.5.6. Cumulative Impacts of the BLNG Proposal and Associated Activities and Projects

The following potential Category B and C activities that may affect species of ethno-biological significance include:

- Category B:
  - additional housing and associated infrastructure in Broome;
  - industrial areas in or near Broome;
  - relocation of the Broome International Airport;
  - gas pipeline from the BLNG Precinct to Broome;
  - offsite quarries for breakwaters and reclamation; and
  - increased recreational use of the Dampier Peninsula due to improved access.
- Category C:
  - new public road from Cape Leveque Road to Precinct; and
  - development of a supply base.

The activities listed above are likely to require some clearing of native vegetation that could contain species of ethno-biological significance; future developments will need to take into account areas used by the Indigenous community, including areas important for the harvest of Indigenous products.

Of the above Category B activities, only the housing development has progressed to a stage where a location has been identified and vegetation and flora investigations completed. The BLNG Precinct is expected to increase the demand for LandCorp's Broome North development which is proposed for an area of land north of Broome. The development comprises up to 695ha of mixed Acacia low woodland (Pindan shrubland/woodland) in good to very good condition, similar to the majority of vegetation within in the James Price Point coastal area. Clearing of this area will not result in any additional direct impacts on the significant ecological communities identified in the area. However, the proposed Broome North development is within the buffer area of monsoon vine thickets (which may contain species of ethno-biological significance) and may be at risk of indirect impacts from edge effects, changes in surface water regime and

increases in human activity in that area. With appropriate management, impacts on vine thickets should be avoided; therefore, the additional impact on vine thicket communities in the region is expected to be insignificant. Mangrove communities also occur near the proposed housing development; however, there are no anticipated impacts to this community.

There may also be a demand for additional industrial areas in or near Broome. Future industrial land may be developed in the Broome port area or in areas north of Broome. Locations of industrial areas have not been determined and, therefore, vegetation and flora surveys have not been conducted. It is likely that vegetation north of Broome will be similar to that surveyed in the Broome North development (Pindan shrubland/woodland).

The international airport relocation is proposed approximately 12km north east of the Broome townsite. This will require the clearing of approximately 200ha of Pindan shrubland/woodland. The EPA assessed the relocation of the airport to this site (EPA Bulletin 1017; EPA, 2001) and concluded that the proposal could be managed in an environmentally acceptable manner.

Broome is also a potential location for the required supply base for support of offshore LNG facilities; therefore, additional Pindan vegetation may be cleared. Avoidance of conservation significant vegetation around Broome, such as monsoon vine thickets and mangrove communities is possible.

It is likely that most Category B and C activities within and near Broome will be developed on Pindan vegetation which can include species of ethno-biological significance. Over 4,000,000ha of Pindan shrubland exists within the Dampierland subregion (Graham, 2001). Cumulatively, clearing of Pindan shrubland for Category A, B and C activities is unlikely to have a significant impact on its abundance and diversity. However, as Pindan vegetation in the Dampier Peninsula is currently in advanced decline due to excessive fire frequency over most of its range, it is important to ensure good examples of this vegetation type are avoided.

Changes to the surface water regime may also occur as a result of any of the above developments which may affect adjacent vegetation. This may include the monsoon vine thickets that are located on the west coast of Broome or the mangrove communities surrounding Roebuck Bay (both could contain species of ethno-biological significance). Impacts from changes to surface water regime can be minimised through effective stormwater drainage systems designed to maintain the natural flow regimes.

Additional Category B activities that may impact flora and vegetation outside of Broome potentially include a gas pipeline from the BLNG Precinct to Broome and offsite quarries. Locations of these have not been finalised, but it is most likely that the pipeline easement will be added to the infrastructure corridor, and will transect several vegetation types. As the pipeline will have a linear pattern of disturbance, local impacts on flora and vegetation should be minimal and clearing widths can be reduced in areas where there is potential habitat for species of ethno-biological significance. Quarries can be located in areas away from species of ethno-biological significance and vegetation and clearing for these should not result in significant cumulative impacts on the distribution and diversity of vegetation in the Dampier Peninsula.

Clearing and related impacts associated with the Main Access Road from Cape Leveque Road to the BLNG Precinct (Category C activity) will be formally assessed by both State and Commonwealth separately from the Strategic Assessment. The estimated clearing required for the road is 191ha with an additional 172ha part of possible future requirements for services such as electricity and gas alongside the Main Access Road. The principal impact from this activity is the clearing of Pindan vegetation which, given its very common occurrence of the Dampier Peninsula, is not considered to have a significant cumulative environmental impact.

■ **Table 2.5-5 Impact Assessment Summary Table for Species of Ethno-biological Significance.**

Factor/Sub-Factor Receptor	Environmental Aspect	Potential Impacts	Mitigation Measures			Significance of Residual Impact
			State Government Measures	Proposed Environmental Conditions	Future Proponent Management Plans	
Plant species of ethno-biological Significance	Vegetation and habitat clearing	Removal of plants will decrease the availability of species for traditional use. Edge effects from road/access	The State Government commits, through the implementation of the Dampier Peninsula Land Use and Infrastructure Plan, to facilitate the establishment of additional nature reserves and/or National Parks within the Dampier Peninsula to secure representative vegetation of the Peninsula in reserves, protect fauna habitat of rare and specially protected fauna and to protect Aboriginal culture and heritage. The establishment of a National Park and its location will be in accordance with agreements with Traditional Owners. Prepare and implement a Fire Management Strategy for the Dampier Peninsula to align with existing fire management strategies to reduce the frequency of fires and the occurrence of late dry season burns on the Peninsula. Prepare an overarching Emergency Response Plan that addresses: • risk assessment of potential emergencies (including bushfires, introduction of foreign pests, flooding and spills); • emergency response equipment and training; • emergency response procedures; • responsibilities during	Prior to the commencement of construction activities, the proponents of derived proposals shall prepare and implement an Ecological Surface Water Requirements Management Plan, to the satisfaction of the Minister for Environment, which shall address the following: Drainage measures to manage surface water flows and minimise environmental impacts as far as practicable on monsoon vine thicket and drainage basin vegetation communities within the affected catchments. A vegetation composition, health and condition monitoring program for areas of vegetation determined likely to be dependent on surface water flows, including the superficial aquifer, for seasonal water requirements. Process to be implemented if monitoring indicates declining vegetation condition or changing composition as a result of	Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets; • environmental management; • environmental training and inductions; • environmental monitoring; • contingencies and reporting; and • stakeholder consultation. In order to address the potential impacts to terrestrial flora and vegetation identified within this section the CEMP may include environmental management measures such as: • the cumulative direct loss of vegetation is not to exceed that detailed in **Table 2.5.3** and should be minimised as far as practicable; • areas of vegetation and habitat to be cleared within the Industrial Precinct to be marked on construction plans; • areas of sensitive vegetation to be cleared to be clearly marked in the field • clearing to be undertaken to minimise disturbance and maintain linkages where possible; • an environmental specialist to be on site during vegetation clearing to supervise the clearing activities;	Low
	Altered fire regime	Hindering recovery of the plants if fire frequency increased from additional ignition sources in area. Regeneration of fire susceptible species if fires become less frequent				Low
	Altered surface water regime	Surface water changes could impact areas that are cut-off from surface water flows or areas that receive too much water.				Low

Factor/Sub-Factor Receptor	Environmental Aspect	Potential Impacts	Mitigation Measures			Significance of Residual Impact
			State Government Measures	Proposed Environmental Conditions	Future Proponent Management Plans	
Animal species of ethno-biological significance	Vegetation and habitat clearing	Removal of habitat (food/refugia) the animals of ethno-biological significance use may be reduced in abundance in the area.	emergency response; and • reporting, review and improvement as required. Mitigation measures to avoid impacts on terrestrial conservation areas from indirect activities associated with the implementation of the Plan include: • assist with fire and weed management in and around Coulomb Point Nature Reserve and any other nature reserves established in the vicinity of the Precinct in collaboration with the DEC; • DEC to monitor visitor numbers to Coulomb Point Reserve camping area; and • DEC to develop a management plan for the Coulomb Point Reserve.	changes in surface water flows	• the progress (measured by area) of clearing activities to be monitored and recorded in a clearing register; • vegetation and habitat clearing for activities not detailed in the Plan and SAR to be subject to normal flora and vegetation assessment requirements provided for under the WA EP Act; • activities should minimise disturbance and avoid clearing in sensitive areas (e.g. significant ecological communities, species of ethno-biological significance and priority flora species as far as practicable; and • implement land management practices to manage threatening processes impacting on significant ecological communities and terrestrial biodiversity (encompassing both flora and fauna species) within the Industrial Precinct and surrounding buffer zone.	Low
	Altered fire regime	Direct death of animals from fire may reduce their abundance in the area.				Low

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2.6. Key Factor: Terrestrial Fauna

The following section describes the predicted impacts on terrestrial fauna (including migratory birds) and fauna habitats from activities, facilities and other requirements to be approved under the Plan for the BLNG Precinct (Category A) and the potential for cumulative impacts from activities that may indirectly arise as a result of the BLNG Precinct development (Category B) and other related resource activities in the region (Category C).

2.6.1. Current Knowledge

The following sub-sections describe the regulatory expectations with respect to fauna and fauna habitat protection, and key information on the fauna and fauna habitats present in the James Price Point coastal area relevant to the assessment of impacts.

2.6.1.1. Key Statutory Requirements, Environmental Policy and Guidance

There are a number of key statutory requirements, environmental policy and guidance that apply to the Strategic Assessment in relation to fauna and fauna habitat protection as discussed below.

International Agreements
Australia is party to the JAMBA, CAMBA and ROKAMBA Migratory Bird Agreements. Most of the birds listed in these agreements are associated with saline wetlands or coastal shorelines. Some migratory birds not associated with aquatic habitats are also listed on these international treaties.

Commonwealth Protection
The Commonwealth (EPBC Act) provides for the protection of matters of National Environmental Significance (**NES**). Listed threatened and migratory species represent matters of NES and are protected as such. Under the EPBC Act, actions that have, or are likely to have, a significant impact on a Matter of National Environmental Significance, require Commonwealth approval.

State Guidance and Policy
The EPA applies the following objective in its assessment of proposals that may affect fauna:

"To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement of knowledge."

In Western Australia all fauna are protected under the WC Act 1950. This Act also provides for taxa (species, subspecies and varieties) of native fauna to be specially protected because they are under identifiable threat of extinction, are rare, or otherwise in need of special protection. Such specially protected fauna are considered to be "threatened".

The DEC Priority Fauna List also nominates conservation species from Priority One to Five; however there is no formal legislative protection associated with these listings. It is expected that the potential impacts of a proposal to these priority listed species should be managed such that the species do not meet the IUCN criteria for threatened species.

EPA Position Statement No. 3 (EPA, 2002a) discusses the principles the EPA would apply when assessing proposals that may have an effect on biodiversity values in WA. The Position Statement intends to provide the following outcomes:

- promote and encourage all proponents and their consultants to focus their attention on the significance of biodiversity and, therefore, the need to develop and implement best practice in terrestrial biological surveys; and
- enable greater certainty for proponents in the EIA process by defining the principles the EPA will use when assessing proposals that may have an effect on biodiversity values.

As described in the EPA Position Statement No. 3, the EPA determined that a series of guidance statements were warranted to provide an easy-to-use decision-making guide to the level of biological survey required. EPA Guidance Statement No. 56, Terrestrial Fauna Surveys for EIA in WA (EPA, 2004c), provides guidance on standards and protocols for terrestrial fauna surveys, particularly those undertaken for the environmental impact assessment of proposals.

2.6.1.2. Description of Factor

Terrestrial fauna and fauna habitats of the Dampier Peninsula and the James Price Point coastal area are described in more detail in **Part 4**, **Section 1**. Relevant key findings include:

Fauna Habitat

Seven distinct fauna habitat types have been identified within the James Price Point coastal area (Biota, 2009b; **Appendix C-17**) (refer to **Part 4**, **Section 1**. The dominant habitat type within the BLNG Precinct is Pindan woodland and shrubland, located immediately inland of a narrow coastal strip composed of coastal heath, coastal communities, and monsoon vine thickets. The condition of this habitat varies, primarily as a result of differences in historical fire frequency and intensity, but is generally in very good or good condition.

The coastal habitats have local importance providing foraging resources for migratory and aquatic bird species, but primarily it is the monsoon vine thicket that is of local and regional conservation significance. It represents a distinct and restricted faunal assemblage and habitat type in the James Price Point coastal area and is a listed Threatened Ecological Community (by the DEC.

The remaining habitats of the James Price Point coastal area are considered to be well-represented and typical of the Dampier Peninsula and do not have particular conservation value for fauna (Biota, 2009b; **Appendix C-17**).

Fauna Assemblages

Wet season surveys (Biota, 2009b; **Appendix C-17**) and dry season surveys (ENV, 2008c; **Appendix C-16** and AECOM, 2010b; **Appendix C-20**) found direct or indirect evidence of 194 vertebrate species at the James Price Point coastal area, comprising 21 mammals, 51 reptiles, four amphibians and 118 bird species.

The species of fauna that occur in the James Price Point coastal area are typical of the wider Dampier Peninsula, with most species having been recorded elsewhere on the Dampier Peninsula (ENV, 2008c; **Appendix C-16**).

Fauna Species of Conservation Significance

Site surveys and habitat analysis identified 19 fauna species of conservation significance as either occurring or possibly occurring within the James Price Point coastal area. Eight of these species were recorded during surveys of the area. Detailed discussion of the fauna species of conservation significance that have the potential to occur within the James Price Point coastal area are provided in **Part 4**, **Section 1**.

No EPBC Act listed threatened species have been directly recorded in the James Price Point coastal area, however there is indirect evidence of possible Greater Bilby (*Isodoon auratus*) (Endangered – EPBC Act (Commonwealth), Schedule 1 WC Act (WA)) activity in the vicinity of the project area and south towards Quondong Point. Other EPBC Act listed threatened species that may occur in the area include:

- Australian Painted Snipe (*Rostratula australis*) - Vulnerable, Migratory (EPBC Act);
- Golden Bandicoot (*Isodoon auratus*) - Vulnerable (EPBC Act), Schedule 1 (WC Act);
- Masked Owl (northern) (*Tyto novaehollandiae kimberli*) - Vulnerable (EPBC Act); and
- Golden-backed Tree-rat (*Mesembriomys macrurus*) - Vulnerable (EPBC Act), Priority 4 (DEC).

Of these, only the Australian Painted Snipe has recently been recorded in the vicinity of the James Price Point coastal area (Biota, 2009b; **Appendix C-17**).

The State WC Act listed Peregrine Falcon (*Falco peregrinus*) (WC Act – Schedule 4) has been recorded within drainage basin vegetation in the James Price Point coastal area (Biota, 2009b; **Appendix C-17**). The species is expected to occupy a diverse range of habitats across the Dampier Peninsula and James Price Point coastal area.

DEC-listed Priority Fauna species recorded in the James Price Point coastal area include:

- Dampierland Burrowing Snake (*Simoselaps minimus*) (Priority 2), recorded within the monsoon vine thickets;
- Dampierland Plain Slider (*Lerista separanda*) (Priority 2), recorded within open forest on sandy soil;
- Bush Stone-curlew (*Burhinus grallarius*) (Priority 4), recorded within Pindan bushland habitat;
- Little North-western Mastiff Bat (*Mormopterus loriae cobourgiana*) - Priority 1 (DEC);
- Chestnut-backed Button-quail (*Turnix castanota magnifica*) (Priority 4), recorded with open woodland; and
- Eastern Curlew (*Numenius madagascariensis*) (Priority 4), recorded during an aerial high tide survey of the coastline.

Migratory Bird Species

A total of 39 bird species listed as 'migratory' under the EPBC Act have been recorded within the James Price Point coastal area and a further 28 species may potentially occur (Galaxia, 2010; **Appendix C-1**). This suite of species is widespread and well-represented on the Dampier Peninsula (Galaxia, 2010; **Appendix C-1**). Suitable habitat for these migratory birds in the James Price Point coastal area includes intertidal sand and reef flats, rocky outcrops, beaches, coastal cliffs, Pindan woodland and drainage basins with ephemeral wetlands. As these habitats are well-represented along the Dampier Peninsula it is unlikely that the James Price Point coastal area (including Coulomb Point) includes any regionally significant habitat for migratory bird species or supports regionally significant populations of migratory birds (Galaxia 2010; **Appendix C-1**).

Subterranean Fauna

Based on a desktop review of existing geological conditions within the James Price Point coastal area, and experience working within the region, Biota (2009b; **Appendix C-17**) concluded that there was a low possibility of significant subterranean fauna values being present within the James Price Point coastal area. This was primarily due to the majority of the area being dominated by clays and Pindan sand plains and absence of geological features known to support important stygofauna values in the Kimberley. However, some stygal taxa, particularly oligochaetes and copepods, may still occur in sand aquifers, but in these habitat settings individual species are usually not restricted at small spatial scales. Biota (2009b; **Appendix C-17**) also concluded that the more coastal and southern areas of the James Price Point coastal area may have calcrete or limestone strata that may support troglofauna.

Short Range Endemic Fauna

The potential presence of short range endemic invertebrates is currently uncertain and will be subject to further studies. Detailed discussion of these species is provided in **Part 4**, **Section 1**.

Two species of land snail, *Quistrachia leptogramma* and *Rhagada bulgana,* were recorded by Biota (2009b; **Appendix C-17**). Both species were recorded from several locations and both were previously known from outside of this area. While there is some morphological variation amongst the *Q. leptogramma* specimens collected, it is unclear whether this represents species-level difference.

Some *Rhagada* shells collected from the monsoon vine thickets at the James Price Point coastal area did not properly match the description *for R. bulgana*, being notably smaller in size. It is not clear whether these shells are from a still extant population or are remnants of a now extinct population as no live material was collected (Biota, 2009b; **Appendix C-17**).

In addition to land snails, several spirobolid millipedes similar to the genus *Austrostrophus* were collected from monsoon vine thicket (Biota, 2009b; **Appendix C-17**). They appear to represent an undescribed taxon and have been lodged with the WA Museum to contribute to ongoing taxonomic work. The taxonomy of this group is poorly resolved (Mark Harvey, WA Museum, pers. comm.) and there is insufficient information to make any further comment on their regional representation

Further invertebrate studies within the James Price Point coastal area have been proposed while analysis of *Q. leptogramma* collections will occur to examine the significance of morphological variations observed.

Six mygalomorph spider taxa and two species of scorpion have been collected from the James Price Point coastal area (Biota 2010, pers comm. June 2010). While it is not currently possible to assess the SRE status of many of those

specimens recorded, it is not considered that the specimens collected would be restricted to the BLNG Precinct (Biota pers. comm. 2010).

2.6.2. Identification of Key Aspects

2.6.2.1. Definition of Relevant Aspects

Aspects associated with the development and operation of the BLNG Precinct and associated infrastructure that may have an environmental impact on terrestrial fauna were identified in the Scope of the Strategic Assessment and considered in this assessment. These aspects are:

- vegetation and habitat clearing;
- vehicle movements;
- site disturbance and excavation;
- light emissions;
- noise and vibration;
- dust emissions;
- groundwater abstraction;
- physical presence (altered hydrological regimes);
- altered fire regime;
- terrestrial discharges and spills; and
- marine discharge and spills.

The following aspects are not addressed in this section:

- spreading of terrestrial introduced pests; and
- physical presence of facilities and associated infrastructure (changes in groundwater conditions).

These two aspects are assessed in **Part 4**, **Section 2.4** and **Section 2.7**.

2.6.2.2. Sources of Impact

The sources of potential impact on terrestrial fauna are summarised under the aspect from which they were derived.

Vegetation and Habitat Clearing
Vegetation clearing is required to facilitate construction and development of the BLNG Precinct, light industrial area, workers accommodation and associated infrastructure. The extent of total land requirements for the BLNG Precinct and associated infrastructure (excluding that required for fire management) is expected to be up to 3,037ha.

Vehicle Movements
The movement of vehicles, such as light and heavy machinery, is required to facilitate construction and development and operation of the BLNG Precinct and associated facilities and activities. Personnel involved in the operation of the BLNG Precinct will either be residential in Broome or on a fly-in-fly-out roster, residing in the accommodation camp, and will commute from Broome. Increased vehicle movement in the area may result in increased fauna injury and mortality.

Site Disturbance and Excavation
Site excavation for establishment of foundations for facilities and associated infrastructure may result in the physical removal or disturbance of subterranean fauna habitat. Open excavations may act as fauna traps causing stress, injury or mortality if fauna fall into excavations.

Earthworks are likely to change the hydrology of the BLNG Precinct, such as surface water flows and recharge of the superficial aquifer, which would affect fauna and fauna habitat.

Light Emissions
The behaviour and movement of terrestrial fauna may be affected by anthropogenic light emissions from the BLNG Precinct facilities and associated infrastructure.

Noise and Vibration
Noise and vibration from the construction and operation of the BLNG Precinct may affect the behaviour and movement of terrestrial fauna.

Dust Emissions
Dust emissions will be created from vegetation clearing, earthworks and site disturbance and excavation activities Dust emissions may degrade fauna habitat by reducing vegetation health.

Groundwater Abstraction
If groundwater is utilised, drawdown of groundwater levels from abstraction of water for construction, and potentially operational needs, may have an impact on subterranean fauna habitats and on vegetation that may be groundwater dependent; hence, affecting fauna habitat.

Altered Hydrological Regimes
Clearing of vegetation and permanent infrastructure may alter surface-water flows through causing flooding or drainage shadows, which may in turn degrade fauna habitats by reducing vegetation health.

Altered Fire Regime
The fire regime of the James Price Point coastal area has already been altered to the extent that the Pindan vegetation is considered in advanced long term decline (AEC OM, 2010a; **Appendix C -19**). Vegetation clearing, construction activities, vehicles, and the BLNG plant and other equipment will introduce new ignition sources that could result in an increase in late (or dry) season fires. However, this is likely to be offset by the reduction in informal access which will reduce the incidence of wildfires caused as a result of human activity. In addition, the presence of a large workforce in the area will enable fire management activities to be initiated prior to fires becoming uncontrolled. Therefore, although new ignition sources will be introduced into the James Price Point coastal area, the incidence of late hot, dry season wildfires it is likely to be reduced as a result of the implementation of a fire management plan, together with a reduction in informal access within the James Price Point coastal area.

Terrestrial Discharges and Spills
Non-routine discharges such as spills into the terrestrial environment may detrimentally affect vegetation communities, surface water and groundwater and ultimately result in decline in health or mortality of fauna species.

Marine Discharge and Spills
Non-routine discharges such as spills into the marine environment may detrimentally affect marine water quality and have subsequent impacts on migratory birds and their habitat.

2.6.2.3. Sensitivity and Resilience

Conservation Significant Fauna Habitat
The monsoon vine thicket is the only fauna habitat within the BLNG Precinct that is of local and regional conservation significance. The sensitivity and resilience of the monsoon vine thicket is detailed in **Part 4**, **Section 2.4**.

Conservation Significant Fauna

Conservation significant fauna species known to, or potentially occurring within the James Price Point coastal area are likely to be subject to one of, or a range of factors that have contributed to their population declines. Threats to conservation significant fauna that are relevant to the James Price Point coastal area are listed as follows and are discussed in detail in **Part 4**, **Section 2.7**:

- introduced fauna pests;
- altered fire regimes; and
- introduced flora (weeds).

Conservation significant fauna are impacted directly by these threats through increased competition for resources, predation, disease transmission and indirectly through introduced flora species altered fire regimes and vegetation communities, and thus habitat availability.

The key direct impacts to conservation significant fauna are associated with vegetation and habitat clearing activities for the BLNG Precinct and supporting infrastructure and include:

- habitat loss and displacement of fauna species;
- decline of habitat availability for conservation significant species, migratory birds and SRE fauna within the local area; and
- habitat fragmentation.

Impacts associated with the BLNG Precinct and supporting infrastructure are unlikely to threaten the continued survival of populations of conservation significant fauna in the James Price Point coastal area. Furthermore, the majority of conservation significant species listed in the James Price Point coastal area have broad habitat requirements and are likely to occur elsewhere on the Dampier Peninsula where suitable habitats occur. Pindan vegetation habitats are likely to provide foraging and nesting habitat opportunities for some of the species listed, however, it should be noted that these habitats are known to be common, both within the James Price Point coastal area and Dampier Peninsula. Key habitat attributes such as large hollow-bearing trees or permanent freshwater are likely to be absent from the James Price Point coastal area and as such preclude the potential presence of a number of species. A large area of monsoon vine thicket within the James Price Point coastal area will also be retained and would continue to support conservation significant fauna species known to prefer this particular habitat type. There is a low possibility of significant subterranean fauna values being present within the James Price Point coastal area.

2.6.3. Predicted Impacts

The predicted impacts on terrestrial fauna from the construction and operation of the BLNG Precinct are discussed in detail in the following sub-sections and summarised in **Table 2.6-8.** Both direct and indirect impacts are considered within these sections. For the purpose of this assessment it is considered that direct impacts would largely be confined to areas of direct disturbance within the BLNG Precinct, and other locations where development activities are proposed to occur.

Additional context on the likely indirect impacts on fauna and proposed management of these is considered in **Part 4**, **Section 2.7**.

2.6.3.1. Potential Impacts to Terrestrial Fauna due to Vegetation and Habitat Clearing

Vegetation and habitat clearing may affect:

- refuge for terrestrial biota – clearing may result in the loss of habitats for vertebrate fauna, including fauna of conservation significance and migratory birds, and SRE fauna;
- dispersal of terrestrial biota – clearing may result in the fragmentation of habitats for terrestrial vertebrate fauna, including fauna of conservation significance, and SRE fauna; and
- fauna –there may be injury and mortality of fauna species, including conservation significant fauna, during the clearing activity.

Vegetation and habitat clearing requirements for each component of the BLNG Precinct and associated infrastructure are shown in **Table 2.6-1**.

The area cleared under the proposal is expected to be up to 3,037ha. Additional to this, some fire management activities are expected to occur within the 2,000 and 3,000m buffer areas to manage fuel loads and reduce fire occurrence. This is likely to involve measures such as hazard reduction burns and vegetation thinning in some areas to reduce fire loads. At this point vegetation disturbance as a result of fire management cannot be accurately quantified. A Fire Management Strategy is to be implemented during the construction, commissioning and operation phases.

- **Table 2.6-1 Extent of Terrestrial Habitat Clearing.**

Proposal Component	Extent of Vegetation Disturbance (ha)
BLNG Precinct Project Area	Up to 2,090
Pipeline corridors	Up to 250
Workers accommodation	Up to 200
Light industrial area	Up to 200
Ancillary infrastructure	Up to 297
Total	**Up to 3,037ha ***

Note: * Fuel reduction activities and clearing for fire access will be as described in the Fire Management Strategy, utilising the above infrastructure where practicable.

The loss of vegetation, including monsoon vine thicket, for the BLNG Precinct, pipeline corridors, light industrial area and workers accommodation would not exceed the limits of cumulative loss prescribed in **Table 2.6-7**. In the context of the ancillary infrastructure (including minor access roads, service corridors, Manari Road diversion and possible groundwater abstraction borefield) the total extent of vegetation loss cannot be accurately quantified at this early stage of BLNG Precinct layout definition. However, the extent of clearing will be within that defined in **Table 2.6-1**. A description of disturbance requirements for ancillary infrastructure and for fire management purposes is presented in **Table 2.6-2**.

- **Table 2.6-2 Additional Infrastructure and Fire Management Vegetation Loss Details.**

Activity	Additional Information
Ancillary infrastructure including: • minor access roads; • service corridors; • Manari Road Diversion; and • borefield.	Clearing for minor access roads and service corridors will be required to link the Light Industrial Area and Workers Accommodation to the Main Access Road and Services Corridor. This will include: • road from Main Access Road to Workers Accommodation (100m corridor) and associated services corridor (60m); • road from Main Access Road to Light Industrial Area (100m corridor) and associated services corridor (60m); and • clearing required for other infrastructure such as the Manari Road diversion and borefield is subject to final design and layout. This total includes a nominal alignment for Manari Road diversion [(1)] and up to 22 groundwater bores, supported by an approximate 70m x 70m compound.
Fuel reduction activities and clearing for fire access within the Plan area in accordance with Fire Management Strategy.	As described in the Fire Management Strategy.

Note: [1] Clearing associated with Manari Road diversion may necessitate the loss of areas of high habitat value.
[2] A borefield in Broome sandstone may necessitate additional bores, however, the borefield source and location will be subject to further hydrogeological, cultural and ecological investigations. The size of the borefields will be dependent upon the selection of the water source for the BLNG Precinct and the total water demand for the BLNG Precinct development.

The exact location of the individual elements of the proposal is still to be finalised as part of detailed planning and engineering studies. Most of the infrastructure corridors will be located within the BLNG Precinct with the exception of pipeline corridors, access roads, light industrial area and workers accommodation. Siting of the light industrial area, workers accommodation and infrastructure outlined in **Table 2.6-7** will avoid areas of high habitat value, where possible.

The proposed disturbance to fauna habitats types resulting from vegetation clearing at the BLNG Precinct is shown in **Table 2.6-3.** These clearing estimates account for the area of each habitat cleared for the BLNG Precinct, pipeline corridors, workers accommodation and light industrial area.

While likely clearing requirements for the ancillary infrastructure and other infrastructure corridors is provided in **Table 2.6-1** above, the location and subsequent habitat types likely to be disturbed as a result of these project components are uncertain. For this reason it is difficult to include these areas within area loss calculations shown at **Table 2.6-3** however, for wide ranging species with broad habitat requirements the area loss calculations have been based on a total disturbance of 3,037ha accounting for all clearing requirements.

- **Table 2.6-3 Estimated Disturbance to Habitat Types in a Local and Regional Context.**

Vegetation Community	Preliminary Estimate of Maximum Area to be Cleared (ha)	Approximate Area Mapped in the James Price Point coastal area (ha)*	Disturbance within the James Price Point coastal area (%)	Known Community Extent on the Dampier Peninsula (ha)*	Disturbance within the Known Extent on Dampier Peninsula (%)
Monsoon vine thicket (TEC)	132.4	572	23.2	1,479[1] (2,710[2])	9.0[1] (4.9[2])
Pindan vegetation (includes shrubland, woodland and open forest)**	2,861.2	24,769	11.6	55,840	5.2
Coastal heath (PEC)	8.9	114	7.8	705	1.3
Coastal communities	34.5	583	5.9	3,712	0.9
Drainage basin	0	395	0	1,018	0

Note: Vegetation clearing takes into account the total land area requirements for the BLNG Precinct and ancillary infrastructure. Vegetation clearing associated with the pipeline corridors has been presented as the maximum extent of required area within the corridor buffers.

* Estimates based on the combined mapping by Biota (2009c; **Appendix C-18**), ENV (2008a; **Appendix C-14**) and CSIRO (2010; **Appendix C-21**)

** For the purposes of this table the Biota (2009c; **Appendix C-18**) vegetation communities of Pindan shrubland, Pindan woodland and open forests have been merged as they represent sub-groups of the broader Pindan vegetation.

[1] Based on results of monsoon vine thicket TM spatial analysis conducted by CSIRO (2010; **Appendix C-21**).

[2] Based on recent mapping studies of monsoon vine thicket conducted by the DEC.

The habitats affected by clearing provide general foraging opportunities for species, shelter from predators as well as breeding and nesting habitats for some species. Small and less mobile species of fauna, such as small mammals and reptiles, may be directly affected by land clearing activities, with some species of fauna being indirectly affected by not being able to relocate themselves into nearby habitats. Indirect effects may occur within nearby habitats from increased competition, lack of vacant niches and the increased densities may cause greater predation. The loss of fauna habitat associated with the BLNG Precinct is considered unlikely to have a significant impact on the populations of species within the area as the potential habitat to be retained within the James Price Point coastal would be sufficient to continue to support local populations.

Loss of Conservation Significant Habitats

The monsoon vine thicket found in the James Price Point coastal area was identified as being a habitat of conservation significance by Biota (2009b; **Appendix C-17**) on basis that it is a State listed TEC. Community analysis indicated that the faunal assemblage of this MVT habitat type (along with the coastal communities habitat type) are distinct from those of Pindan and open woodland habitats further inland (Biota, 2009b; **Appendix C-17**). Clearing will result in the removal

of approximately 14.5% of this combined habitat assemblage in the James Price Point coastal area, and 3.2% of combined habitat distribution in the Dampier Peninsula. This calculation is based on the area of monsoon vine thicket and coastal communities removed as a result of the BLNG Precinct and associated infrastructure and the area of habitats retained within the James Price point coastal area and Dampier Peninsula (**Table 2.6-3**). If the DEC estimates of vine thicket distribution on the Dampier Peninsula are correct, the regional loss of this habitat type would be reduced to 2.6%.

Based on current clearing estimates, 439ha of monsoon vine thicket habitat will be retained within the James Price Point coastal area. As such a large area of this particular habitat type will be retained within the James Price Point coastal area and would continue to support habitat for fauna species known to prefer this particular habitat type. In addition the retention of areas of coastal communities would also see that further areas of this habitat assemblage would be retained. As a result it is considered unlikely that the removal of this habitat type would have a significant impact on locally occurring fauna species.

Habitat Loss and Conservation Significant Fauna

The majority of conservation significant fauna species under consideration have broad habitat requirements and are likely to occur elsewhere on the Dampier Peninsula. Open forest and Pindan shrubland habitats are likely to provide foraging and nesting habitat opportunities for some of the conservation significant species listed however, these habitats are known to be common, both within the James Price Point coastal area and the Dampier Peninsula. Key habitat attributes such as large hollow-bearing trees or permanent freshwater are generally absent from the area and, as such, preclude the potential presence of a number of species of conservation significance.

State and Commonwealth listed fauna species known to, or considered to have the potential to occur within the James Price Point coastal area have been identified in **Part 4**, **Section 1**. The James Price Point coastal area is considered to represent potential habitat for a number of species however, habitat potential is somewhat limited by the absence of important habitat attributes such as permanent fresh water or large hollow-bearing trees. A number of the fauna species identified in **Part 4**, **Section 1** as potentially occurring have relatively broad habitat requirements which are well represented within the local and regional area, as a result of this these species have not been assessed further. This impact assessment specifically addresses conservation significant species which were recorded during surveys within the James Price Point coastal area, and those species which have restricted habitat types that are present within the James Price Point coastal area, or those whose potential presence could not be discounted.

Predicted impacts of habitat loss on migratory birds and SRE fauna are dealt with separately. Significant impacts to matters of National Environmental Significance are discussed in **Part 6**, **Section 2** (Matters of National Environmental Significance).

Australian Painted Snipe (*Rostratula australis*) – Vulnerable (EPBC Act), Migratory (EPBC Act)

This species has been recorded near the James Price Point coastal area by the DEC (Biota, 2009b; **Appendix C-17**). Although its preferred habitat is shallow freshwater swamps which are not present in the James Price Point coastal area, it may occur within the drainage basin habitat of the area following wet season rainfall. This area of potential habitat will not be removed as a result of BLNG Precinct and pipeline corridors construction while additional areas of similar habitat are known to occur at flat rock to the north. Areas of potential habitat are also likely to occur on the Dampier Peninsula in association with freshwater swamps. The BLNG Precinct is unlikely to significantly affect the availability of habitats for this species within the local or regional area.

Greater Bilby (*Macrotis lagotis*) – Vulnerable (EPBC Act), Schedule 1 (WC Act)

The Greater Bilby is historically known to occur in the Gourdon Bay area, there is a population known to exist in the Beagle Bay area, to the north of James Price Point (ENV, 2008c; **Appendix C-16**) and it is occasionally seen as roadkill on an adjacent section of the Great Northern Highway. The latest DEC record was at Roebuck Bay in 2001. Based on these recordings, it is likely this species occupies most of the Dampier Peninsula in very low densities (ENV, 2008c; **Appendix C-16**).

There was no conclusive evidence of Greater Bilby presence during any of the fauna surveys; however, during the AECOM (2010b; **Appendix C-20**) survey some foraging holes were identified that were indicative of this species. It could not be determined whether this was a result of Bilby foraging activity or a varanid lizard species. These foraging holes were recorded in the vicinity of the project area and south towards Quondong Point in Pindan shrubland. The

number of foraging holes recorded suggests they belong to a small number of transient individuals present in the area, rather than a resident colony (AECOM, 2010b; **Appendix C-20**). Therefore it is unlikely that a resident population of this species would be in jeopardy of being significantly affected by the habitat clearing requirements of the BLNG Precinct.

The Greater Bilby is highly mobile, and can have large foraging ranges, moving up to five kilometres between burrows on consecutive days (DEWHA, 2010f). Based on the presence of suitable habitats within much of the James Price Point coastal area it is possible that the species may forage within the BLNG Precinct Project area, and other locations within the James Price Point coastal area.

While no direct evidence of the species was recorded, Pindan vegetation of the James Price Point coastal area is considered to provide the most likely habitat type for this species. Approximately 2,861ha of Pindan habitat will be cleared as a result of the BLNG Precinct and associated clearing requirements. This equates to 11.6% of habitats mapped within the James Price Point coastal area and 5.2% of habitats mapped on the Dampier Peninsula by ENV (2008a; **Appendix C-14**) (see **Table 2.6-3**). The area of habitat retained within the James Price Point coastal area, along with additional areas of Pindan habitat known to occur to the north, east and south of the BLNG Precinct are likely to be sufficient to continue to support locally occurring individuals.

Golden-backed Tree-rat (*Mesembriomys macrurus*) - Vulnerable (EPBC Act), Priority 4 (DEC)

The vast majority of records of the Golden-backed Tree-rat are located north of Derby extending up to the Mitchell Plateau; however, the species has been recorded near Broome, so it could be present within the James Price Point coastal area. Monsoon vine thicket, Pindan vegetation and areas of pandanus scrub within the drainage basin provide suitable habitat for the Golden-backed Tree-rat; however, no evidence of the occurrence of this species was found during surveys of James Price Point coastal area. Recent information suggests that the Golden-backed Tree-rat may be regionally extinct from the Dampier Peninsula (AWC, 2010).

Approximately 11.6% of suitable combined habitat within the James Price Point coastal area will be removed for the construction of the BLNG Precinct and associated infrastructure, while approximately 22,742ha (or over 88% of habitat within the local area) would be retained (calculation is derived from area of monsoon vine thicket, Pindan vegetation and drainage basin vegetation occurring within the James Price Point coastal area, **Table 2.6-3**). It is unlikely that the species will be significantly affected by the proposed clearing as the species would only exist in very low densities, if at all, given the patchy nature of food resources and lack of evidence of the species presence. It is also likely that the area of potential habitat to be retained within the James Price Point coastal area would be sufficient to continue to support a local population, should one occur. In addition, habitat clearing is not listed as a threat to the survival the species rather the most likely threats are predation by feral cats and changed fire regimes (DEWHA, 2010k).

Golden Bandicoot (*Isodoon auratus*) - Vulnerable (EPBC Act), Schedule 1 (WC Act)

This species was not recorded at James Price Point during recent surveys; however suitable habitat of monsoon vine thickets, drainage basin and Pindan vegetation, occurs within the area. The last DEC record was in 1971 from the Coulomb Point Nature Reserve (Biota, 2009b; **Appendix C-17**) and currently there are no known populations of the species on the Dampier Peninsula. All known populations on the Kimberley mainland are further north at Yampi Peninsula, Prince Regent Nature Reserve and Mitchell Plateau (DEWHA, 2010g). Based on these records it is highly unlikely that a population of this species occurs within the James Price Point coastal area.

Up to 11.6% of suitable combined habitat within the James Price Point coastal area will be removed for the construction of the BLNG Precinct and associated infrastructure, while approximately 22,742ha (or over 88% of habitat within the local area) would be retained (calculation is derived from area of vine thicket, Pindan vegetation and drainage basin vegetation occurring within the James Price Point coastal area, **Table 2.6-3**).

In the unlikely event that a population does occur, the retention and management of monsoon vine thicket and wider area Pindan vegetation habitat is likely to continue to support a local population of this species. In addition, habitat clearing is not listed as a threat to the survival the species rather the most likely threats are predation by feral cats and changed fire regimes (DEWHA, 2010g).

Masked Owl (northern) (*Tyto novaehollandiae kimberli*) - Vulnerable (EPBC Act)

Whilst there is a single record of the Northern Masked Owl in the vicinity of Broome, there have been no other records of the subspecies from the Dampier Peninsula. The Masked Owl has broad habitat requirements and may utilise all habitat

types within the BLNG Precinct area, and wider Dampier Peninsula as part of larger foraging territory as no roosting sites are present. A total of 3,037ha, or 11.5% of suitable foraging habitat from the James Price Point coastal area may be lost as a result of clearing requirements for the BLNG Precinct and associated clearing requirements (**Table 2.6-1**). Similar areas of potential habitat are likely to occur across the Dampier Peninsula and based on similar habitats mapped on the Dampier Peninsula by ENV (2008a; **Appendix C-14**) approximately 59,717ha or 93% of habitats would continue to persist (or 60,948ha, representing 95% of habitats using DEC mapping data for vine thicket). Given the lack of records from the locality, and large areas of similar foraging habitat elsewhere on the Dampier Peninsula, habitat loss associated with the BLNG Precinct area and pipeline corridors is unlikely to significantly impact the Masked Owl.

Peregrine Falcon (*Falco peregrinus*) – Schedule 4 (WC Act)
The Peregrine Falcon was recorded within the drainage basin habitat and on a coastal cliff in the James Price Point coastal area (Biota, 2009b; **Appendix C-17**). No clearing of drainage basin vegetation will occur; however, this species inhabits a wide range of habitats including forest, woodlands, wetlands and open country (Biota, 2009b; **Appendix C-17**). Therefore all vegetation types within the BLNG Precinct Project area are likely to provide potential habitat for this species. These broad habitat requirements suggest that adequate suitable habitat for the Peregrine Falcon will remain in the local and regional area after clearing for the BLNG Precinct has occurred. Coastal cliff habitats are located to the north of the James Price Point coastal area and while the northern pipeline crossing will be located in this area, this is unlikely to result in a significant area of this habitat being disturbed.

A total of 3,037ha or 11.5% of suitable foraging habitat from the James Price Point coastal area may be lost as a result of clearing requirements for the BLNG Precinct and associated clearing requirement (**Table 2.6-1**). Similar areas of potential habitat are likely to occur across the Dampier Peninsula and based on similar habitats mapped on the Dampier Peninsula by ENV (2008a; **Appendix C-14**) up to 95% of habitats would continue to persist.

Little North-western Mastiff Bat (*Mormopterus loriae cobourgiana*) – DEC Priority 1
The little North-western Mastiff Bat was recorded within the Coulomb-Quondong Point area by ENV (2008c; **Appendix C-16**). While the species preferred roosting habitat (mangroves) was not identified, the monsoon vine thicket may offer roosting habitat that would be removed as a result of the BLNG Precinct and the southern pipeline corridor. While some areas of potential roosting habitat may be disturbed as a result of the BLNG Precinct construction, it is unlikely that this would represent a significant area of habitat. Roosting habitat would be retained within the James Price Point coastal area, while preferred mangrove habitats would continue to persist elsewhere along the Dampier Peninsula and northern WA coastline.

Dampierland Burrowing Snake (*Simoselaps minimus*) – Priority 2 (DEC)
The Dampierland Burrowing Snake was recorded on a single occasion within the monsoon vine thicket during the Biota (2009b; **Appendix C-17**) survey. The species is only known from the Dampier Peninsula but is likely to occur within a variety of habitat types including monsoon vine thickets, coastal communities and Pindan vegetation. Approximately 3,037ha of these habitats will be cleared for the BLNG Precinct and associated clearing requirements (**Table 2.6-1**) equating to approximately 11.5% of the local extent of this habitat within the James Price Point coastal area. However, these habitat types are widespread and occur across much of the Dampier Peninsula, and as such, up to 95% of suitable habitat for the Dampierland burrowing snake will remain throughout the Dampier Peninsula.

Dampierland Plain Slider (*Lerista separanda*) – Priority 2 (DEC)
The Dampierland Plain Slider was recorded from a single location within the Pindan vegetation on sandy soil within the James Price Point coastal area (Biota, 2009b; **Appendix C-17**). Approximately 2,861ha of these habitats will be disturbed during the construction of the BLNG Precinct and associated infrastructure, equivalent to approximately 11.6% of the extent of these habitats within the James Price Point coastal area and 5.2% of these habitats within the Dampier Peninsula. This amount of clearing is not expected to have a significant local impact on the Dampierland Plain Slider,

Bush Stone-curlew (*Burhinus grallarius*) – Priority 4 (DEC)
The Bush Stone-curlew is widespread in Australia and remains common in tropical Australia. This bird species was recorded within Pindan vegetation within the James Price Point coastal area however would be expected to occur in most habitat types. Clearing of 3,037ha for the BLNG Precinct and associated clearing requirements (**Table 2.6-1**) will remove 11.5% of suitable habitat within the James Price Point coastal area, while over 88% will remain, with additional areas of similar habitat occurring to the north, south and east of the BLNG Precinct. Given the widespread distribution of

the Bush Stone-curlew, clearing associated within the BLNG Precinct is not anticipated to have a significant impact on the local or regional distribution and abundance of this species.

Chestnut-backed Button-quail (*Turnix castanota magnifica*) – Priority 4

The Chestnut-backed Button-quail was recorded within Pindan vegetation in the James Price Point coastal area. Approximately 2,861ha of this habitat type will be cleared for the BLNG Precinct and associated infrastructure, equating to 11.6% of the local extent of the habitat within the James Price Point coastal area (**Table 2.6-3**). This amount of clearing and the fact that this species distribution extends into the Northern Territory (AECOM, 2010b; **Appendix C-20**) suggests that it is unlikely that disturbance associated with the BLNG Precinct will significantly affect the abundance and distribution of the Chestnut-backed Button-quail.

Eastern Curlew (*Numenius madagascariensis*) – Priority 4 (DEC), Migratory (EPBC Act)

The Eastern Curlew occurs mainly on tidal mudflats, and also on sandy beaches and occasionally near coastal lakes. Although core habitat is not present within the James Price Point coastal area, beach fronts are present and a small number of Eastern Curlew individuals were observed during a high tide aerial survey of the coastline in November (AECOM, 2010b; **Appendix C-20**). Approximately 2.5km of beach front will be disturbed for the shore crossings for the BLNG Precinct and pipeline corridors while 1.5km would be permanently modified. This disturbance is not expected to affect the populations of Eastern Curlew on the Dampier Peninsula as suitable habitat will continue to persist for the species both in the vicinity of James Price Point coastal area and elsewhere on the Dampier Peninsula.

Habitat Loss and Migratory Birds

Approximately 1.5km of shoreline will be permanently modified for the shore crossing, with temporary disturbance of an additional one kilometre for pipeline corridors. Based on the findings of Galaxia (2010; **Appendix C-1**), this removal of nearshore and coastal habitat is unlikely to have a significant impact on migratory bird species for the reasons listed below.

- The number of migratory birds recorded in the James Price Point coastal area are considered very low when compared to other areas on or near the Dampier Peninsula (for example Roebuck Bay, Eighty Mile Beach, Bidyanga and Dessault Bay).
- The James Price Point coastal area does not include any intertidal or coastal strip habitats that are not well represented in the region, and hence is unlikely to host any regionally significant populations of migratory birds showing a preference for these habitats.
- More extensive and suitable feeding and roosting areas for migratory birds (e.g. intertidal sand and mudflats, tidal creeks and mangals) on the Dampier Peninsula are likely to be located both south and north of the James Price Point coastal area, in locations such as Willie Creek and Barred Creek to the south; and Carnot Bay, Baldwin Creek, Camp Inlet, Beagle Bay, Tappers Inlet, Pender Bay, Chile Creek and Thomas Bay to the north.
- Pindan woodland is likely to be an additional habitat for migratory bird species within James Price Point coastal area, although it is less suitable than inshore seas, intertidal sand and reef flats, rocky outcrops, beaches and coastal cliffs. This vegetation type predominates across the whole of the Dampier Peninsula, covering some 70% of the area. Therefore, any migratory bird species exhibiting a preference for this type of habitat could be expected to be fairly widespread across the region.

Habitat Loss for Short Range Endemic Fauna

The potential presence of SRE invertebrates is currently uncertain and will be subject to further studies. If present, SRE species are perhaps most likely to occur in monsoon vine thicket habitats within the James Price Point coastal area, given that this represents a distinct fauna habitat. Approximately 132.4ha of potential SRE habitat would be removed as a result of vegetation and habitat clearing activities. This loss equates to the removal of up to 23% of this community's distribution within the James Price Point coastal area, but only 4.9% of the distribution within the Dampier Peninsula (based on DEC's latest estimates - see **Table 2.6-3**). The local viability of populations of SRE fauna are unlikely to be compromised by habitat loss as none of the habitats to be cleared will be removed in their entirety from the local area while approximately 439ha of vine thicket habitat would continue to persist within the James Price Point coastal area.

Habitat Fragmentation

Fragmentation of coastal habitats will occur as a result of clearing for the onshore pipelines and for the shore crossing approach linking the BLNG Precinct to the Marine Facility. As a result the coastal habitats would be fragmented into three areas containing monsoon vine thicket and coastal communities. The northern pipeline crossing will cause fragmentation of the coastal heath vegetation.

Habitat fragmentation has the potential to isolate individuals from the breeding population or create three or more breeding populations and is of particular concern for species with limited mobility such as reptiles and SRE fauna and ground-dwelling mammals with limited home ranges (e.g. less than 30ha). Most bird species and large macropods are likely to be able to traverse cleared areas and in the case of macropods, jump barriers to dispersion such as pipelines or fences, and therefore should not be significantly affected by habitat fragmentation. Mechanisms to allow fauna dispersal will be investigated as part of the design of both the onshore pipeline and shore crossing to minimise the effects of habitat fragmentation where possible.

Two fauna species of conservation significance recorded at James Price Point, the Dampierland Burrowing Snake (*Simoselaps minimus*) and the Dampierland Plain Slider (*Lerista separanda*) may be found within the coastal community habitat and coastal heath habitat, although they are also known to occur in other habitats. The Water-rat (*Hydromys chrysogaster*) may also potentially occur in these coastal communities. Given that coastal communities are widespread along the coastline of Dampier Peninsula and that fragmentation is likely to result in the isolation of few individuals only, populations of these species, as well as other reptiles and ground-dwelling mammals, are unlikely to be significantly impacted.

Fauna of conservation significance with limited motility are known to use or potentially occur within the monsoon vine thicket such as the Dampierland Burrowing Snake (*Simoselaps minimus*) (recorded), the Golden Bandicoot (*Isodoon auratus*) (possibly occurring) and Golden-backed Tree-rat (*Mesembriomys macrurus*) (possibly occurring). Given that these species are known to occur in habitats other than monsoon vine thicket, and that fragmentation is likely to result in the isolation of few individuals only, populations of these species, as well as other reptiles and ground-dwelling mammals, are unlikely to be significantly compromised.

Due to the severely limited dispersal of SRE fauna, fragmentation of habitats has the potential to split local breeding populations. If present at James Price Point, coastal area SRE fauna are likely to occur in monsoon vine thicket habitats inside and outside of the BLNG Precinct area. Given the retention of large areas of monsoon vine thicket north and south of the potential disturbance locations, it is unlikely local population viability will be threatened. Further studies will be conducted to understand the likely presence of SRE fauna species within the James Price Point coastal area.

Fauna Injury or Mortality

Direct loss or injury to fauna, including fauna of conservation significance, and SRE fauna may occur as a result of clearing and earthworks. Fauna which are ground-dwelling, exhibit limited home ranges, exhibit limited mobility (e.g. reptiles) or burrow in the soil as an escape mechanism or for nesting, may be in jeopardy of death from heavy construction machinery during the clearing process. Fauna of conservation significance which may be impacted include:

- ground-dwelling mammals such as Greater Bilby (*Macrotis lagotis*), Golden Bandicoot (*Isodoon auratus*), Lakeland Downs Mouse (*Leggadina lakedownensis*)and Water-rat (*Hydromys chrysogaster*);
- burrowing reptiles such as Dampierland Burrowing Snake (*Simoselaps minimus*) and Dampierland Plain Slider (*Lerista separanda*);
- the Rainbow Bee-eater (*Merops ornatus*) which is known to have nests in burrows built in sandy embankments; and
- the semi-arboreal Golden-backed Tree-rat (*Mesembriomys macrurus*) which is known to spend considerable time on the ground when foraging.

The agility and aerial nature of bat species and most avifauna, make them unlikely to be directly impacted by clearing machinery. Furthermore, no roosting sites or nesting sites were observed during fauna surveys (Biota, 2009b; **Appendix C-17**).

Pre-clearance surveys and the identification and mapping of specific habitats such as tree hollows prior to clearing will enable potential habitats to be identified and inspected for fauna prior to clearing, and species relocated. While injury or

death to some fauna species of conservation significance is possible, it is unlikely that these would place a local population of the species at risk.

The construction and operation of the BLNG Precinct would result in the loss of terrestrial fauna habitat. However, this disturbance is not expected to affect conservation significant fauna species as suitable habitat will continue to persist for these species both in the vicinity of James Price Point coastal area and elsewhere on the Dampier Peninsula. Fragmentation of fauna habitat resulting from clearing activities is likely to result in the isolation of few individuals only, populations of these species, as well as other reptiles and ground-dwelling mammals, are unlikely to be significantly impacted. While injury or death to some fauna species of conservation significance is possible, it is unlikely that these would place a local population of the species at risk. The removal of nearshore and coastal habitat is unlikely to have a significant impact on migratory bird species.

It is expected that potential impacts to terrestrial fauna due to vegetation and habitat clearing can be minimised through measures such as setting limits on the area to be cleared and avoiding locating infrastructure in areas of high habitat value, where possible. A more detailed description of proposed mitigation measures is presented in **Section 2.6.4**. The significance of residual impacts on terrestrial fauna due to vegetation and habitat clearing is assessed to be low as this disturbance is not expected to affect conservation significant fauna species as suitable habitat will continue to persist for these species both in the vicinity of James Price Point coastal area and elsewhere on the Dampier Peninsula, and direct impacts are likely to only affect a small number of animals which would not place a local population of the species at risk.

2.6.3.2. Potential Impacts to Terrestrial Fauna due to Vehicle Movements

Roads will be established during the construction and operation of the BLNG Precinct. These will include service roads within the BLNG Precinct boundary and a transport infrastructure corridor linking the BLNG Precinct to surrounding areas.

Direct loss of, or injury to fauna, including fauna of conservation significance, may occur as a result of vehicle strikes when fauna are crossing tracks and roads in the area during the construction and operational phases of the project. While some fauna deaths are likely to currently occur as a result of vehicle traffic along Manari Road, the construction of additional transport corridors may result in an increase in fauna injury or mortality. Ground-dwelling fauna or those with limited mobility (e.g. reptiles) may be at risk of death or injury, and may include fauna of conservation significance such as:

- the Greater Bilby (*Macrotis lagotis*), Golden Bandicoot (*Isodoon auratus*), Lakeland Downs Mouse (*Leggadina lakedownensis*) and Water-rat (*Hydromys chrysogaster*);
- reptiles such as Dampierland Burrowing Snake (*Simoselaps minimus*) and Dampierland Plain Slider (*Lerista separanda*); and
- the semi-arboreal Golden-backed Tree-rat (*Mesembriomys macrurus*).

Avifauna, including migratory birds, are considered to be at less likely to experience vehicle strikes due to their agility, but may collide with vehicle windshields when vehicles are travelling at high speeds.

It is expected that potential impacts to terrestrial fauna due to vehicle movements can be minimised through measures such as the setting of appropriate vehicle speed limits during construction and operation phases. A more detailed description of proposed mitigation measures is presented in **Section 2.6.4**. The significance of residual impacts on terrestrial fauna due to vehicle movements is assessed to be very low as vehicle strike is likely to result in only individual deaths, and therefore is unlikely to affect the conservation status of the species involved.

2.6.3.3. Potential Impacts to Terrestrial Fauna due to Site Disturbance and Excavation

Construction and excavation activities associated with the BLNG Precinct have the potential to impact vertebrate fauna and subterranean fauna and include:

- the construction and installation of the onshore pipelines which may require large trenches to be excavated during pipe laying; and
- excavation of trenches and pits elsewhere within the BLNG Precinct construction area.

Injury or death of fauna may result from terrestrial fauna becoming accidentally trapped in excavation trenches associated with the construction areas. Animals that are trapped in trenches are exposed to various factors, such as stress, predators, effects from the sun and subsequent dehydration. Species that are particularly susceptible to entrapment include reptiles and small mammals and may include fauna of conservation significance such as:

- mammal species - Greater Bilby (*Macrotis lagotis*), Golden Bandicoot (*Isodoon auratus*), Lakeland Downs Mouse (*Leggadina lakedownensis*) and Water-rat (*Hydromys chrysogaster*), Golden-backed Tree-rat (*Mesembriomys macrurus*); and
- reptile species - Dampierland Burrowing Snake (*Simoselaps minimus*) and Dampierland Plain Slider (*Lerista separanda*).

Through the prior clearing and establishment of work areas it is likely that only transient individual fauna species would become trapped within trenches and excavated areas, rather than large numbers of individual species. Furthermore, a variety of management measures will be adopted to prevent fauna from falling into the trench in the first instance, as well as facilitating their escape or removal.

Site disturbance and excavation during construction (including blasting and foundation-preparation activities) may also result in the loss of or disturbance of subterranean fauna habitat, however it is considered that there is a low possibility of significant subterranean fauna values being present within the James Price Point coastal area Biota (2009b; **Appendix C-17**). If any subterranean fauna species are present within the James Price Point coastal area, they could be expected to occur within similar geological formations on the wider Dampier Peninsula (Biota, 2009b; **Appendix C-17**); hence, populations in the area, if present, are unlikely to be restricted in their distribution.

It is expected that potential impacts to terrestrial fauna due to site disturbance and excavation can be minimised through measures such as implementing procedures to avoid trapping fauna in excavations. A more detailed description of proposed mitigation measures is presented in **Section 2.6.4**. The significance of residual impacts on terrestrial fauna due to site disturbance and excavation is assessed to be very low as any deaths or injury to fauna species of conservation significance from site disturbance and excavation are likely to be to transient individuals only and it is unlikely that this would significantly affect local fauna populations.

2.6.3.4. Potential Impacts to Terrestrial Fauna due to Light Emissions

Light emissions associated with the BLNG Precinct may include temporary lighting on the gas plant site during construction, and permanent lighting during operations such as that from the gas plant during night operations, flaring and lighting from the accommodation facility.

The light emissions associated with the BLNG Precinct have the potential to disrupt fauna behaviour, particularly with regards to mammals and avifauna. Light sources may attract insect predators such as birds and bats through the attraction and concentration of insects in localised well-lit areas. This potentially puts species at risk of other hazards associated with the project, such as vehicle strike and gas flares. Birds have been reported to become disoriented by the strong light of gas flares. Fauna of conservation significance that may be affected in such a away by light emissions if present include the Little Northwestern Mastiff Bat (*Mormopterus loriae cobourgiana*) - Priority 1 (DEC) and various birds, listed as ‘Migratory’ under the EPBC Act, including but not limited to gulls, terns and shearwaters (see **Part 4**, **Section 1** (Environmental Overview)). Considering the area is not regarded as a primary habitat for the Little Northwestern Mastiff Bat or migratory birds in comparison to other coastal areas and offshore islands, the possible impact to these species from light emissions is considered to be low. Furthermore, impacts are likely to be restricted to individual deaths and unlikely to compromise the conservation status of the species.

Light emissions also have the potential to disturb fauna, predominantly mammals and nesting birds, from habitat within the vicinity of the BLNG Precinct site resulting in a local decrease in fauna abundance. Any potential impact on terrestrial fauna species (including fauna of conservation significance, if present) due to light emissions is expected to be restricted to the BLNG Precinct site and the immediate area, and, as such, only a small portion of available habitats for locally occurring fauna species would be disturbed. In addition, any impacts to local fauna populations are expected to represent a minor behavioural disruption as displaced fauna are likely to relocate to other areas of similar habitat in the local area.

Light emissions from the BLNG Precinct are considered unlikely to impact the nearest significant area for migratory birds, Ramsar wetland at Roebuck Bay, as the site is located greater than 60km away. Lighting from the town of Broome, which is approximately 10km from Roebuck Bay Ramsar site, is expected to represent a much larger source of light as opposed to light emissions from the BLNG Precinct (Galaxia, 2010; **Appendix C-1**).

Any potential impact on terrestrial fauna species (including fauna of conservation significance, if present) due to light emissions is expected to be restricted to the BLNG Precinct site and the immediate area. As such, only a small portion of available habitats for locally occurring fauna species would be disturbed. Based on current information the James Price Point coastal area is not considered to provide any regionally significant habitat for migratory bird species. The potential consequence of lighting is expected to be only a minor impact on a small portion of the population resulting from minor and temporary behavioural disruption and so no threat to the overall population viability is likely. Following the implementation of appropriate management and mitigation measures presented in **Section 2.6.4**, the significance of the residual impact to terrestrial fauna due to light emissions is assessed to be very low.

2.6.3.5. Potential Impacts to Terrestrial Fauna due to Noise and Vibration

The major sources of noise and vibration associated with the BLNG Precinct will be associated with:

- construction: construction traffic, earthworks, pile driving, blasting (<120dB), heavy machinery work and construction of the onshore processing facilities; and
- operations: power generators (multiple), compressors (multiple), air-fin coolers (multiple), piping and flaring systems (60dB at 1,200m).

Of these activities, the most significant contributing sources of noise and vibration during construction of facilities within the Precinct are expected to be pile driving and blasting, whilst the intermittent discharge of gas from the gas flare is expected to be the dominant source of noise during operations. Generally, construction activities are expected to produce occasional peaks in noise and vibration, whilst operational noise is expected to be of lower magnitude and more constant in nature. There may be irregular noise peaks during operations when gas is discharged from the flare.

Fauna
Research into the effects of noise and vibration on Australian animals is relatively scarce (Environment Australia, 1998; DEWHA cited in Brockman Resources, 2010). The majority of available literature on noise and vibration effects on fauna is focussed on the impacts associated with roads and military activities in North America. The findings of species specific studies suggest that demonstrated responses are not common to all species, or even all individuals within a species, and so highlight the need for a greater number of species to be studied in this context. No published information is available regarding the possible impacts of noise and vibration on any of the listed vulnerable species that may potentially occur in the Browse LNG Precinct area.

Fauna considered at most risk of noise and vibration effects generally include mammals and birds. The most commonly reported effect of noise on such fauna is abandonment of territory (Larkin, 1994). Irregular loud noise may alarm fauna and cause them to temporarily vacate the immediate area, but it is usually the case that fauna will return when noise levels return to normal. Furthermore, many fauna species show a decreased responsiveness after repeated exposure to noise has been frequently observed and is usually attributed to habituation (Larkin,1994). Examples of fauna returning to an area following infrequent loud noise and habituation include:

- Western Australian mammals: Aeroplanes and helicopters land and take-off from the airstrip at Barrow Island at least four days per week with noise levels of approximately 80dB(A) at 100m from the aircraft, yet a number of mammals including euros, burrowing bettongs, golden bandicoots, hare wallabies and brush-tail possums persist in close proximity.
- Peregrine Falcon: Pruitt *et al.* (2002) concluded that there was no significant effect of exposure to jet overflight on peregrine nest success or productivity.
- Red-cockaded Woodpeckers successfully raised young near a highly active bombing range in Mississippi (Jackson, 1983).
- Burrowing Owls nesting productivity was found to be unaffected by road traffic Plumpton and Lutz (1993).

Based on existing evidence, it is considered likely that fauna may exhibit short-term displacement initially to infrequent loud noises associated with the BLNG Precinct such as blasting, piling and discharge of the gas flare(s), but then will habituate. Fauna in the vicinity of the operating gas processing facility are expected to become habituated to the ongoing, low level noise associated with the facility. Slight changes to local faunal assemblages and abundance may result from noise effects, but is unlikely to constitute a significant impact.

More serious effects of noise on fauna include hearing loss. Immel (1995) conducted experiments on the impact of dune buggy sounds on the Desert Rat Kangaroo and found that noise levels above 95dB at a range of 4m resulted in temporary hearing loss which greatly reduced chances of detecting approaching predators. It is possible that fauna in the immediate vicinity of construction at the BLNG Precinct may experience such hearing loss when blasting occurs. There is no evidence to suggest whether exposure to blasting (<120dB) would cause temporary or permanent hearing loss in small Australian mammals or birds.

Vibration effects from blasting during construction may have physiological effects on fauna in the immediate vicinity of construction works. This may result in individual fauna deaths, or reproductive consequences such as marsupials ejecting their pouch young. This would not be expected to decrease the viability of local populations and is unlikely to constitute a significant impact.

Fauna of Conservation Significance and Migratory Birds

Potential impacts to conservation significant fauna are considered in the same context as general terrestrial fauna, as outlined in the above discussion. Considering the area is not regarded as a primary habitat for migratory birds in comparison to other coastal areas and offshore islands, the possible impact to these species from noise and vibration is considered to be low.

Subterranean Fauna

Physical vibration associated with earthworks, particularly the shock waves associated with any blasting, or seismic surveys could potentially impact subterranean fauna and/or habitat through compromising the integrity of small fissures or crevices that provide habitat to subterranean fauna.

Construction vibration impacts at the BLNG Precinct, such as those associated with blasting, piling, heavy machinery work, will be localised and of short duration and the operational facilities within the BLNG Precinct will be, by necessity, constructed and secured on paved hardstand areas in the localised industrial zone. As such, vertical propagation of vibration effects to subterranean habitats is considered highly unlikely to result in significant impacts. Furthermore, while it is possible that stygofauna and troglofauna habitat may be present within the BLNG Precinct area, these habitats are associated with geological formations which are common to the James Price Point coastal area, and stygofauna, if present, are likely to include typically widespread taxa. As a result, it is unlikely that the local viability of subterranean fauna populations or their habitat, if present, would be compromised.

Based on existing evidence, it is considered likely that fauna may exhibit short-term displacement initially to infrequent loud noises associated with the BLNG Precinct such as blasting, piling and discharge of the gas flare(s), but then will habituate. Fauna in the vicinity of the operating gas processing facility are expected to become accustomed to the ongoing, low level noise associated with the facility. Slight changes to local faunal assemblages and abundance may result from noise effects, but is unlikely to constitute a significant impact.

The James Price Point area is not considered to support significant nesting sites for migratory shorebirds or seabirds and is not expected to represent a significant flight path. The potential consequence of noise and vibration is expected to be only a minor impact on a small portion of the population resulting from minor and temporary behavioural disruption and there is no threat to the overall population viability.

The aquifers in the James Price Point coastal area are unlikely to represent significant habitat for stygofauna, although it is acknowledged that some stygal species, which are typically widespread, may be present within the sand-based aquifers (Biota, 2009b; **Appendix C-17**). Construction vibration impacts at the BLNG Precinct, such as those associated with blasting, piling, heavy machinery work, will be localised and of short duration and the operational facilities within the BLNG Precinct will be, by necessity, constructed and secured on paved hardstand areas in the BLNG Precinct. As such, vertical propagation of vibration effects to subterranean habitats is considered highly unlikely to result in significant impacts.

It is expected that potential impacts to terrestrial fauna due to noise and vibration can be minimised through measures such as addressing noise management in the proposed Fauna Management Plan. A more detailed description of proposed mitigation measures is presented in **Section 2.6.4**. The significance of residual impacts on terrestrial fauna due to noise and vibration is assessed to be low or very low as vibration impacts at the BLNG Precinct, such as those associated with blasting, piling and heavy machinery work, will be localised and of short duration and the area is not considered to support significant nesting sites for migratory shorebirds or seabirds and is not expected to represent a significant flight path.

2.6.3.6. Potential Impacts to Terrestrial Fauna due to Dust Emissions

Construction activities such as vegetation clearing and earthworks, traffic movements on unsealed roads, trenching and loading may potentially result in carriage of dust onto nearby vegetation and into ephemeral drainage lines. Dust generation is likely to be more pronounced during construction rather than during the BLNG Precinct's operational phase. If unmanaged, fugitive dust emissions have the potential to result in reduced condition or stress of surrounding vegetation in the vicinity of the development area.

Dust may be deposited on nearby vegetation communities and may result in their potential degradation through reducing access to light, water and nutrients. As vegetation health deteriorates, so too may the value of habitat in the provision of resources to fauna (e.g. food, shelter etc.). Degradation to fauna habitats may cause more mobile fauna to re-locate to more pristine versions of these habitats elsewhere leading to a decrease in local fauna abundance or in the case of more sedentary fauna (such as ground-dwelling mammals, reptiles or SRE fauna), a decrease in fitness or possible death due to a demise in suitable resources. Fauna of conservation significance with limited mobility or small home ranges that could be affected if unable to relocate to more suitable habitat include:

- ground-dwelling mammals such as Golden Bandicoot (*Isodoon auratus*), Lakeland Downs Mouse (*Leggadina lakedownensis*) and Water-rat (*Hydromys chrysogaster*);
- burrowing reptiles such as Dampierland Burrowing Snake (*Simoselaps minimus*) and Dampierland Plain Slider (*Lerista separanda*); and
- the semi-arboreal Golden-backed Tree-rat (*Mesembriomys macrurus*).

Following the implementation of appropriate management and mitigation measures, such as dust suppressant techniques to minimise dust emissions, the local viability of populations of fauna, fauna of conservation significance or SRE fauna are unlikely to be significantly compromised by dust deposition. A more detailed description of proposed mitigation measures is presented in **Section 2.6.4**, and also further assessed in **Part 4**, **Section 2.8** (Air Quality). The significance of the residual impact on terrestrial fauna from dust emissions was deemed to be very low as dust emissions will be localised, temporary and controllable with management.

2.6.3.7. Potential Impacts to Terrestrial Fauna due to Groundwater Abstraction

Multiple options are currently being considered for water supply for operation while construction activities are highly likely to require access to groundwater. One of these options includes abstraction of groundwater from the Broome Sandstone aquifer. If this was pursued, drawdown of groundwater would occur in the immediate vicinity of the proposed bore fields. Groundwater abstraction has the potential to lower groundwater levels either directly if the abstraction is from an unconfined surface aquifer or indirectly if the abstraction is from a semi-confined lower aquifer where the abstraction would cause leakage from the upper aquifer(s). The extent and magnitude of any groundwater level drawdown will depend on the aquifer, borefield layouts, groundwater pumping rates and duration.

If groundwater is used, groundwater drawdown may potentially affect areas of vegetation that are groundwater dependent. Areas of monsoon vine thicket and drainage basin communities, which are important fauna habitats, may be groundwater dependent (**Part 4**, **Section 2.4**). Further evaluation of the likely level of groundwater dependence of vine thickets together with detailed groundwater mapping following field investigations will be undertaken to inform a groundwater operating strategy for construction and, if proposed, for each proponent of derived proposals' operations. Based on current borefield designs it is unlikely that groundwater would be extracted in close proximity to coastal vegetation such as vine thicket, this may limit the potential for drawdown to affect habitats such as vine thicket. Areas of vegetation potentially affected by drawdown would be identified following groundwater investigations and modelling.

Alteration of the natural saltwater/freshwater interface near the coast may also occur as a result of groundwater abstraction, with subsequent impacts on groundwater dependant vegetation possible. This would also be further evaluated as part of future groundwater studies and investigations.

The aquifers in the James Price Point coastal area are unlikely to pose significant habitat for stygofauna, although it is acknowledged that some stygal species, which are typically widespread, may be present within the sand-based aquifers (Biota, 2009b; **Appendix C -17**). Consequently, if groundwater is used, groundwater drawdown is not expected to significantly affect stygofauna as the species which may be present are likely to be typically widespread. This is because the Broome sandstone aquifer covers much of the Dampier Peninsula. Some preliminary stygofauna sampling and geological investigations are proposed to further inform this initial assessment and the requirement for further sampling or investigations would be based on these initial results.

It is expected that potential impacts to terrestrial fauna due to groundwater abstaction can be minimised through measures such as appropriate design and location of borefields and monitoring potential impacts on vegetation and stygofauna if present. A more detailed description of proposed mitigation measures is presented in **Section 2.6.4**. The significance of residual impacts on terrestrial fauna due to groundwater abstraction is assessed to be very low as there is a low likelihood that stygofauna are present, and because groundwater abstraction will be appropriately controlled under licence requirements set and monitored by the Department of Water who will not issue a licence unless it is demonstrated that significant impacts are manageable.

2.6.3.8. Potential Impacts to Terrestrial Fauna due to Physical Presence of Infrastructure

The physical presence of the BLNG Precinct and subsequent alterations to natural surface water flow regimes has the potential to degrade fauna habitats which are sensitive to surface water flows due to the creation of drainage shadow effects and localised flooding or ponding. Fauna habitats within the James Price Point which may be sensitive to surface water flows include the drainage basin habitat, as suggested by the presence of the flora species *Melaleuca dealbata* and *Lophostemon grandiflorus*, and the monsoon vine thicket habitat, based upon the data presented by the DoW discussion papers (McGilvray, 2008). Degradation to fauna habitats may cause more mobile fauna to re-locate to other similar habitat types, leading to a decrease in local fauna abundance.

Degradation to fauna habitats may cause more mobile fauna to re-locate to more pristine versions of these habitats elsewhere leading to a decrease in local fauna abundance or in the case of more sedentary fauna (such as ground-dwellling mammals, reptiles or SRE fauna), a decrease in fitness or possible death due to a demise in suitable resources. Fauna of conservation significance with limited mobility or small home ranges which may be most affected within the monsoon vine thicket habitat include the Dampierland Burrowing Snake (*Simoselaps minimus*) (recorded), the Golden Bandicoot (*Isodoon auratus*) (possibly occurring) and Golden-backed Tree-rat (*Mesembriomys macrurus*) (possibly occurring). It is proposed that an Ecological Surface Water Requirements management Plan be developed to prevent, as far as practicable, impacts to surface water dependant vegetation and habitat types. As a result it is unlikely that the local viability of populations of fauna, fauna of conservation significance or SRE fauna will be significantly compromised by altered surface water flows as a result of the BLNG Precinct.

It is expected that impacts to terrestrial fauna due to the physical presence of the precinct altering hydrological regimes be can be minimised through the implementation of application of mitigation measures such as engineering to maintain surface flows to areas where flows are obstructed where practicable, which will be detailed in an Ecological Surface Water Requirements Management Plan. A more detailed description of proposed mitigation measures is presented in **Section 2.6.4**. The significance of residual impacts associated with altered hydrological regimes is assessed to be low because the majority of the impacts will be minimised or avoided through the management measures proposed, and the design of infrastructure to manage surface water flows.

2.6.3.9. Potential Impacts to Terrestrial Fauna due to Altered Fire Regime

The current frequent fire regime on the Dampier Peninsula is considered to be having a negative impact on all vegetation types (McKenzie *et al.,* 2002). Further changes in fire regimes may have the potential to reduce the habitat availability of the James Price Point coastal area for conservation significant and more common fauna species.

In recent decades, fire regimes on the Dampier Peninsula have been more frequent and often occur in the mid to late dry season with high intensity. There is some evidence that altered fire regimes result in habitat simplification and degradation, and, together with increased predators and herbivores, are implicated in the decline and extinction of

medium-sized mammals in the semi-arid and arid zones of the Kimberley region (EPA, 2006a). Many of the negative impacts within the Kimberley region attributed to frequent, high intensity fires have also been observed to occur within the James Price Point coastal area.

A CSIRO study (Legge *et al.,* (2008) found that there is considerable evidence that small to medium mammals from a range of taxa including rodents, dasyurids, possums and bandicoots are relatively intolerant of fire, regardless of timing or intensity. A number of reports now suggest that, following on from the direct effects of wildfire in which it is inescapable that large numbers of small mammals are killed, population decline is apparent over the course of a year following a fire. This may indicate that increased predation and/or reduced available resources following fires may be more important than direct fire related mortality.

Further changes in fire regimes may have the potential to reduce the habitat availability of the James Price Point coastal area for both rare and more common fauna species. As described, the change in fire regimes has been attributed to the decline of some species and decline in habitat quality.

While the BLNG Precinct may result in the introduction of potential ignition sources it is expected that the impact of this can be managed through measures such as the implementation of a fire management program, together with a reduction in informal access. A more detailed description of proposed mitigation measures is presented in **Section 2.6.4**. The significance of residual impacts associated with altered fire regimes is assessed to be low because the mitigation measures are likely to reduce the incidence of late dry season wildfires, which are known to be particularly damaging to vegetation communities and associated fauna habitats. It is expected that the management of fire within the James Price Point coastal area has the potential to improve local fauna habitat quality over time, particularly for those species that are particularly sensitive to fire or rely on habitats that are sensitive to frequent or high intensity fires.

2.6.3.10. Potential Impacts to Terrestrial Fauna due to Terrestrial Wastes and Discharges

Non-routine discharges such as spills into the terrestrial environment may detrimentally affect vegetation communities, surface water and ground water and ultimately results in direct poisoning of fauna or the restriction of habitat for terrestrial fauna species. Non-routine discharges are unlikely; however, spill response procedures will be implemented to contain and rectify any spills and minimise adverse impacts to fauna habitat.

It is expected that potential impacts from non-routine discharges such as spills into the terrestrial environment which may detrimentally impact vegetation communities and fauna directly can be minimised through the application of measures such as spill response procedures which will be implemented to contain and rectify any spills. A more detailed description of proposed mitigation measures is presented in **Section 2.6.4**. The significance of residual impacts to fauna associated with discharges and spills is assessed to be very low, as there is a low likelihood of uncontained spills and comprehensive emergency response measures will be in place to minimise impacts.

2.6.3.11. Potential Impacts to Terrestrial Fauna due to Marine Discharges and Spills

The James Price Point coastal area is not considered to provide any regionally significant habitat for migratory bird species. Any routine discharge is highly unlikely to be toxic to marine birds and as they are highly mobile any contact is likely to be very short duration. Indirect impacts are only possible if contaminants accumulate where birds are feeding, for example in intertidal areas.

Leaks and spills into the marine environment may result from storage and transport of chemicals, fuels, or other hazardous material, and the failure of equipment or pipelines. Such leaks may detrimentally affect marine water quality and have subsequent impacts on migratory birds and their habitat. Leaked or spilt liquids in the intertidal environment surrounding James Price Point will be dispersed by regular tidal flushing, with the exception of hydrocarbons which may persist in the environment. The external contact of shorebirds with leaked or spilt hydrocarbons may reduce the birds' ability to waterproof feathers and subsequently regulate body temperature and buoyancy. Preening of feathers in contact with hydrocarbons may lead to ingestion.

A number of preventative measures have been identified to minimise the significance of the residual impact on marine discharges and spills from the construction and operation of the BLNG precinct on shorebirds. Routine discharges would be treated to an acceptable standard and released in a manner to maximize dispersion and at a location to minimise potential contact with sensitive receptors or accumulation of contaminants. The key management measure for non-routine discharges is the implementation of preventative measures through design and operational procedures. In the

unlikely event that a major leak or spill does occur the emergency response plan would be implemented to minimise impacts.

Following the implementation of appropriate management and mitigation measures presented in **Section 2.6.4**, the significance of the residual impact on shorebirds due to Marine Discharges and Spills is assessed as being very low as major leaks or spills are unlikely and comprehensive emergency response measures will be in place to minimise impacts.

2.6.3.12. Matters of NES

Under the EPBC Act, an action will require approval from the Minister if it has or will have, or is likely to have, a significant impact on MNES. MNES relevant to this project include potentially occurring terrestrial fauna species that are listed as Vulnerable or Migratory under the EPBC Act.

An assessment of significance criteria for fauna species that are listed under the EPBC Act is discussed in **Part 6**, **Section 2** (Matters of National Environmental Significance).

2.6.4. Management Measures

Mitigation measures and safeguards that have been identified to manage potential impacts to terrestrial fauna are outlined below in **Table 2.6-4**, **Table 2.6-5**, **Table 2.6-6** and **Table 2.6-7**.

Refer also to the Management Arrangements specifically defined for Commonwealth matters, summarised in **Part 6**.

- **Table 2.6-4 State Government Measures for Terrestrial Fauna.**

State Government Measure	Responsibility	Timing
The State Government commits, through the implementation of the Dampier Peninsula Land Use and Infrastructure Plan, to facilitate the establishment of additional nature reserves and/or National Parks within the Dampier Peninsula to secure representative vegetation of the Peninsula in reserves, protect fauna habitat of rare and specially protected fauna and to protect Aboriginal culture and heritage. The establishment of a National Park and its location will be in accordance with agreements with Traditional Owners.	DSD through its involvement in the BLNG Precinct Control Group, with advice from State Planning Commission, DEC and Traditional Owners.	Throughout the life of the Plan.
Prepare and implement a Fire Management Strategy for the Dampier Peninsula to align with existing fire management strategies to reduce the frequency of fires and the occurrence of late dry season burns on the Peninsula.	DSD through its involvement in the BLNG Precinct Control Group, with advice from DEC and Indigenous ranger groups.	Prior to commencement of construction of an LNG plant.
Prepare an overarching Emergency Response Plan that addresses: • risk assessment of potential emergencies (including bushfires, introduction of foreign pests, flooding and spills); • emergency response equipment and training; • emergency response procedures; • responsibilities during emergency response; and • reporting, review and improvement as required.	DSD through its involvement in the BLNG Precinct Control Group, with advice from FESA.	Prior to commencement of construction of an LNG plant.
Develop and implement a Management and Monitoring Strategy for Vegetation of Medium to High Conservation Significance, with particular reference to remnant monsoon vine thicket and drainage basin vegetation. The Strategy will inform all proponents of derived proposals of requirements for detailed management plans specific to individual activities and will include a framework in which the following Plans will be implemented: • Fire Management Plan; • Terrestrial Fauna Management Plan; • Terrestrial Weed Management Plan; and • Appropriate management of hydrology (both surface water and groundwater). Refer also the commitment for Ecological Surface Water Requirements Management Plan and surface water and groundwater management commitments in **Part 4**, **Section 2.2** and **Section 2.3**. The effectiveness of the Strategy is to be measured via condition and health monitoring for a defined area within and surrounding the BLNG Precinct area and associated buffer zones. Annual reporting on success of the program is to be made publicly available.	DSD through its involvement in the BLNG Precinct Control Group, with advice from DEC.	Throughout the life of the Plan.
Prepare and implement a closure and decommissioning strategy for the Browse LNG Precinct and related activities for the purpose of providing a timely and consistent approach to removal or retention of plant and infrastructure, rehabilitation of disturbed areas and identification of contaminated areas.	DSD through its involvement in the BLNG Precinct Control Group.	5 years prior to decommissioning of BLNG Precinct infrastructure.

- **Table 2.6-5 Proposed Environmental Conditions for the Strategic Proposal that may affect Terrestrial Fauna.**

Condition No.	Proposed Environmental Conditions for the Strategic Proposal
T3.1	The proponent of derived proposals shall not cause the loss of vegetation including monsoon vine thicket in excess of the limits of cumulative loss prescribed in **Table 2.6-6** for the BLNG Precinct.
T6.1	Prior to commencement of ground disturbance activities, proponents of derived proposals shall undertake further taxonomic work and prepare a report, to the satisfaction of the Minister for Environment, on the endemicity of SRE invertebrates (Camaenidae snails) collected by Biota (2009b) within the BLNG Precinct.
T1.2	Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address: • detailed measures to be implemented for final closure; • the schedule and timing of final closure activities; • completion criteria for closure; and • closure monitoring requirements.
T1.3	Proponent of derived proposals shall implement the Final Closure Plan required by condition 1.2 until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.
T2.1	Prior to the commencement of construction activities, the proponent of derived proposals shall prepare and implement an Ecological Surface Water Requirements Management Plan, to the satisfaction of the Western Australian Minister for Environment on advice from DEC, which shall address the following: • Drainage measures to manage surface water flows and minimise environmental impacts as far as practicable on monsoon vine thicket and drainage basin vegetation communities within the affected catchments. • A vegetation composition, health and condition monitoring program for areas of vegetation determined likely to be dependent on surface water flows, including the superficial aquifer, for seasonal water requirements. • Process to be implemented if monitoring indicates declining vegetation condition or changing composition as a result of changes in surface water flows.

- **Table 2.6-6 Extent of Terrestrial Vegetation Clearing with Respect to Impacts on Fauna.**

Activity	Total terrestrial vegetation loss (ha)	Monsoon Vine Thicket Community (ha)
Construction and operation of BLNG Precinct.	2,090	96
Construction and operation of pipeline corridors.	250	35
Construction and operation of light industrial area.	200	0
Construction and operation of workers accommodation.	200	0
Construction and operation of ancillary infrastructure (for example, minor roads and service corridors, Manari Road diversion and groundwater borefield).	297	1.4
Fuel reduction activities and clearing for fire access within the Plan area in accordance with fire management strategy.	As described in Fire Management Strategy.	As described in Fire Management Strategy.

- **Table 2.6-7 Requirements to be Addressed via Development of a Management Plan to Support a Derived Proposal in regards to Terrestrial Fauna.**

Derived Proposal Requirements	Timing
Undertake further geotechnical and hydrogeological investigations to refine the assessment of the likely presence/absence of subterranean fauna in accordance with EPA Guidance Statement No. 54 and 54a.	Prior to submission of Derived Proposal.
Prepare and implement a Fauna Management Plan, in consultation with the Department of Environment and Conservation, that addresses: • objectives, targets and associated monitoring; • pre-clearing searches for conservation significant species; • fauna handling procedures; • speed limits; • waste management measures; • procedures to deal with trapped fauna and trap mortality; • noise management associated with terrestrial blasting and piling; • monitoring of pest species numbers, with particular reference to feral cats and the European Red Fox; • potential trapping and baiting control programs; and • potential exclusion measures such as fencing. Note: Management Arrangements for conservation significant fauna will be incorporated into this Fauna Management Plan. The Management Plan will be prepared in accordance with relevant Threat Abatement Plans and the National Recovery Plans.	Prior to construction and updated for ongoing operational requirements.
Prepare and implement a BLNG Precinct Fire Management Plan for construction and operation. See **Part 4**, **Section 2.7**.	Prior to construction and updated for ongoing operational requirements.
Prepare and implement a Rehabilitation Plan. See **Part 4**, **Section 2.4**.	Prior to construction and updated for ongoing operational requirements.
Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan for construction and operation activities. See **Part 4**, **Section 2.1**.	Prior to commencement of associated construction activities.
Prepare and implement a Quarantine Management Plan for construction and operation. See **Part 4**, **Section 2.7**.	Prior to construction and updated for ongoing operational requirements.
Prepare and implement a Terrestrial Weed Management Plan. See **Part 4**, **Section 2.7**.	Prior to construction and updated for ongoing operational requirements.
Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets; • environmental management; • environmental training and inductions; and • environmental monitoring, contingencies and reporting, and stakeholder consultation. In order to address the potential impacts to terrestrial fauna identified within this section the CEMP will specifically include measures outlined in **Part 4**, **Section 2.4**.	Prior to commencement of associated construction activities.

The implementation of the aforementioned mitigation measures and safeguards will be effective in mitigating the impact of the BLNG Precinct. All management plans will be developed in consultation with DEC and other relevant agencies.

2.6.5. Environmental Outcome

Cumulative impacts from all Category A activities indicate that the impact to terrestrial fauna will be at its greatest during construction when clearing and site disturbance activities will be undertaken.

After management and mitigation measures have been applied, the implementation of the Plan will result in the following outcomes in relation to terrestrial fauna:

2.6.5.1. Direct Impacts

- The removal of up 3,037ha of habitat during construction of the BLNG Precinct and associated infrastructure.
- The TEC monsoon vine thickets will be disturbed resulting in the removal of up to 9% of the regional extent of this TEC. This figure would be reduced to 4.9% taking into account the DEC estimates of vine thicket distribution on the Dampier Peninsula.
- No threatened fauna species under the EPBC Act are expected to be significantly affected by the Plan as none have been recorded within the James Price Point coastal area; however, several species have the potential to occur, perhaps at low densities.
- Priority fauna and other significant species may be displaced by the implementation of the Plan; but the conservation status or regional distribution of these species will not be affected.
- Impacts on terrestrial fauna associated with dust deposition, light emissions, noise and vibration, groundwater abstraction, altered hydrological regimes and terrestrial wastes and discharges have been considered within this section of the SAR. It is expected that these are capable of being managed during construction and throughout the life of the project to the extent that these aspects are unlikely to pose a significant risk to local fauna populations.

2.6.5.2. Indirect Impacts

- Changes to fauna habitat condition as a result of changes to hydrology, fragmentation and 'edge effects.
- The requirement for proponents of derived proposals to prepare a construction environmental management plan as part of their derived proposal application will ensure controls are in place to minimise the risks to vegetation outside the clearing areas.
- The potential impacts on groundwater dependent ecosystems from groundwater abstraction will be assessed through the groundwater licence application process.
- Potential impacts to monsoon vine thicket habitats as a result of fragmentation and 'edge effects' from clearing activities for the BLNG Precinct, and pipeline crossings.
- Additional disturbance to vegetation resulting from fragmentation and edge effects. While the cumulative impacts may be greater than 3,037ha, the implementation of detailed management measures will minimise the impacts to vegetation outside the clearing areas.
- The loss of fauna habitat associated with the BLNG Precinct is considered unlikely to have a significant impact on the populations of species within the area as the potential habitat to be retained within the James Price Point coastal would be sufficient to continue to support local populations.
- Implementation of a fire management plan, together with a reduction in informal access within the James Price Point coastal area is likely to reduce the incidence of late hot, dry season wildfires, which are known to be particularly damaging to vegetation communities. As such, it is considered likely that vegetation and fauna habitats may improve over time. Where habitat types are restricted and currently determined to be under threat, such as the monsoon vine thicket, it is considered that an improvement in vegetation condition is likely to improve habitat availability and local ecosystem function. In the absence of fire it is possible that occurrences of monsoon vine thicket may increase in size (V. English, 2010, pers. comm. DEC, 20 July 2010).

Consistent with EPA objectives, the abundance, species diversity, geographic distribution and productivity of fauna at species and ecosystem levels will be maintained, thereby conserving regional biological diversity.

2.6.6. Cumulative Impacts of the BLNG Proposal and Associated Activities

2.6.6.1. Category B Activities

The following Category B activities may apply to cumulative impacts to species of terrestrial fauna:

- Housing and associated infrastructure: The BLNG Precinct is expected to accelerate demand for the Broome North development which is within the buffer zone of a vine thicket community (TEC) that could potentially contain similar fauna species to those found at the BLNG Precinct. No impacts are expected from the construction of the Broome North Development on this TEC (GHD, 2009b).
- Industrial areas: The BLNG Precinct will increase demand for industrial services. Future industrial land may be developed in the port area or future industrial areas earmarked further north of Broome.
- Solid waste: The BLNG Precinct will facilitate the need for a new facility sooner than previously expected. No location is yet proposed.
- Airport: The project will increase the number of flights and/or the size of the aircraft that fly to Broome. A control tower is currently being built to handle additional air traffic and a new airport site has been identified 12km out of town; however, the current site is expected to be adequate until 2025.
- Offsite quarries for breakwaters and reclamation.
- Increased recreational use of the Dampier Peninsula due to improved access.

These activities are likely to require some clearing of native vegetation (and potential fauna habitat) and their construction and operation may result in the introduction and/or spread of weeds and changes in surface water regime. Whether their impacts are potentially 'cumulative' and exacerbate those predicted for the BLNG Precinct and associated activities is dependent on the presence of similar fauna habitats to that occurring in the James Price Point coastal area.

Of the above Category B activities, only the housing development has progressed to a stage where a location has been identified and vegetation and flora investigations completed. The BLNG Precinct is expected to accelerate the demand for LandCorp's Broome North development which is proposed for an area of land north of Broome. The development comprises up to 695ha of mixed *Acacia* low woodland (Pindan shrubland/woodland) in good to very good condition, similar to the majority of vegetation within the James Price Point coastal area. This vegetation is considered to be important habitat in the area. Clearing of the housing development area will not result in any additional direct impacts on the significant ecological communities identified in the James Price Point coastal area. However, the proposed development is within the buffer area of an area of monsoon vine thickets (defined as important habitat in the area) and may be at risk of indirect impacts from edge effects, changes in surface water regime and increases in human activity in that area. With appropriate management, impacts on vine thickets should be avoided; therefore, the additional impact on vine thicket communities in the region from the housing development is expected to be insignificant. Mangrove communities also occur near the proposed housing development; however, there are no anticipated impacts to this community. No conservation significant fauna were identified in the development area (GHD, 2009b), therefore cumulative impacts on the conservation significant fauna identified in the BLNG Precinct is unlikely.

Demand for additional industrial areas and a new solid waste facility in Broome may result in sites for these being required and subsequent clearing. Future industrial land may be developed in the Broome Port area or in areas north of Broome. Locations of industrial areas and the solid waste facility have not been determined and therefore fauna surveys have not been conducted. Vegetation and habitats north of Broome is likely to be similar to that surveyed in the Broome North development (Pindan shrubland/woodland); however, the presence of conservation significant fauna in these northern areas is not known.

The international airport relocation is proposed approximately 12km northeast of the Broome townsite and would require the clearing of approximately 200ha of Pindan shrubland/woodland. The EPA assessed the relocation of the airport to this site (EPA Bulletin 1017, EPA 2001) and concluded that the proposal could be managed in an environmentally acceptable manner. It is possible that increased air traffic may impact migratory bird habitats at nearby Roebuck Bay and Eighty Mile Beach through increased noise and physical disturbance. Such impacts should be factored into final site selection and identification of proposed flight paths.

Most Category B activities within and near Broome are likely to be developed on Pindan vegetation, which may support conservation significant fauna; however, over 4,000,000ha of Pindan shrubland exists within Dampierland subregion (Graham, 2001). Cumulatively, clearing of Pindan shrubland for Category A, B and C activities is unlikely to have a

significant impact on its abundance and diversity. However, Pindan vegetation in the Dampier Peninsula is currently in advanced decline due to excessive fire frequency over most of its range (Biota, 2009c; **Appendix C-18**), therefore avoiding good examples of this vegetation type is desirable.

Changes to the surface water regime may also occur as a result of any of the above developments, which may affect adjacent vegetation that has important habitat values. This may include the monsoon vine thickets that are located on the west coast of Broome or the mangrove communities surrounding Roebuck Bay. Impacts from changes to surface water regime can be minimised through effective stormwater drainage systems designed to maintain the natural flow regimes. Maintenance of existing flows to significant vegetation areas and prevention of impacts from contaminated runoff to Roebuck Bay should be a key focus for management of these developments.

Additional Category B activities that may affect flora and vegetation outside of Broome potentially include a gas pipeline from the BLNG Precinct to Broome and offsite quarries. Locations of these have not been finalised, but it is most likely that the pipeline easement will be added to the transport corridor, and will transect several vegetation types. As the pipeline will have a linear nature of disturbance, local impacts on vegetation and habitats should be minimal and clearing widths can be reduced in areas where there is potential important fauna habitat. Quarries can be located in areas away from important fauna habitat and clearing for these should not result in significant cumulative impacts on the distribution and diversity of important fauna habitats in the Dampier Peninsula.

Increased recreational use of the Dampier Peninsula due to improved access may result in further spread of weeds which can affect the viability of fauna habitats. This is discussed in more detail in **Part 4**, **Section 2.7**.

2.6.6.2. Category C Activities

Clearing and related impacts associated with the Main Access Road from Cape Leveque Road to the BLNG Precinct will be formally assessed by both State and Commonwealth separately from the Strategic Assessment. The estimated clearing required for the road is 191ha with an additional 172ha part of possible future requirements for services such as electricity and gas alongside the Main Access Road. The principal impact from this activity is the clearing of Pindan vegetation which, given its very common occurrence of the Dampier Peninsula, is not considered to have a significant cumulative environmental impact.

The construction and operation of supply base to service the Browse upstream development has the potential to impact fauna habitats. Broome is also the most likely location for the required supply base; therefore additional Pindan vegetation may be cleared. Avoidance of conservation significant vegetation (and important habitats) around Broome, such as monsoon vine thickets and mangrove communities is possible and as such impacts to significant habitat areas can be avoided.

If the supply base is located in Broome frequent helicopter movements in the area may potentially affect migratory birds in areas such as Roebuck Bay. Proximity to Roebuck Bay (and Eighty Mile Beach) should be considered during selection of a supply base site and helicopter transport routes to avoid disturbance to these habitats. Refer also **Part 6**, **Section 2** (Matters of National Environmental Significance).

Table 2.6-8 Impact Assessment Summary for Terrestrial Fauna.

<table>
<tr><th rowspan="2">Factor/
Sub-factor</th><th rowspan="2">Environmental Aspect</th><th rowspan="2">Potential Impacts</th><th colspan="3">Mitigation Measures</th><th rowspan="2">Significance of Residual Impact</th></tr>
<tr><th>State Government Measures</th><th>Proposed Environmental Conditions</th><th>Future Proponent Management Plans</th></tr>
<tr><td>Terrestrial Fauna - Declared rare protected fauna</td><td rowspan="6">Vegetation/ habitat clearing (Construction)</td><td>Loss of conservation significant fauna habitat</td><td rowspan="9">Protection of habitat of conservation significant species will be a key consideration in determining the location and extent of conservation reserves on the Dampier Peninsula established under the Plan.
Develop and implement a Management and Monitoring Strategy for Vegetation of Medium to High Conservation Significance, with particular reference to remnant monsoon vine thicket and drainage basin vegetation. The Strategy will inform all proponents of derived proposals of requirements for detailed management plans specific to individual activities and will include a framework in which the following Plans will be implemented:
• Fire Management Plan;
• Terrestrial Fauna Management Plan;
• Terrestrial Weed Management Plan; and
• relevant management of hydrology (both surface water and groundwater). Refer also the commitment for Ecological Surface Water Requirements Management Plan and surface water and groundwater management</td><td rowspan="9">Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address:
• detailed measures to be implemented for final closure;
• the schedule and timing of final closure activities;
• completion criteria for closure; and
• closure monitoring requirements.
Proponents of derived proposals shall implement the Final Closure Plan until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.
Prior to the commencement of construction activities, the proponents of derived proposals shall prepare and implement an Ecological Surface Water Requirements Management Plan, to the satisfaction of the</td><td rowspan="9">Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following:
• schedule of construction activities;
• details of the construction methods to be used;
• objectives and targets;
• environmental management
• environmental training and inductions; and
• environmental monitoring, contingencies and reporting, and stakeholder consultation.
In order to address the potential impacts to terrestrial fauna identified within this section the CEMP will specifically include measures outlined in Part 4, Section 2.4.
Prepare and implement a Fauna Management Plan, in consultation with the Department of Environment and Conservation, that addresses:
• objectives, targets and associated monitoring;
• pre-clearing searches for conservation significant species;</td><td>Low</td></tr>
<tr><td>Terrestrial Fauna - Surface SRE</td><td>Loss of habitat</td><td>Low</td></tr>
<tr><td>Terrestrial Fauna - Declared rare protected fauna</td><td>Injury or death of conservation significant fauna</td><td>Very low</td></tr>
<tr><td>Terrestrial Fauna - Declared rare protected fauna</td><td>Habitat fragmentation and edge effects</td><td>Low</td></tr>
<tr><td>Terrestrial Fauna - Surface SRE</td><td>Habitat fragmentation and edge effects</td><td>Low</td></tr>
<tr><td>Terrestrial Fauna - Other terrestrial fauna</td><td>Loss of habitat</td><td>Low</td></tr>
<tr><td>Terrestrial Fauna - Declared rare protected fauna</td><td>Vehicle movements</td><td>Injury or death of conservation significant fauna</td><td>Very low</td></tr>
<tr><td>Terrestrial Fauna - Subterranean SRE</td><td rowspan="2">Site disturbance/ excavation (Construction)</td><td>Loss of habitat</td><td>Very low</td></tr>
<tr><td>Terrestrial Fauna - Declared rare protected fauna</td><td>Injury or death of conservation significant fauna</td><td>Very low</td></tr>
</table>

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<tr><th rowspan="2">Factor/
Sub-factor</th><th rowspan="2">Environmental Aspect</th><th rowspan="2">Potential Impacts</th><th colspan="3">Mitigation Measures</th><th rowspan="2">Significance of Residual Impact</th></tr>
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<tr><td>Terrestrial Fauna - Subterranean SRE</td><td>Groundwater abstraction</td><td>Disturbance of fauna habitat</td>
<td rowspan="9">commitments in Part 4, Section 2.2 and Section 2.3.

The effectiveness of the Strategy is to be measured via condition and health monitoring for a defined area within and surrounding the BLNG Precinct area and associated buffer zones. Annual reporting on success of the program is to be made publicly available.

Prepare and implement a closure and decommissioning strategy for the Browse LNG Precinct and related activities for the purpose of providing a timely and consistent approach to removal or retention of plant and infrastructure, rehabilitation of disturbed areas and identification of contaminated areas.

Prepare an overarching Emergency Response Plan that addresses:
• risk assessment of potential emergencies (including bushfires, introduction of foreign pests, flooding and spills);
• emergency response equipment and training;
• emergency response procedures;
• responsibilities during</td>
<td rowspan="9">Western Australian Minister for Environment, which shall address the following:
• Drainage measures to manage surface water flows and minimise environmental impacts as far as practicable on monsoon vine thicket and drainage basin vegetation communities within the affected catchments.
• A vegetation composition, health and condition monitoring program for areas of vegetation determined likely to be dependent on surface water flows, including the superficial aquifer, for seasonal water requirements.
• Process to be implemented if monitoring indicates declining vegetation condition or changing composition as a result of changes in surface water flows.

The Proponent shall not cause the loss of vegetation including monsoon vine thicket in excess of the limits of cumulative loss prescribed in Part 4, Section 2.4.

Prior to commencement of</td>
<td rowspan="9">• fauna handling procedures;
• speed limits;
• waste management measures;
• procedures to deal with trapped fauna and trap mortality;
• noise management associated with terrestrial blasting and piling;
• monitoring of pest species numbers, with particular reference to feral cats and the European Red Fox;
• potential trapping and baiting control programs; and
• potential exclusion measures such as fencing.

Note: Management Arrangements for conservation significant fauna will be incorporated into this Fauna Management Plan.

Prepare and implement a Rehabilitation Plan. See Part 4, Section 2.4.

Undertake further geotechnical and hydrogeological investigations to refine the assessment of the likely presence/absence of subterranean fauna in accordance with EPA Guidance Statement No. 54 and 54a.

Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan for construction</td>
<td>Very low</td></tr>
<tr><td>Terrestrial Fauna - Subterranean SRE</td><td rowspan="2">Terrestrial discharges, including non-routine discharges</td><td>Contamination of subterranean habitats</td><td>Very low</td></tr>
<tr><td>Terrestrial Fauna - Declared rare protected fauna</td><td>Loss of habitat</td><td>Very low</td></tr>
<tr><td>Terrestrial Fauna - Birds (including shore and migration)</td><td>Non-routine discharges (spills and leaks)</td><td>Disturbance of fauna habitat</td><td>Very low</td></tr>
<tr><td>Terrestrial Fauna - Declared rare protected fauna</td><td>Dust emissions</td><td>Disturbance of fauna habitat</td><td>Very low</td></tr>
<tr><td>Terrestrial Fauna - Declared rare protected fauna</td><td rowspan="2">Light emissions</td><td>Disturbance of conservation significant fauna individuals</td><td>Very low</td></tr>
<tr><td>Terrestrial Fauna - Birds (including shore and migration)</td><td>Disturbance of conservation significant fauna individuals</td><td>Very low</td></tr>
<tr><td>Terrestrial Fauna - Declared rare protected fauna</td><td rowspan="2">Noise and vibration</td><td>Disturbance of conservation significant fauna individuals</td><td>Low</td></tr>
<tr><td>Terrestrial Fauna - Birds (including shore and migration)</td><td>Disturbance of conservation significant fauna individuals</td><td>Low</td></tr>
</table>

Factor/ Sub-factor	Environmental Aspect	Potential Impacts	Mitigation Measures			Significance of Residual Impact
			State Government Measures	Proposed Environmental Conditions	Future Proponent Management Plans	
Terrestrial Fauna - Subterranean SRE		Disturbance of fauna individuals	emergency response; and • reporting, review and improvement as required. Prepare and implement a Fire Management Strategy for the Dampier Peninsula to align with existing fire management strategies to reduce the frequency of fires and the occurrence of late dry season burns on the Peninsula.	ground disturbance activities, the Proponent shall undertake further taxonomic work and prepare a report, to the satisfaction of the Minister for Environment, on the endemicity of SRE invertebrates (Camaenidae snails) collected by Biota (2009b) within the BLNG Precinct.	and operation activities. See **Part 4**, **Section 2.1**. Prepare and implement a BLNG Precinct Fire Management Plan for construction and operation. See **Part 4**, **Section 2.7**.	Very Low
Terrestrial Fauna	Altered fire regime	Disturbance of fauna habitat				Low
Terrestrial Fauna	Physical presence	Alteration of flow regimes				Low

2.7. Relevant Factor: Terrestrial Ecosystem Integrity

In line with *EPA Position Statement No 7 Principles of Environmental Protection* (EPA, 2004d), the conservation of biological diversity and ecological integrity is a basic principle of environmental protection, natural resource management and sustainability and needs to be considered in terms of genetic, species and ecosystem diversity.

The term 'Ecosystem Integrity' is used in this document to describe the principle of conserving the natural function and attributes of biological diversity.

The following section describes the potential threats and associated impacts that may reduce or cause loss of ecosystem integrity as a result of activities, facilities and other characteristics to be implemented under the Plan for the BLNG Precinct (Category A) and the potential for cumulative impacts from activities that may indirectly arise as a result of the Precinct development (Category B) and other related resource activities in the region (Category C).

2.7.1. Current Knowledge

The following sub-sections describe the regulatory expectations with respect to terrestrial ecosystem integrity, potentially sensitive receptors and the current threats to the ecosystem integrity in the James Price Point coastal area.

2.7.1.1. Key Statutory Requirements, Environmental Policy and Guidance

There are a number of international, Commonwealth and State guidelines, strategies and policies that apply to the Strategic Assessment in relation to groundwater protection.

International Agreements

Australia is party to the JAMBA, CAMBA and ROKAMBA Agreements. Most of the birds listed in these agreements are associated with saline wetlands or coastal shorelines, some migratory birds not associated with water are also listed on these international treaties. These international agreements provide protection to the listed species and assist in their long term survival in the wild.

Commonwealth Protection

The EPBC Act relates to ecosystem integrity by affording protection to threatened species, communities and matters of National Environmental Significance. The *Quarantine Act 1908*, related to imported goods, is one of several Acts that protect Australia's animal, plant and human health status and to maintain market access for Australian food and other agricultural exports.

The Australian Government and DEWHA have developed and implemented key plans and guidance documents that relate to threatening processes of relevance to ecosystem integrity:

- Threat Abatement Plans (DEWHA, 2008b). Threat abatement plans provide for the research, management, and any other actions necessary to reduce the impact of a listed key threatening process on native species and ecological communities. Implementing the plan should assist the long term survival in the wild of affected native species or ecological communities.
- Weeds of National Significance (**WONS**) (DEWHA, 2010i). The WONS is a prioritised list of weeds of national significance that pose a threat to primary industries, land management, human or animal welfare, biodiversity and conservation values. WONS status brings a weed species under national management for the purpose of restricting its spread and eradicating it from parts of Australia.
- National Environmental Alert List for Environmental Weeds (DEWHA, 2000). This is a list of 28 non-native plants that threaten biodiversity and cause other environmental damage. These weeds have the potential to seriously degrade Australia's ecosystems.
- Sleeper Weeds List (DEWHA, 2003). This is a list of 17 potential agricultural sleeper weeds. Sleeper weeds are non-native plants that appear benign for many years but which may spread suddenly following certain natural events such as flood, fire, drought or change in land and water management.

State Guidance and Policy

Given the holistic nature of ecosystem integrity, a number of guidelines and regulatory frameworks are applicable to the BLNG Precinct area and ecological integrity including:

- *Agriculture and Related Resources Protection Act 1976.*
- *Biosecurity and Agriculture Management Act 2007.*
- *Bushfires Act 1954.*
- *Conservation and Land Management Act 1984.*
- DEC Code of Practice for Fire Management (2008).
- Department of Planning WA - Development Control Policy 3.7, Fire Planning.
- EPA Guidance Statements No. 20, 51, 54 and 56.
- *Fire and Emergency Services Authority of Western Australia Act 1998.*
- *Fire Brigades Act 1942.*
- *Mining Act 1978.*
- *Plant Diseases Act 1914.*
- Plant Diseases Regulations 1989.

2.7.2. Description of Factor

A number of baseline fauna assessments and flora and vegetation assessments have been used to identify the biological diversity of the James Price Point coastal area. Flora and fauna, both within the potential BLNG Precinct site and in the general James Price Point coastal area are described in **Part 4**, **Section 1**. Key findings relevant to terrestrial ecosystem integrity include:

2.7.2.1. Terrestrial Flora and Vegetation

Vegetation assessments at James Price Point (ENV, 2008a; **Appendix C-14**; ENV, 2008b; **Appendix C-15**; Biota, 2009c; **Appendix C-18** and AECOM, 2010a; **Appendix C-19**) identified a moderate to high local species richness (308 native taxa recorded), with the area supporting a number of vegetation communities and priority flora (five taxa recorded). The majority of the survey area is dominated by pindan vegetation of varying composition and density, which is regionally widespread. Flora and vegetation communities of conservation significance in the James Price Point coastal area include:

- Priority flora species, undescribed flora species and taxon of restricted distribution.
- Monsoon vine thicket vegetation, which occurs on the Dampier Peninsula, is listed as a Vulnerable TEC (WA). The monsoon vine thicket is further classified into Criteria C, meaning that while this ecosystem is still widespread it is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes (DEC, 2009c). Monsoon vine thickets occur behind sand dunes along the coastal stretch north of Broome and are well represented around James Price Point and further north along the Dampier Peninsula (Biota, 2009c; **Appendix C-18**). They form one of the most interesting plant communities on the Dampier Peninsula, containing a predominance of Indo-Malesian plant species more commonly found in the wetter north-west Kimberley (Biota, 2009c; **Appendix C-18**). They are also an important traditional and commercial resource for Aboriginal people.
- Drainage basin vegetation, which comprises areas subject to ephemeral freshwater flooding, ponding or seepage, and are found behind coastal sand dunes that are subjected to seasonal inundation. Such areas are often associated with monsoon vine thickets but are characterised by the occurrence of Lardik (*Lophostemon grandiflorus*) and the Paperbark, Karnbor (*Melaleuca dealbata*). The drainage basin area supports flora restricted to this habitat type.
- Coastal heath vegetation and coastal communities, which are considered to be of conservation significance primarily due to their restricted distributions within the James Price Point coastal area. Coastal heath vegetation was identified by Biota (2009c; **Appendix C-18**) as corresponding to the PEC listed as dwarf pindan heath community of the Broome coast. These communities are known to be represented elsewhere on the Dampier Peninsula but are restricted to the narrow coastal fringe.

2.7.2.2. Terrestrial Fauna and Habitat

Fauna assessments identified that the James Price Point coastal area supports a wide range of terrestrial fauna and conservation significant species protected under the EPBC Act, WC Act and DEC Priority species list (ENV, 2008c; **Appendix C-16**; Biota, 2009b; **Appendix C-17**; Galaxia, 2010; **Appendix C-1** and AECOM, 2010b; **Appendix C-20**).

A total of 194 vertebrate species were recorded (or evidentially recorded) in surveys that consisted of a wet season survey by Biota (2009b; **Appendix C-17**) and dry season surveys by ENV (2008c; **Appendix C-16**) and AECOM (2010b; **Appendix C-20**). The recordings comprise of 21 mammals, 51 reptiles, four amphibians and 118 bird species within the James Price Point coastal area and surrounds.

Eight fauna species of conservation significance were recorded within the James Price Point coastal area (Biota, 2009b; **Appendix C-17**; ENV, 2008c; **Appendix C-16** and AECOM, 2010b; **Appendix C-20**) and a further eleven species were determined to possibly occur within the area based on the presence of suitable habitat. Key habitat attributes, such as large hollow-bearing trees or permanent freshwater, are generally absent from the James Price Point coastal area and, as such, preclude the potential presence of a number of species of conservation significance.

The conservation significant species likely to occur or those which could potentially occur include:

- five species (possible presence) listed as Vulnerable under the EPBC Act. Two of these species are also listed as Schedule 1 under the WC Act with another listed as Priority 4 by the DEC; and
- six additional species listed by the DEC as Priority 4 species.

The majority of conservation significant species occurring or potentially occurring in the James Price Point coastal area have broad habitat requirements and are likely to occur elsewhere on the Dampier Peninsula where woodland or shrubland habitats occur. Open forest and shrubland habitats are likely to provide foraging and nesting habitat opportunities for some of the species, however, it should be noted that these habitats are known to be common, both within the James Price Point coastal area and Dampier Peninsula.

A total of 39 migratory bird species listed as ‘Migratory’ under the EPBC Act have been recorded within the James Price Point coastal area (Galaxia, 2010; **Appendix C-1**). All of these species are also listed as ‘Marine’ birds under the EPBC Act, however, none are listed ‘Threatened’ species. With the exception of the Osprey, all of the migratory bird species recorded in the James Price Point coastal area are protected under the WC Act.

In addition to the 39 species known to occur, there are an additional 28 species of migratory bird that could potentially occur within the James Price Point coastal area. Of these, the Painted Snipe is listed as Vulnerable under the EPBC Act.

Of the fauna habitats present in the James Price Point coastal area, only the monsoon vine thicket habitat was identified as having elevated regional conservation significance (Biota, 2009b; **Appendix C-17**). The monsoon vine thicket was considered to represent a distinct faunal assemblage and habitat type, providing foraging, refuge and breeding habitat for a range of fauna species. The remaining terrestrial habitat types in the James Price Point coastal area were considered to be well represented within, and typical of, the Pindanland subregion of the Dampierland bioregion.

The James Price Point coastal area provides habitat for a range of migratory shorebird species, including migratory waders and terns, many of which breed in the northern hemisphere. However, in comparison with other sites on or near the Dampier Peninsula, and in other parts of north-western Australia (for example Roebuck Bay (approximately 66km south of James Price Point), Eighty Mile Beach (approximately 197km south of James Price Point), Bidyadanga, and Dessault Bay,), the coastline between Coulomb Point (approximately 15 km north of James Price Point) south to Quondong Beach supports relatively low numbers of migratory shorebirds (Galaxia, 2010; **Appendix C-1** and AECOM, 2010b; **Appendix C-20**). This is considered to result from a lack of optimal foraging habitat for migratory shorebirds, in particular intertidal mudflats and extensive sandflats.

2.7.2.3. Current Threats to Terrestrial Ecosystem Integrity

A threatening process in natural ecosystems is a process that detrimentally affects the conservation of native species or ecological communities (Lindenmayer and Burgman, 2005). The identification and listing of a key threatening process is the first step to addressing the impact of a particular threat under Commonwealth law.

Currently there are 19 Key Threatening Processes listed under the EPBC Act. It should be noted that the Commonwealth list is not definitive and that local threats identified by state conservation agencies must be understood. The following high priority threats operating within the Dampierland bioregion were identified in consultation with local DEC officers:

- introduced flora pests (weeds);
- altered fire regime;
- grazing; and
- introduced fauna pests.

Fragmentation and edge effects were considered additional threats to ecosystem integrity.

There is some interaction between these threats to ecosystem integrity; they do not work in isolation. For example weed invasions are likely to alter fire regimes and water flows (Environs Kimberley, 2010). However, these interactions are poorly understood and interaction between fire and weeds, particularly Buffel grass, was identified by the EPA (2006a) as an area for future research.

Introduced Flora Pests

Weeds are considered a major threat to the conservation of biodiversity assets on the Dampier Peninsula. The impact of invasive weeds on the condition of the Dampier Peninsula vegetation is not well quantified. Anecdotal information suggests that areas affected by networks of tracks in the southern part of the peninsula experience greater weed impacts than remote locations. In general, weed invasions have been associated with the loss of native species, through smothering and/or shading out native vegetation and chocking waterways, and alteration of fire regimes by making the area more flammable in the dry season (Ellison, 2009). Weeds thrive in the landscape where the integrity of the native vegetation has been reduced by disturbance, such as grazing by feral cattle and altered fire regimes (Ellison, 2009).

Twenty two weed species have been identified at the James Price Point coastal area in studies completed to date. These include the weed *Sida acuta*, which is a Declared Plant under the ARRP Act, as well as nine species considered serious environmental weeds as they are highly aggressive and can have significant impacts on vegetation (Biota, 2009c; **Appendix C-18**). The weeds are mostly distributed within areas of existing disturbance, for example along vehicle access tracks/roads.

The most widespread serious weeds are Buffel grass (*Cenchrus ciliaris*) and Kapok bush (*Aerva javanica*) (Biota, 2009c; **Appendix C-18**). The rapid regrowth and high biomass of Buffel grass may alter the intensity, frequency and extent of fires, changing vegetation structure and composition (CRC Weed Management, 2010). Encouraged by fire, it is known to encroach into monsoon vine thicket communities, increasing fuel load and flammability, thus impacting on vine thicket incrementally and sustaining further weed spread (McGilvray, 2008).

Wild passionfruit, Hairy merremia, Siratro and Leucana all represent a threat to monsoon vine thicket vegetation. However, while their presence reduces the condition, these weeds may not substantially diminish the overall conservation value of the vegetation type of the area (Biota, 2009c; **Appendix C-18**).

Another weed species that is of concern but has not to date been recorded on the James Price Point coastal area is the Neem tree (*Azadirachta indica*). This weed has only been recorded in one vine thicket at Broome; however, is a highly invasive species which is mainly spread by bird-dispersed seeds from domestic plantings.

The monsoon vine thickets on the Dampier Peninsula have been part of a management program since 2007, when a pilot project was initiated through Rangelands Natural Resource Management (**NRM**) WA and DEC. The management plan addresses a number of threats to this TEC on the Dampier Peninsula, including introduced weeds, stock and feral animals. In addition to this, an on-ground weed control program within the monsoon vine thicket on the Dampier

Peninsula, with the DEC working in partnership with Environs Kimberley, has been in place since 2007 (Environs Kimberley, 2010).

In regards to priority flora, *Pittosporum moluccanum* has been recorded in areas of monsoon vine thicket with and without invasive weed species such as wild passionfruit. *Gomphrena pusilla* was found growing in association with the coastal community and low densities of Buffel grass (1-2 percent cover) (Biota, 2009c; **Appendix C-18**). *Eriachne semiciliata* and *Polymeria distigma* appear to be widespread in occurrence, with specimens recorded in relatively undisturbed areas in pindan woodland.

Altered Fire Regime

Fire is a natural and important process; however, altering the frequency or timing of fires can have a detrimental impact on ecosystem integrity. Altered fire regimes in the Kimberley have contributed to the contraction and loss of rainforest patches, such as monsoon vine thicket, and decline and extinction of medium-sized mammals (Ellison, 2009).

Fire is important for the regeneration of vegetation; however, altering fire regimes can reduce the integrity of vegetation communities. Although the interactions between current fire regimes and Kimberley ecosystems are complex and not fully understood, the implications of frequent, large, and intense dry season fires are known to be serious (EPA, 2006a). The current fire regime in the Kimberley is believed to be a major factor in biodiversity loss with some plants, particularly fire-sensitive ones, being unable to recover (EPA, 2006a). There is sufficient evidence that altered fire regimes are resulting in habitat simplification and degradation, which together with increased predators and herbivores, is implicated in the decline and extinction of medium size mammals in the semi-arid and arid zones (EPA, 2006a).

The amount of time between fires and the frequency with which fires occur in a given area is an important factor in biodiversity conservation. Long term effects on landscape and biodiversity are generally the result of a pattern of fires over time rather than the result of a single fire; although a single fire can potentially significantly impact on a given area such as a patch of monsoon vine thicket. Studies from the NT (EPA, 2006a) suggest that certain species preferred long unburnt areas, whilst other species persisted in frequently burnt habitat and were most abundant in areas that were subjected to late dry season burning. No particular fire regime was found to be beneficial to the entire region's biota. Different plants were affected in various ways by different fire regimes; however lower frequency fire regimes had ecological benefits as key components of the savannah woodland biota, such as in the James Price Point coastal area, preferred habitat that had been unburnt for a number of years. In terms of a landscape scale approach to fire management, in savannah areas, the objective should be to increase the area remaining unburnt for five or more years to at least 10 percent at any given time (EPA, 2006a).

Evidence from the Kimberley Region suggests that there has been a significant increase in the extent, intensity and frequency of fire over the past 30 years, and that this is impacting on the ecology of the Kimberley environment (EPA, 2006a).

The majority of the vegetation in the James Price Point coastal area (mainly pindan vegetation) was subject to fire up to seven times between 1997 and 2008, with a lessening of this frequency approaching the coast. However, during a late 2009 vegetation survey, most of the James Price Point coastal area (including the BLNG Precinct site) was reported as recently burnt, with approximately 80 to 90 percent of the James Price Point coastal area affected (AECOM, 2010a; **Appendix C-19**).

Within the James Price Point coastal area, it was noted that fire is likely to have impacted on vegetation structure and condition, and biodiversity (Biota. 2009c; **Appendix C-18**).

Fire sensitive vegetation in the James Price Point coastal area includes species such as the conservation significant flora *Pittosporum moluccanum* (P4) and the Gubinge (*Terminalia ferdinandiana*), which is an important species harvested by Traditional Owners elsewhere across the Dampier Peninsula. Important vegetation communities such as the monsoon vine thicket, coastal heaths and drainage basins are also fire sensitive.

Refer to **Part 4, Section 1** for additional information regarding existing fire regimes in a local and regional context.

Grazing and Trampling by Introduced Cattle

Grazing and trampling is seen as a major threatening process affecting biodiversity assets within the broader Kimberley region. Recent unpublished reviews undertaken by DEC suggest this issue may be of less concern on the Dampier Peninsula. The James Price Point coastal area was historically subjected to heavy grazing pressure which led to associated changes in vegetation. There may be stray cattle located near James Price Point; however, considering the closure of cattle stations, signalled by the State Government purchase of the Waterbank Station, near James Price Point in 1996 (Environs Kimberley, 2002), impacts from grazing are likely to be low and are not considered further in this assessment.

Introduced Fauna Pests

Four introduced vertebrate fauna have been identified within the James Price Point coastal area comprising European cattle (*Bos taurus*), house mouse (*Mus musculus*), feral cat (*Felis catus*) and black rat (*Ratus ratus*). The feral cat is listed as a key threatening process under the EPBC Act (DEWHA, 2008b). Other introduced species such as the dog (*Canis lupus familiaris*) or donkey (*Equus asinus*) may also inhabit the area.

Although the Dampier Peninsula is not mapped within the extent of the European red fox's distribution, the species has been observed on occasions by locals at Gourdon Bay (approximately 111km south of James Price Point) (ENV, 2008c; **Appendix C-16**). The European red fox is listed as a key threatening process under the EPBC Act.

Cane toads (*Bufo marinus*) have not been recorded in the James Price Point area, however a cane toad was discovered in the Broome Light Industrial Area in July 2010. Analysis of climatic variables and adaptive abilities of the cane toad suggest that suitable habitat may extend to wet coastal areas as far south as Broome (DEWHA, 2010j). The biological effects caused by cane toads are listed under the EBPC Act as a key threatening process. The cane toad is highly invasive and as a result a number of native species, particularly invertebrates, are considered to be at risk.

Information on the current status of invertebrate pests in the James Price Point coastal area is limited as the area has not been widely surveyed. However, their presence in the area is possible as there has been uncontrolled public access. Tramp ant species such as the coastal brown ant, *Pheidole megacephala*, and the hairy ant, *Paratrechina longicornis,* are present in Broome and other parts of the Kimberley, and thus may be present at James Price Point. These species can invade an area and change the function of the ecosystem. Quarantine inspections of illegal vessels at Willie Creek (approximately 30km south of James Price Point) have intercepted pest species such as exotic dry wood termites (*Cryptotermies* species) Asian tiger mosquitoes (*Aedes albopictus)*, and auger beetles (*Heterobostrychus brunneus* and *Heterobostrychus aequalis)*. Invertebrate pests are not considered further in this section, but will be addressed through a Quarantine Management Plan.

Fragmentation and Edge Effects

Fragmentation and edge effects were not identified in the original Scope of the Strategic Assessment (DSD, 2010b; **Appendix A-2**), however further study highlighted the importance of this aspect to ecosystem integrity and it is discussed herein.

Fragmentation occurs when the continuity of original vegetation is disrupted and reduced into a smaller number of patches (Collinge and Forman 1998 cited in Walker *et al.,* 2006). Fragmentation affects ecosystems by altering the conditions within patches, such as altered irradiance, increased wind exposure (resulting in reduced understorey humidity), increased flora and fauna pest invasion, altered hydrological regimes and nutrient inputs, and the flow of resources, such as seeds and nutrients (Walker *et al.,* 2006).

Ecological models generally predict a decline in biodiversity in response to fragmentation (Walker *et al.,* 2006). This reflects the increased disruption to colonisation and local extinction events which are the result of decreasing habitat size and increasing spatial and temporal isolation (Walker *et al.*, 2006). However, the resulting effects of fragmentation reflect physical distances between habitat fragments and intact areas (i.e. degree of isolation), reduced habitat area, changes in fragment composition and structure, and a species ability to cope with these changes (Walker *et al.,* 2006). Therefore, the degree to which a species is affected by habitat fragmentation is largely influenced by their individual habitat requirements and dispersal ability (Turner and Corlett 1998 and Vos *et al.* 2001, both cited in Walker *et al.,* 2006).

The health and resilience of the remaining vegetation is largely dependent on the size of the fragments and their proximity to each other (DEWHA, 2007). As remnants become smaller and more isolated, they become less viable and

more vulnerable, as plants and animals are exposed to increased external pressures and disturbances. In regards to fauna, as remnants of vegetation become more isolated population dynamics are altered as individual and population behaviour is disrupted (Walker *et al.,* 2006). For example social structures may be altered and opportunities for mating are reduced.

Fragmentation also creates a higher ratio of 'edge' to 'core' areas. The edges of vegetation are influenced by adjacent vegetation or disturbances and consequently exhibit a higher degree of alteration when compared to core vegetation (Walker *et al.,* 2006). For example, edge areas tend to be exposed to more solar radiation, which can result in higher temperatures and drier conditions. Edge effects have the potential to alter vegetation structure, composition, productivity and microclimate conditions (Davies-Colley *et al.,* 2000 cited in Walker *et al.,* 2006).

Vegetation communities that are linear in structure are sensitive to fragmentation and edge effects. At James Price Point, the monsoon vine thicket will be susceptible to these processes.

Edge effects, such as weed incursion, are already apparent in previously disturbed areas such as along existing tracks.

Other

Further threats to ecological integrity include plant and animal diseases, arboviruses and changes in hydrology. The status of animal or plant diseases in proximity to the James Price Point coastal area has not been specifically documented, however, no widespread occurrence of plant diseases were observed during the vegetation assessments (Biota, 2009c; **Appendix C-18** and AECOM, 2010a; **Appendix C-19**). The plant disease, *Phytophthora cinnamomi* (or dieback), currently does not occur further north than Geraldton in the south-west of WA. However, there is insufficient knowledge of pathogen epidemiology to predict its potential to become a problem in the future (DEH, 2006). Some species of fungus, moulds and bacteria such as Eucalyptus rust (*Puccinia psidii)*, Sudden oak death (*Phytothora ramorum)*, and Sumatra disease (*Pseudomonas syzygii)*, are already present in Northern Australia and can affect native vegetation.

Arboviruses are discussed in detail in **Part 5, Section 4.9** (Human Health).

Additional external pressures on the Dampier Peninsula ecosystem include tourism, fishing, aquaculture, pearling, agro-forestry, small scale horticulture, recreation and climate change.

2.7.3. Identification of Key Aspects

2.7.3.1. Definition of Relevant Aspects

Aspects associated with the development and operation of the BLNG Precinct and associated infrastructure that may have an impact on terrestrial ecosystem integrity were identified in the Scope of the Strategic Assessment and considered in this assessment. These aspects include:

- vegetation and habitat clearing;
- introduced flora and fauna pests;
- physical presence of facilities and associated infrastructure (changes in surface water flows and groundwater availability); and
- alteration of fire regimes.

2.7.3.2. Sources of Potential Impact

Vegetation and Habitat Clearing

Vegetation clearing, earthworks and vehicle movements are required to facilitate construction and development of the BLNG Precinct, light industrial area, workers accommodation and associated infrastructure. The extent of vegetation clearing for the BLNG Precinct and and ancillary infrastructure is detailed in **Part 4**, **Section 2.4.**

Clearing will result in the removal of vegetation which will affect significant ecological communities and may affect conservation significant flora (including priority flora) and fauna. Clearing will also result in the indirect effect of fragmentation, with associated edge effects.

Introduced Flora and Fauna Pests

Introduced flora and fauna pests can be introduced or spread during construction, operation or decommissioning activities as a result of via poor equipment quarantine, contaminated imported fill or through the supply chain (the system of organisations, people, activities, information and resources involved in moving a product or service from supplier to customer), via the supplier of equipment and transfer of equipment and goods.

Vegetation clearing and earthworks have the potential to spread introduced flora pests via poor equipment quarantine or contaminated imported fill and disturbance of existing dormant weeds in the soil profile

The construction of the BLNG facilities and infrastructure requires the importation of equipment and movement of transport vehicles. The potential marine port facility at James Price Point will support marine operations for the BLNG Precinct. The initial construction phase of the BLNG Precinct will focus on the establishment of the port to enable direct importation of equipment and materials to the James Price Point coastal area. Until the port is constructed, commissioned and recognised as a first port of call, all construction equipment to be imported from overseas for the BLNG Precinct construction phase will be received at a Materials Offloading Facility to allow for offloading heavy pieces of equipment and assembled (modularised) units.

Shipping frequencies during the construction phase from overseas or other parts of WA or the eastern states are not currently known. However, during BLNG Precinct export operations, preliminary estimates of shipping frequency ranges from approximately three ships per day under a range of development scenarios. The actual number of shipping movements will be dependent on vessel size and capacity of the facilities installed.

The movement of vehicles, such as light and heavy machinery, is required to facilitate construction and development and operation of the BLNG Precinct and associated facilities and activities. Personnel involved in the operation of the BLNG Precinct will either be residential in Broome or on fly-in-fly-out roster, residing in the accommodation camp, and will commute from Broome.

Introduced flora and fauna pests have the potential to result in additional competition to native flora and fauna species and may impact the quality of any significant ecological communities present in the area. There is the potential for the BLNG Precinct facilities and associated infrastructure to attract native fauna and introduced fauna species as a result of new freshwater sources, food sources from waste or increased areas of shade.

Changes in Surface Water Flows and Groundwater Availability

Earthworks are likely to change the hydrology of the BLNG Precinct, such as surface water flows and recharge of the superficial aquifer, particularly at the dune interface.

The physical presence of the BLNG Precinct and associated infrastructure may alter the flow paths and volumes of surface water and subsequently the amount of surface water received by adjacent vegetation communities. Groundwater abstraction could impact vegetation, such as the monsoon vine thicket, which is likely to utilise groundwater to some extent, as a result of groundwater drawdown.

Alteration to Fire Regimes

The fire regime of the James Price Point coastal area has already been altered to the extent that the pindan vegetation is considered in advanced long term decline (Biota, 2009c; **Appendix C-18**). Vegetation clearing, construction activities, vehicles, and the BLNG plant and other equipment will introduce new ignition sources that could result in an increase in late (or dry) season fires. However, this is likely to be offset by the reduction in informal access which will reduce the incidence of wildfires caused as a result of human activity. In addition, the presence of a large workforce in the area will enable fire management activities to be initiated prior to fires becoming uncontrolled.

Alterations to fire regimes will occur which may result in altered vegetation structure and composition in areas surrounding the BLNG Precinct and may affect conservation significant flora or significant ecological communities.

2.7.3.3. Sensitivity and Resilience

Conservation Significant Flora

Existing weed infestations within the monsoon vine thicket are likely to be currently having some impact on *Pittosporum moluccanum. Eriachne semiciliata and Polymeria distigma* are currently unlikely to be significantly impacted by weeds, as they appear to be widespread in occurrence, with specimens recorded in relatively undisturbed areas in pindan woodland. *Gomphrena pusilla,* associated with coastal community vegetation south of Quondong Point (approximately 10km south of James Price Point), was found to be growing in association with Buffel grass (Biota, 2009c; **Appendix C-18**).

Pittosporum moluccanum (P4) is restricted to monsoon vine thicket communities, which is known to be particularly sensitive to fire and thus would be affected by altered fire regimes. The population of the Priority 2 taxon *Gomphrena pusilla* located in the survey area during the wet season survey (Biota, 2009c; **Appendix C-18**) has since been burnt (AECOM, 2010a; **Appendix C-19**). The sensitivity to fire of this species is not currently known and AECOM (2010a; **Appendix C-19**) recommended the re-survey of the location where *Gomphrena pusilla* (P2) was recorded by Biota (2009c), to determine if any recruitment has occurred in these burnt areas. No published information regarding the sensitivity and resilience to fire of the remaining priority flora known to occur and potentially occur is available.

Conservation Significant Vegetation

Important vegetation communities such as the monsoon vine thicket, coastal heath and drainage basins are fire sensitive (Biota, 2009c; **Appendix C-18** and AECOM, 2010a; **Appendix C-19**). It has been noted that the integrity of the monsoon vine thickets in the Dampier Peninsula is jeopardised by current fire regimes, which have been dramatically altered in recent history (V. English, 2010, pers. comm. DEC, 20 July 2010). Weed invasion into these communities increases their sensitivity to fire and other threatening processes, and in the case of Buffel grass invasion, may replace them completely with a monoculture.

The introduced weeds of Wild passionfruit and Siratro are highly likely to be threatening the integrity of the monsoon vine thickets in the area. For example, Siratro is identified in the recently published Biodiversity Monitoring Protocol for monsoon vine thickets on the Dampier Peninsula, as the highest priority weed to target for vine thicket conservation, with James Price Point as one of two key locations of infestation (Harding *et al.,* 2009).

Monsoon vine thicket and coastal heath vegetation form discrete narrow linear patches along the coast and consequently the community is highly vulnerable to disturbance through fragmentation and 'edge effects'.

Monsoon vine thicket and drainage basin vegetation in the James Price Point area appears to be maintained by both surface water and groundwater inflow (Ray Froend, 2010, pers. comm. Edith Cowan University, 25 June 2010). The surface water input pathways are directly through run-on into the area during the wet season, and indirectly via recharge of the local superficial aquifer. The removal of the dune system for the shore crossing and the physical presence of facilities and infrastructure associated with the BLNG Precinct may alter surface water flow paths and groundwater conditions and thus indirectly impact on the vine thicket. The impacts of this are considered in **Part 4**, **Section 2.4**.

While the monsoon vine thicket vegetation is listed as a Vulnerable TEC (WA) it is further classified into Criteria C, meaning that while this ecosystem is still widespread it is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes (DEC, 2009c).

Conservation Significant Fauna

Conservation significant fauna are impacted directly by introduced fauna species through increased competition for resources, predation, disease transmission and indirectly through introduced flora species altered fire regimes and vegetation communities, and thus habitat availability.

Predation by feral cats and European red fox are listed as threatening processes under the EPBC Act, as these species are considered to be a major threat to Australian native fauna. Cats are thought to have contributed to the extinction of many small to medium-sized mammals and ground-nesting birds in the arid zone, and have seriously affected populations of bilby, mala and numbat. They also kill and eat reptiles, amphibians and invertebrates, and indirectly impact native fauna by carrying and transmitting infectious diseases (DEWHA, 2008b). Native fauna susceptible to predation by the European red fox are small to medium sized terrestrial mammals (particularly those within the critical

weight range of 35-5,500 grams) and ground nesting birds (DEWHA, 2008c). Of the threatened species listed under the EPBC Act, foxes are considered a threat to 14 species of birds, 48 mammals, 12 reptiles and 2 amphibians (DEWHA, 2008c).

The biological effects of cane toads is listed as a threatening process under the EPBC Act, with particular concern over their impact on native species and in particular, invertebrate communities, through predation and competition. Cane toads possess highly toxic chemical predator defences and many scientific and anecdotal reports exist of deaths of native predators that have attempted to consume cane toads.

2.7.4. Predicted Impacts

Potential impacts on terrestrial ecosystem integrity from the construction and operation of the BLNG Precinct are discussed below and summarised in **Table 2.7-4**. Both direct and indirect impacts are considered within these sections. For the purpose of this assessment it is considered that direct impacts would largely be confined to areas of direct disturbance within the BLNG Precinct, and other locations where development activities are proposed to occur.

Further definition of likely indirect impacts and proposed management of these will be provided within the derived approval applications. Indirect impacts are discussed in **Section 2.7.6.2** while Category B and C impacts are discussed in **Section 2.7.7**. The assessment focused on those key aspects and receptors identified to be of particular relevance to the proposed BLNG Precinct activities.

2.7.4.1. Vegetation and Habitat Clearing

The indirect impacts of vegetation and habitat clearing are fragmentation and associated edge effects. Fragmentation and edge effects have the potential to occur as a result of the construction of the shore crossing and southern pipeline corridor and is of particular concern for vegetation communities that are linear in structure such as the monsoon vine thicket and coastal communities and for fauna for species with limited mobility such as reptiles.

A direct impact of fragmentation is the loss of connectivity in terms of species recruitment, movement and migration. This potentially affects flora and vegetation structure, for example, reduced seed movement will result in less regeneration of species and possibly result in impacts on local species. Another direct impact of fragmentation is a change in the micro-climate as vegetation structure is altered.

Indirect impacts of fragmentation include increased erosion and weed invasions. Smaller fragments of vegetation experience greater edge effects and are more prone to weed invasions. The invasion of weeds may displace conservation significant flora and alter vegetation communities and fauna habitats.

It is expected that locally occurring bird and mammal species would be capable of continuing to access other habitat areas within the James Price Point coastal area and while there is the potential for the fragmentation of coastal habitats, it is considered unlikely that this would significantly impact local fauna populations. Through the adoption of appropriate flora and vegetation management strategies and a fauna management plan, impacts to flora, vegetation and fauna communities as a result of fragmentation are likely to be avoided. These may include ongoing weed management and rehabilitation activities where appropriate.

A fauna management plan will be designed to manage impacts to locally occurring fauna species as a result of all aspects of the BLNG Precinct. While fragmentation of habitats such as monsoon vine thicket has the potential to impact some fauna groups, measures to minimise impacts as a result of fragmentation would be implemented as part of the development of future management plans. Where possible this would include strategies to allow for the movement of species between fragmented habitats within the James Price Point coastal area.

It is expected that potential impacts to terrestrial ecosystem integrity can be mitigated through measures such as the development and implementation of vegetation management strategies including weed control and rehabilitation of degraded areas. A more detailed description of proposed mitigation measures is presented in **Section 2.7.5**. The significance of residual impacts on terrestrial ecosystem integrity due to vegetation and habitat clearing is assessed to be low as it is a localised impact and because the range of mitigation measures are likely to result in improvements in ecosystem condition within the James Price Point coastal area.

2.7.4.2. Introduced Flora Pests

Clearing and earthworks for the BLNG development and increased vehicle movements have the potential to facilitate the spread of existing weeds into vegetation communities, which support both flora and fauna of conservation significance, and into the surrounds of the James Price Point coastal area. The clearing process will potentially disturb existing weed seeds stored in the soil profile and promote growth of pioneer weed species. Areas that remain bare following clearing (for example road side drains and the James Price Point coastal area perimeter boundary) that adjoin remnant vegetation also have potential for edge effects from encroachment of weeds. The spread of existing weeds depends on the biology of the weed, mode of movement and availability of effective control measures.

Increased traffic in proximity of the Declared Plant *Sida acuta* infestation may potentially disturb or facilitate the spread of this P1 declared weed species. Should the presence of *Sida* be more widespread than reported by the vegetation assessments, then it may impact on the clearing process.

The potential impact from weeds is loss or decline in conservation significant ecological communities or conservation significant flora and fauna through both competition and alteration of habitat and fire regimes. Twenty two weed species currently occur within the James Price Point coastal area and it is unlikely that new introductions of weeds will occur from terrestrial pathways (vehicles and excavation activities) as there is already uncontrolled access and weeds established in the area. However, marine pathways (vessels and internationally imported equipment or machinery) may be a pathway to introduce new weed species.

The coastal communities and monsoon vine thickets identified within the James Price Point coastal area and Priority flora within these vegetation communities are likely to be subject to weed invasions as they have small areas of representation in the local area and are linear in nature. However, while the potential spread of existing weeds caused by clearing and earthworks may reduce the condition of remnant vegetation around the James Price Point coastal area, introduced invasive weeds may not substantially diminish the overall conservation value of the vegetation types, as has been observed under the current environment. If left uncontrolled site construction and operation may have the potential to result in the introduction of new weed species or an expansion of existing weed species populations.

Weeds are considered a major threat to the conservation of biodiversity assets on the Dampier Peninsula and are currently having a negative impact on important vegetation communities such as monsoon vine thicket within the James Price Point coastal area. The potential impact from weeds is loss or decline in conservation significant ecological communities or conservation significant flora and fauna through both competition and alteration of habitat and fire regimes. Weed quarantine and management plans are proposed to control the introduction of weeds and management of existing weed species and populations. Following the adoption of proposed management plans it is considered likely that the incidence of weed species in some vegetation types would be maintained or reduced, and remnant vegetation condition in communities such as monsoon vine thicket maintained or improved.

It is expected that potential impacts to terrestrial ecosystem integrity from introduced flora pests can be mitigated through measures such as implementing hygiene procedures for vehicles entering the Precinct during the construction phase and applying weed control and rehabilitation in degraded areas. A more detailed description of proposed mitigation measures is presented in **Section 2.7.5**. The significance of residual impacts on terrestrial ecosystem integrity due to introduced flora pests is assessed to be low.

2.7.4.3. Introduced Fauna Pests

Introduced fauna species currently occur within the James Price Point coastal area and are likely to be having negative impacts on native fauna populations. An increase in introduced fauna species, or in numbers of existing introduced species, has the potential to impact on native fauna in the James Price Point coastal area by increasing predation and competition for resources, degrading habitat and potentially introducing disease as vectors. The key risk pathway for invasive fauna species is the large increase in vehicle movements, both on road or by sea, associated with the construction and operation of the BLNG Precinct and associated infrastructure. In addition, the introduction of new food sources as well as permanent freshwater have the potential to attract populations of invasive species, including rodents, feral cats, and the red fox to the area, or provide a mechanism for existing populations to increase in size.

During construction and operation of the BLNG Precinct and associated infrastructure, there is potential for an increase in populations of introduced rodents, such as the house mouse and black rat, along with the introduction of new species, such as the brown rat. In addition, the introduction of new food sources as well as permanent freshwater have the

potential to attract populations of invasive species, including rodents, feral cats, and the red fox to the area, or provide a mechanism for existing populations to increase in size.

Existing movements of transport vehicles across the top end from Queensland and the NT into WA have potential to facilitate the movement of cane toads into the Kimberley region. The cane toad is highly invasive and as a result a number of native species are considered to be at risk of displacement or decline due to competition and poisoning. Currently, quarantine control points at the WA/NT border minimise the potential for accidental movement of cane toads.

An increase in introduced fauna species, or in numbers of existing introduced species, has the potential to impact on native fauna in the James Price Point coastal area by increasing predation and competition for resources, degrading habitat and potentially introducing disease as vectors. It is unlikely that new introductions of fauna pests will occur from terrestrial pathways as there is already uncontrolled access and introduced fauna in the area. However, introduction of new pests may occur via marine pathways.

The adoption of appropriate quarantine controls and pest management plans are likely to control the potential introduction of new pest species and help to control existing populations within the James Price Point coastal area. It is considered unlikely that the presence of the BLNG Precinct and associated infrastructure would have significant impact on the numbers of larger introduced pests, such as feral donkeys and cattle, as it is likely that water sources would be fenced and unavailable as a resource to these species.

It is expected that potential impacts to terrestrial ecosystem integrity from introduced fauna pests can be mitigated through measures such as implementing quarantine controls and pest management plans. A more detailed description of proposed mitigation measures is presented in **Section 2.7.5**. The significance of residual impacts on terrestrial ecosystem integrity due to introduced fauna pests is assessed to be low.

2.7.4.4. Physical Presence - Changes in Surface Water Flows and Groundwater Availability

The physical presence of the BLNG Precinct and subsequent alterations to natural surface water flow regimes has the potential to degrade vegetation communities which are sensitive to surface water flows due to the creation of drainage shadow effects and localised flooding or ponding. Vegetation communities within the James Price Point which may be sensitive to surface water flows include the drainage basin habitat, as suggested by the presence of the flora species *Melaleuca dealbata* and *Lophostemon grandiflorus*, and the monsoon vine thicket habitat. Monsoon vine thicket vegetation in the James Price Point coastal area appears to be maintained by both surface water and groundwater inflow (Ray Froend, 2010, pers. comm. Edith Cowan University, 25 June 2010). The surface water input pathways are directly through run-on into the area during the wet season, and indirectly via recharge of the local superficial aquifer. Given the depth to the superficial aquifer surface and knowledge of the lithology in the monsoon vine thicket habitat, it is likely that some of the dominant species are utilising groundwater reserves.

It is proposed that an Ecological Surface Water Requirements Management Plan be developed to prevent, as far as practicable, impacts to surface water dependant vegetation and habitat types. Following completion of hydrological studies it will be possible to gain a detailed understanding of the relationship between vegetation communities and surface water flow requirements. It is likely that this information will be used to identify opportunities to manage flows to sensitive vegetation types such as monsoon vine thicket and the drainage basin community.

The construction of hardstand areas and drainage structures within the BLNG Precinct may alter the distribution of recharge to aquifers beneath the site. The impacts on groundwater as a consequence of the physical presence of the BLNG Precinct are likely to be localised and permanent. Whilst this may not be significant in a regional context, localised reductions in recharge to the Broome and superficial aquifers may impact sensitive vegetation communities, such as monsoon vine thicket and drainage basin communities. If the rate and extent of drawdown is beyond the natural tolerance of the dependant species and communities present, it may cause a decline in the condition and a ‘retreat’ in the extent of this vegetation. A gradual drop in groundwater levels within the tolerance of the plants may allow dependent species time to adapt to the altered conditions. Such adaptations would include extension of roots into the lowered water table.

Groundwater conditions within the James Price Point coastal area and the presence of groundwater dependant vegetation communities will be determined as part of future hydrological studies and modelling. While the impacts of physical presence on groundwater levels within the Broome sandstone aquifer and superfical aquifers are uncertain, a

groundwater abstraction licence will be sought from the Department of Water and this will need to demonstrate that impacts to groundwater as a result of abstraction and other impacts such as a reduction in recharge will not result in unacceptable environmental impacts.

It is expected that potential impacts to terrestrial ecosystem integrity from changes to surface water flows and groundwater availability can be mitigated through the implementation measure for ensuring terrestrial vegetation health is maintained as detailed in **Part 4**, **Section 2.4**. This includes measures to maintain surface water flow regimes and condition monitoring. A more detailed description of proposed mitigation measures is presented in **Section 2.7.5**. The significance of residual impacts on terrestrial ecosystem integrity due to changes to surface water flows and groundwater availability is assessed to be low as the range of mitigation measures will ensure maintenance of vegetation condition.

The indirect impacts of changes to surface water flows and groundwater abstraction on monsoon vine thickets and drainage basin communities are detailed in **Part 4**, **Section 2.4**.

2.7.4.5. Altered Fire Regime

The current frequent fire regime on the Dampier Peninsula is considered to be having a negative impact on all vegetation types (Graham, 2001). Further changes in fire regimes may have the potential to reduce the habitat availability of the James Price Point coastal area for conservation significant and more common fauna species. In the monsoon vine thickets, frequent fire threatens the many species that require long periods between fires in order to flourish and is likely to be causing retreat in their extent following each burn. Priority species found within these habitats may be similarly affected. Vegetation clearing, construction activities, vehicles, LNG facilities within the BLNG precinct and other equipment may introduce new ignition sources that could result in an increase in late (or dry) season fires. However, this is likely to be offset by the reduction in informal access which will reduce the incidence of wildfires caused as a result of human activity. In addition, the presence of a large workforce in the area will enable fire management activities to be initiated prior to fires becoming uncontrolled.

Fire sensitive plant species can be impacted by fire through failed recruitment or death. Fire sensitive flora species occurring in the James Price Point coastal area include species such as the conservation significant flora *Pittosporum moluccanum* (P4) and the Gubinge (*Terminalia ferdinandiana*), which is of ethnobiological significance. Important vegetation communities such as the monsoon vine thicket, coastal heath and drainage basins are also fire sensitive (Biota, 2009c; **Appendix C-18** and AECOM, 2010a; **Appendix C-19**).

Suppression of fire-sensitive species and increased weed invasion from altered fire regimes can alter both floristic and vegetation structure (Biota, 2009c; **Appendix C-18**). In savannah woodland communities, such as in the James Price Point coastal area, fire frequency affects the ability of species to persist because it alters the balance between woody species and grasses. Frequent burning tends to produce open, grassy landscapes, whereas in places where fire has been excluded or is rare, shrubs and young trees tend to increase in numbers. Fire sensitive vegetation communities in particular, are being severely affected and potentially, are unable to recover (EPA, 2006). Fire sensitive vegetation at the James Price Point coastal area includes the monsoon vine thicket, coastal heath and within the drainage basins (Biota, 2009c; **Appendix C-18** and AECOM, 2010a; **Appendix C-19**). Fire is considered to be a key threatening process to the integrity of monsoon vine thickets on the Dampier Peninsula, with the intense and frequent fires currently affecting the impacting on species diversity and causing encroachment of pindan vegetation (V. English, 2010, pers. comm. DEC, 20 July 2010).

Altered fire regimes may act together with weed invasions to intensify impacts on fire sensitive vegetation. Weed infestations can also supply a larger amount of fuel than that which occurs naturally. When this vegetation is burnt, it burns hotter and for longer, increasing the likelihood that plants will not regenerate after the fire.

It is likely that, while there will be a greater presence of ignition sources, the presence of the BLNG Precinct will have a positive impact on the fire regime of the area as fire management is a high priority for LNG facilities.

While the BLNG Precinct may result in the introduction of potential ignition sources it is expected that the implementation of a fire management program, together with a reduction in informal access, within the James Price Point coastal area are likely to reduce the incidence of late dry season wildfires, which are known to be particularly damaging to vegetation communities and associated fauna habitats. A fire management plan would be developed and would aim to introduce a

managed fire regime to the James Price Point coastal area. This is likely to include consideration of the fire ecology of locally occurring fauna species and habitat types.

The introduction of a fire management plan as well as other strategies designed to monitor and manage threats to conservation significant vegetation communities, is likely to result in a reduction of frequent high intensity fires and has the potential to result in improvements to the condition of vegetation communities such as monsoon vine thicket.

It is expected that altered fire regimes arising from development activities that may impact ecosystem integrity in the vicinity of the BLNG Precinct can be mitigated by the application of measures such as the implementation of a managed fire regime in areas around the precinct including the application of low intensity prescribed burning. A more detailed description of proposed mitigation measures is presented in **Section 2.7.5**. The significance of the residual impact is assessed as low as it is likely that the implementation of a managed fire regime will result in reduced fire intensity and improvements to vegetation condition to the overall benefit of ecosystem integrity.

2.7.5. Management Measures

Mitigation measures and safeguards that have been identified to manage potential impacts to terrestrial ecosystem integrity are outlined below in **Table 2.7-1** and **Table 2.7-2**.

- **Table 2.7-1 State Government Measures for Terrestrial Ecosystem Integrity.**

State Government measure	Responsibility	Timing
Prepare and implement a Fire Management Strategy for the Dampier Peninsula to align with existing fire management strategies to reduce the frequency of fires and the occurrence of late dry season burns on the Peninsula.	DSD through its involvement in the BLNG Precinct Control Group, with advice from DEC and Indigenous ranger groups.	Prior to commencement of construction of an LNG plant.
Prepare an overarching Emergency Response Plan that addresses: • risk assessment of potential emergencies (including bushfires, introduction of foreign pests, flooding and spills); • emergency response equipment and training; • emergency response procedures; • responsibilities during emergency response; and • reporting, review and improvement as required.	DSD through its involvement in the BLNG Precinct Control Group, with advice from FESA.	Prior to commencement of construction of an LNG plant.
Develop and implement an Engagement Plan to manage all interactions with public users of the marine and terrestrial environment in and around James Price Point, including recreational users and tourism operators.	DSD through its involvement in the BLNG Precinct Control Group, with advice from Broome Port Authority and LandCorp.	Prior to the commencement of construction.
Develop and implement a Management and Monitoring Strategy for Vegetation of Medium to High Conservation Significance, with particular reference to remnant monsoon vine thicket and drainage basin vegetation. The Strategy will inform all proponents of derived proposals of requirements for detailed management plans specific to individual activities and will include a framework in which the following Plans will be implemented: • Fire Management Plan; • Terrestrial Fauna Management Plan; • Terrestrial Weed Management Plan; and • Appropriate management of hydrology (both surface water and groundwater). Refer also the commitment for Ecological Surface Water Requirements Management Plan and surface water and groundwater management commitments in **Part 4**, **Section 2.2** and **Part 4**, **Section 2.3**. The effectiveness of the Strategy is to be measured via condition and health monitoring for a defined area within and surrounding the BLNG Precinct area and associated buffer zones. Annual reporting on success of the program is to be made publicly available.	DSD through its involvement in the BLNG Precinct Control Group, with advice from DEC.	Throughout the life of the Plan.
Prepare and implement a closure and decommissioning strategy for the Browse LNG Precinct and related activities for the purpose of providing a timely and consistent approach to removal or retention of plant and infrastructure, rehabilitation of disturbed areas and identification of contaminated areas.	DSD through its involvement in the BLNG Precinct Control Group.	5 years prior to decommissioning of BLNG Precinct infrastructure.

- **Table 2.7-2 Proposed Environmental Conditions for the Strategic Proposal that may Affect Terrestrial Ecosystem Integrity.**

Condition No.	Proposed Environmental Conditions for the Strategic Proposal
T3.1	Proponents of derived proposals shall not cause the loss of vegetation including monsoon vine thicket in excess of the limits of cumulative loss prescribed in **Part 4**, **Section 2.4** for the BLNG Precinct.
T1.2	Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address: • detailed measures to be implemented for final closure; • the schedule and timing of final closure activities; • completion criteria for closure; and • closure monitoring requirements.
T1.3	Proponents of derived proposals shall implement the Final Closure Plan required by condition 1.2 until such time that the Minister for Environment, on advice from the Chief Executive Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.
T2.1	Prior to the commencement of construction activities, the proponents of derived proposals shall prepare and implement an Ecological Surface Water Requirements Management Plan, to the satisfaction of the Minister for Environment on advice of DEC, which shall address the following: • Drainage measures to manage surface water flows and minimise environmental impacts as far as practicable on monsoon vine thicket and drainage basin vegetation communities within the affected catchments. • A vegetation composition, health and condition monitoring program for areas of vegetation determined likely to be dependent on surface water flows, including the superficial aquifer, for seasonal water requirements. • Process to be implemented if monitoring indicates declining vegetation condition or changing composition as a result of changes in surface water flows.

- **Table 2.7-3 Requirements to be Addressed via Development of a Management Plan to Support a Derived Proposal in Regards to Terrestrial Ecosystem Integrity.**

Derived Proposal Requirements	Timing
Prepare and implement a Fire Management Plan for construction and operation activities, which addresses the following: • objectives, targets and associated monitoring; • roles and responsibilities of response personnel; • risk assessment of proposed activities ; • fire response equipment that will be available; • alignment and compliance with the State Government Fire Management Strategy for the Dampier Peninsula; and • fire risk reduction and management measures, which may include vegetation thinning to reduce fuel load and installation of firebreaks around the perimeter fence, within the areas surrounding the BLNG Precinct.	Prior to construction and updated for ongoing operational requirements.
Prepare and implement a Quarantine Management Plan, to the satisfaction of the Western Australian Minister for Environment, for construction and operation activities, which addresses the following: • baseline information regarding non-indigenous species; • objectives, targets and associated monitoring; • profile of potential quarantine risks based on where the equipment is sourced (locally, interstate, overseas); • species-specific or generic response plans to minimise and manage any incursions or spread; • on-site management measures (including investigation of the requirements for	Prior to construction and updated for ongoing operational requirements.

Derived Proposal Requirements	Timing
establishing an on-site fumigation facility, wash-down facility and Quarantine Approved Premise); • process for earth moving machinery, vehicles, plant and equipment to be free of soil and vegetation prior to entering and exiting the BLNG Precinct; • management and control of Declared Plants (as defined by the Agriculture and Related Resources Protection Act 1976); • monitoring program during and after the activity has been completed; • reporting on inspections and monitoring; • consultation with AQIS, DAFWA and DEC; and • integration with the State Government Emergency Response Plan.	
Prepare and implement a Terrestrial Weed Management Plan for a defined area surrounding James Price Point to manage the impacts of the BLNG Precinct development. The Plan will address: • issues around management of fragmentation and edge effects; and • annual reporting on success of the control program to be made publicly available.	Prior to commencement of associated construction activities.
Prepare and implement a Rehabilitation Plan. See **Part 4**, **Section 2.4**.	Prior to commencement of associated construction activities.
Prepare and implement a Fauna Management Plan. See **Part 4**, **Section 2.6**.	Prior to commencement of associated construction activities.
Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan for construction and operation activities. See **Part 4**, **Section 2.1**.	Prior to commencement of associated construction activities.
Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets; • environmental management; • environmental training and inductions; and • environmental monitoring, contingencies and reporting, and stakeholder consultation. In order to address the potential impacts to ecosystem integrity identified within this section the CEMP will specifically include measures covered in **Part 4**, **Section 2.1 – Section 2.4** and **Section 2.6**.	Prior to commencement of associated construction activities.

The implementation of the aforementioned mitigation measures and safeguards will be effective in mitigating the impact of the BLNG Precinct. Management plans will be developed in consultation with DEC and other relevant agencies.

2.7.6. Environmental Outcome

2.7.6.1. Direct Impacts

After management and mitigation measures have been applied, it is expected that the BLNG Precinct will result in the following direct impacts in relation to the ecosystem integrity:

- Direct impacts resulting from the removal of vegetation during construction of the BLNG Precinct, pipeline corridors, light industrial area, workers accommodation and supporting infrastructure. Details of predicted areas of disturbance are presented in **Part 4**, **Section 2.4**.
- The occurrence of weeds will be controlled through a terrestrial weed management plan, as detailed in **Section 2.7.5**.
- The occurrence of introduced fauna pests will be managed through appropriate control programs. At this point in time, control of feral cats is difficult. However, should future research establish effective baits for feral cats, then

management measures for feral cats should be implemented to encourage the return of the critical weight native fauna species (within the 35 to 5,500 gram weight range).

- The introduction of new weed and pest species will be controlled through a quarantine management plan, as detailed in **Section 2.7.5.**

2.7.6.2. Indirect Impacts

After management and mitigation measures have been applied, it is expected that the BLNG Precinct will result in the following indirect impacts in relation to the ecosystem integrity:

- Potential impacts to monsoon vine thicket and coastal communities as a result of fragmentation and 'edge effects' from clearing activities for the BLNG Precinct, and pipeline crossings.
- The requirement to implement drainage measures to manage surface water flows to prevent as far as is practicable adverse impacts on vegetation that has been defined as at high or moderate risk of being dependent on surface water flows or at high or moderate risk of being susceptible to flooding will minimise the impacts of an altered surface water regime on these potentially water dependent vegetation types. The potential impacts on groundwater dependent ecosystems from groundwater abstraction will be assessed through the groundwater licence application process (refer to **Part 4**, **Section 2.3** and **Part 4**, **Section 2.4**).
- Implementation of a fire management plan, together with a reduction in informal access within the James Price Point coastal area is likely to reduce the incidence of late hot, dry season wildfires, which are known to be particularly damaging to fire sensitive vegetation communities and associated fauna habitats. As such, it is considered likely that flora and fauna habitats may improve over time. Where habitat types are restricted and currently determined to be under threat, such as the monsoon vine thicket, it is considered that an improvement in vegetation condition is likely to improve habitat availability and local ecosystem function. In the absence of fire it is possible that occurrences of monsoon vine thicket may increase in size (V. English, 2010, pers. comm. DEC, 20 July 2010).

2.7.7. Cumulative Impacts of the Proposal and Associated Activities

2.7.7.1. Category B Activities

Category B activities are anticipated to be largely associated with the development of urbanised or industrial precinct areas around Broome and indirectly associated with the BLNG Precinct.

Category B activities associated with the BLNG Precinct that could potentially affect ecosystem integrity include:

- expansion for additional housing and associated infrastructure in Broome;
- expansion of industrial areas in Broome;
- a new solid waste facility;
- expansion or relocation of the Broome International Airport ;
- expansion or development of new sea port facilities;
- additional gas pipeline infrastructure from the BLNG Precinct to Broome;
- development of service corridors; and
- development of offsite quarries for breakwaters and reclamation.

The remaining Category B activities within and near Broome will most likely be developed on pindan vegetation. Over 4,000,000 hectares of pindan shrubland exists within Dampierland subregion (Graham, 2001). Impacts on ecosystem integrity will largely relate to fragmentation and associated edge effects from clearing.

The potential relocation of the Broome airport has already been assessed, whereby the EPA concluded that the proposal could be managed in an environmentally acceptable manner (EPA Report 1017; EPA, 2001). Should the airport be relocated sometime soon in the future, it is likely that the current airport site will be redeveloped for additional housing and thereby reduce the need for housing expansion projects in remnant vegetation areas. Impacts from the relocation of the airport would also be related to, but will edge effects into surrounding vegetation.

LandCorp's 695 hectares Broome North development for housing may impact on nearby monsoon vine thickets through edge effects.

Future industrial land may be developed in the Broome port area or in areas north of Broome. Locations of industrial areas and the solid waste facility have not been determined and therefore vegetation and flora surveys have not been conducted.

Road access in some sections of the Dampier Peninsula may improve as a result of the BLNG Precinct. Improved road access may result in increased recreational use, which in turn, may in increase the potential for introduced weeds, or further spread of existing weeds (for example from vehicles, camping equipment, fishing nets). Increased recreational use may also increase the potential for accidental or deliberately lit fires.

A common infrastructure corridor is likely to be established for provision of power infrastructure, water supply, communications and transport of goods and services to the BLNG Precinct facilities from the main public road.

2.7.7.2. Category C Activities

Clearing and related impacts associated with the Main Access Road from Cape Leveque Road to the BLNG Precinct will be formally assessed by both State and Commonwealth separately from the Strategic Assessment. The estimated clearing required for the road is 191ha with an additional 172ha part of possible future requirements for services such as electricity and gas alongside the Main Access Road. The principal impact from this activity is the clearing of Pindan vegetation which, given its very common occurrence of the Dampier Peninsula, is not considered to have a significant cumulative environmental impact.

The potential development of a supply base to service upstream development is a Category C activity which may affect terrestrial ecosystem integrity. Impact assessment is dependent on the location of the proposed supply base and will be defined as the development progresses.

- **Table 2.7-4 Impact Assessment Summary for Terrestrial Ecosystem Integrity.**

Factor/ Sub-factor	Environmental Aspect	Potential Impacts	Mitigation Measures			Significance of Residual Impact
			State Government Measures	**Proposed Environmental Conditions**	**Future Proponent Management Plans**	
Terrestrial Flora - Refuge value for terrestrial biota	Vegetation/habitat clearing (Construction)	Habitat fragmentation and edge effects	Develop and implement a Management and Monitoring Strategy for Vegetation of Medium to High Conservation Significance, with particular reference to remnant monsoon vine thicket and drainage basin vegetation. The Strategy will inform all proponents of derived proposals of requirements for detailed management plans specific to individual activities and will include a framework in which the following Plans will be implemented: • Fire Management Plan; • Terrestrial Fauna Management Plan; • Terrestrial Weed Management Plan; and • Appropriate management of hydrology (both surface water and groundwater). Refer also the commitment for Ecological Surface Water Requirements Management Plan and surface water and groundwater management commitments in **Part 4**, **Section 2.2** and **Section 2.3**. The effectiveness of the Strategy is to be measured via	Proponents of derived proposals shall not cause the loss of vegetation including monsoon vine thicket in excess of the limits of cumulative loss prescribed in **Part 4**, **Section 2.4** for the BLNG Precinct. Proponents of derived proposals shall develop a Final Closure Plan, in consultation with key stakeholders, to be submitted to the Chief Executive Officer of DEC at least five years prior to the planned date of closure. The Plan shall address: • detailed measures to be implemented for final closure; • the schedule and timing of final closure activities; • completion criteria for closure; and • closure monitoring requirements. Proponents of derived proposals shall implement the Final Closure Plan until such time that the Minister for Environment, on advice from the Chief Executive	Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets; • environmental management; • environmental training and inductions; • environmental monitoring, contingencies and reporting; and • stakeholder consultation. In order to address the potential impacts to ecosystem integrity identified within this section the CEMP will specifically include measures covered in **Part 4**, **Section 2.1 – Section 2.4** and **Section 2.6**. Prepare and implement a Rehabilitation Plan. See **Part 4**, **Section 2.4**. Prepare and implement a Fire Management Plan for construction and operation activities, which addresses the following: • objectives, targets and associated monitoring; • roles and responsibilities of response personnel; • risk assessment of proposed activities; • fire response equipment that will be	Low
Terrestrial Fauna - Declared rare protected fauna	Vegetation/habitat clearing (Construction)	Habitat fragmentation and edge effects				Low

Factor/ Sub-factor	Environmental Aspect	Potential Impacts	Mitigation Measures			Significance of Residual Impact
			State Government Measures	Proposed Environmental Conditions	Future Proponent Management Plans	
Terrestrial Ecosystem Integrity	Altered fire regime	Disturbance of fauna habitat	condition and health monitoring for a defined area within and surrounding the BLNG Precinct area and associated buffer zones. Annual reporting on success of the program is to be made publicly available. Prepare and implement a closure and decommissioning strategy for the Browse LNG Precinct and related activities for the purpose of providing a timely and consistent approach to removal or retention of plant and infrastructure, rehabilitation of disturbed areas and identification of contaminated areas. Prepare and implement a Fire Management Strategy for the Dampier Peninsula to align with existing fire management strategies to reduce the frequency of fires and the occurrence of late dry season burns on the Peninsula. Prepare an overarching Emergency Response Plan that addresses: • risk assessment of potential emergencies (including bushfires, introduction of foreign pests, flooding and spills); • emergency response equipment and training;	Officer of DEC, determines that the proponents of derived proposals closure and decommissioning responsibilities have been fulfilled.	available; • alignment and compliance with the State Government Fire Management Strategy for the Dampier Peninsula; and • fire risk reduction and management measures, which may include vegetation thinning to reduce fuel load and installation of firebreaks around the perimeter fence, within the areas surrounding the BLNG Precinct. Prepare and implement a Quarantine Management Plan, to the satisfaction of the Western Australian Minister for Environment, for construction and operation activities, which addresses the following: • baseline information regarding non-indigenous species; • objectives, targets and associated monitoring; • profile of potential quarantine risks based on where the equipment is sourced (locally, interstate, overseas); • species-specific or generic response plans to minimise and manage any incursions or spread; • on-site management measures (including investigation of the requirements for establishing an on-site fumigation facility, wash-down facility and Quarantine Approved Premise); • process for earth moving machinery, vehicles, plant and equipment to be free of soil and vegetation prior to	Low
Terrestrial Flora - Significant Ecological Communities	Altered fire regime	Disturbance of conservation significant vegetation communities				Low
Terrestrial Ecosystem	Altered fire regime	Disturbance of conservation				Low

Factor/ Sub-factor	Environmental Aspect	Potential Impacts	Mitigation Measures			Significance of Residual Impact
			State Government Measures	Proposed Environmental Conditions	Future Proponent Management Plans	
Integrity		significant flora	• emergency response procedures; • responsibilities during emergency response; and • reporting, review and improvement as required. Develop and implement an Engagement Plan to manage all interactions with public users of the marine and terrestrial environment in and around James Price Point, including recreational users and tourism operators.		entering and exiting the BLNG Precinct; • management and control of Declared Plants (as defined by the Agriculture and Related Resources Protection Act 1976); • monitoring program during and after the activity has been completed • reporting on inspections and monitoring; • consultation with AQIS, DAFWA and DEC; and • integration with the State Government Emergency Response Plan. Prepare and implement a Terrestrial Weed Management Plan for a defined area surrounding James Price Point to manage the impacts of the BLNG Precinct development. The Plan will address: • issues around management of fragmentation and edge effects; and • Annual reporting on success of the control program to be made publicly available. Prior to the commencement of construction activities, the proponents of derived proposals shall prepare and implement an Ecological Surface Water Requirements Management Plan, to the satisfaction of the Minister for Environment on advice of DEC, which shall address the following: • Drainage measures to manage surface water flows and minimise environmental impacts as far as practicable on monsoon vine thicket	
Terrestrial Ecosystem Integrity	Introduced pests	Disturbance of conservation significant vegetation communities				Low
Terrestrial Ecosystem Integrity	Introduced pests	Disturbance of fauna population				Low
Terrestrial Ecosystem	Physical presence	Decline in vegetation health due to				Low

Factor/ Sub-factor	Environmental Aspect	Potential Impacts	Mitigation Measures			Significance of Residual Impact
			State Government Measures	Proposed Environmental Conditions	Future Proponent Management Plans	
Integrity		reduction of surface water flows			and drainage basin vegetation communities within the affected catchments. • A vegetation composition, health and condition monitoring program for areas of vegetation determined likely to be dependent on surface water flows, including the superficial aquifer, for seasonal water requirements. • Process to be implemented if monitoring indicates declining vegetation condition or changing composition as a result of changes in surface water flows. Prepare and implement a Hydrocarbon and Chemical Spill Contingency Plan for construction and operation activities. See **Part 4**, **Section 2.1**.	
Terrestrial Ecosystem Integrity	Physical presence	Decline in health of groundwater dependent vegetation (where groundwater drawdown occurs)				Very low

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2.8. Relevant Factor: Air Quality

The following section describes the predicted impacts on air quality in a local and regional context from activities, facilities and other components to be approved under the Plan for the BLNG Precinct (Category A) and the potential for cumulative impacts from activities that may indirectly arise as a result of the BLNG Precinct development (Category B) and other related resource activities in the region (Category C). The section also discusses the controls to be implemented to mitigate anticipated impacts.

The assessment addresses the potential impacts of atmospheric emissions from the construction and operation of the Precinct on sensitive receptors and the surrounding environment using the following approach:

- generation of an emissions inventory for the existing and proposed emissions of pollutants from the LNG Precinct;
- air dispersion modelling of the estimated pollutant emissions with reference to the EPA guidelines (DoE, 2006). The modelling was based on The Air Pollution Model (**TAPM**) – Chemical Transport Model (**CTM**) (for regional application) and TAPM (for local application);
- assessment of the dispersion modelling results against relevant environmental air quality criteria;
- identification of significant considerations for the Precinct layout and design; and
- recommendation of mitigation and management strategies to minimise impacts on the surrounding environment from the sources and pollutants identified as arising from the LNG Precinct.

2.8.1. Current Knowledge

The following sub-sections describe the regulatory context for assessment of the impact of the BLNG Precinct on air quality at a local and regional level, as well as a summary of existing ambient atmospheric conditions. Further discussion on existing air quality is provided in **Part 4**, **Section 1** (Environmental Overview).

This assessment has focussed on the 'key receptors' in the vicinity of the BLNG Precinct, where a reduction in ambient air quality has potential to affect human health, amenity or environmental values. With the exception of the proposed BLNG workers' accommodation facilities, there are no current or planned permanent residential receptors within 30km of the BLNG Precinct area, however the coastal area is used for recreational, tourism and traditional owner purposes.

2.8.1.1. Key Statutory Requirements, Environmental Policy and Guidance

The following provides a summary of the International, Commonwealth and State air quality guidelines, standards and goals used for the air quality impact assessment.

International Protection
*World Health Organisation (**WHO**) Guidelines for Air Quality*

The WHO Air Quality Guidelines are designed to offer guidance in reducing the health impacts of air pollution based on expert evaluation of current scientific evidence.

Commonwealth and State Protection
The following guidelines and regulatory frameworks are applicable to air quality:

- *National Environmental Protection Council Act 1994* (NEPC Act) (Commonwealth) and *National Environment Protection Council (Western Australia) Act 1996* (WA) and National Environmental Protection Measures (**NEPMs**) developed under this legislation, in particular:
    - National Environment Protection (Ambient Air Quality) Measure (as varied 2003).
    - National Environment Protection (Air Toxics) Measure 2004.
    - National Environment Protection (National Pollutant Inventory) Measure 1998 (as varied 2008).

- State Environmental (Ambient Air) Policy 2009, Draft.
- *Environmental Protection Act 1986* (the EP Act (WA).
- Environmental Protection Regulations 1997 (WA).
- Environmental Protection (Unauthorised Discharges) Regulations 2004 (WA).
- *Town Planning and Development Act 1928* (WA).
- *Health Act 1911* (WA).
- State Industrial Buffer Statement of Planning Policy 4.1.
- EPA Guidance Statement No. 3 – Separation Distances between Industrial and Sensitive Land Uses. (EPA, 2005).
- EPA Guidance Statement No. 15 – Emissions of Oxides of Nitrogen from Gas Turbines. (EPA, 2000c).
- EPA Guidance Statement No. 18 – Prevention of Air Quality Impacts from Land Development Sites. (EPA, 2000d).
- EPA Guidance Statement No. 55 - Implementing Best Practice in Proposals submitted to the Environmental Impact Assessment Process. (EPA, 2003a).
- DEC Guideline for the Development and Implementation of a Dust Management Program. Draft, 2008.

A summary of the statutory and policy context at the Commonwealth and Western Australian level and is provided in the following section.

Commonwealth Protection

*National Environment Protection Measures (**NEPMs**)*

In June 1998 the National Environment Protection Council (**NEPC**) released the Ambient Air Quality NEPM, setting out national standards and goals for six common ambient air pollutants (known as the "criteria" air pollutants) (NEPC, 2003). These are sulphur dioxide (**SO_2**), particulate matter as PM_{10}, carbon monoxide (**CO**), lead, ozone (**O_3**) and NO_2. In May 2003, the NEPC released a variation to the Ambient Air Quality NEPM, which introduced advisory reporting standards for $PM_{2.5}$. These advisory reporting standards have been designed to assist in gathering sufficient data nationally for $PM_{2.5}$ to inform the review process for the ambient air quality NEPM.

When reviewing the standards and goals set out in the Ambient Air Quality NEPM, it is important to note that the standards established as part of the NEPM are designed to be used to give an 'average' representation of ambient air quality for large population centres of more than 25,000 people. The associated NEPM monitoring protocol was not designed to assess air quality at locations close to pollutant sources, such adjacent to major roads or industrial premises.

In 2004 NEPC also released the National Environment Protection (Ambient Air Toxics) Measure (Air Toxics NEPM) (NEPC, 2004). The Air Toxics NEPM specifies monitoring investigation levels for five compounds: benzene, toluene, xylenes, formaldehyde and benzo(a)pyrene (as a marker for polycyclic aromatic hydrocarbons - PAHs). The monitoring investigation levels are those below which lifetime exposure, or exposure for a given averaging time, does not constitute a significant health risk. The levels are not compliance standards but provide guidelines in order to assess the significance of the monitored levels of air toxics with respect to protection of human health. The levels are intended to gather data and not for application in modelling or other air quality assessments. If these levels are exceeded in the short-term it does not mean that adverse health effects have occurred.

A formal requirement of the Ambient Air Quality NEPM is that the responsible agency of each State or Territory will establish monitoring procedures and commence assessment and reporting of pollutant levels in accordance with the protocols set out in the NEPM. **Table 2.8-1** and **Table 2.8-2** list the Ambient Air Quality NEPM and Air Toxics NEPM goals for the pollutants relevant to this study.

- **Table 2.8-1 Air Quality Criteria defined by the Ambient Air Quality NEPM.**

Pollutant	Concentration		Averaging Period	Maximum Number of Allowable Exceedances
	(ppm)	($\mu g/m^3$)		
CO	9	11,240	8 hours	1 day per year
NO_2	0.12	246	1 hour	1 day per year
	0.03	62	Annual	None
O_3	0.10	214	1 hour	1 day per year
	0.08	171	4 hours	1 day per year
SO_2	0.20	570	1 hour	1 day per year
	0.08	228	1 day	1 day per year
	0.02	57	1 year	None
PM_{10}	-	50	24 hour	5 days per year
	-	30	Annual	-
$PM_{2.5}$	-	25	24 hour	Advisory reporting standard
	-	8	Annual	

Note: Concentrations of gaseous pollutants have been converted to 0°C, 1 atmosphere pressure.

- **Table 2.8-2 Air Quality NEPM Monitoring Investigation Levels defined in the Air Toxics NEPM.**

Pollutant	Monitoring Investigation Level	Averaging Period	Goal
Benzene	0.003ppm	Annual	8-year goal to gather data
Benzo(a)pyrene as a marker for polycyclic aromatic hydrocarbons	0.3ng/m^3	Annual	8-year goal to gather data
Formaldehyde	0.04ppm	24 hour	8-year goal to gather data
Toluene	1ppm	24 hour	8-year goal to gather data
	0.1ppm	Annual	
Xylenes	0.25ppm	24 hour	8-year goal to gather data
	0.2ppm	Annual	

State Guidance and Policy
The relevant EPA objective for air quality is:

"to minimise the impacts that atmospheric emissions may have on the environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards."

Where necessary, the EPA adopts ambient air quality guidelines to assess new proposals and to manage local and regional ambient air quality. As a matter of policy, the National Environment Protection Measure standards for ambient air quality are adopted. In the absence of a NEPM standard, the EPA adopts the World Health Organisation Guidelines for Air Quality (2000), with appropriate amendments to suit the WA context.

The EPA has released a draft Ambient Air State Environmental Policy (**SEP**) and explanatory document, developed by the EPA, for public and stakeholder comment (EPA, 2009d). A date for the finalisation of the SEP and its approval by Government is unknown at this time. The policy considers the management of not only large, individual point sources but also of small, dispersed non-point sources that collectively contribute to episodes of unacceptable air quality in an area or region. This includes dispersed emissions from motor vehicles and marine vessels, domestic fuel combustion, land management activities such as prescribed burning and land clearing, and dispersed commercial activities.

Relevant Human Health Criteria from other Australian States

In the absence of relevant WA-specific ambient air criteria, for this assessment guidelines from Victoria and New South Wales have been adopted to assess impacts of emissions of benzene, toluene, ethyl benzene, xylenes, hydrogen sulphide, formaldehyde and acetaldehyde (Victoria Government Gazette, 2001; NSW EPA, 2005) (see **Table 2.8-3**).

The NSW guidelines specify that Level 2 impact assessments (i.e. using site specific emissions data) are assessed as follows:

- the incremental concentration from the facility alone is assessed;
- the assessment is based on predictions of 99.9th percentile concentrations for an averaging period of 1 hour, except for H_2S, which must be reported as peak concentrations (i.e. of approximately one second average) and as a 99th percentile;
- air toxic pollutants are assessed at or beyond the boundary of the facility, while odorous pollutants are assessed at the nearest existing or likely future off-site sensitive receptor; and
- H_2S is assessed as a function of the population density of the affected community (see **Table 2.8-4**).

The H_2S peak concentration is specified as the peak 1-second average within that hour. For tall wake free stacks in the far field (for example at distances greater than 5km, such as outside a buffer area) and for the unstable conditions where plumes containing H_2S are brought to ground, a peak to mean factor of three is recommended. Therefore in terms of hourly averages, the equivalent 1-hour 99th percentile criteria for these conditions would range from 1.6µg/m^3 for a single residence, to 0.46µg/m^3 for an urban centre with greater than 2,000 people. For neutral and stable conditions a peak to mean ratio of 6 is recommended. For assessing peak concentrations the model predicted 1 hour concentrations have been converted using these factors dependent on the stability class at that time.

It should be noted that the NSW criteria are derived to protect the public from annoyance at sensitive receptors. Health effects occur at much higher concentrations, typically at 500 times above the odour threshold (i.e. the lowest concentration of a vapour in air which can be detected by smell) of around 1.2µg/m^3.

- **Table 2.8-3 NEPM Relevant Criteria from Victoria and New South Wales.**

Pollutant	Averaging Period	99.9th Percentile Concentration	
		(ppb)	(µg/m^3)
Benzene	1 hour	9	29
Ethyl benzene	1 hour	1,800	8,000
Toluene*	1 hour	90	360
Xylenes*	1 hour	40	190
Formaldehyde	1 hour	18	20
Acetaldehyde*	1 hour	23	42

Note: * Victorian guidelines specify limits for odour and toxicity; the most stringent criteria were used for this assessment.

- **Table 2.8-4 Impact Assessment Criteria for Hydrogen Sulphide.**

Population of affected community	Impact assessment criteria (µg/m^3)
Urban (≥2000)	1.38
~500	2.07
~125	2.76
~30	3.45
~10	4.14
Single residence (≤2)	4.83

Other

Air Quality Criteria (Vegetation)
Elevated pollutant concentrations can impact vegetation and ecosystems by affecting plant physiology, growth and vitality. The direct effects can be described by critical levels – *the concentration of pollutant in the atmosphere above which adverse effects on receptors such as plants, ecosystems or materials may occur* (WHO, 2000).

Acid deposition has been identified as an issue in areas of heavy industry. The WHO provides critical deposition loads for the assessment of nitrogen and 'acid equivalent' effects on vegetation (WHO, 2000). Critical load is an estimate of exposure in the form of deposition, below which significant harmful effects on specified sensitive elements of the environment do not occur (WHO, 2000).

Criteria for critical levels and loads have been determined for plant species and ecosystems for Europe and North America, however, no data is available for the north-west of Australia. The vegetation and soil types in the north-west of WA are very different to those on which the European studies were based. As such, for the similar Gorgon LNG project on Barrow Island in the Pilbara, the WA EPA stated that:

"There are no data available on the effects of these pollutants on the fauna and flora of Barrow Island. In the absence of such standards, the EPA considers that the limit for humans is the only available surrogate for mammals and the WHO deposition limits are the only available surrogate for vegetation" (EPA, 2009c).

Therefore, for this assessment of the likely impact on vegetation, the WHO deposition limits have been adopted. WHO (2000) reports that critical loads for acid deposition range from less than 250 to greater than 1,500eq/ha/yr (eq - acid equivalents), depending on the type of soil and ecosystem. Less than 250eq/ha/yr is stated for sands, granites and gravel base material of coarse texture (i.e. less than 18% clay content) to greater than 1500eq/ha/yr for base material from dolomite, basalt and volcanic deposits with fine soil texture (i.e. clay content greater than 35%). For the sandy soils of the Barrow Island region and as for the Dampier Peninsula, a critical load at the low end of around 200 to 500eq/ha/yr is considered appropriate. This is equivalent to a sulphur load of 4 to 8kg/ha/yr.

For nitrogen, WHO (2000) estimates that critical loads for various ecosystems range between 5 and 35kg/ha/yr of nitrogen, depending on the type of soil and ecosystem. The low critical loads of 5 to 10kg/ha/yr of nitrogen occur for the most sensitive species (e.g. arctic bogs, soft-water lakes, forests in humid climates) with an average value for natural and semi natural ecosystems of 15 to 20kg of N per hectare per year. For areas not covered by the categories, (such as the Kimberley) the WHO (2000) document offers guidance that the values should be increased for the following factors: hot climates, wet soils, no frosts and high base cation availability. For this study critical loads toward the middle to high end would be expected and the average value for natural and semi natural ecosystems of 15 to 20kg/ha/yr of nitrogen is considered appropriate.

2.8.1.2. Description of Factor

Existing Meteorological Conditions
Local and regional air quality dispersion conditions have been assessed using meteorological data from sites in the vicinity of James Price Point and in similar coastal environments where the meteorological conditions are expected to reflect those at James Price Point (see **Part 4**, **Section 1** (Environmental Overview)). Within the region, reliable meteorological data are available from the Bureau of Meteorology (**BoM**) station at Broome Airport and the Department of State Development sites at Gourdon Bay (approximately 111km from James Price Point), Lacepede Island (approximately 67km from James Price Point) and North Head. An instrumented tower has recently been installed to provide specific meteorological data for the James Price Point coastal area. The recorded data will be incorporated into future reporting. Seasonal wind roses derived from measurements at Broome airport are presented in **Figure 2.8-1**.

The Kimberley region has a tropical monsoon climate with two dominant seasons separated by short transitional periods. The two seasons correspond to the occurrence of two major atmospheric pressure systems: a subtropical ridge of high pressure cells (highs or anticyclones), and a broad tropical low pressure region called the monsoon trough (BoM, 2010a and BoM, 2010b). Hot and humid conditions characterise a 'tropical summer' season that extends from November to April. During this period low pressure systems and unstable air dominate the weather pattern with the region receiving about 90% of its annual rainfall. From May to October the Kimberley comes under the influence of high pressure systems and predominantly south easterly airflows from the continents interior.

Tropical cyclones can be experienced in the Kimberley region from November to April, although typically most common during January and March, bringing heavy rainfall, high seas and very strong winds.

Over 75% of the average annual rainfall in the Kimberley region falls between January and March and this rainfall is associated with thunderstorms and tropical cyclones (BoM, 2010a). Rainfall is however highly variable. Very little rainfall occurs during the dry season months from May to October, with the median rainfall for July to October being zero (BoM, 2010a).

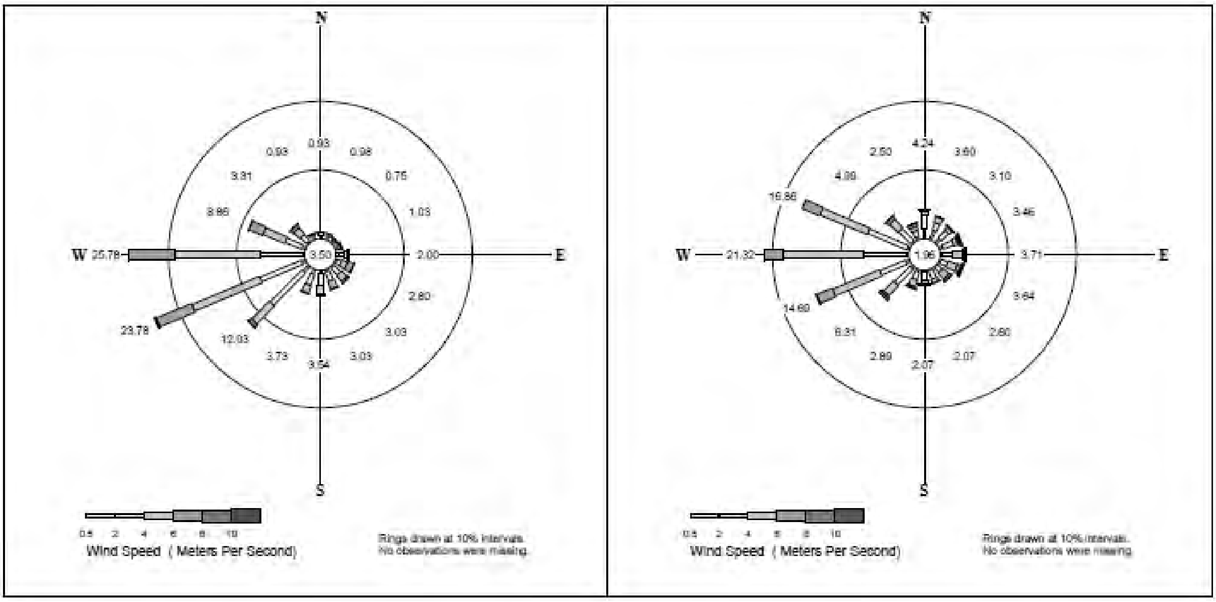
The mean maximum monthly temperature fluctuates between 29°C in July and 40°C in November. The mean minimum monthly temperature ranges between 14°C in July and 26°C in December. There is a larger temperature variation over the dry season than in the wet season.

Relative humidity is higher during the wet season than in the dry season, mirroring rainfall patterns, generally ranging from 85% in the wet season to 45% in the dry season as measured at Broome (approximately 53km from James Price Point). Humidity is generally higher in the morning than the afternoon due to the cooler morning air being more readily saturated with moisture.

In regard to wind conditions, the overall pattern for the year is dominated by westerlies (blowing approximately 20% of the year at speeds typically between 3.5 and 8.8m/s). During the wet season, almost all winds are westerlies and in the dry season an east-south-easterly breeze prevails. There is very little wind from the north or south in the region.

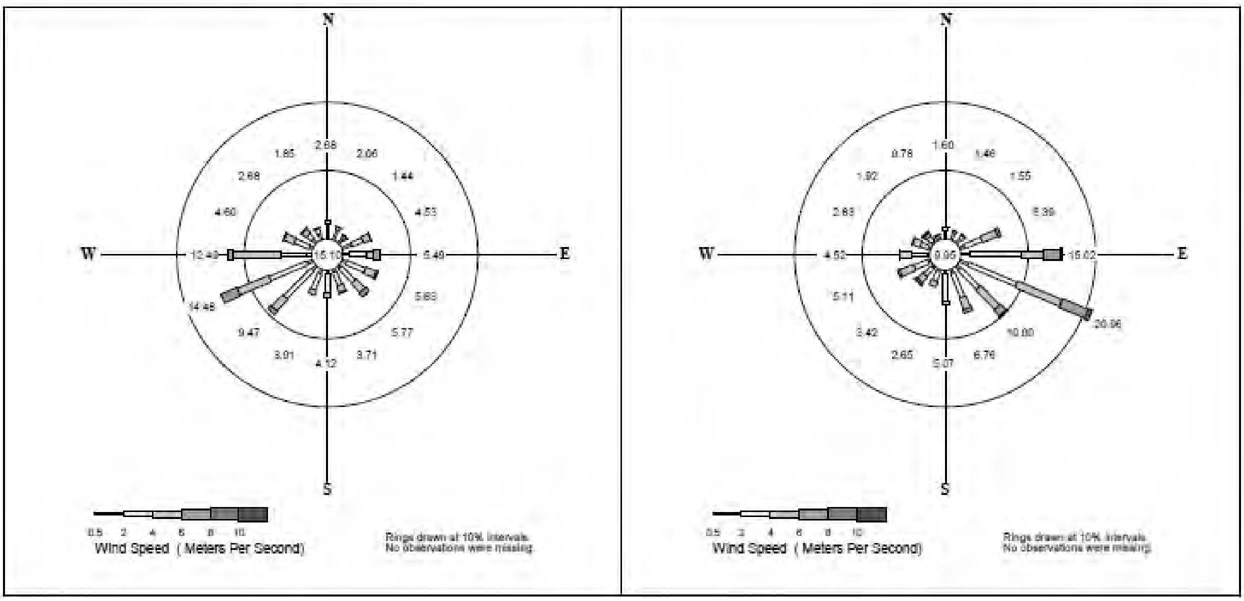
The existing meteorological conditions would have the following air quality implications for the operation of the BLNG Precinct:

- air quality impacts would be greatest to the east of the BLNG Precinct due to the dominant westerly winds;
- sea breeze fumigation would combine with the consistent, steady westerly winds to result in greater air quality impacts to the east of the BLNG Precinct; and
- air quality impacts on areas to the south of the BLNG Precinct (for example, Broome) would be least due to the low frequency of northerly winds.



Transitional Months (April and August)

Early Dry Season (May to July)



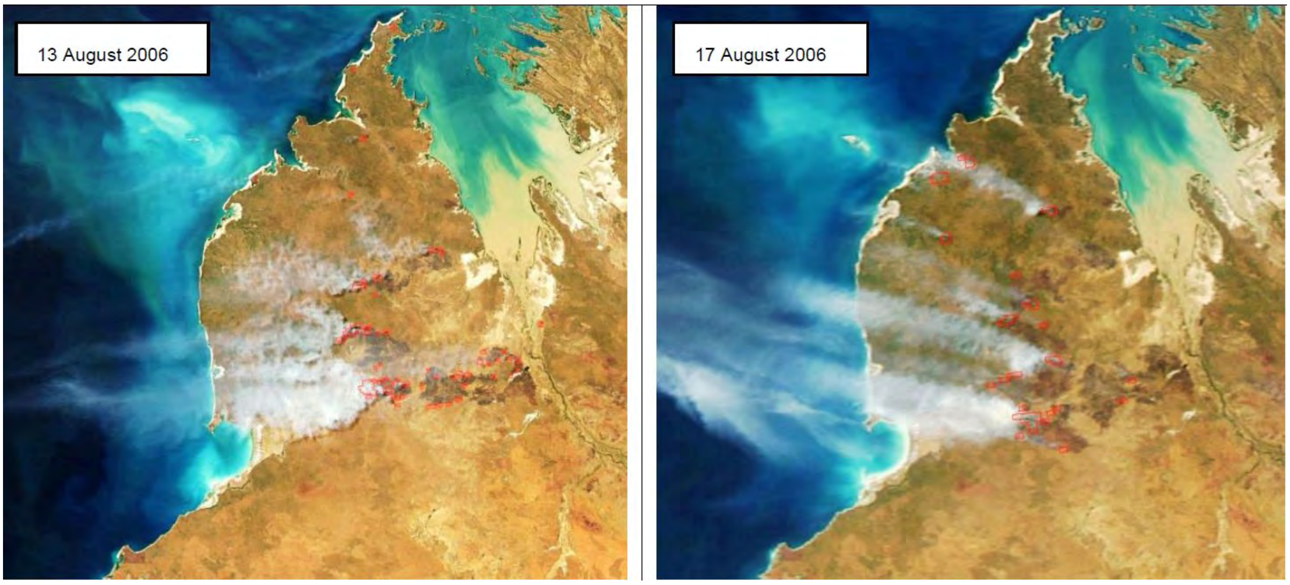
- **Figure 2.8-1 Observed Seasonal Wind Roses at Broome Airport.**

Note: Data from 1 October 2008 to 30 September 2009.

Existing Local and Regional Air Quality

A combination of bushfires, dust storms and remote industrial activities are currently the major causes of reduced air quality in the Kimberley. The most significant existing source is bushfires, which contribute to seasonal smoke haze conditions across the Kimberley region. The EPA recognises that smoke haze is persistent during the dry season, raising the potential for increased asthma symptoms (EPA, 2006a). Satellite imagery showing the geographical extent of smoke from seasonal fires is presented in **Figure 2.8-2** Burning (including wildfires) produced the largest proportion of pollutants in the Broome area in 2007-08 with an estimated 28.2% contribution to the total reported emissions of National Pollutant Inventory (**NPI**) substances. Pollutants emitted as a result of bushfires in the region consist of oxides of nitrogen (**NOX**), volatile organic compounds (**VOCs**), carbon monoxide (**CO**), particulate matter as PM_{10} and benzene, toluene, ethylbenzene and xylenes (**BTEX**). Besides fires contributing to high particulate, there is occasional dust from distant dust storms that can create high dust/haze levels in the region.

There are no major man-made atmospheric emission sources in the vicinity of James Price Point coastal area. Broome with the power station, fuel depots and motor vehicle use, is the main source of atmospheric emissions in the region. Potential emissions include NOX, VOCs, CO, particulate matter and BTEX, as well as SO_2 and polycyclic aromatic hydrocarbons (**PAHs**). A review of the National Pollutant Inventory database for the 2007-08 reporting year shows the nearest facilities reporting to NPI are located in Broome, approximately 53km south of James Price Point coastal area, and in Derby, approximately 167km to the east. Industrial activities in these areas include electricity generation, iron ore mining, quarrying, and other non-metalliferous mining activities.



Source: Extract from Air Assessment, 2010; **Appendix C-25**.

- **Figure 2.8-2 MODIS Satellite Images of the Dampier Peninsula in August 2006 showing Smoke from Fires and Development of Fire Scars.**

Note: Fire scars are dark land areas. Red shapes are the estimated fire scar for the last 24 hours.

To date, there has been little monitoring of air pollutants in the Kimberley region. The remoteness of the location has generally dictated that the few studies that have been undertaken have used monitoring methods that do not enable direct comparison to the short-term air quality standards of most interest for human health and amenity. Taking into account all available information, including on-site measurements, measurements from other locations in the region and modelling undertaken for this assessment, indicates that:

- The pollutant of most concern is particulate matter ($PM_{2.5}$ and PM_{10}) which is associated with smoke during the fire season from September to November and can generate levels likely to be abov e the Ambient Air Quality NEPM standards. Similarly, the standard can potentially be exceeded during dust storms, principally over the months from June to August.
- Ozone is the pollutant of next most concern, with smoke plumes from fires leading to ground-level concentrations at or just below the 4-hour NEPM standard.

- NO_2 is also generated from fires, however maximum concentrations are around 50 to 67% of the NEPM standard.
- Ambient concentrations of other pollutants such as CO and BTEX are well below relevant criteria.

In summary, the existing state of knowledge of local and regional air quality is that:

- Fires, which have the potential to generate high concentrations of air-borne particulate matter and ozone, are the dominant source of pollutants in the region. The high levels are due to the very large area of land burned, and the potential for pollutants to accumulate as the fires burn for several days.
- Although there are industrial and other development activities in the Kimberley region, there are no major anthropogenic emission sources in the Precinct area or generally within the Dampier Peninsula.
- Current information indicates that for the pollutants of most concern at a regional level (particulates, ozone and NO_2), concentrations may occasionally approach or exceed ambient air NEPM standards.

2.8.2. Identification of Key Aspects

2.8.2.1. Definition of Relevant Aspects

Aspects associated with the construction and operation of the BLNG Precinct and associated infrastructure which have the potential to affect air quality were identified in the Scope of the Strategic Assessment and considered in the assessment. These aspects include:

- particulate (dust) emissions;
- gaseous (atmospheric) emissions; and
- altered fire regimes.

2.8.2.2. Sources of Potential Impact

The sources of potential impact on air quality are summarised under the aspect from which they were derived, as relevant to construction and operation phase emissions.

These emissions have the potential to reduce ambient air quality adjacent to the industrial precinct which could affect human health or amenity values. Atmospheric emissions during the construction and operational phases of the BLNG Precinct have the potential to adversely impact on the surrounding environment.

With the exception of the proposed BLNG workers' accommodation facilities, there are no permanent residential receptors within 30km of the James Price Point coastal area, however the coastal area is used for recreational, tourism and traditional owner purposes.

Construction Phase Emissions

Particulate Emissions
The following sources of potential impact have been identified from particulate emissions during construction:

- clearing and excavation as well as vehicle movements would generate dust which at high concentrations, has the potential to reduce local amenity (nuisance effects), be deposited on nearby vegetation or cause human health effects.
- altered fire regime resulting from the introduction of new ignition sources due to activities and infrastructure in the Precinct has the potential to affect the emission of particulate matter and therefore have an impact on ambient air quality.

Dust emissions are likely to be the dominant concern during the construction phase of facilities within the BLNG Precinct. Specifically, these emissions will be generated from activities such as vegetation clearing and earthworks, traffic movements on unsealed roads, trenching, loading and dumping of material, concrete batching and wind action over cleared areas.

Gaseous Emissions
The following sources of potential impact have been identified from gaseous emissions during construction:

- Construction of infrastructure – fuel combustion emissions from vehicles and equipment used in construction and transportation activities.

Emissions from fuel combustion from vehicles and equipment during construction would largely be diesel engine based and depend on the grade and composition of the fuel and the status of equipment maintenance. Fuel combustion emissions of concern include:

- CO;
- NO_X;
- organic compounds such as VOCs and PAHs; and
- heavy metals.

Typically, emissions from construction activities are not quantitatively predicted due to the variability and transient nature of the sources involved.

Operational Emissions
Gaseous emissions from the following sources are likely to occur during operation:

- The combustion of fuel gas for energy generation and flaring, and fugitive emissions associated with the LNG processing facilities.
- Altered fire regime resulting from the introduction of new ignition sources due to activities and infrastructure in the Precinct during ongoing operation and maintenance has the potential to affect the emission of CO, NO_X and VOCs and therefore have an impact on ambient air quality.

A summary of primary emission sources is provided below, with a more comprehensive overview of sources and assumed configurations outlined in the air quality study report (Air Assessments, 2010; **Appendix C-25**).

Primary sources of atmospheric emissions during operation of the BLNG Precinct include:

- Electrical power generation (to provide electricity; and power refrigerant compressors) via gas turbines. Emissions of pollutants from gas turbines fired with low sulphur gas are primarily NO_X, with smaller amounts of CO, VOC and SO_2.
- Atmospheric emissions under normal operation from a LNG train consists of the combustion products from the gas turbine refrigerant compressors with emissions of concern primarily being NO_X and to a lesser extent CO, PM and VOCs. Traditionally, gas turbines have been open cycle, however newer technologies utilise waste heat recovery on the hot exhaust gas to improve the efficiency of the LNG plant. Additionally, the Acid Gas Removal Unit (**AGRU**) removes CO_2 from the raw gas stream, which is typically vented.
- Flaring of pressurised hydrocarbons (gas) for which four flares are generally used. These are the wet and dry gas flares for emergency releases, the operational/startup flare and the marine flare. For the BLNG Precinct, stack flares will be designed in accordance with safety requirements to minimise radiant heat at the surface. Smokeless flares will be installed resulting in near zero particulate emissions.
- Fugitive emissions from connections and valves, and LNG and condensate storage tanks. Emissions from the tanks are expected to be minimal because the proposed tanks are fully enclosed or will have a floating roof with no headspace. Current practice is to use dry seals on connections to minimise VOC release.
- The loading of condensate ships which has the potential to release VOCs.

Emissions from shipping and tug boat operations due to fuel combustion would largely depend upon the number and duration of vessel movements.

The atmospheric emissions generated by these activities are as follows:

- NOX (including NO_2 and NO);
- SO_2;
- VOCs (such as BTEX);
- Formaldehyde;
- Acetaldehyde;
- PAHs;
- particulate matter (PM_{10} and $PM_{2.5}$);
- ozone (O_3, as a secondary pollutant); and
- greenhouse gases such as CO_2, CH_4 and NO_2 (discussed in **Part 4**, **Section 2.9**).

Routine Operations

Emissions from the BLNG Precinct will depend on the operating conditions, including normal or routine plant operations, non-routine operations such as commissioning and plant start-up, shut-down and upset conditions. The proposed gas processing facility at James Price Point coastal area will initially comprise of 2 or 3 trains with a nominal capacity of 15Mtpa of LNG, expanding to a potential 50Mtpa as more trains are added.

Four different LNG liquefaction technology configurations have been considered for the air quality impact assessment for BLNG Precinct. These include:

- large industrial gas turbines (**LIGT**);
- medium industrial gas turbines (**MIGT**);
- integrated steam **(IS**); and
- aero-derivative gas turbines (**AGT**).

In terms of emissions of key pollutants per tonne of LNG there are differences of up to 20% between the configurations. All gas turbines and boilers were assumed to have low NO_X burners for each of the four plant types. The summary emissions from these LNG technology scenarios are detailed in the air quality assessment report (Air Assessments, 2010; **Appendix C-25**).

Sensitivity analyses demonstrated little variation between different technology cases for the predicted maximum levels. As such, the cumulative modelling scenarios presented are representative of likely impacts from anticipated emissions from operational LNG facilities within the BLNG Precinct, regardless of selected technology.

Non-routine Operating Conditions

Non-routine plant operations include start-up, shutdown and emergency or upset events. Plant de-inventory may also occur during an emergency event. Non-routine operations would be of several days duration, with the LNG processing facilities operating under minimal conditions (approximately 15 to 50% reduced throughput depending on start up/shut down procedures). During non-routine (upset) conditions flaring of gas is anticipated to contribute significant atmospheric emissions of short duration.

During commissioning, gas will be flared at high rates over prolonged periods while equipment is being tested. Gas used for testing and conditioning of equipment will be disposed of via the emergency flare. Initially, atmospheric emissions from flaring will be significant; however as the process continues the systems will approach normal operating conditions and as LNG is produced, flaring will reduce to standard operational levels.

Flaring under upset condition scenarios has the potential to be a more significant air emissions source than the gas turbines. For example, all the gas turbines could be deactivated while the flares are operating to full capacity.

In the air quality assessment, three scenarios were modelled as representative worst case non-routine events:

- Start-up: includes ramping up and achieving steady state conditions for each unit in succession.
- Emergency flaring: is associated with safe-guarding the facility by allowing the controlled destruction of hydrocarbons to prevent the over-pressure of processing vessels or pipework. The worst credible case flaring emissions scenario assumed for the study results from a blocked propane compressor outlet, leading to emergency flaring.
- Turn-down: may occur if gas supplies are likely to be low for a number of days and instead of shutting down the LNG train, the production of one or more trains is reduced to minimise the gas usage, with the intent of averting a shutdown and later start-up.

Also modelled in non-routine operating conditions is the removal of two thermal combustion units (**TCU**). TCUs have been included in air quality modelling for each LNG train as a conservative approach to manage emissions of BTEX and H_2S in the AGRU waste gas stream. The non-routine emissions from specified plant layouts, and the assumed scenarios, are provided in the air quality assessment report (Air Assessments, 2010; **Appendix C-25**).

Emissions during Decommissioning

Atmospheric emissions are likely to result from the purging and flushing of hydrocarbons from equipment and facilities over a relatively short period of time during decommissioning of the BLNG Precinct.

Other Regional Sources

Besides the proposed LNG precinct other significant existing sources of atmospheric emissions in the area include:

- Emissions from bushfires;
- Emissions from vegetation (terpenes etc) and soils (NO_X);
- Existing industrial sources within the area. These are generally listed in the National Pollutant Inventory (**NPI**). See www.npi.gov.au;
- Emissions from combustion from vehicles, aircraft and shipping;
- Emissions from domestic activities (cooking, lawn-mowing, painting etc); and
- Emissions from small commercial facilities such as from service stations, dry cleaning, evaporative losses from tanks.

These sources were estimated, drawing on publicly available data, with the exception of fires where a methodology based on fuel loadings and area burned on a daily basis was used. The derivation of emissions of other regional sources is described in detail in the air quality report (**Appendix C-25**).

2.8.2.3. Sensitivity and Resilience

Ambient air quality standards and guidelines are derived by taking into account population exposure and the possible human health and amenity effects relevant to the pollutants of concern. For example, in developing the standards for the Ambient Air Quality NEPM, reviews of the existing information on the health effects of the pollutants were undertaken to inform recommendations on the range of potential standards for each pollutant that would protect susceptible groups within the population.

For reference, the common sources and effects of the principal air pollutants discussed in this study are included in the air quality report (Air Assessments, 2010; **Appendix C-25;** Chapter 4).

2.8.3. Predicted Impacts

The following sub-section provides an assessment of potential impacts on air quality from particulate and gaseous emissions (with particular focus on operational emissions as the predominant source) and altered fire regimes.

The contribution of seasonal fires to local and regional air quality is well established, as outlined in the previous sections. The introduction of new ignition sources from activities and infrastructure in the BLNG Precinct has the potential to alter the existing fire regime and therefore have an impact on ambient air quality. Conversely, improved control of fires as a

result of the BLNG Precinct operational requirements may result in the reduced incidence of large-scale regional fires, which may provide air quality benefits.

Altered fire regime, as a key aspect of relevance to terrestrial ecological integrity, is considered in more detail in **Part 4**, **Section 2.7**. The contribution of existing fires, as relevant to the impact on air quality, was factored into the air quality assessment, and is implicitly addressed in the following sections.

2.8.3.1. Potential Impacts to Air Quality Due to Particulate (Dust) Emissions

Dust emissions from construction activities could cause short duration nuisance for construction staff, off-site visible amenity issues and carriage of dust onto nearby vegetation and into ephemeral drainage lines. Dust generation is likely to be more pronounced during construction rather than during the BLNG Precinct's operational phase. Intermittent dust emissions are likely to occur under certain meteorological conditions, however these are likely to be restricted to the BLNG Precinct construction site. Such intermittent fugitive dust sources will be expected largely during construction activities, but could occur during operations as a result of vehicle traffic movements on unsealed roads or any exposed stockpiles.

If unmanaged, fugitive dust emissions have the potential to result in a reduction of local air quality, with a consequent impact on human health, amenity (visual or nuisance) values or reduced condition or stress of surrounding vegetation in the vicinity of the development area.

Dust emissions will be controlled through the application of standard measures to minimise off-site effects, which will be defined in construction environment management plans for the works in accordance with standard industry practice. The application of land use buffer zones surrounding the LNG Precinct will ensure appropriate separation distances from other land users. A more detailed description of proposed mitigation measures is presented in **Section 2.8.4**. The significance of the residual impact of dust on air quality is assessed as very low as there are many effective mitigation measures which will be applied and it is a localised impact.

2.8.3.2. Potential Impacts to Air Quality Due to Gaseous Emissions

The proposed BLNG Precinct, particularly at an upper development scenario of 50Mtpa LNG capacity, would contribute to atmospheric emissions in the vicinity of James Price Point coastal area, with potential consequential impacts on human health and amenity values if high off-site concentrations at sensitive receptors are experienced. As discussed above, the most significant background atmospheric emission sources in the region are bushfires. Pollutants emitted as a result of bushfires in the region consist of NO_x, VOCs (including BTEX), CO, and PM_{10}. The potential impacts of atmospheric emissions from the BLNG Precinct on local and regional air quality, in isolation and including background sources, have been assessed using The Air Pollution Model (**TAPM**), which is a prognostic meteorological and air dispersion pollution model developed by the CSIRO, with reference to WA DEC modelling guidelines.

The assessment of impacts was undertaken using two models, TAPM for the local area (up to 14 to 18km from the sources) and TAPM-CTM (Chemical Transport Model) for regional impacts including photochemistry for an area up to several hundred kilometres from the BLNG Precinct. As the BLNG Precinct may consist of various types of LNG plants, four different representative LNG technologies were modelled to assess the variability in the predicted concentrations.

TAPM and TAPM-CTM have been verified in numerous sites around the world, and in particular TAPM has been validated for a range of studies in Australia including northwest WA. To gauge the suitability of the models for this study, both models were validated where possible against observations, discussed further in the following section. The validation provides confidence that overall the modelling system (meteorology, emissions and chemistry) is providing reasonable predicted concentrations.

Ground-level concentrations of the emissions of concern were predicted for key operating and LNG development scenarios to obtain a quantitative assessment of potential off-site air quality issues. A summary of the key conclusions is provided in the following sections, with reference to the air quality assessment report in **Appendix C-25** (Air Assessments, 2010) for a full detailed analysis.

These results are considered preliminary to inform the Strategic Assessment, and will likely be subject to further refinement and update as further engineering details are progressed for individual facilities within the proposed Precinct.

Modelling Approach

Ground-level concentrations of the pollutants identified in **Section 2.8.2** for key operating and LNG development scenarios were predicted. See the air quality assessment report in **Appendix C-25** (Air Assessments, 2010) for a further discussion on model selection and inputs (meteorology, terrain, emissions data, locations of sensitive receptors, background concentrations).

The air quality study undertaken to inform this Strategic Assessment was completed with reference to the DEC Air Quality and Air Pollution Modelling Guidance Notes, and was reviewed by the DEC Air Quality Branch.

Sensitive Receptors

Eight sensitive receptors were identified as being relevant for the dispersion modelling, these being Broome, Coconut Wells (approximately 37km from James Price Point), Country Downs station, Kilto station, Beagle Bay settlement (approximately 81km from James Price Point), 12 Mile, Willie Creek Pearl Farm and the likely location for the BLNG workers accommodation facilities (**Figure 2.8-3**).

Model Verification

The suitability of using TAPM and TAPM-CTM to predict concentrations in the area was verified in two stages. Initially, the meteorological parameters predicted by TAPM were verified by comparing model predictions against available meteorological observations. The second stage was to verify the predicted concentrations from TAPM-CTM against monitored O_3 and NO_2 data to confirm that the combination of meteorology, emissions estimates, dispersion and chemical reactions is realistic.

Good agreement was demonstrated between the observed and predicted wind directions at Broome Airport and Lacepede Island, with TAPM also reproducing the wind variation between sites with more westerly winds at Broome and more south westerly winds at Lacepede Island. The wind speeds at both sites were however not well predicted with TAPM generally predicting lighter winds.

As discussed in **Section 2.8.1**, limited ambient air monitoring data is available for the region. Verification was therefore undertaken using a comparison of data collected for the Karratha-Dampier area in the Pilbara region, 650km to the south-west of the James Price Point coastal area. An area with a similar fire regime to Broome was selected due to the significant contribution bushfires make to background pollutant concentrations. Although the model and observations are for different years (because complete monitoring data was limited to 1999) and there was difficulty in removing industry impacts, the model concentrations were within 10% for O_3, over-predicting slightly for CO, and under-predicting by a factor of 2 for NO_2. The under prediction of NO_2 may be due to local sources contributing more to concentrations as these are more difficult to remove from the data base. These comparisons therefore provide some confidence that the overall modelling approach, including meteorology, emissions and chemistry, is providing reasonable estimates of pollutant concentrations.

■ **Figure 2.8-3 Locations of Sensitive Receptors included in the Air Quality Assessment.**

Background Concentrations

Available measurements at the site, measurements from nearby regions and dispersion modelling have been used to estimate background pollutant concentrations. Fire emission data and meteorology for the year 2006 which was considered to be an extreme fire year in the region, was used within the model. Existing sources that have been included in the modelling include those from:

- the town of Broome including, vehicles, Broome power station and other small sources;
- biogenic emissions from vegetation and soils; and
- emissions from fires.

Most regional smog assessments neglect the contribution from fires, therefore, the total cumulative impact from all sources is not modelled. This approach is acceptable if the contribution from fires is small. However, for the Kimberley region where fires are the greatest cause of high air pollution events, it is considered that the contribution from fires should be included to adequately determine both existing and cumulative concentrations (Air Assessments, 2010; **Appendix C-25**).

The maximum existing pollutant concentrations predicted by the modelling are summarised in **Table 2.8-5**, and the background concentrations of pollutants (not modelled) derived from available measurements are provided in **Table 2.8-6**.

- **Table 2.8-5 Maximum Existing Concentrations of Pollutants Predicted by the Modelling.**

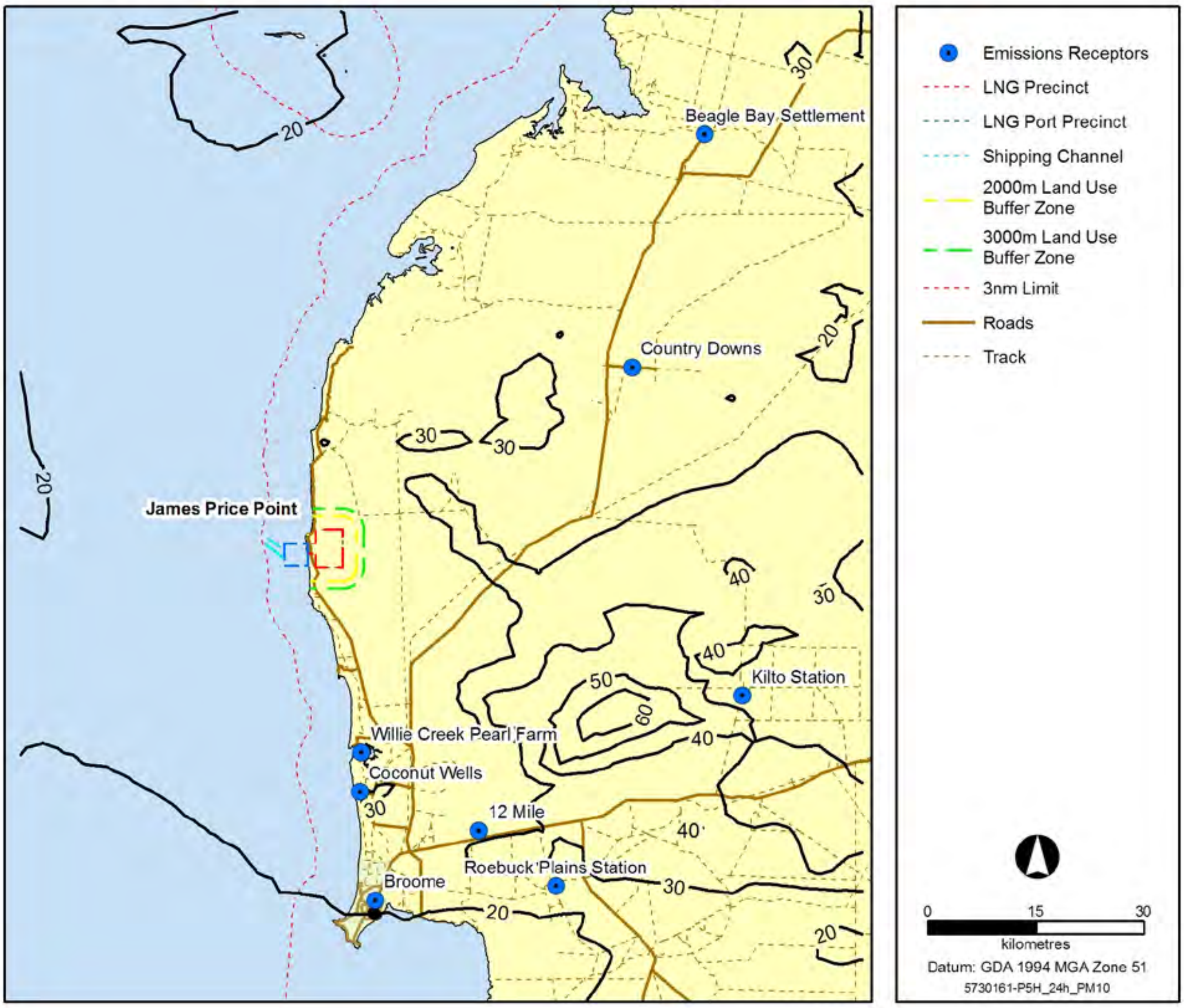
Pollutant	Averaging Period	Maximum Concentration Statistic	Criteria (ppb)	Goal	Maximum Predicted Concentration at Receptor (ppb)	Percent of Criteria	Receptor
NO_2	1-hour 1-hour Annual	Max 3rd Ave	120 30	1 day per year None	73 36 4.4	61 - 15	12 Mile 12 Mile Broome
O_3	1-hour 4-hour	Max Max	100 80	1 day per year 1 day per year	78 74	78 92	BLNG BLNG
CO	8-hour	Max	9,000	1 day per year	1,520	17	Kilto
Formaldehyde	1-hour	99.9th percentile	18	99.9 percentile	6.0	33	Kilto Kilto
Acetaldehyde	1-hour	99.9th percentile	23	99.9 percentile	4.8	21	Beagle Bay
			(μg/m^3)		**(μg/m^3)**		
PM_{10}	24-hour 24-hour	Max 5th	- 50	Maximum 5th highest	86 38	- 76	Kilto Kilto
$PM_{2.5}$	24-hour 24-hour Annual	Max 5th Ave	25 - 8	Maximum 5th highest Average	75 33 3.6	- - -	Kilto

- **Table 2.8-6 Existing Concentrations of Pollutants Derived from Available Measurements.**

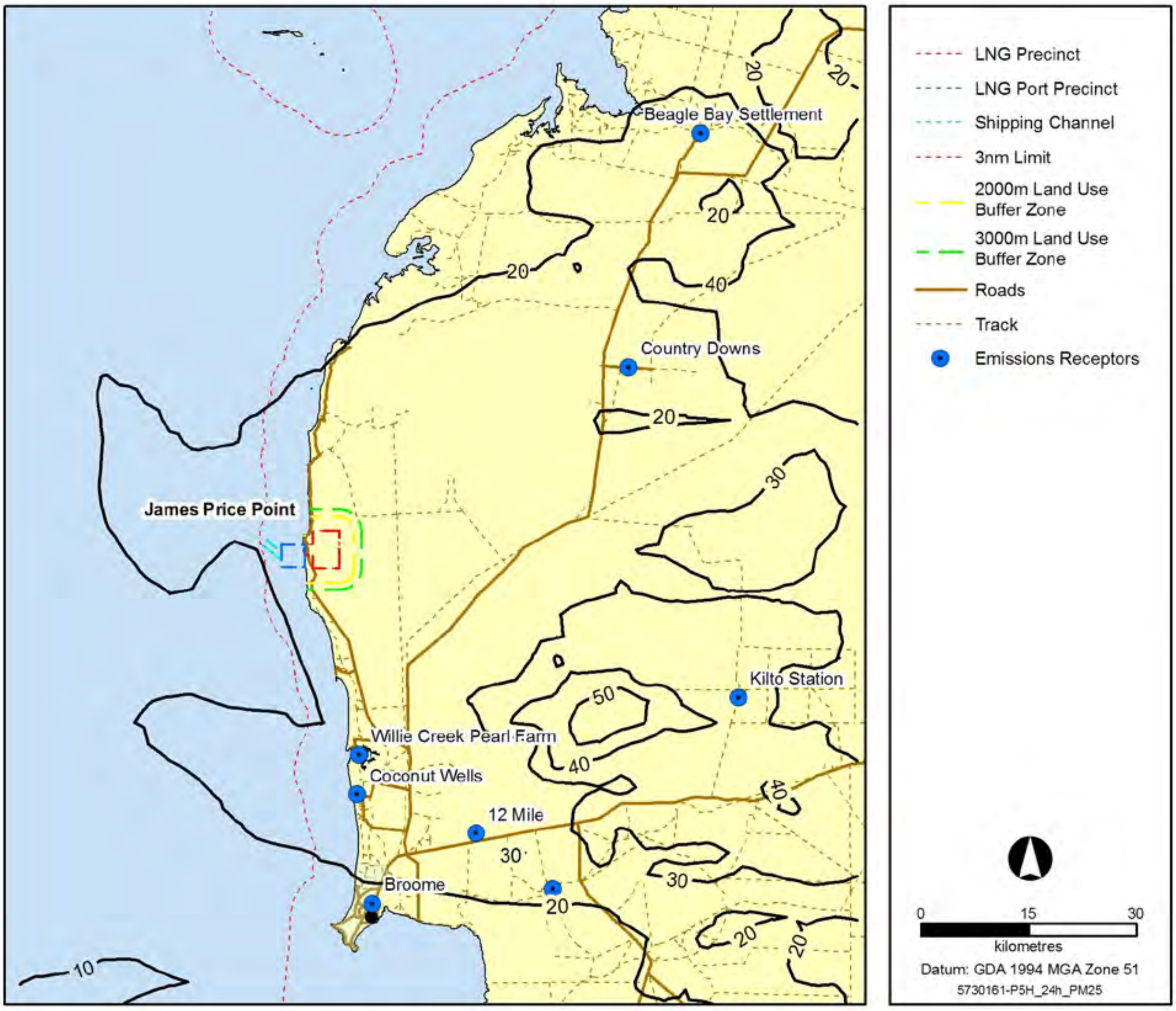
Pollutant	Averaging Period	Criteria (ppb)	Goal	Measured Concentration (ppb)	Percent of Criteria	Reference
SO_2	1-hour 24-hour Annual	200 80 20	1 day per year 1 day per year None	Negligible Negligible Negligible	Negligible Negligible Negligible	Dampier measurements
Benzene	Annual	3	Advisory reporting standard *	0.02	0.7	Dampier measurements
Toluene	24-hour Annual	1,000 100	Advisory reporting standard *	Low 0.03	Low 0.03	- Dampier measurements
Xylenes	24-hour Annual	250 200	Advisory reporting standard *	0.015 -	0.06 -	Dampier measurements

Note: * The Air Toxics NEPM specifies advisory reporting standards as monitoring investigation levels. The levels are not compliance standards but provide guidelines in order to assess the significance of the monitored levels of air toxics with respect to protection of human health. The levels are intended to gather data and not for application in modelling or other air quality assessments.

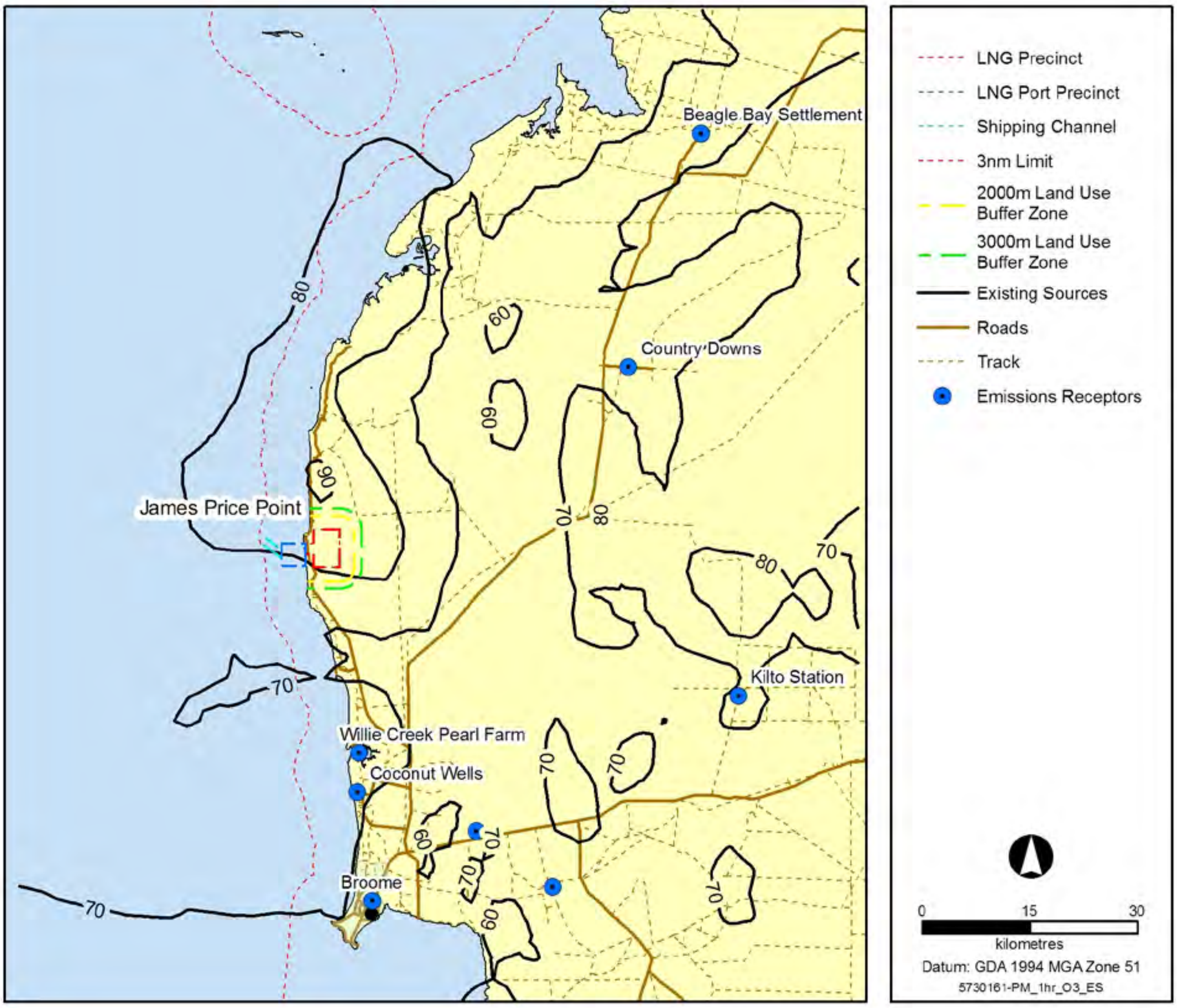
As shown in **Table 2.8-5**, the predicted existing concentrations of particulate matter (PM_{10} and $PM_{2.5}$), O_3 and NO_2 in the regional airshed are above or close to the relevant ambient air criteria. **Figure 2.8-4**, **Figure 2.8-5**, **Figure 2.8-6** and **Figure 2.8-7** display the contour plots of predicted ground level concentrations from existing sources for these pollutants. Contour plots for the remaining pollutants modelled are provided in the air quality assessment report in **Appendix C-25** (Air Assessments, 2010).



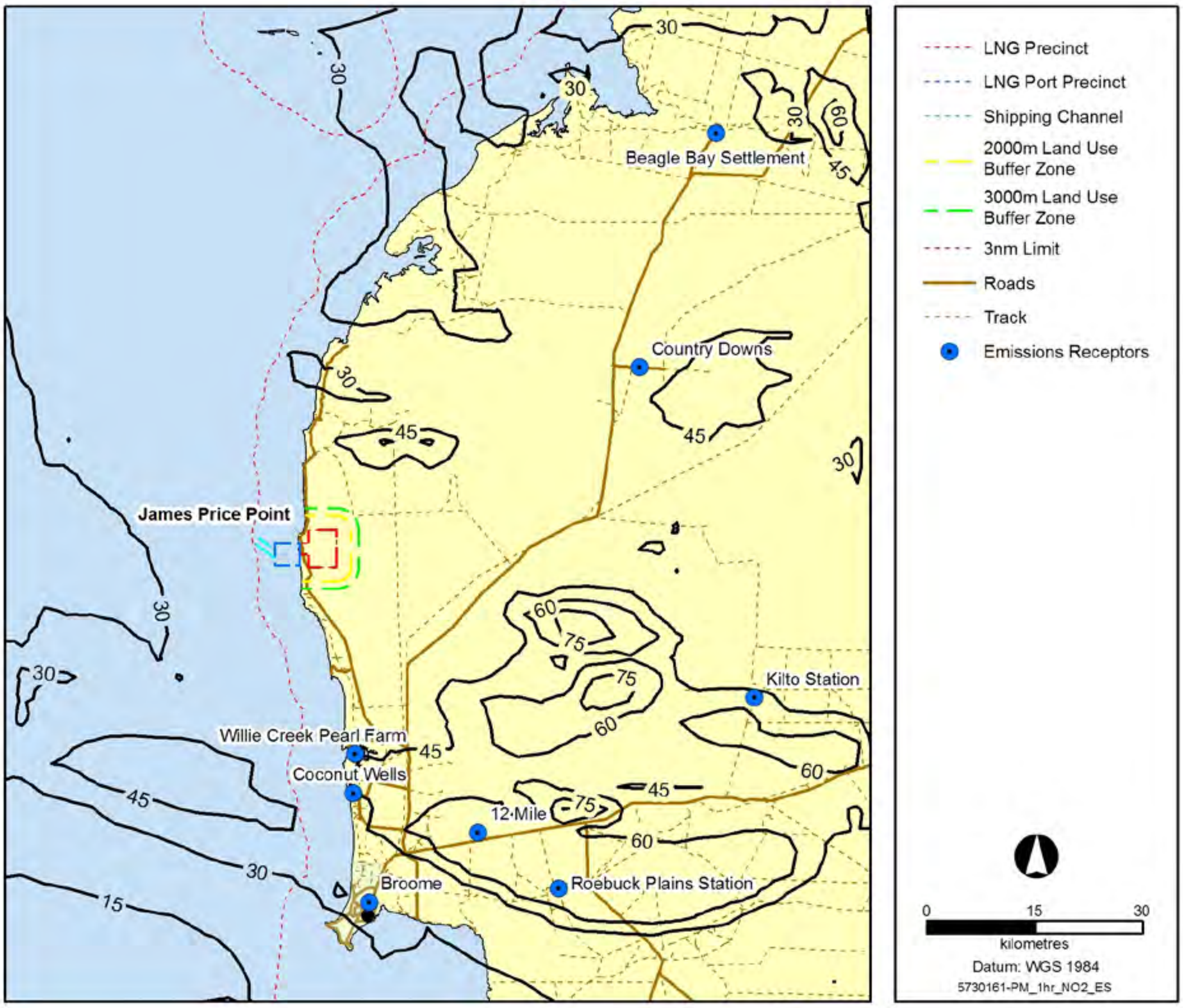
- **Figure 2.8-4 Predicted 5th Highest 24-hour Average PM_{10} Concentrations (µg/m3) for Existing Sources, 2006.**



- **Figure 2.8-5 Predicted 5 th Highest 24 -hour Av erage P $M_{2.5}$ Concentrations (μg/m3) fo r Ex isting So urces, 2006.**



- **Figure 2.8-6 Predicted Maximum 1-hour Average O_3 Concentrations (ppb) for Existing Sources, 2006.**



- **Figure 2.8-7 Predicted Maximum 1-hour Average NO_2 Concentrations (ppb) for Existing Sources, 2006.**

2.8.3.3. Regional Air Quality Modelling Assessment

Modelling was undertaken to assess potential air quality impacts at both a regional and local level. Key results are presented in the following sections.

Predicted Cumulative Regional Concentrations

This section provides an assessment of the potential impacts on sensitive receptors and the surrounding regional environment from the proposed BLNG Precinct operating under a representative LNG case (**LIGT**) at 50Mtpa capacity (**Table 2.8-7**and **Table 2.8-8**). It includes a comparison of predicted regional concentrations for O_3, NO_2, CO, formaldehyde, acetaldehyde and particulate matter with the criteria outlined in **Section 2.8.1**. Predicted concentrations from existing sources (fires and Broome sources) with the addition of a 50Mtpa BLNG LIGT precinct (in normal operation) are presented to inform a cumulative assessment.

Contour plots showing the regional impacts with predicted ground level concentrations of particulate matter, O_3 and NO_2 excluding (from the BLNG Precinct alone) and including background (cumulative) for the LIGT 50Mtpa scenario are displayed in **Figure 2.8-8**, **Figure 2.8-9**, **Figure 2.8-10**, **Figure 2.8-11**, **Figure 2.8-12** and **Figure 2.8-13**. Contour plots for the remaining pollutants modelled are provided in the air quality assessment report in **Appendix C-25** (Air Assessments, 2010).

The contour plot results indicate there would minimal changes to the various concentration statistics used for the air quality criteria. Maximum concentrations increase by no more than 1% for any of the criteria, and in some cases there is even a decrease, as for ozone and CO.

The Air Quality Assessment report (Air Assessments, 2010; **Appendix C-25**) presents the results of a sensitivity analysis of the 32 possible combinations of LNG plant scenarios: four 15Mtpa and four 50Mtpa cases along with the four modes of operations (normal operation and three non-routine operations).

- **Table 2.8-7 TAPM-CTM Predicted Cumulative Regional Concentrations from the BLNG Precinct under Normal Operation Including Background.**

Pollutant	Averaging Period	Concentration Statistic	Criteria	Max at Sensitive receptor	Receptor	Percent of Criteria	Max predicted Anywhere
CO	8-hour	Max	9,000ppm	1,500 (0)	Kilto	17	2,448 (4)
NO_2	1-hour	Max	120ppb	73 (0)	12 Mile	61	89 (-2)
	1-hour	3rd	-	36 (0)	12 Mile	-	54 (7)
	1-year	Ave	30ppb	4.5 (0.07)	Broome	15	4.5 (0.07)
O_3	1-hour	Max	100ppb	82 (4)	BLNG	82	92 (1)
	4-hours	Max	80ppb	79 (5)	BLNG	99	90 (1)
PM_{10}	1-day	Max	-	88 (2)	Kilto	-	158 (3)
		5th	50μg/m^3	40 (2)	Kilto	80	69 (2)
$PM_{2.5}$	1-day	Max	25μg/m^3	77 (2)	Kilto	-	134 (3)
	1-day	5th		35 (2)	Kilto	-	61 (2)
	1-year	Ave	8μg/m^3	3.6 (0.2)	Kilto	45	4.0 (0.2)
Formaldehyde	1-hour	99.9	18ppb	6.1 (0.1)	Kilto	34	8.4 (-0.05)
Acetaldehyde	1-hour	99.9	23ppb	5.0 (0.2)	Kilto	17	6.6 (-0.1)

Notes: 1) Values in brackets represent the Precinct addition to the existing levels.
2) Modelled sensitive receptors include Broome, Coconut Wells, Country Downs station, Kilto station, Beagle Bay settlement, 12 Mile and the likely BLNG workers accommodation facilities.

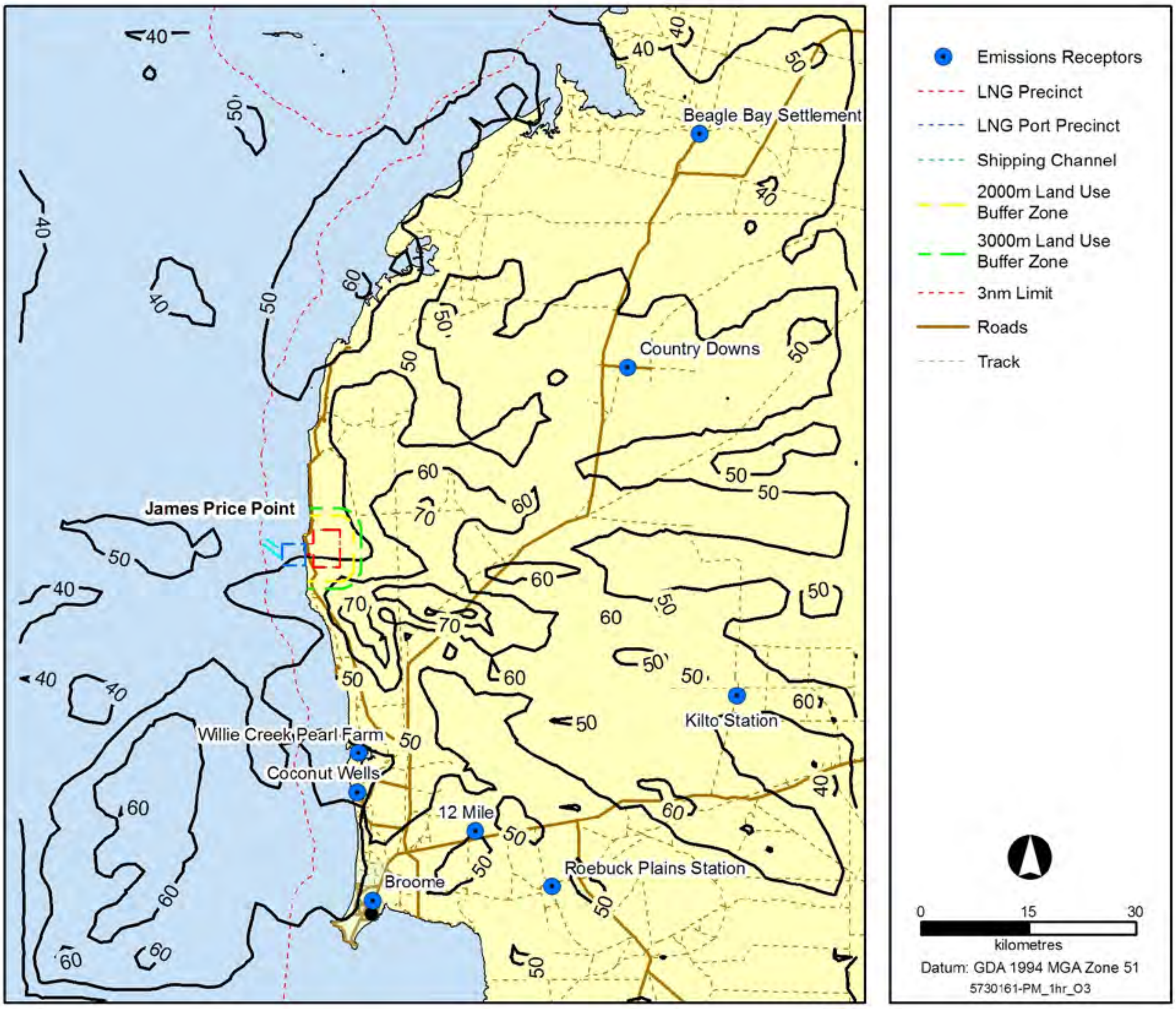
- **Table 2.8-8 TAPM-CTM Predicted Regional Concentrations from the B LNG Precinct under Start-up, including Background.**

Pollutant	Averaging Period	Concentration Statistic	Criteria	Max at Sensitive receptor	Receptor	Percent of Criteria	Max predicted Anywhere
CO	8-hour	Max	9,000ppb	1520 (-30)	Kilto	17	2,480 (32)
NO_2	1-hour	Max	120ppb	73 (0)	12 Mile	61	93 (4)
	1-year	Ave	30ppb	4.5 (0.0)	Broome	15	4.5 (0.0)
O_3	1-hour	Max	100ppb	84 (2)	BLNG	84	92 (0.7)
	4-hour	Max	80ppb	81 (2)	BLNG	101	91 (1)
Formaldehyde	1-hour	99.9	18ppb	5.8 (-0.3)	Kilto	32	8.4 (0.0)
Acetaldehyde	1-hour	99.9	23ppb	4.8 (-0.2)	Kilto	21	6.4 (-0.2)

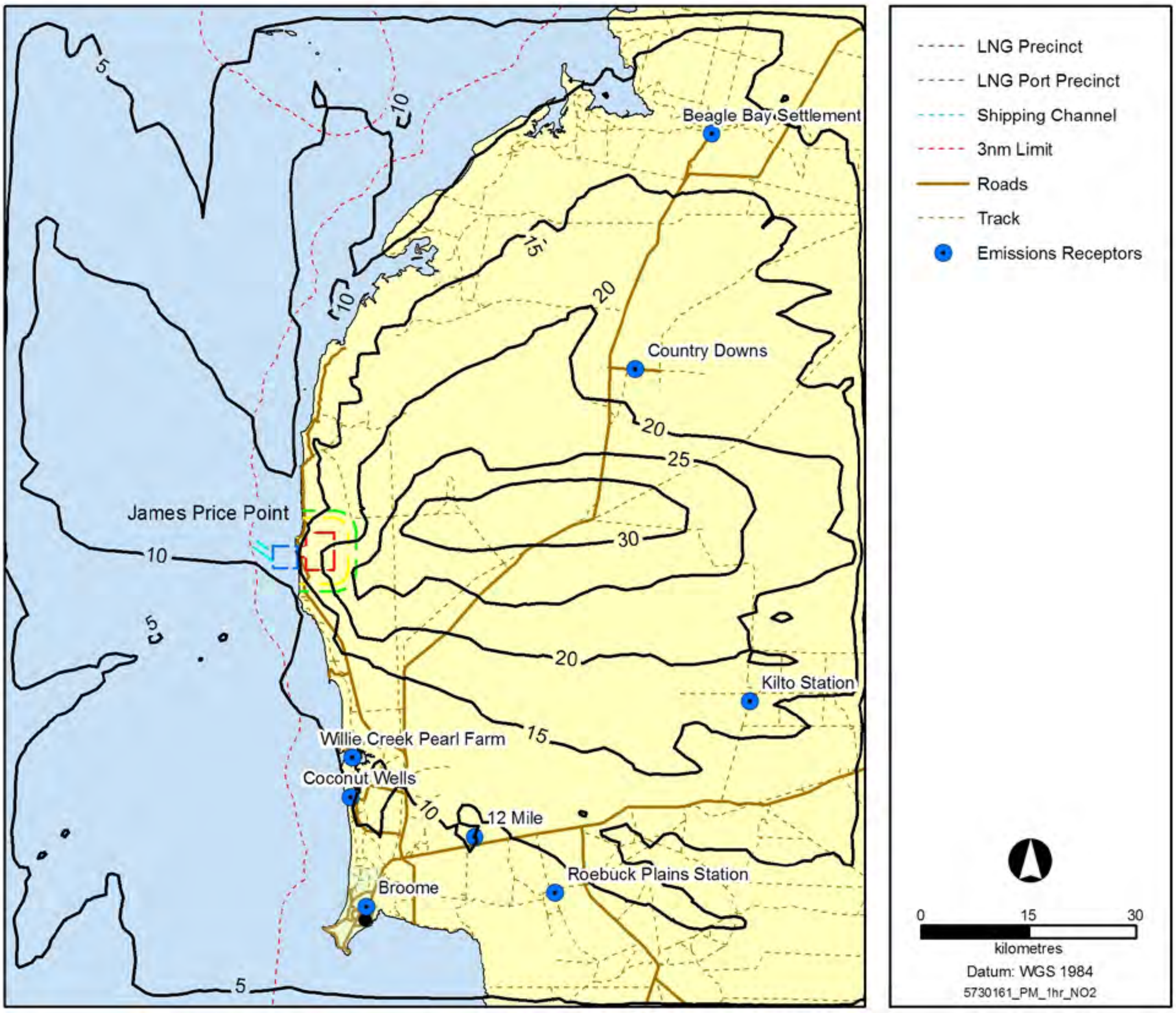
Notes: 1) Values in brackets represent the start-up addition to the LNG Precinct mode in normal operations.

2) Modelled sensitive receptors include Broome, Coconut Wells, Country Downs station, Kilto station, Beagle Bay settlement, 12 Mile and the likely BLNG workers accommodation facilities.

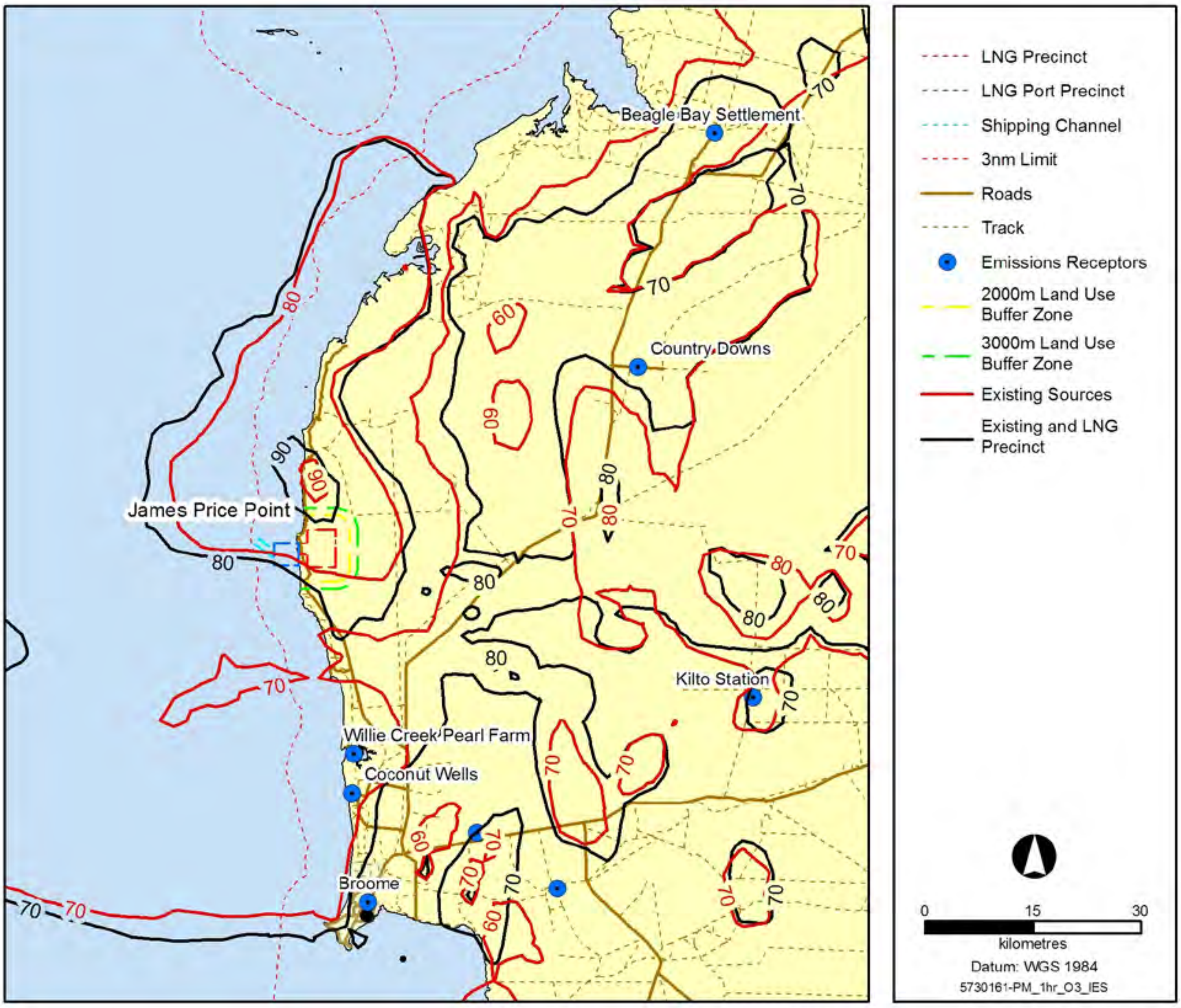
3) Particulate concentrations were not modelled for start-up operation. Particulate concentrations are expected to show the same small relative increase as the gaseous concentrations (Air Assessments, 2010; **Appendix C-25**).



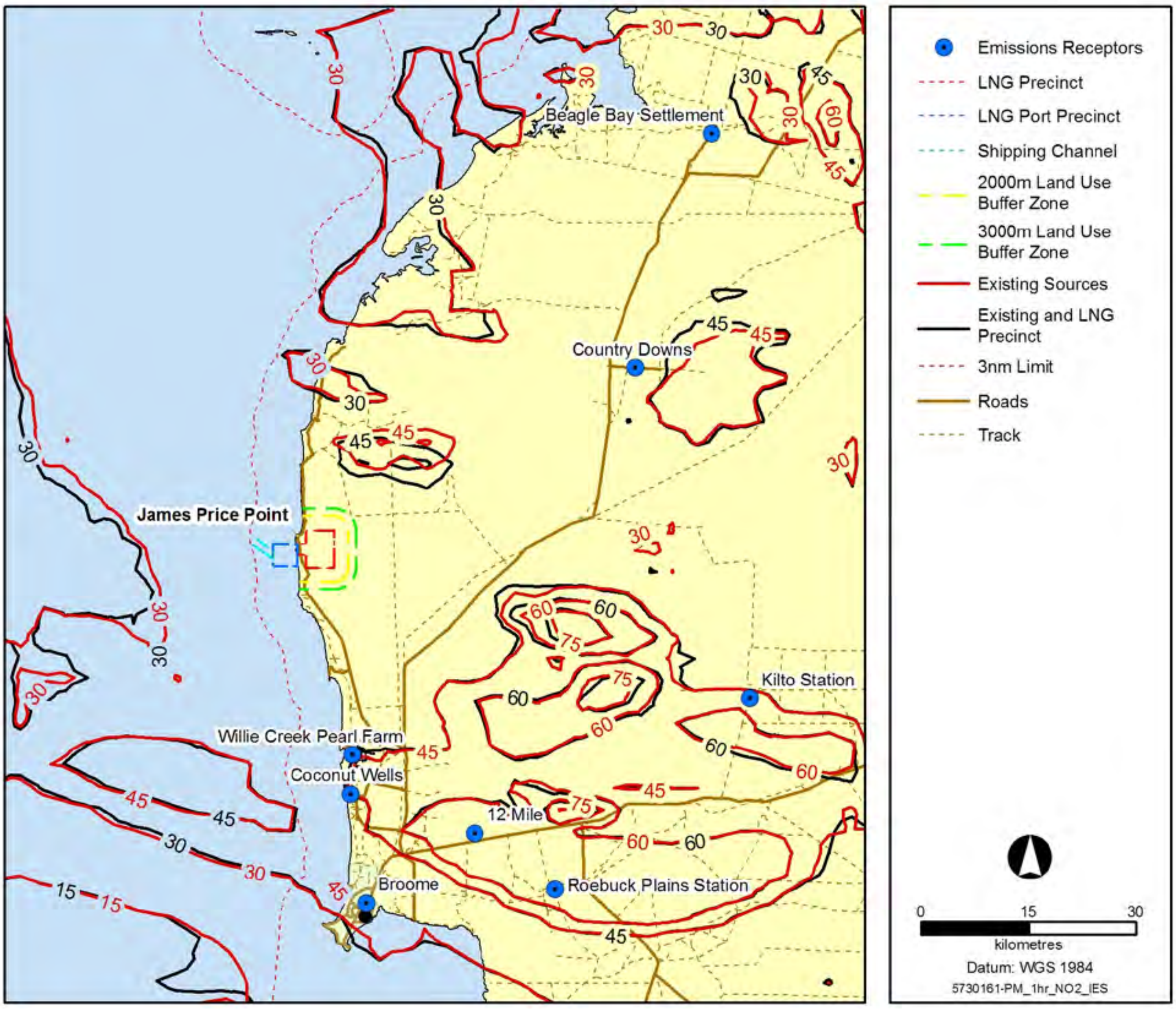
- **Figure 2.8-8 Predicted Maximum 1-hour Average O_3 Concentrations (ppb) for a 50Mtpa LIGT without Existing Sources.**



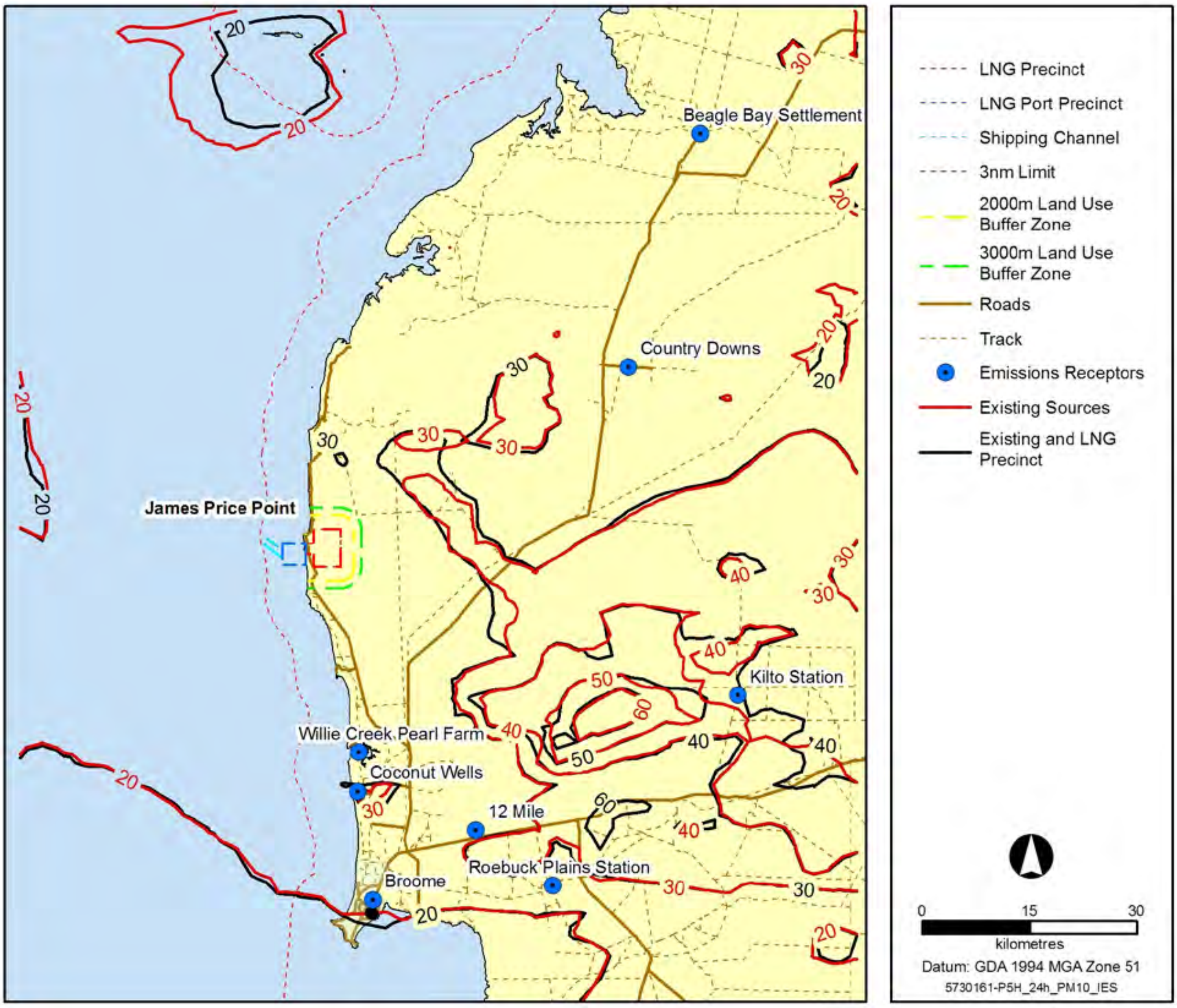
- **Figure 2.8-9 Predicted Maximum 1-hour Average NO_2 Concentrations (ppb) for a 50Mtpa LIGT without Existing Sources.**



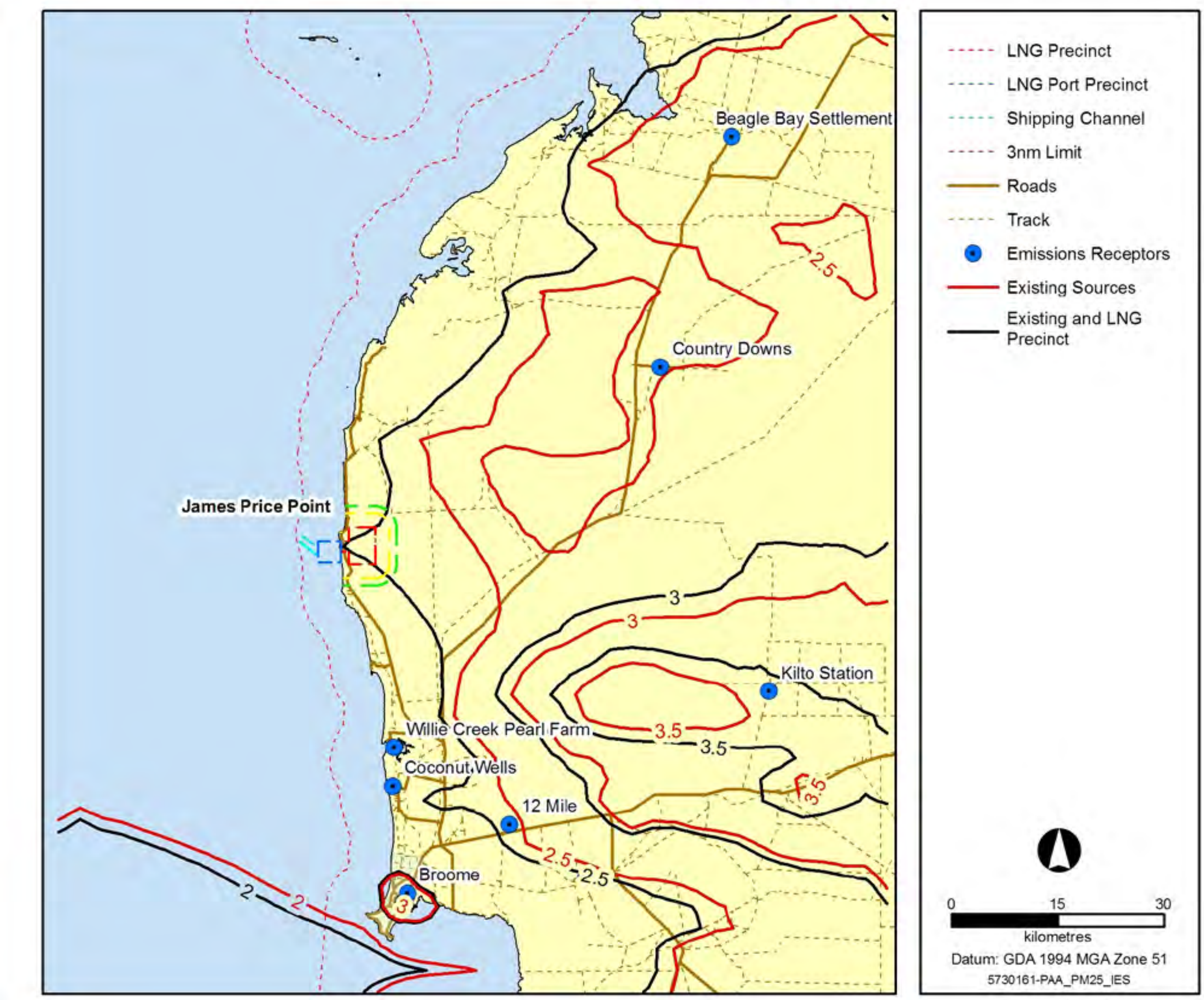
- **Figure 2.8-10 Predicted Maximum 1-Hour Average O_3 Concentrations (ppb) for a 50Mtpa LIGT including Existing Sources.**



■ **Figure 2.8-11 Predicted Maximum 1-Hour Average NO_2 Concentrations (ppb) for a 50Mtpa LIGT including Existing Sources.**



- **Figure 2.8-12 Predicted 5th Highest 24-hour Average PM_{10} Concentrations (µg/m^3) for a 50Mtpa LIGT Precinct including Existing Sources.**



- **Figure 2.8-13 Predicted Annual Average $PM_{2.5}$ Concentrations (µg/m^3) for a 50Mtpa LIGT Precinct including Existing Sources.**

Predicted Deposition Levels

The deposition of nitrogen and sulphur was modelled to assess the potential impacts on vegetation and ecosystems. Dry nitrogen deposition was predicted for the gaseous species, NO, NO_2, HONO, HNO_3, NH_3, NH_4 and nitrate aerosols. Dry sulphur deposition was predicted for the gaseous species SO_2, SO_3 and sulphate aerosol. Wet deposition was not predicted from TAPM, as TAPM performed poorly in predicting rainfall for the region, predicting far too many light rainfall hours. Instead an estimate of the total deposition (dry and wet) was made based on the Burrup rock art study which found that for the background sites near Dampier wet deposition contributed between 15 to 40% of total deposition for a dry and a wet year respectively. As such, wet deposition was estimated to contribute around 50% of the total deposition for the wetter Dampier Peninsula at Broome (Air Assessments, 2010; **Appendix C-25**).

The results of the dry deposition modelling can be summarised as follows:

- Predicted nitrogen deposition was in the range 1.5 to 2.1kg/hectares/yr for existing sources and up to 2.22kg per hectare per year for the 50Mtpa operating scenario including background. If wet deposition of up to 50% of total deposition is assumed, then 4.44kg per hectare per year total nitrogen deposition is predicted which is below the WHO critical load guideline for nitrogen of 5 to 35kg per hectare per year.
- Predicted maximum sulphur deposition was up to 0.6kg per hectare per year over water in the berth area, and 0.18kg per hectare per year over land which is below the sulphur critical load of 4 to 8kg per hectare per year specified by WHO.

Conclusions from the Regional Modelling

The results of the regional modelling are summarised as follows:

- Fires are the dominant existing source of air emissions in the region leading to high particulate and O_3 concentrations. These high levels are a consequence of the very large extent of land burned and the build up of pollutants in the atmosphere from fires, typically lasting for several days.
- The predicted existing concentration levels of O_3 are typically in the range of 60% to 85% of the NEPM standard.
- The predicted particulate levels exceed the NEPM PM_{10} standard with more than five exceedances of the NEPM for much of the Dampier Peninsula. Note, for both O_3 and particulate matter there are no measurements within the Kimberley to confirm the predictions. This is due to the overwhelming contribution from natural fires.
- The BLNG Precinct is predicted to make a relatively small contribution. Maximum predicted concentrations of O_3 from the Precinct are low (~ 40 to 50ppb).
- Cumulative pollutant concentrations at a regional level predicted by the modelling are dominated by the impacts from fires.
- Deposition rates of nitrogen and sulphur were predicted to be below the WHO guidelines.

2.8.3.4. Local Air Quality Modelling Assessment

This section presents results from the local modelling using TAPM with predictions undertaken on a 500m grid. Concentrations were predicted for NO_2, CO, SO_2, PM_{10} and $PM_{2.5}$, benzene, toluene, xylenes and H_2S. These concentrations are compared with criteria adopted and conclusions drawn as to the impacts of the proposed BLNG Precinct.

Table 2.8-9 provides the predicted concentrations from the BLNG Precinct excluding and including background for the 50Mtpa LIGT normal operations and at turn down. Contour plots showing the local impacts for emissions with predicted ground level pollutant concentrations that approach assessment criteria, excluding and including background contributions, are shown in **Figure 2.8-14** to **Figure 2.8-22** inclusive. The results of the modelling and contour plots for the remaining scenarios and pollutants are provided in the air quality assessment report in **Appendix C -25** (Air Assessments, 2010).

The pollutants of most concern (with predicted impacts closest to or exceeding their assessment criteria) are benzene and H_2S, and to a lesser extent toluene.

Figure 2.8-15 presents contour plots of 99.9 percentile concentrations of benzene for comparison with the NSW short-term (1 -hour) criteria. Predicted concentrations exceed the criteria throughout the modelled area. However, this modelling scenario has conservatively assumed that two TCUs are down throughout the year. A more accurate estimate of the cumulative impact of TCU downtime is presented in **Figure 2.8-16**, which displays the expected annual number of exceedances of the criteria, statistically combining modelling scenarios with various numbers of TCUs operating. It is evident that maximum impacts are located around ships at berth and are associated with loading of condensate.

The NSW short-term guideline was developed primarily as a screening tool, using large conservative uncertainty or safety factors, and is not directly related to health or environmental impacts. Of more relevance for assessing benzene is the annual average criterion, which is based on the studies of carcinogenicity of benzene and does not require the uncertainty correction factors as used in the NSW guidelines. **Figure 2.8-17** presents the predicted annual concentrations, incorporating the probabilities of the TCUs being offline. This indicates that the maximum concentrations will be at most 5.5µg/m^3 (110% of the European standard) and would occur at the south-western edge of the buffer zone, decreasing rapidly with distance away from the ship-loading facility.

A sensitivity test was undertaken for the impact of ship-loading emissions on cumulative impacts. **Figure 2.8-18** to **Figure 2.8-20** present corresponding modelling results to those above with condensate ship-loading emissions excluded. **Figure 2.8-18** and **Figure 2.8-19** show that the cumulative impact is significantly decreased, and the area in which the short-term guideline is exceeded is confined to the east of the Precinct. **Figure 2.8-20** shows that the annual average concentrations are much lower than the health impact criteria at all locations.

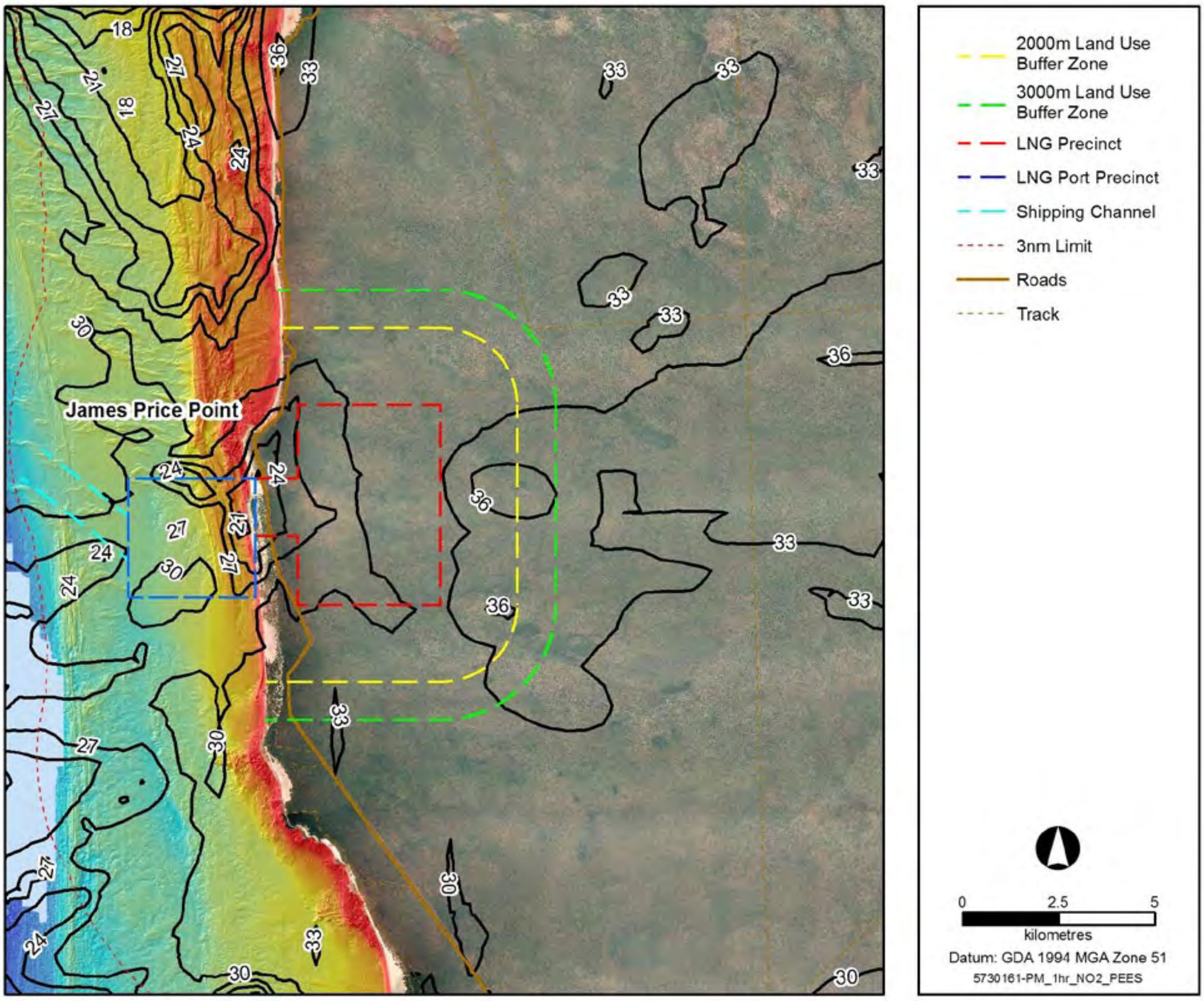
Improved emissions estimates from condensate ship-loading would become available as engineering design proceeds. VOC emissions control options may be required depending on further analysis by proponents of derived proposals for particular plant.

For hydrogen sulphide (**H_2S**) the level of emissions is governed by the feed gas H_2S concentration and the frequency of emissions is a function of TCU downtime. **Figure 2.8-21** presents a contour plot of the 99th percentile 1 -second (instantaneous) H_2S concentrations, for comparison with the assessment criteria presented in **Table 2.8-4** This shows that the NSW guideline for a single residence (4.8µg/m^3) is expected to be to exceeded across an area to the east of the precinct and extending to the edge of the modelling domain. These modelling results are based on conservative assumptions of two TCUs down and a feed gas H_2S concentration of 20.5ppm. This is very conservative given that measured H_2S concentrations from the gas field drilling program have been in the range of 4 to 7ppm. **Figure 2.8-22** shows the expected annual number of hours for which the single residence guideline would be exceeded given a more reasonable but still conservative feed gas H_2S concentration of 13ppm, and assuming a TCU offline probability of 10%. This shows that the area for which the single residence guideline would be exceeded (i.e. concentrations greater than the 99th percentile) is restricted to a relatively small area to the east of the precinct. These odour impacts would occur intermittently for short periods.

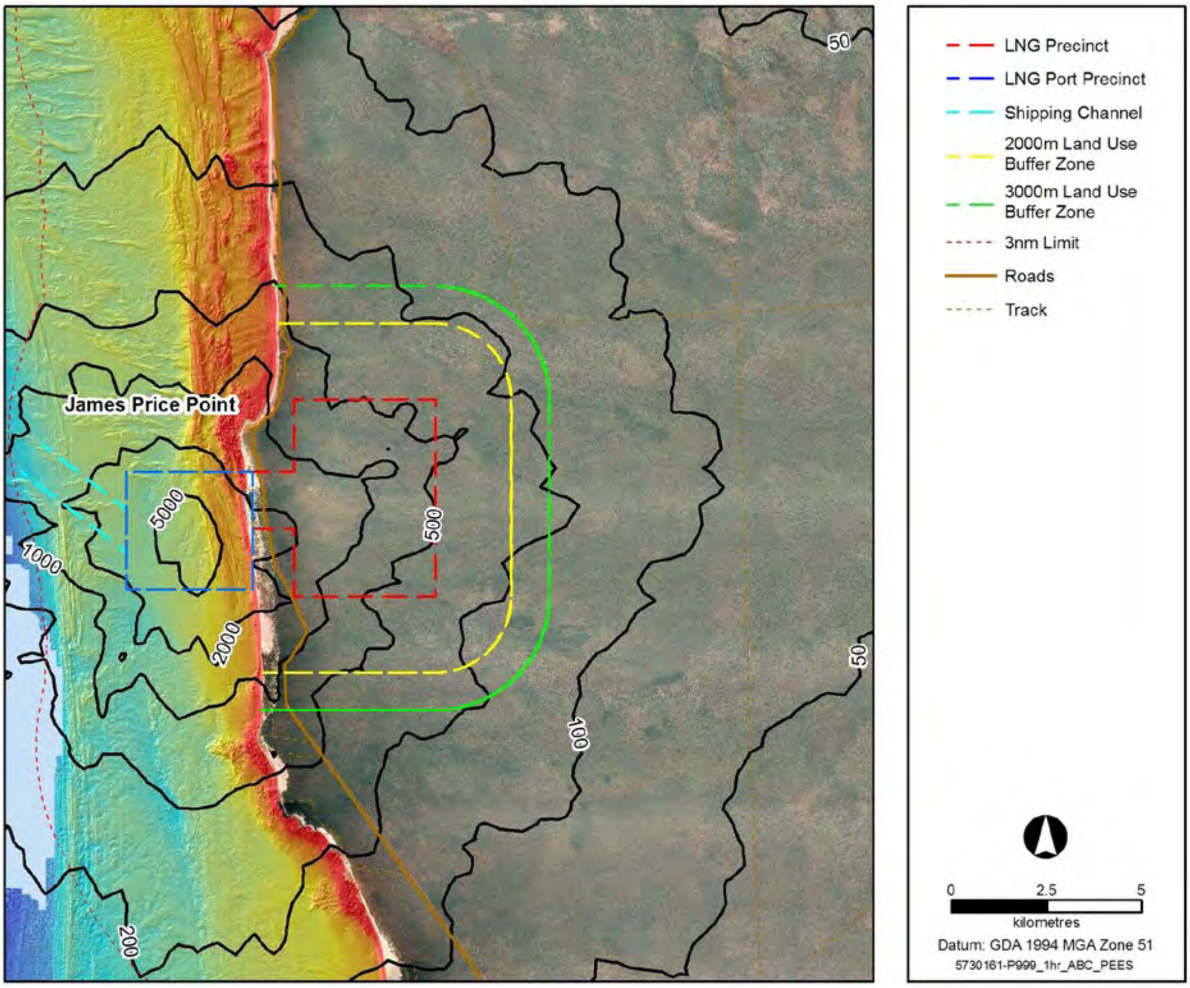
Table 2.8-9 TAPM Predicted Local Concentrations from the BLNG Precinct under LIGT at 50Mtpa and Turn Down Excluding and Including Background.

Pollutant	Averaging Period	Concentration Statistic	Unit	Criteria	LIGT 50Mtpa		LIGT 50Mtpa Turn down	
					Exc bgrnd	Inc bgrnd	Exc bgrnd	Inc bgrnd
CO	8-hour	Max	ppb	9,000	48.3	148	206	306
NO_2	1-hour	Max	ppb	120	35.8	37.3	37.0	38.5
	1-year	Ave	ppb	30	2.05	2.6	3.69	4.2
SO_2	1-hour	Max	ppb	200	44.2	44.2	44.5	44.5
	1-day	Max	ppb	80	9.0	9.0	9.0	9.0
	1-year	Ave	ppb	20	0.64	0.64	0.64	0.64
PM_{10}	1-day	Max	µg/m^3	50	3.6	25.6	3.6	25.6
$PM_{2.5}$	1-day	Max	µg/m^3	25	3.6	10.6	3.6	10.6
	1-year	Ave	µg/m^3	8	0.25	5.3	0.25	5.2
H_2S	Peak	99th	µg/m^3	1.38-4.8	12.6		12.6	
	1-hour			0.47-1.6		4.53		4.53
Including Ship-loading Emissions of BTEX								
Benzene	1-hour	99.9th	µg/m^3	29	840	840	840	840
	Annual	Ave	µg/m^3	5	5.5	5.6	5.5	5.6
Ethyl benzene	1-hour	99.9th	µg/m^3	800	19	19	19	19
Toluene	1-hour	99.9th	µg/m^3	360	470	470	470	470
Xylenes	1-hour	99.9th	µg/m^3	190	8	8.1	8	8.1
Excluding Ship-loading Emissions of BTEX								
Benzene	1-hour	99.9th	µg/m^3	29	36.3	36.4	36.3	36.4
	Annual	Ave	µg/m^3	5	0.85 (0.44)	0.9	0.85	0.9
Ethyl benzene	1-hour	99.9th	µg/m^3	800	0.29	0.4	0.29	0.4
Toluene	1-hour	99.9th	µg/m^3	360	14.73	14.9	14.7	14.9
Xylenes	1-hour	99.9th	µg/m^3	190	8.0	8.1	8.0	8.1

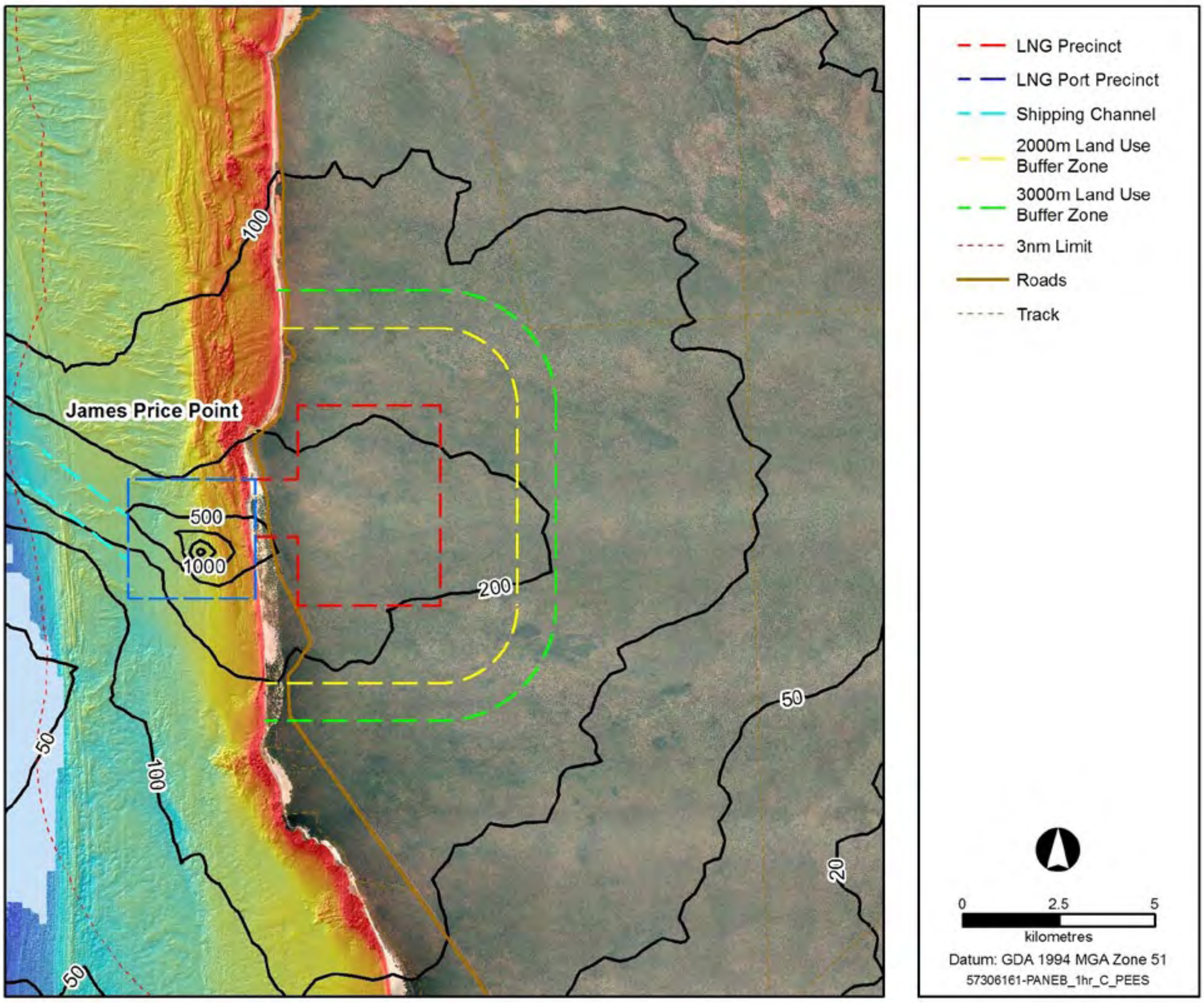
Notes:
1) The benzene annual average and maximum 1-hour concentrations were predicted assuming 2 TCUs offline. This is conservative for predicting the annual average concentrations. The value in brackets is a more accurate estimate of the annual average concentration based on the probability of each TCU being offline for 10% of the year.
2) Highest concentration for H_2S evaluated on land outside the buffer. Slightly higher concentrations over-water.
3) Criteria for H_2S concentrations converted based on the peak-to-mean factors described in **Section 2.8.1.1** and Air Assessments (2010; **Appendix C-25**).



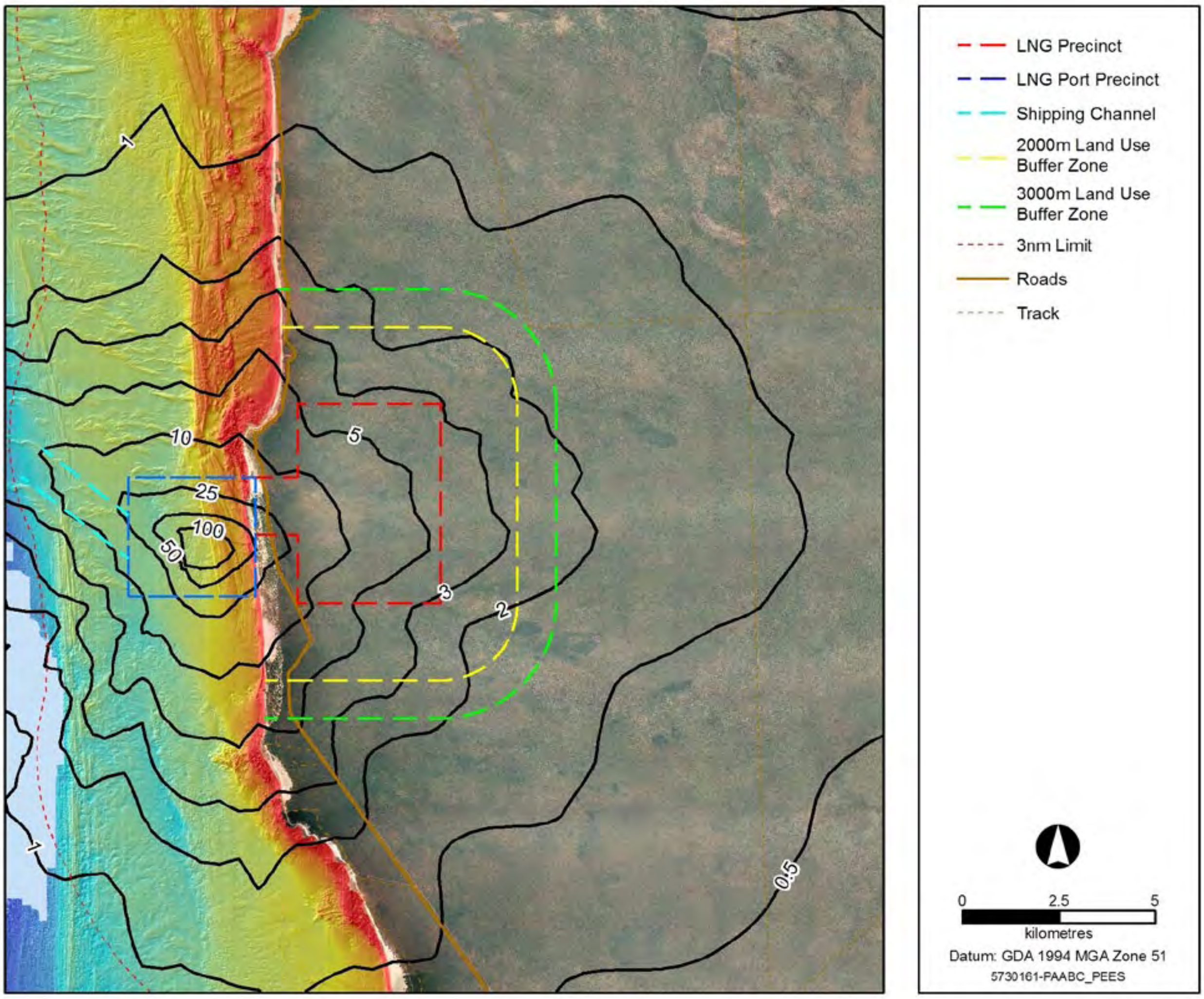
- **Figure 2.8-14 Predicted Maximum 1-hour NO_2 Concentrations (ppb) for a 50Mtpa LIGT Precinct excluding Existing Sources.**



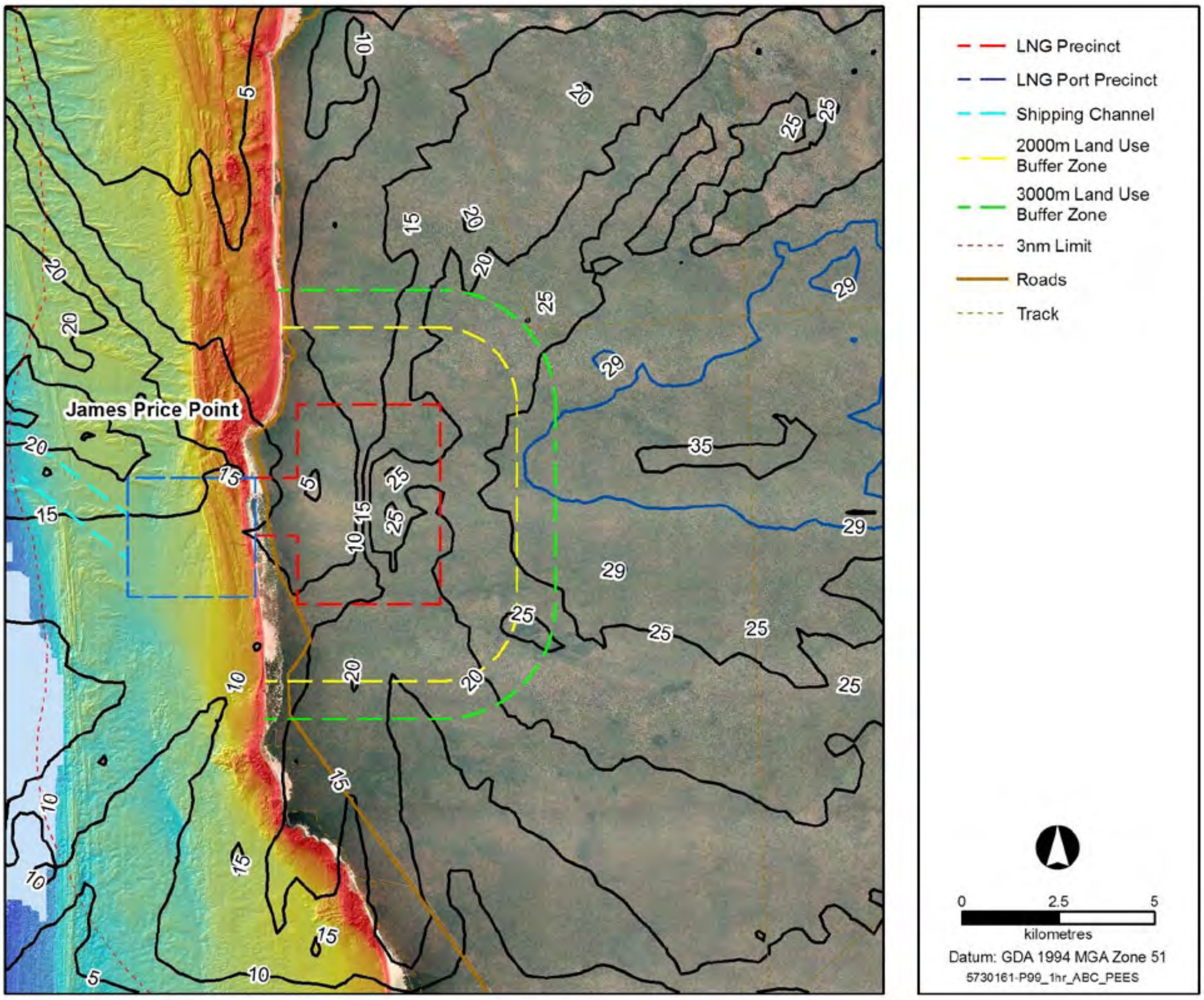
- **Figure 2.8-15 Predicted 99.9th Percentile 1-hour Average Benzene Concentrations (μg/m^3) for a 50Mtpa LIGT Precinct (Assuming Two TCUs Offline Continuously) Excluding Existing Sources.**



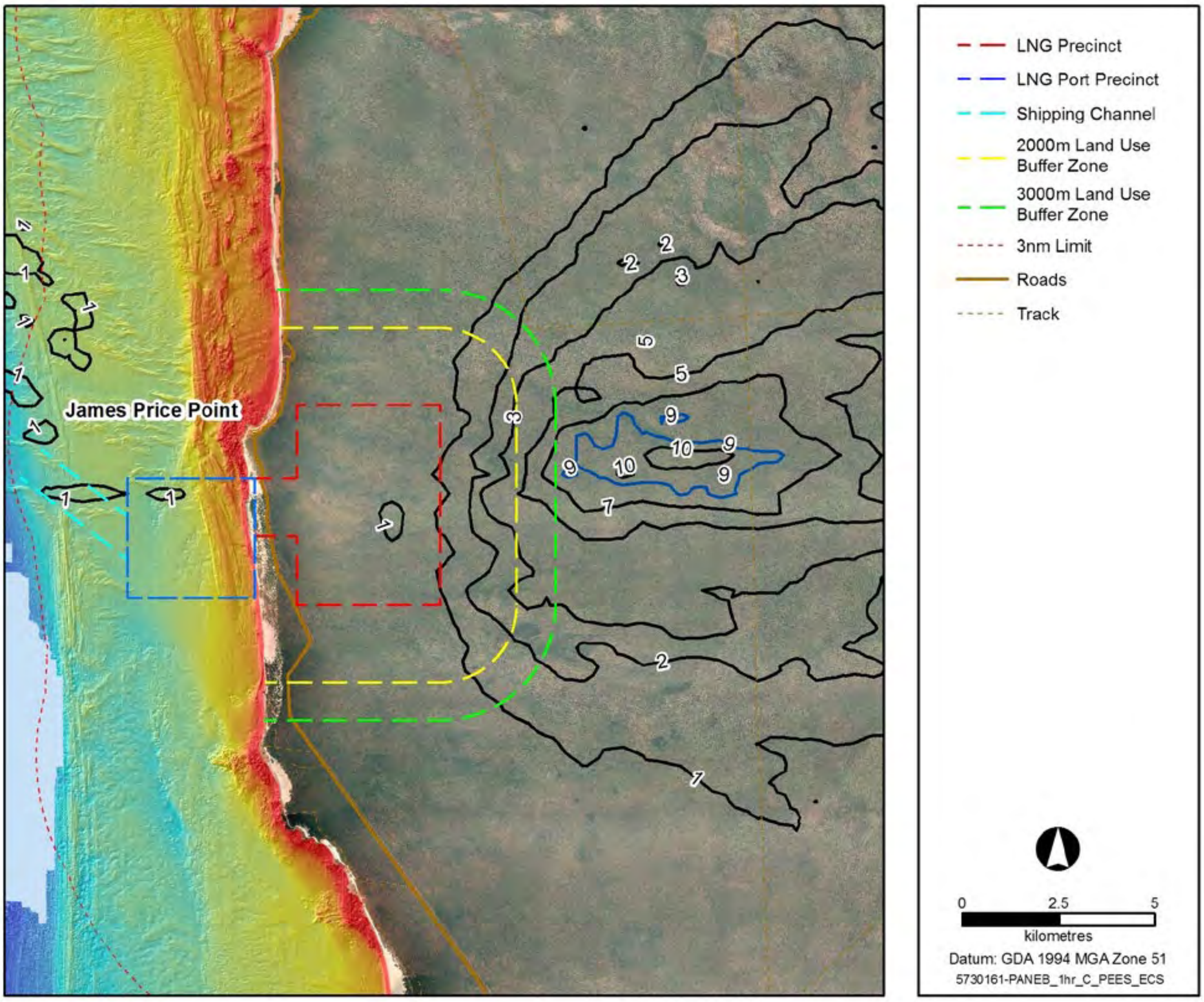
- **Figure 2.8-16 Predicted Annual Number of Exceedances of Benzene 1-hour Concentration of 29µg/m^3 for a 50Mtpa L IGT Pr ecinct (A ssuming Two TCUs Offline C ontinuously) E xcluding E xisting Sources.**



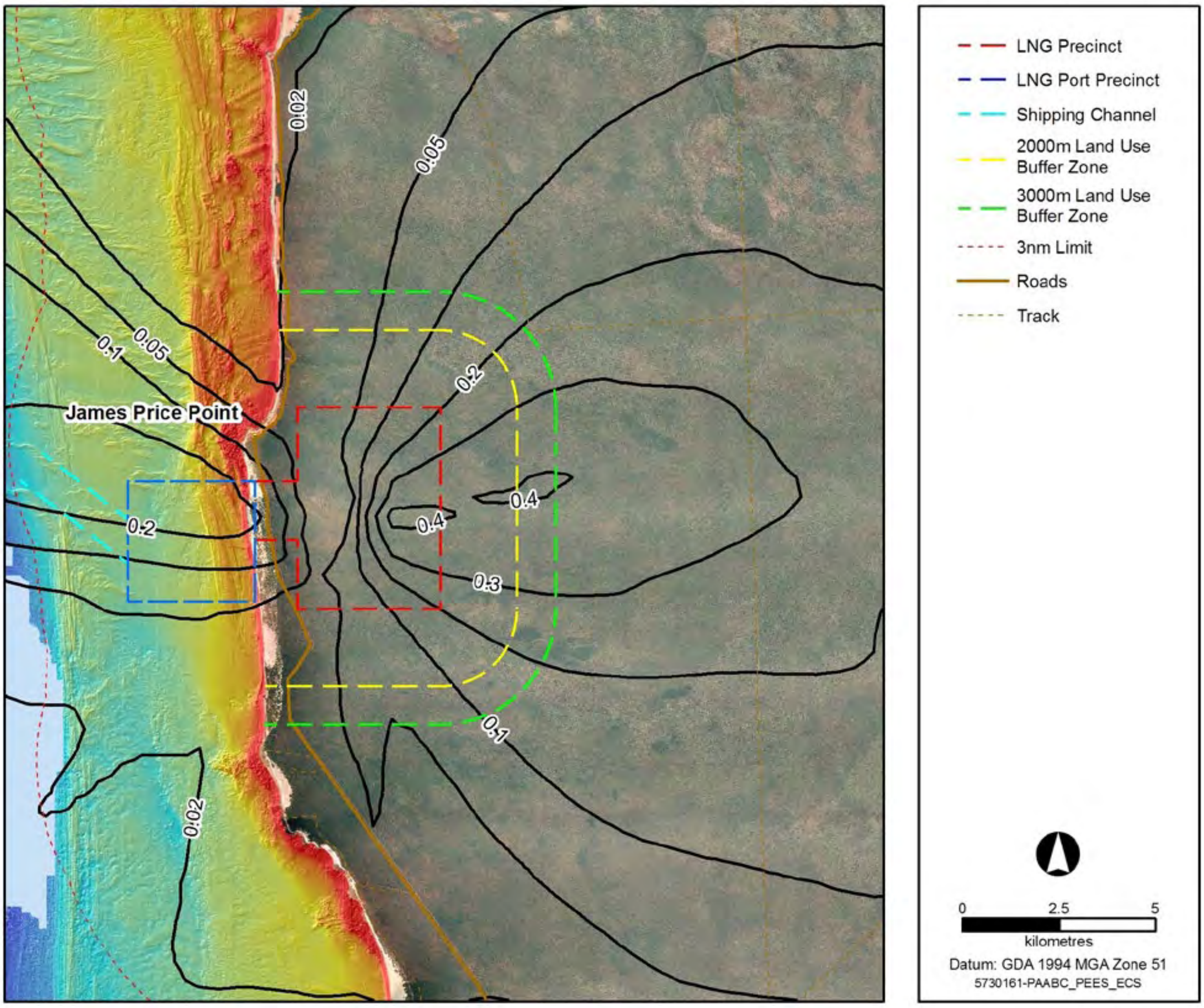
- **Figure 2.8-17 Predicted Annual Average Benzene Concentrations (µg/m^3) for a 50Mtpa LIGT Precinct Excluding Existing Sources.**



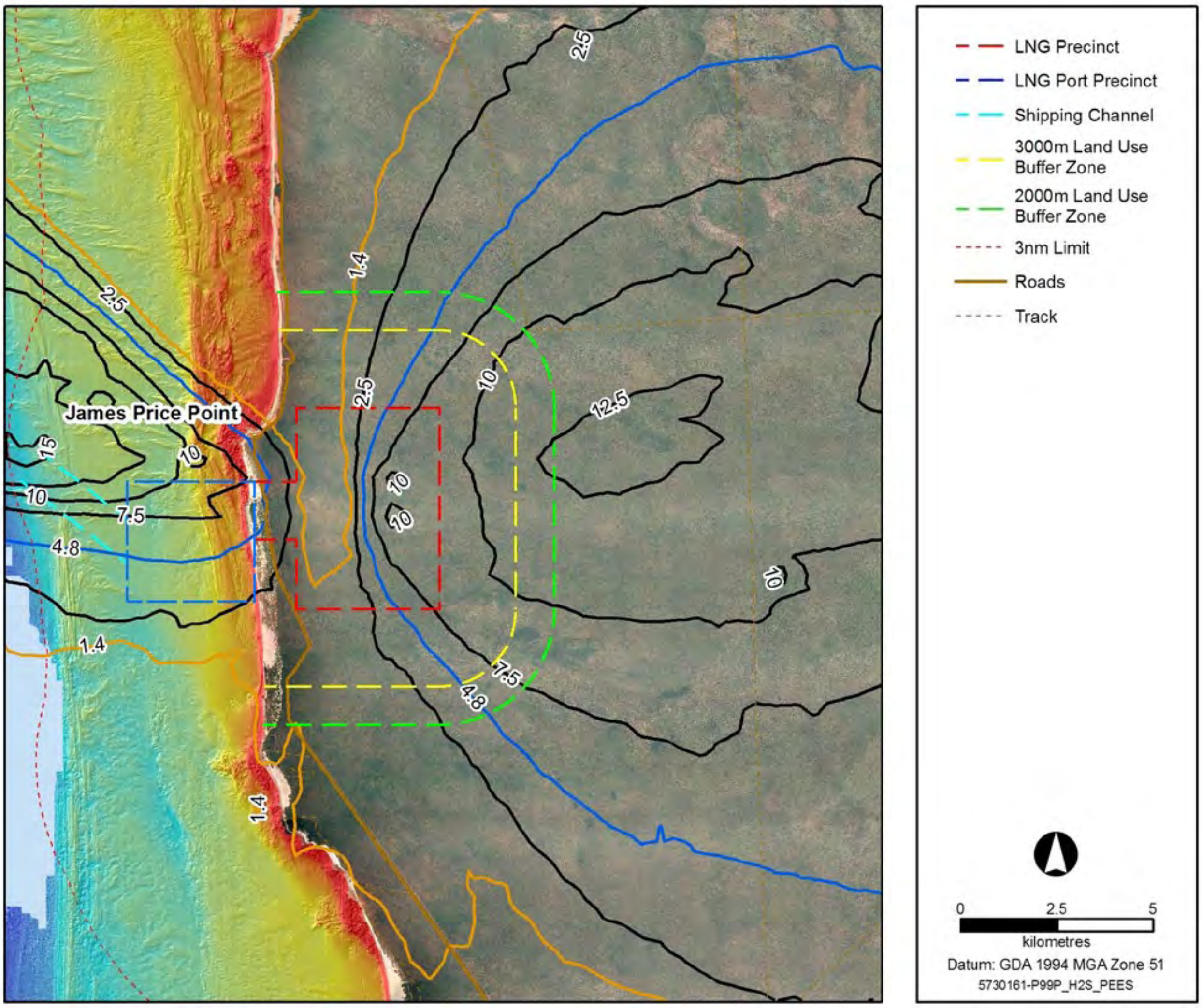
■ **Figure 2.8-18 Predicted 99.9th Percentile 1-hour Average Benzene Concentrations (µg/m^3) for a 50Mtpa LIGT Precinct (Assuming Two TCUs Offline Continuously) Excluding Existing Sources and Excluding Condensate Ship-loading.**



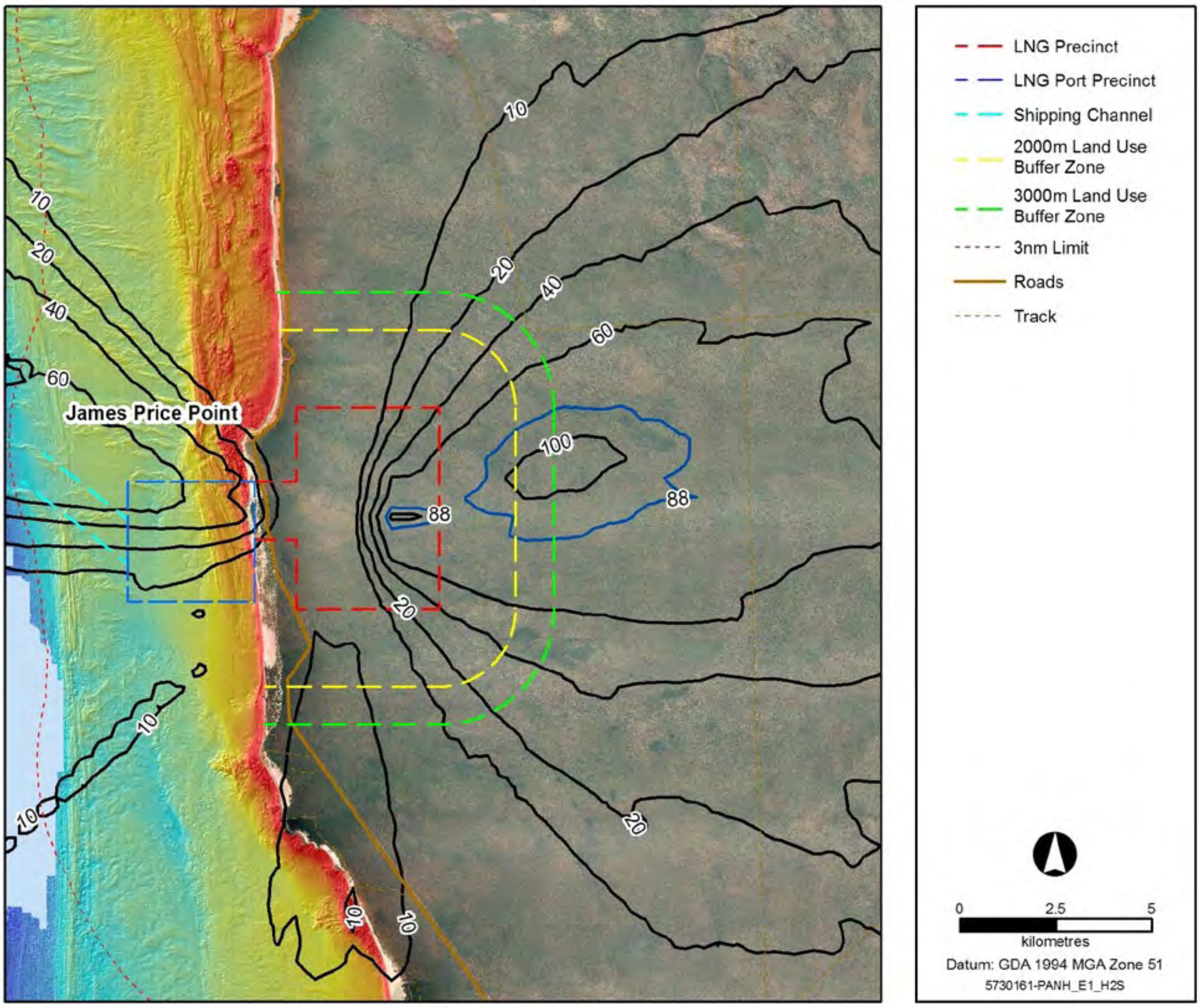
- **Figure 2.8-19 Predicted Annual Number of Exceedances of Benzene 1-hour Concentration of 29µg/m^3 for a 50Mtpa LIGT Precinct (Assuming Two TCUs Offline Continuously) Excluding Existing Sources and Excluding Condensate Ship-loading.**



- **Figure 2.8-20 Predicted Annual Average Benzene Concentrations (μg/m^3) for a 50Mtpa LIGT Precinct Excluding Existing Sources Excluding Condensate Ship-loading.**



- **Figure 2.8-21 Predicted 99.9th Predicted 99th Percentile 1-second (Instantaneous) H_2S Concentrations ($\mu g/m^3$) for a 50Mtpa LIGT Precinct (Conservative Estimate Assuming Two TCUs Offline Continuously and Feed Gas H_2S Concentration of 20.5ppm) Excluding Existing Sources.**



- **Figure 2.8-22 Predicted Annual Number of Hours in which an Exceedance of a 1-second H_2S Concentration of 4 .8µg/m^3 Occurs f or a LIGT 5 0Mtpa Pr ecinct (T CU O ffline Probability 1 0% with H $_2$S Concentration in the Feed Gas of 13ppm).**

Conclusions from the Local Modelling
The local modelling conducted using TAPM demonstrated that:

- Conservative local modelling predicts that impacts for all pollutants from the LNG Precinct are predicted to be well within the adopted criteria except for benzene, H_2S and to a lesser degree toluene. The primary source of benzene and toluene emissions is from venting from ships' holds during condensate loading. Predictions indicate that benzene concentrations would be well in excess of the adopted short-term modelling guideline. This criterion, obtained from the NSW modelling guidelines, is primarily intended to be a screening level to identify potential issues. Of more relevance to human health end points is the annual average criterion. Annual benzene concentrations were predicted to just exceed the annual criteria (5.5µg/m^3 or 110% of the European standard) outside the south west corner of the Precinct buffer. Model sensitivity tests without condensate ship-loading emissions predicted that BTEX concentrations are greatly reduced, with the annual average benzene level outside the buffer being less than 10% of the WHO annual guideline of 5µg/m^3. There are currently no existing sensitive receptors in this area. This was a key consideration in the siting of the Precinct. Buffer zones will be established to ensure appropriate separation distances from the Precinct and other future land uses. Further refinement of this conservative assessment will be undertaken as engineering details for individual facilities are matured, to ensure this is actively managed and reduced to achieve best practice measures.
- Conservative modelling has predicted that H_2S levels may exceed the adopted criteria for single residences to the east of the buffer zone for short durations. The assessment criteria are amenity-based and modelling indicates that predicted H_2S concentrations are comparable to those experienced in some Perth suburbs due to bore water usage. Consequently, no adverse health impacts are anticipated. Land use planning around the BLNG Precinct and, in particular, the selection of the workers accommodation, will give appropriate consideration to the outcomes of this assessment.
- Hydrogen sulphide levels were predicted to exceed the adopted NSW single residence criteria (1-second 99th percentile of 4.8µg/m^3) up to 9km east of the buffer zone. For the more stringent criteria applicable for an urban area with >2,000 people (or very sensitive land uses such as hospitals), the 1-second 99th percentile criteria of 1.38µg/m^3 would be exceeded to 20 to 30km to the east of the buffer. In these areas the maximum 1-second H_2S concentration predicted to be around 50 µg/m^3 and therefore H_2S levels would at times be above the odour threshold of about 1.2µg/m^3 and would be recognizable by its characteristic rotten egg gas smell. Though detectable by its odour, the concentrations are well below the level of concern for health, with the WA Health Department recently recommending a limit of 2ppm (approximately 3,000µg/m^3 for a 30-minute average). Therefore, in the area to the east of the Precinct it is predicted that the H_2S odour will at times be recognisable, though the concentrations are 60 times lower than levels that can cause health effects.

The impact assessment determined that taking into account existing contributing sources, gaseous emissions could potentially contribute to an incremental reduction in air quality. On a local and regional scale, the contribution from the BLNG Precinct to the predicted concentrations of all other pollutants will be low.

Emissions associated with the BLNG Precinct will be managed, monitored and responded to through the Air Quality Management Plan, to ensure that efficient technologies are used to minimise and monitor air emissions from the LNG facilities during operations.

It is expected that the impact to air quality from gaseous emissions during operational activities can be minimised by the application of measures such as the application of efficient technologies and continuous monitoring of emissions. A more detailed description of proposed mitigation measures is presented in **Section 2.8.4**. The significance of the residual impact of gaseous emissions on air quality is assessed as very low taking into account the remote location away from residential receptors, the small incremental contributions of pollutants from the BLNG Precinct to regional air quality, and the application of buffer zones to further ensure sensitive receptors are appropriately distanced from the source.

2.8.4. Management Measures

Mitigation measures and safeguards that have been identified to manage potential impacts to air quality are outlined below in **Table 2.8-10**, **Table 2.8-11** and **Table 2.8-12**.

- **Table 2.8-10 State Government Measures for Air Quality.**

State Government measures	Responsibility	Timing
Ensure planning and layout of the BLNG Precinct is subject to appropriate strategic land use buffer zoning in alignment with State Planning Policy (Industrial Buffer Policy) and EPA requirements (Guidance Statement No. 3), to ensure appropriate separation distances between industrial and other land uses. Key considerations will include: • Proposed buffer areas for the BLNG Precinct will align with the principles and objectives of the State Industrial Buffer Statement of Planning Policy 4.1, as agreed on by the WAPC, in consultation with local government and other appropriate regulatory authorities. • Identification of the nature of off-site impacts which may affect more sensitive land uses (noise, smoke, dust, odour, vibration and light) or create potential risks, in line with WA EPA Guidance Statement No. 3 – Separation Distances between Industrial and Sensitive Land Uses. • Identification of appropriate land uses that may be compatible within and surrounding the buffer area, and appropriate control measures to ensure that social amenity and heritage values in the vicinity of the Precinct Project Area are maintained. • Demonstration that cumulative emissions from multiple premises in the BLNG Precinct will comply with NEPM standards outside buffer zones. Implementation of buffer zones for the BLNG Precinct will meet the national environment protection goals of approved NEPM and other established environmental quality criteria, while recognising contributions from other existing sources. The buffer zone will acknowledge: • environmental and social protection 'no go' areas; • location of supporting infrastructure; and • social, heritage and recreational user groups outside buffer zones.	DSD through its involvement in the BLNG Precinct Control Group, with advice from LandCorp, DEC, and State Planning Commission	On approval of the BLNG Precinct

- **Table 2.8-11 Proposed Environmental Conditions for the Strategic Proposal that may affect Air Quality.**

Condition No.	Proposed Environmental Condition for Strategic Proposal
T8.1	Proponents of derived proposals shall submit a report annually to the EPA, and make publicly available air monitoring results and emission control performance for their LNG facility.

- **Table 2.8-12 Requirements to be Addressed via Development of a Management Plan to Support a Derived Proposal in regards to Air Quality.**

Item No.	Derived Proposal Requirements	Timing
T8.2	Prepare an Air Quality Management Plan that addresses the following: • compliance within the buffer zones determined by the State Government; • results of cumulative air quality modelling; • compliance with ambient NEPM standards; • meteorological monitoring results; • an emissions monitoring programme, which will likely include nitrogen compounds, BTEX, and hydrogen sulphide emissions from the LNG plant; • participation in an ambient air monitoring program with other proponents of derived proposals; and • annual reporting obligations.	Prior to commissioning and updated for ongoing operational requirements.
T8.3	Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Minister for Environment, which addresses the following: • schedule of construction activities; • details of the construction methods to be used; • objectives and targets; • environmental management; • environmental training and inductions; and • environmental monitoring, contingencies and reporting, and stakeholder consultation. *In order to address the potential impacts to air quality identified within this Section the CEMP may include environmental management measures such as:* • *dust control measures for unsealed roads, exposed surfaces and active construction areas;* • *restriction of vehicle movements and vehicle speeds to reduce dust emissions; and* • *an awareness program of the need to minimise dust generation.* Management Plans will be developed in accordance with current industry practice and regulatory guidance, including DEC Guideline for the Development and Implementation of a Dust Management Program (Draft, 2008).	Prior to commencement of associated construction activities.

2.8.5. Environmental Outcome

After management and mitigation measures have been applied, it is expected that the BLNG Precinct will result in the following outcomes in relation to air quality:

2.8.5.1. Direct Impacts

Construction and operational atmospheric emissions from the BLNG Precinct will be largely contained within the area in close proximity to the BLNG Precinct, encapsulated by the Sensitive Land Use Buffer Zone. Ground-level pollution concentrations are anticipated to be low for most of the year and unlikely to give rise to adverse air quality or amenity issues beyond the boundary.

Air emissions from the proposed BLNG Precinct, which will mostly be from the combustion of natural gas in the gas turbines and from flaring associated with the gas processing plants, will be well within adopted air quality criteria, with the exception of benzene and H_2S. The concentrations of these pollutants were predicted by the modelling to be above the short term (1-hour average) ambient air criteria to the east of the proposed BLNG Precinct however on predicted annual average levels, benzene will still meet annual average guidelines outside the buffer. No existing sensitive receptors are in this area and therefore unlikely to be affected but as H_2S levels may exceed the adopted New South Wales criteria for single residences up to nine kilometres to the east of the buffer zone, land use planning around the BLNG Precinct and, in particular, the selection of the workers accommodation, will consider these modelling results.

Emissions will be managed, monitored and responded to through the Air Quality Management Plan, to ensure that best available practicable and efficient technologies are used to minimise and monitor air emissions from the LNG facilities during operations. Dust emissions from construction activities will be managed through the Construction Environmental Management Plan.

On a local and regional scale, the contribution from the BLNG Precinct to the predicted concentrations of all other pollutants will be low and therefore the risk of potential air quality impacts from the Precinct from these pollutants is also low. Regional levels of NO_2, O_3 and particulate matter will continue to remain close to or exceed NEPM standards on occasions as a result of bushfires in the region, but this may be mitigated by reduced intensity and number of burns through the proposed fire management strategy for the Dampier Peninsula.

2.8.5.2. Indirect Impacts

Indirect impacts arising from emissions are anticipated to be limited in extent. Dust deposition effects on vegetation may result in a localised decrease in health and condition of vegetation in close proximity to verges of unpaved roads and near exposed areas. Taking into account the existing natural levels of elevated particulates in the region from dust and fires on a seasonal basis, and proposed measures to suppress dust especially during site clearing and construction, such indirect impacts are not anticipated to represent a significant risk to surrounding vegetation.

The results of modelling to inform this assessment demonstrated that deposition rates of nitrogen and sulphur were predicted to be below relevant WHO guidelines. Indirect impacts of wet and dry deposition on surrounding ecosystem values are therefore considered low.

2.8.6. Cumulative Impacts of the Proposal and Associated Activities

The cumulative emissions of the BLNG Precinct proposal and from emissions from indirectly facilitated or related projects in the region have been considered in this section.

2.8.6.1. Category B Activities

Emissions from activities that may indirectly arise as a result of the development and operation of the BLNG Precinct (Category B activities) are largely driven by increases to the population base in Broome as result of the BLNG Precinct development. These include air emissions generated by increased activities associated with:

- electricity demands from the Broome power station;
- transportation including vehicle and aircraft traffic;
- construction and associated activities for housing;
- demand for industrial services;
- solid waste; and
- recreational use of the Dampier Peninsula due to improved access.

As discussed in **Section 2.8.1,** emissions from existing sources in Broome were modelled as an assessment of the impacts from background emissions. These sources included vehicles, the Broome power station and other small sources, biogenic emissions from vegetation and soil and the emissions from fires. The predicted ground level concentrations from these sources were shown to be very close to the relevant air quality guidelines for NO_2, O_3 and particulate matter. Any increases in the activities such as power generation and transportation could result in increases in ground level concentrations of these pollutants at or above the guidelines. However, regional modelling has shown that fires are the dominant existing source of these pollutants. Further assessment, in particular of relative source contributions to the predicted ground level concentrations of pollutants, is recommended. This can include the implementation of ongoing meteorological and air quality monitoring at a local and regional level.

The emissions from the proposed BLNG Precinct were predicted by the modelling to represent a small percentage of emissions in comparison to background emissions in a regional context.

2.8.6.2. Category C Activities

Category C emissions include supply chain emissions (upstream) associated with the gas production in the Browse Basin and the pipeline from the Browse to James Price Point. Potential upstream emissions include fugitive emissions from the pipelines associated with the transport of the gas. Air emissions from these sources would be expected to be minor relative to the Category A and B emissions discussed above.

Table 2.8-13 Impact Assessment Summary for Air Quality.

<table>
<tr><th rowspan="2">Environmental Aspect</th><th rowspan="2">Potential Impacts</th><th colspan="3">Mitigation Measures</th><th rowspan="2">Significance of Residual Impact</th></tr>
<tr><th>State Government Measures</th><th>Proposed Environmental Conditions</th><th>Future Proponent Management Plans</th></tr>
<tr><td rowspan="2">Dust emissions during construction</td><td>Decrease in air quality resulting in public health or amenity impacts</td><td rowspan="2">Ensure planning and layout of the BLNG Precinct is subject to appropriate strategic land use buffer zoning in alignment with State Planning Policy (Industrial Buffer Policy) and EPA requirements (Guidance Statement No. 3), to ensure appropriate separation distances between industrial and other land uses.
Key considerations will include:
• Proposed buffer areas for the BLNG Precinct will align with the principles and objectives of the State Industrial Buffer Statement of Planning Policy 4.1, as agreed on by the WAPC, in consultation with local government and other appropriate regulatory authorities.
• Identification of the nature of off-site impacts which may affect more sensitive land uses (noise, smoke, dust, odour, vibration and light) or create potential risks, in line with WA EPA Guidance Statement No. 3 – Separation Distances between Industrial and Sensitive Land Uses.
• Identification of appropriate land uses that may be compatible within and surrounding the buffer area, and appropriate control measures to ensure that social amenity and heritage values in the vicinity of the Precinct Project Area are maintained.
• Demonstration that cumulative emissions from multiple premises in the BLNG Precinct will comply with NEPM standards outside buffer zones.
Implementation of buffer zones for the BLNG</td><td rowspan="2">Proponents of derived proposals shall submit a report annually to the EPA, and make publicly available air monitoring results and emission control performance for their LNG facility.</td><td rowspan="2">Prepare and implement a Construction Environmental Management Plan to the satisfaction of the Western Australian Minister for Environment, which addresses the following:
• schedule of construction activities;
• details of the construction methods to be used;
• objectives and targets;
• environmental management;
• environmental training and inductions;
• environmental monitoring, contingencies and reporting; and
• stakeholder consultation.
In order to address the potential impacts to air quality identified within this section the CEMP may include environmental management measures such as:
• dust control measures for unsealed roads, exposed surfaces and active construction areas;
• restriction of vehicle movements and vehicle speeds to reduce dust emissions; and
• an awareness program of the need to minimise dust generation.
Management Plans will be developed in accordance with current industry practice and regulatory guidance, including DEC Guideline for the Development and Implementation of a Dust Management</td><td>Very Low</td></tr>
<tr><td>Potential dust deposition impacts from atmospheric emissions</td><td>Very Low</td></tr>
</table>

<table>
<tr><th rowspan="2">Environmental Aspect</th><th rowspan="2">Potential Impacts</th><th colspan="3">Mitigation Measures</th><th rowspan="2">Significance of Residual Impact</th></tr>
<tr><th>State Government Measures</th><th>Proposed Environmental Conditions</th><th>Future Proponent Management Plans</th></tr>
<tr><td rowspan="3">Atmospheric (gaseous) emissions during operations</td><td>Decrease in air quality resulting in health impacts</td><td rowspan="3">Precinct will meet the national environment protection goals of approved NEPM and other established environmental quality criteria, while recognising contributions from other existing sources. The buffer zone will acknowledge:
• environmental and social protection ‘no go’ areas;
• location of supporting infrastructure; and
• social, heritage and recreational user groups outside buffer zones.

Prepare and implement a Fire Management Strategy for the Dampier Peninsula to align with existing fire management strategies to reduce the frequency of fires and the occurrence of late dry season burns on the Peninsula. Refer to Part 4, Section 2.7.</td><td rowspan="3"></td><td rowspan="3">Program (Draft, 2008).

Prepare an Air Quality Management Plan that addresses the following:
• compliance within the buffer zones determined by the State Government;
• results of cumulative air quality modelling;
• compliance with ambient NEPM standards;
• meteorological monitoring results;
• an emissions monitoring programme, which will likely include nitrogen compounds, BTEX, and hydrogen sulphide emissions from the LNG plant;
• participation in an ambient air monitoring program with other proponents of derived proposals; and
• annual reporting obligations.</td><td>Very Low</td></tr>
<tr><td>Local amenity impacts from atmospheric emissions</td><td>Very low</td></tr>
<tr><td>Potential deposition impacts from atmospheric emissions</td><td>Very Low</td></tr>
</table>

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2.9. Key Factor: Greenhouse Gas Emissions

The following section describes the predicted impacts anticipated from greenhouse gas (**GHG**) emissions from activities, facilities and other components to be implemented under the Plan for the BLNG Precinct (the Precinct) and the potential for cumulative impacts from activities that may indirectly arise as a result of the Precinct development (Category B) and other related resource activities in the region (Category C). The section also sets out the controls to be implemented to mitigate these impacts.

The objectives of this GHG assessment are to:

- identify and characterise the greenhouse gases that are relevant to the LNG Precinct, consistent with State, National and International standards, guidelines and methodologies;
- undertake an evaluation of proposed emissions in the context of State, National and International estimates and prediction of climate change scenarios; and
- assess the potential impacts anticipated to arise from LNG Precinct activities, as a basis to inform a future GHG management strategy.

This section provides an overview of the existing state of knowledge of greenhouse and climate change, the regulatory and Policy context at the State, National and international levels, anticipated emission sources and contribution to predicted impacts, and proposed mitigation and monitoring as a framework for managing greenhouse gas emissions for facilities within the BLNG Precinct going forward.

Background to Greenhouse Gases and Climate Change
GHG emissions are those gases within the atmosphere that absorb long-wave radiation, and thus trap heat reflected from the Earth's surface resulting in higher air temperatures which subsequently create the greenhouse effect. The main gases responsible for this effect are water vapour, carbon dioxide (**CO_2**), methane (**CH_4**) and nitrous oxide (**N_2O**). Other greenhouse gases include perfluorocarbons (**PFCs**), hydrofluorocarbons (**HFCs**) and sulphur hexafluoride (**SF_6**). The internationally recognised measure of greenhouse emission is CO_2-e which is an abbreviation of 'carbon dioxide equivalent'.

Climate change is a complex global issue requiring cooperative solutions to manage the impacts resulting from increased concentrations of greenhouse gases in the Earth's atmosphere. In responding to climate change, two broad approaches exist: the reduction of greenhouse gas emissions (avoidance) and concentrations in the atmosphere (mitigation) and preparing for the expected impacts that arise from changes to the climate system (adaptation). International efforts are underway to regulate greenhouse gas emissions across the Earth, with many developed nations committing to emission reductions as a result of being signatories to the Kyoto Protocol. Adaptation planning has already begun by governments and the private sector both in Australia and internationally.

Natural gas has an important role to play in displacing coal and crude oil derived fuels from existing and future power generation projects, as part of initiatives to reduce global carbon emissions. Technologies for power generation using natural gas, including LNG transportation, are proven and LNG projects have a key role to play in facilitating a transition to a low carbon future. Australia has 1.6% of known natural gas reserves worldwide (BP, 2010) and has for more than 20 years demonstrated its ability to reliably supply LNG to international customers.

Where used as a transitional fuel, LNG power generation systems produce on average 1.7 times more power for the same carbon emissions as coal fired generation (Hondo, 2005). This means that a peak production rate of 50Mtpa of LNG exported from the Browse reservoir could generate 750,000,000MWh of electricity; resulting in emission reductions of 312Mt CO_2 equivalents (**CO_2-e**) per year where LNG displaces coal fired power generation. This saving is equivalent to a 1.26% of global emissions referenced against a year 2000 baseline (Boden *et al.,* 2009).

2.9.1. Current Knowledge

The following sub-section describes the current and emerging Policy setting with respect to greenhouse emissions and climate change, and a summary of the existing state of knowledge relevant to potential impacts.

2.9.1.1. Key Regulatory Requirements, Environmental Policy and Guidance

A number of International frameworks, Commonwealth and State guidelines, strategies and policies are applicable and provide the context for assessing the key issues relating to greenhouse gas emissions and expectations for management. This section describes relevant International and Australian domestic regulatory frameworks, including an overview of known developments in policy.

International Framework

Greenhouse gas emissions are addressed internationally through the United Nations Framework Convention on Climate Change (**UNFCCC**). The Convention provides a framework for intergovernmental responses to climate change through the establishment of national emissions inventories, the avoidance and mitigation of future emissions and assistance for adaptation to the expected impacts resulting from emissions. The development and sharing of new policies to address these issues and the identification of best practice policies and actions is also a key outcome of the UNFCCC. The Convention imposes no binding obligations on governments as these are addressed in protocols, such as the Kyoto Protocol.

In December 2009, a conference of parties for the UNFCCC was held in Copenhagen. This meeting was expected to have announced binding reduction targets for the period beyond 2012. The Copenhagen Accord required all industrialised nations to submit emissions targets for 2020 by the end of January 2010. However, no agreement was reached on legally binding targets to supersede those negotiated under the Kyoto Protocol, and uncertainty surrounding the likely magnitude of future emissions targets remains. Developing countries were also required to submit voluntary mitigation actions by this deadline.

The IPCC is also associated with the UNFCCC and is the primary international advisory body on the science of climate change, including the environmental and socio-economic impacts associated with the projected changes to the Earth's climate system. The IPCC does not however have any regulatory function but operates only in a peer review advisory capacity.

National Framework

The UNFCCC and the Kyoto Protocol are the international regulatory frameworks for Australia's international obligations on climate change. The Kyoto Protocol established binding emissions targets for industrialised nations, including Australia. These emission targets are typically reductions compared to the emissions of the baseline year to be achieved by the end of 2012 and represent an average emission reduction of 5% of 1990 levels. Australia's emissions target was set under the Kyoto Protocol at 108% of 1990 levels.

In 2007, the Australian Government ratified the Kyoto Protocol, committing Australia to the reporting of emissions utilising a National Inventory and the binding emissions targets set out in the Protocol. Australia had been collating information about Australia's greenhouse emissions as part of the Australian Greenhouse Emissions Information System, well before ratification of the Protocol in Australia and as a result emissions inventories for 1990 to 2007 are available.

In July 2008 the Australian Government released the Carbon Pollution Reduction Scheme (**CPRS**) Green Paper, which outlined the Government's preferred position on how an emissions trading scheme should be designed and implemented in Australia (Commonwealth of Australia, 2008a).

In December 2008 the Australian Government released the CPRS White Paper, which set out the Government's policy in relation to two major elements of its mitigation strategy – a medium-term target range for national emissions and the final design of the CPRS. The White Paper committed the Government to reducing greenhouse gas emissions by at least 5% from 2000 levels by 2020, with a pledge to increase the cut to 15% if a global agreement on carbon reductions was reached (Commonwealth of Australia, 2008b).

In May 2009, the Government also committed to reducing national emissions to 25% below 2000 levels by 2020, in the context of a comprehensive global agreement capable of stabilizing atmospheric concentrations of greenhouse gases at 450ppm CO_{2}-e or lower. If it is not possible to secure international agreement, the Government will adopt a 2020 emissions reduction target within the original target range of 5 to 15%.

In April 2010 the Australian Government announced it had deferred the proposed implementation of the CPRS until at least 2013. In late September 2010, the Prime Minister announced the establishment of a new multi-Party Climate

Change Committee to investigate options for implementing a carbon price and to assist in establishing community consensus for action on climate change.

The *National Greenhouse and Energy Reporting Act 2007* (**NGER Act**) was enacted in 2008. It is designed to establish a single framework for the reporting of greenhouse emissions, energy production and energy consumption across all Australian jurisdictions for large organisations with large greenhouse emissions or energy consumption. The NGER Act forms the basis for the reporting elements, including reporting for the CPRS, through the establishment of a national system for reporting greenhouse gas emissions, energy consumption and production by corporations, which commenced on 1 July 2008. Data for the first 2008-09 reporting year was published by the Department of Climate Change and Energy Efficiency (**DCCEE**) in March 2010.

Two thresholds for the reporting of greenhouse and energy emissions are identified in the NGER Act:

- facility thresholds; and
- corporate group thresholds.

The facility threshold is set at 25kt of greenhouse gas emissions or 100 terajoules (**TJ**) of energy or fuel consumption for the first four reporting years (2008/9, 2009/10, 2010/11 and 2011/12). Corporate thresholds are set at 500TJ (0.5PJ) or 125kt for the 2008/9 reporting year, in line with the existing threshold for the *Energy Efficiency Opportunities Act 2006*, decreasing to 350TJ (87.5kt) in the 2009/10 reporting year and 200TJ (50kt). It is anticipated that proponents of derived proposals within the BLNG Precinct will trigger participation thresholds for both NGER and Energy Efficiency Opportunity programs, should these programs continue beyond the current program years.

State Framework

The overarching EPA environmental objective for this factor is to *"minimise emissions to levels as low as practicable on an on-going basis, and consider offsets to further reduce cumulative emissions."* (EPA, 2009d).

The primary State guidance for addressing greenhouse emissions for assessment of new developments is through the EPA's Guidance Statement Number 12 (EPA, 2002a). This guidance statement aims to assist in minimising the emission of greenhouse gases arising from projects. The guidance statement provides strategic direction for proponents with regards to the management and minimisation of greenhouse emissions. It requires proponents to consider five key aspects to the management of emissions, and specifically to address:

- GHG emissions inventory and benchmarking;
- Measures to minimise greenhouse gas emissions;
- Carbon sequestration;
- Minimising emissions over the life of the project; and
- Benefits on a national or global scale.

Two previous greenhouse and climate change policies have been released by former governments; the WA Greenhouse Strategy (WA Greenhouse Taskforce, 2004) and Making Decisions for the Future (DCC, 2007). Making Decisions for the Future, also known as the Premier's Action Statement on Climate Change, committed WA to a 60% reduction in emissions based on the 2000 baseline year to 26Mtpa by 2050. The State Government has also committed to developing a climate change adaptation and mitigation strategy for the State of WA.

2.9.1.2. Description of Factor

Recent climate change (global warming) has largely been attributed to the increase in atmospheric concentrations of greenhouse gases caused largely by anthropogenic emissions (IPCC, 2007). Global atmospheric concentrations of CO_2 in 2005 were 379ppm, up from 280ppm in pre-industrialised times. In particular, increases in CO_2, CH_4, nitrous oxide and the halocarbons are very likely to be the result of human activities (IPCC, 2007).

The IPCC, in their Fourth Assessment Report, stated that observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level are indicative of warming of the climate system. Discernible human influences extend also beyond average temperature to other aspects of climate, including temperature extremes and wind patterns (IPCC, 2007). There is a growing consensus within the international

scientific and political communities of the need to keep the increases in global average temperature to within 2°C, corresponding to a concentration of less than 400ppm of CO_2 in the atmosphere (IPCC, 2007). Progress has begun to establish binding emissions targets in support of reducing the annual growth in global emissions, but regulatory frameworks to support reduced emissions reductions are yet to be fully implemented.

The principles and approaches for managing the risk of climate change, including greenhouse gas mitigation, are developing rapidly and there is much debate as to the mechanisms for managing greenhouse gas emissions, including the magnitude and timing of reduction targets. Notwithstanding this, emissions targets are likely be referenced against emissions from a baseline year, potentially either the years 1990 or 2000. Global emissions, excluding land use changes, in 1990 were estimated to be 22,530Mt CO_2-e, with 2000 emissions estimated to be 24,697Mt CO_2-e (Boden *et al.,* 2009).

Global Climate Change Projections

Since 1990, the IPCC has provided regular scientific assessments of past, present and future climate scenarios. Four scientific assessments have been undertaken to date – in 1990, 1996, 2001 and 2007. A fifth assessment report is due in 2014.

In its Fourth Assessment Report, the IPCC concluded that:

- warming of the climate system is unequivocal;
- most of the warming in the past 50 years is very likely (more than 90% probability) due to the observed increase in greenhouse gas concentrations from human activities such as the burning of fossil fuels and land use change; and
- it is very likely that changes in the global climate system will continue well into the future, and that they will be larger than those seen in the recent past (IPCC, 2007).

Climate Change Projections at a Regional Level

CSIRO and Bureau of Meteorology are the lead agencies responsible for the development of climate change projections for Australia. These agencies have provided projections of the potential impacts of climate change for the North-West of WA in the Climate Change in Australia: Technical Report released in 2007 (CSIRO and Bureau of Meteorology, 2007). The spatial resolution of data in the report is insufficient to provide specific scenarios for the James Price Point area but projections for the Dampier Peninsula region can be interpolated using the 50th percentile (mean) projections and using the medium and high emissions scenarios (A1B and A1FI[1]) (**Table 2.9-1**). Increases in extreme weather conditions, including the number of days over 35°C (heatwave conditions) and increases in mean wind speed during the cyclone season (Australian summer) are also expected.

- **Table 2.9-1 Summary of Climate Change Projections for a Range of Climate Variables.**

Climate Variable	2030 mean ranges	2050 mean ranges
Temperature	+ 1.5 to 2°C	+ 2 to 2.5°C
Rainfall	-2 to -5%	-2 to -5%
Evaporation	+2 to +4%	+4 to +8%
Wind speed	-2 to +2%	-2 to +2%
Humidity	-0.5 to +0.5%	-0.5 to +1%

Source: CSIRO and BoM, 2007.

Potential regional impacts arising from climate change, based on the 2007 CSIRO / Bureau of Meteorology Report, a recent coastal vulnerability assessment (DCC, 2009a) and on a high-level understanding of the geography and existing climate in the region, include the risk of:

- inundation of low lying coastal regions due to sea level rise of up to 1.1m by 2100;
- increased intensity of extreme storm events, in particular cyclone activity;

[1] A1B is the name given to an emissions scenario where there is rapid economic growth and population increases until mid century with a balanced portfolio of energy sources, rather than relying on fossil fuel intensive sources. A1FI has the same population and economic conditions, but relies on fossil fuel intensive energy sources.

- changes in surface water coverage as a result of storm or flood waters exacerbated by sea level rise and extreme rainfall events;
- increased wind and lightning activity;
- increased ground movement and changes in groundwater which are likely to accelerate degradation of power generation and refinery plant foundations, as well as of transmission lines, gas and oil pipelines;
- extreme heatwave events, which are likely to increase in frequency with impact on infrastructure and living systems, including an increase of heat related illnesses; and
- increases in vector borne tropical diseases affecting workers and the community.

Changes to the climate system have already been observed throughout WA, including in the Kimberley, where sea level is rising at a rate of 8.1mm per year, more than twice the global average (National Tidal Centre, 2009). Increases in rainfall in the north-west of WA may be due to aerosol pollution from Indonesia affecting cloud cover, resulting in reduced temperatures and increased rainfall in that area (Bates, pers comm. 2009). Although it is too early to determine whether these changes are due to anthropogenic climate change or variations in natural processes associated with oceanographic and atmospheric processes, the impact of these observed changes is not diminished by this uncertainty.

2.9.2. Identification of Key Aspects

2.9.2.1. Definition of Relevant Aspects

Aspects associated with the development and operation of the BLNG Precinct and associated infrastructure relevant to climate change / GHG emissions include the following:

- Atmospheric emissions (greenhouse gases) – greenhouse gas emissions will be produced during construction, commissioning, operation and decommissioning phases of the LNG facilities within the BLNG Precinct.
- Vegetation and habitat clearing - clearing of vegetation will result in some greenhouse gas emissions being released to the atmosphere.
- Altered fire regime – fires are an existing significant contributor to local and regional air quality conditions (assessed in detail in **Part 4**, **Section 2.8**). The BLNG Precinct may result in altered fire regimes, which may lead to an improvement in local/regional air quality conditions.

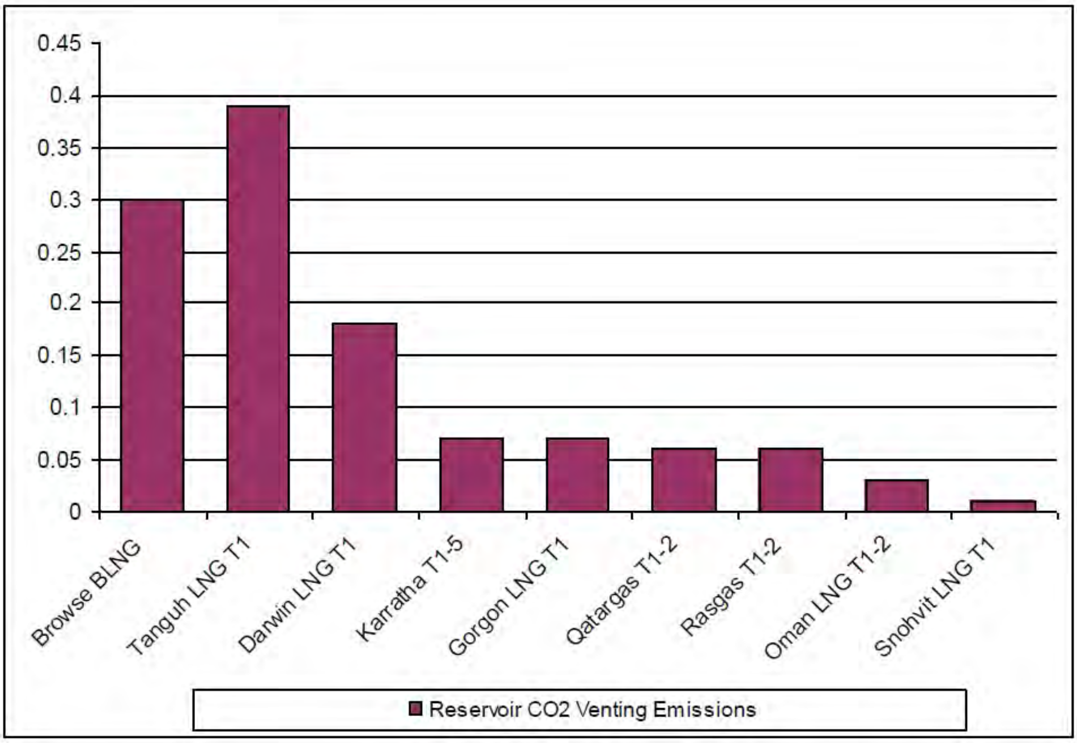
2.9.2.2. Sources of Potential Impact

Greenhouse gas emissions would be produced during the construction, commissioning, operation and decommissioning phases of the LNG facilities within the BLNG Precinct. Indicative estimates of greenhouse gas emissions have been made, reflecting current available information on typical technology and process selection by the potential Foundation Proponent, and based on predicted greenhouse intensity of reservoir CO_2 from the Browse Basin, compared to the reported greenhouse intensities of other LNG projects. It is important to keep in context that LNG processing technologies within the BLNG Precinct are unknown, and multiple proponents may introduce different technologies, which will influence the GHG intensity at an individual facility level.

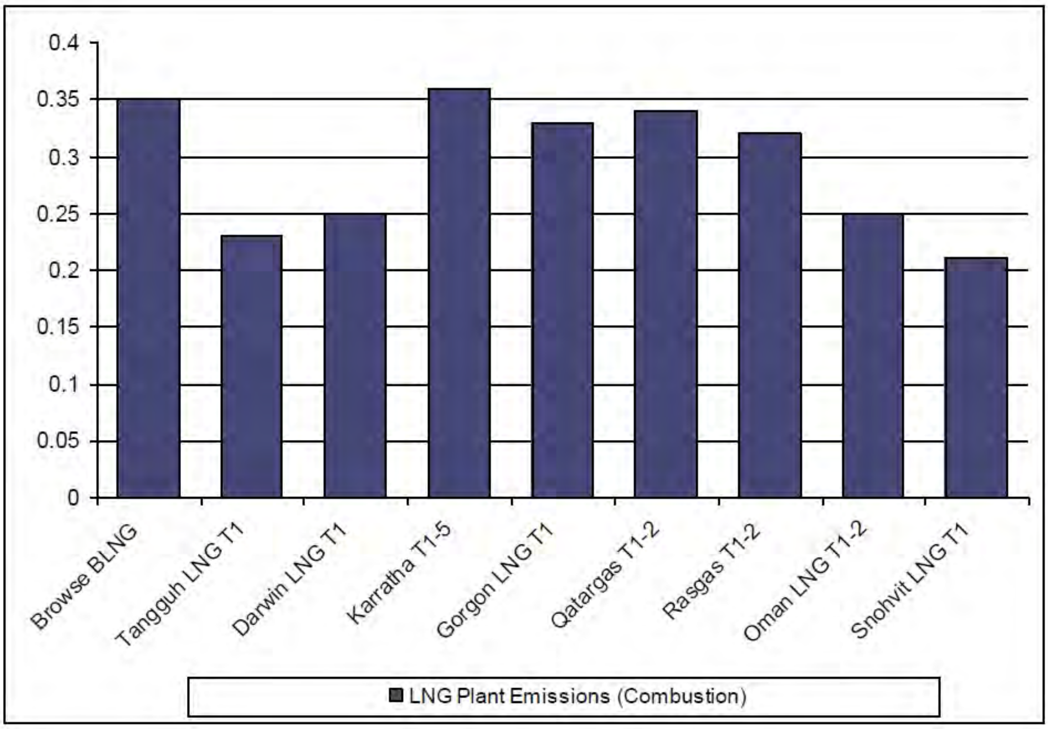
Emissions associated with the construction and decommissioning phases will be very small in comparison to those associated with the operational phase (in the order of 1%). Similarly fugitive emissions include emissions resulting from intentional or unintentional GHG releases (such as natural gas leaks from joints and seals) are expected to be minor. Based on industry best practices, a conservative estimate of 0.1% of total GHG emissions will result from fugitive emissions.

The two most significant sources of emissions to atmosphere from large LNG projects are reservoir emissions and emissions resulting from the combustion of natural gas for the purposes of energy generation to operate the plant. Reservoir emissions are dependent on the concentrations of CO_2 naturally occurring in the reserve. Emissions from combustion can vary according to the plant design and operating procedures, as well as be influenced by the prevailing environment that may impact the efficiency of operations.

Figure 2.9-1 and **Figure 2.9-2** summarise the greenhouse intensities of some of the major LNG plants worldwide (existing and planned) compared to the BLNG Precinct emission intensity, separated by emissions associated with reservoir CO_2 and those related to combustion. The benchmarking emissions do not include any allowance for upstream emissions, which are Category C activities considered in **Section 2.9.6.2** of this section.



- **Figure 2.9-1 GHG Emissions Intensity Comparison – Reservoir CO_2 (Tonnes CO_2-e / Tonnes LNG).**



- **Figure 2.9-2 GHG Emissions Intensity Comparison – LNG Plant Combustion Emissions (Tonnes CO_2-e / Tonnes LNG).**

The basis for combustion emission for the BLNG Precinct is anticipated to be in the region of 0.35 tonnes of CO_2-e / tonne of LNG and reservoir CO_2 will vary based on the CO_2 of the reservoir. The average reservoir CO_2 content of the Browse Basin gas reserves is expected to range between 6-12mol percent of the gas content. A 10mol percent reservoir CO_2 content, as an intermediate value, equates to approximately 0.3 tonnes of CO_2e per tonne of LNG, and reservoir CO_2 will vary based on the CO_2 of the reservoir (giving total GHG emission of 0.65).

The reservoir CO_2 content of other LNG gas reserves varies from as little as 1mol percent (Oman), Qatargas (2.1mol percent), Rasgas (2.3mol percent) to 14 percent and higher (for example Gorgon). The reservoir CO_2 content of the Browse gas fields is at the high end of the range.

It should also be noted that the Snohvit facility, which has the lowest greenhouse index, is located in the Arctic Circle. The cooler ambient conditions provide a significant efficiency advantage compared to warmer climates. Snohvit uses an electric drive for the refrigerant compressors with the electricity sourced from aeroderivative turbines (with waste heat recovery for the process). Snohvit also incorporates a connection to the main power grid to reduce requirements for spinning reserve. The Snohvit facility is also subject to a mandatory Norwegian carbon tax regime, providing greater financial incentives for increased efficiency compared to other plants. The Oman LNG facility uses water cooling. This contributes to its high efficiency coupled with low reservoir CO_2 content.

CO_2 contained in the feed gas stream must be removed prior to the liquefaction process (to avoid CO_2 freezing in piping and processing units) and therefore higher CO_2 content feed gas results in greater CO_2 removal prior to liquefaction. Vented reservoir CO_2 directly influences the GHG footprint of an LNG plant. CO_2 is typically disposed of to atmosphere by venting, however the final disposal method is yet to be determined and may include the use of a thermal oxidizer or thermal combustion unit (for removal of BTEX), or venting CO_2 to air (refer to **Part 2**, **Section 5** (Description of Activities and Facilities)).

Notwithstanding these differences, benchmarking the GHG emissions intensity of the proposed BLNG Precinct against other LNG projects provides a measure of performance in the industry. The Browse reservoir CO_2 content is at the high end of the range. It is important to keep in context that LNG processing technologies within the BLNG Precinct are unknown, and multiple proponents may introduce different technologies, which will influence the GHG intensity at an individual facility level.

Table 2.9-2 identifies GHG emission sources from downstream activities.

- **Table 2.9-2 Sources of Significant GHG Emissions from Expected Downstream Activities.**

Key Characteristics	Activity Sources
Gas processing and liquefaction plant	• gas pre-treatment, conditioning and liquefaction processing; and • fugitive emissions.
Hydrocarbon storage facilities	• fugitive emissions.
Supporting Utilities	• flare and fuel systems facilities; • energy generation (diesel drive generators); • nitrogen plant; • CO_2 removal unit ; and • utility liquid and gaseous fuel systems.

Table 2.9-3 presents a summary of the anticipated emissions of CO_2-e, by source, based on the emissions profiles as described in **Part 2**, **Section 5** (Description of Activities and Facilities).

Table 2.9-3 Emissions by Source Based on Different BLNG Precinct Development Scenarios.

Emissions Area / Source	GHG (CO_2-e) (Mtpa)			
	Low case (15Mtpa)	Medium case A (25Mtpa)	Medium case B (35Mtpa)	High case (50Mtpa)
Energy Generation	5.6	9.3	13	19
CO_2 removal unit *	6.2	10.3	14	20
Flares	0.02	0.033	0.046	0.066
Fugitive emissions	0.0018	0.0029	0.004	0.006
Total emissions (Mtpa)	**12**	**20**	**27**	**39**

Note: * There may be variability in the magnitude of emissions from CO_2 removal unit, dependent on range of reservoir CO_2 content (between 6-12mol percent). The emissions presented in this table reflect the average expected (10mol percent) assumed for the purpose of this assessment.

There will also be supply chain emissions (Category C) associated with the gas production in the Browse Basin and the pipeline from the Browse Basin to James Price Point. This is considered in **Section 2.9.6** of this section in the context of cumulative impacts.

Other Minor Contributing Sources – Vegetation Clearing, Bushfires and Indirect Operational Activities

Some GHG emissions will be produced by the activities associated with the workers accommodation facilities as energy and resource consumption servicing the fly-in fly-out population. Using a per capita estimate of emissions, it is possible to capture at a strategic level the emissions associated with typical activities of daily life including those associated with electricity, gas, water, wastewater, solid waste, transport, etc in a single emissions factor. Based upon the latest estimate of the greenhouse gas emissions and population for WA (DCC, 2009b and ABS, 2008a), the emissions factor would be 0.036kt per capita per annum. Due to changes in the workforce numbers associated with construction phases, the annual emissions profile varies significantly as shown in **Table 2.9-4.**

Table 2.9-4 Population Based Emissions Associated with the Accommodation Facilities for the Proposed Development Scenarios.

Year	Total Emissions Mt CO_2-e			
	Scenario 2 (15Mtpa)	Scenario 3A (25Mtpa)	Scenario 3B (35Mtpa)	Scenario 4 (50Mtpa)
Cumulative total	0.945	1.308	2.030	2.174
Annual percentage of BLNG Precinct emissions	0.28%	0.23%	0.25%	0.19%

On average, annual emissions from this source represent between 0.19 and 0.28% of annual BLNG Precinct emissions, based on a conservative assumption.

Trees and other vegetation store a portion of the CO_2 that they absorb from the atmosphere during growth as woody biomass. Clearing of vegetation will result in some carbon being lost to the atmosphere as CO_2, along with small amounts of CH_4 and NO_2 as a result of decomposition or burning. The magnitude of the emissions associated with the clearing of vegetation for the purposes of site preparation or construction associated with earthworks for the BLNG Precinct will be very minor compared to that generated from operation of the BLNG Precinct. In view of this, GHG emissions associated with vegetation clearing are not discussed further in this section.

The development of the BLNG Precinct at James Price Point has the potential to introduce new ignition sources to the area. As part of the BLNG Precinct development, an extensive fire management program will be implemented for bushfire and safety purposes in the areas surrounding the BLNG Precinct for bushfire safety purposes. With implementation of these measures, the development is unlikely to increase the number and intensity of fires locally. In view of this, GHG emissions associated with increased bushfires are not discussed further in this section.

2.9.3. Predicted Impacts

Potential impacts from GHG emissions relevant to the construction and operation of the BLNG Precinct, and corresponding management approach, are discussed in the following sub-sections and summarised in **Table 2.9-11**.

Operation of facilities within the LNG Precinct would result in the release of greenhouse gases. Taking into account a range of potential outcomes and also recognising that global warming and associated climate change are the cumulative results of many such sources across the globe, its contribution to climate change is currently unknown.

Combustion emissions from energy generation will vary depending on the type of technology selected for the LNG processing facilities. However, it is anticipated that technology selection and associated generation of emissions will be selected to achieve a range of emissions within those indicated in the tables above.

Emissions of GHG, unlike other common air emissions, affect the Earth's weather system globally. Emissions from WA are a small component of annual greenhouse gas emissions on a global scale and it is the cumulative effect of emissions from all nations that are responsible for the changes being experienced in the climate system, including sea level rise.

The BLNG Precinct may result in the emission of between 12Mt CO_2-e and 39Mt CO_2-e per year, based on the greenhouse intensity assumed for this Strategic Assessment, assuming base case without abatement of CO_2. However, it is anticipated that proponents of derived proposals would be expected to demonstrate best practice measures to further reduce GHG emissions through implementation of greenhouse gas abatement plans. The base case emissions, without abatement, represents between 15.7 and 51.1% of the total emissions for WA based on the 2007 estimate of 76.3Mt CO_2-e (DCC, 2009b). The indicative emissions projected for the BLNG development scenarios represent between 2.0 and 6.5% of Australia's domestic emissions (DCC, 2009b) of 597.2Mt CO_2-e as summarised in **Table 2.9-5**.

- **Table 2.9-5 Projected GHG Emissions Relative to Baseline Emissions for WA and Australia.**

LNG Project	LNG Production Rate (Mtpa)	GHG Emissions – No Abatement (Mtpa CO_2-e)	GHG Emissions – With Abatement (Mtpa CO_2-e)	Percent relative to 1990 WA Baseline (Mtpa CO_2-e)	Percent relative to 2007 WA Emissions (Mtpa CO_2-e)	Percent relative to 1990 Australian Baseline (Mtpa CO_2-e)	Percent relative to 2007 Australian Emissions (Mtpa CO_2-e)
Pluto (Phase 1)	6		1.9	3.3	2.5	0.34	0.32
Pluto (Phase 2)	12		4.1	7.2	5.4	0.74	0.69
Gorgon (Expanded to 3 trains)	15		5.45	9.7	7.3	1.0	0.93
Browse – low case	15	12		20.8	15.7	2.2	2.0
Browse – medium case A	25	20		34.7	26.2	3.7	3.3
Browse – medium case B	35	27		46.9	35.4	4.9	4.5
Browse – high case	50	39		67.7	51.1	7.1	6.5

Source: DCC, 2009b; EPA, 2007; and EPA, 2009c.

To place these values in a policy context for national reduction targets (previously summarised in **Section 2.9.1.1**) the Commonwealth Government has committed to an unconditional 5% reduction of CO_2-e emissions target by 2020, below 2000 levels. This represents an emissions target of approximately 525Mt CO_2-e, approximately 72Mt CO_2-e less than 2007 estimates. The potential emissions from this project are the equivalent of 2.2 percent to 7.4 percent of the reduced emissions target. Development of the BLNG Precinct will result in emissions equivalent to between 0.05% and 0.16% of global emissions referenced against a 2000 baseline of 24,697Mt CO_2-e.

2.9.3.1. Approach to Mitigation and Safeguards

The EPA's environmental objective for GHG emissions is to minimise emissions to levels as low as practicable on an on-going basis, and consider offsets to further reduce cumulative emissions (EPA, 2009f).

In accordance with EPA Guidance Statement No.12, it is expected that best practicable measures should be applied to maximise energy efficiency and minimise emissions. To achieve this the EPA's environmental assessment objective is to ensure that potential greenhouse gas emissions emitted from proposed projects are adequately addressed in the planning/design and operation of projects and that:

- best practicable measures are applied to maximise energy efficiency and minimise emissions;
- comprehensive analysis is undertaken to identify and implement appropriate offsets; and
- proponents of derived proposals undertake an ongoing program to monitor and report emissions and periodically assess opportunities to further reduce greenhouse gas emissions over time.

In line with EPA guidance and recent environmental approvals in Western Australia, it is expected that proponents of derived proposals seeking to locate in the BLNG Precinct will be required to submit a Greenhouse Gas Abatement Plan with any referral to EPA seeking a derived proposal under this Strategic Assessment. In addition, a condition would be proposed to require any proponents of derived proposals to submit a report annually to the EPA on the progress of the implementation of the abatement plan.

Proponents of derived proposals will be expected to prepare and implement a Greenhouse Gas Abatement Plan (**GGAP**) in consultation with the relevant regulatory agencies. The Greenhouse Gas Abatement Plan would include an evaluation of options for sequestration or other carbon capture methods.

The Greenhouse Gas Abatement Plan would address the following:

- targets for greenhouse gas emissions;
- inventory of greenhouse gas emissions;
- best practice measures to reduce greenhouse gas emissions including controls to maintain plant reliability and reduce venting and flaring;
- strategies to incorporate greenhouse considerations in plant design, technology selection and operation;
- evaluation of the feasibility of greenhouse gas emissions reductions, carbon sequestration and/or capture opportunities;
- compliance with any National scheme for reduction of CO_2-e emissions;
- independent verification of emissions in line with National schemes for managing and reporting greenhouse gas emissions;
- regular monitoring and external reporting, auditing of greenhouse gas emissions and performance; and
- periodically review the effectiveness of improvement measures through the regular monitoring of greenhouse gas emissions and adaptive management of emissions, aimed at reducing greenhouse gas emissions per tonne of LNG produced where practicable.

The GGAP for individual LNG facilities would be expected to include specific abatement targets and timeframes for achievement, including 'no regrets' measures such as energy efficiency programs.

A range of options to further reduce emissions are available, and will be the subject of further investigation to evaluate their feasibility as part of the greenhouse gas abatement plan. These are discussed below.

Improved Fire Management Regime
The State's commitments and proposed management measures to improve the local fire management regime, including a Dampier Peninsula Fire Management Strategy (refer **Part 4**, **Section 2.7**) may also provide the opportunity for GHG benefits to be derived.

The establishment and operation of a strategic fire management program on the Dampier Peninsula, in cooperation with the Traditional Owners is an option to reduce GHG emissions, similar to the West Arnhem Land Fire Abatement

(**WALFA**) project in the Northern Territory. Under this program, Indigenous ranger groups are established and trained to undertake strategic early season burning across country, through a partnership agreement between the Aboriginal Traditional Owners and Indigenous ranger groups, Darwin Liquefied Natural Gas (**DLNG**), the Northern Territory Government and the Northern Land Council.

The EPA has advised that controlled burning could reduce overall greenhouse gas emissions by preventing more intense late season wildfires (EPA, 2006a). This is based on the assumption that frequent late dry season fires in the Northern Kimberley may be slowly reducing the plant biomass in the region and creating a net release of CO_2 into the atmosphere.

The Kimberley Land Council (**KLC**) is already advancing a North Kimberley Fire Abatement Project, based on this partnership model with local indigenous rangers. The State Government is in discussions with the KLC to extend this project to the Dampier Peninsula and confirm mechanisms and resources for support and funding by the State and proponents of derived proposals.

Consideration of Reservoir CO_2 Reinjection

Geological storage or geosequestration refers to the injection of CO_2 into suitable deep petroleum reservoirs or saline aquifers, where the geological conditions trap the gas, preventing it from migrating back to the surface. Injection to this depth usually requires compression to a dense supercritical fluid state. Three industrial scale storage projects are currently in operation: at Sleipner in Norway (saline aquifer offshore); Snohvit in Norway (CO_2 returned down-dip of producing reservoir); and at In Salah in Algeria (CO_2 returned down-dip of producing reservoir). In addition the CO2CRC Otway project is trialling CO_2 reinjection in Victoria.

There are many challenges for geological storage including certainty of trap integrity, the requirement for long-term monitoring of CO_2; the jurisdictional and legal implications of a multi-generational monitoring commitment; associated corporate liability; and public acceptance. Over the longer term, the injected CO_2 will dissolve completely into the reservoir fluids (over centuries) with a small proportion eventually forming mineral complexes (depending on the mineralogy of the reservoir rocks) where it will become permanently fixed and stable in the subsurface. The distance between CO_2 source and sink (i.e. structural traps) is also a key consideration on the technical and commercial feasibility of geosequestration as a viable option.

Geosequestration is one of a range of GHG options that are subject to a range of investigations for feasibility by proponents of derived proposals. The outcomes of these investigations, together with a review of other greenhouse gas emissions reductions and carbon sequestration and/or capture opportunities, will be addressed as part of the Greenhouse Gas Abatement Plan.

Total Carbon Capture

Total carbon capture refers to the capture of the exhaust plumes from power generation and liquefaction turbines and the subsequent removal of the CO_2 for either storage such as through geosequestration or treatment. Total carbon capture from all exhausts is a technology not yet proven for commercial applications.

Based on currently available studies from the power sector, capture costs have been estimated by the IPCC to be in the range of US$ 38 – 91/ t CO_2-e for an onshore facility. Also the additional process machinery required to implement total carbon capture would significant increase energy use and GHG emission needing to be geosequestered in its own right. The energy required to operate post-combustion capture system reduces the overall efficiency of the system by as much as 24-40%. Given the experimental nature of this technology it is not recommended for the Browse development at this stage. Consideration shall be given to provision of space in the case of future retrofit (e.g. blowers in the vicinity of the gas turbines).

Forestry Carbon Sequestration and Market Mechanisms

Specific investment in biological carbon sinks is a potential avenue for offsetting carbon emissions. Establishing forestry carbon sinks is one of the current benchmark methods for offsetting greenhouse emissions. There are inherent risks associated with biological carbon sinks. To use forestry as an example, natural disasters such as bush fires and drought may affect performance of offsets.

While modelling suggests forestry would require around 500,000ha of new forest to be established and maintained to offset forecast emissions from a 50Mtpa LNG Precinct, biological carbon sinks may play a role in an integrated GHG management approach or as a source of emission permits.

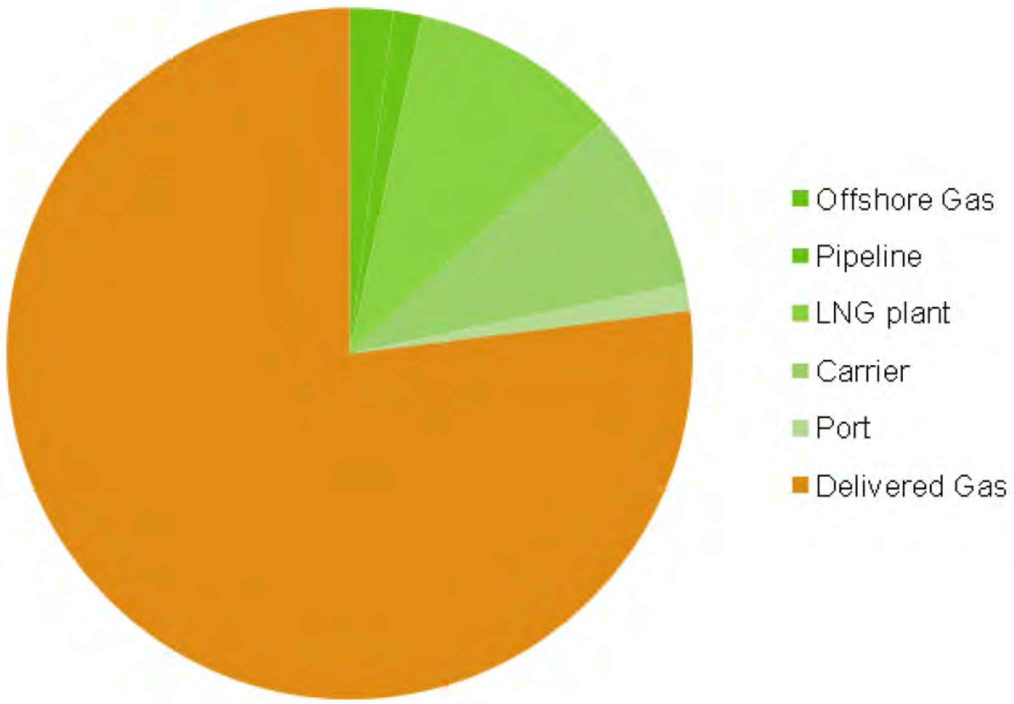
Carbon emission permits refer to systems where emitters purchase the right to emit a certain amount of CO_2-e. The Commonwealth government's approach to emissions trading is currently subject to further policy development by the recently established Climate Change Committee. The advantages to emissions trading lie in the ability to offset the emissions in a market based system without having the high capital expenses of reservoir CO_2 reinjection and other methods. However the market based approach introduces the risk of variable costs for offsetting the carbon emissions due to market and offset performance, availability and provision of permits particularly over the long time period Browse will be operating.

2.9.3.2. Lifecycle Emissions

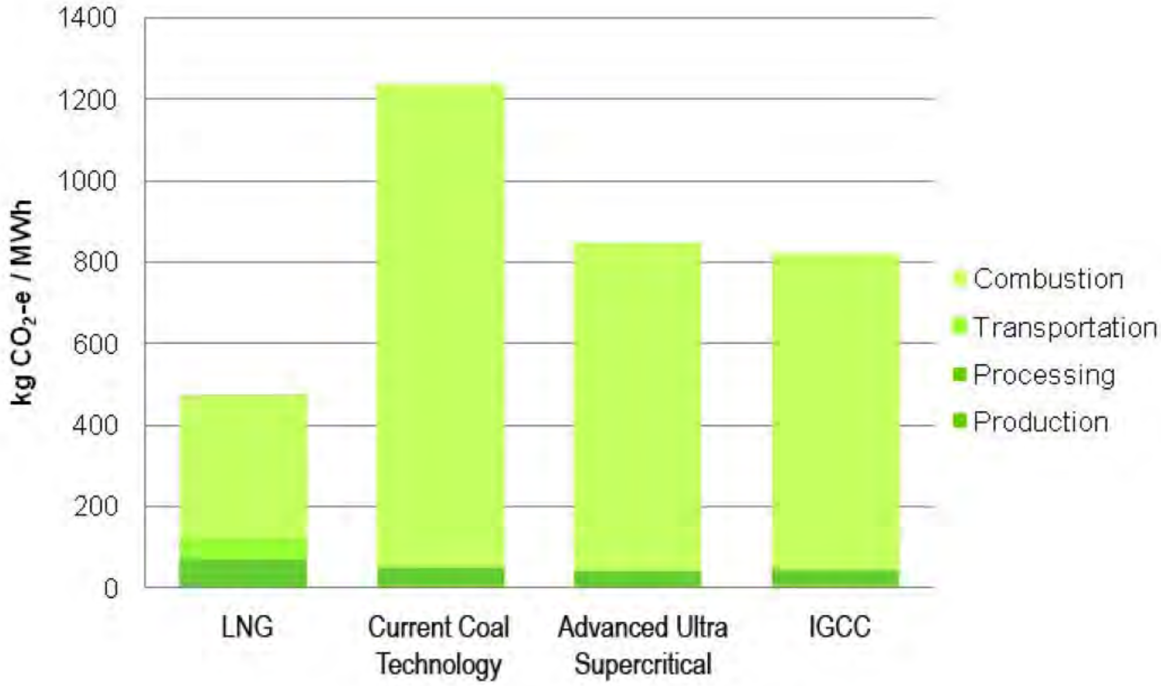
Upstream and BLNG Precinct emissions represent only a fraction of the total greenhouse gas emissions associated with LNG. Downstream and end use emissions are illustrated in **Figure 2.9-3**. BLNG Precinct and upstream emissions represent approximately 17% of the supply chain emissions based on the relative percentages for the average of high and low estimates for each element of the supply chain (Heede, 2006).

As can be seen in **Figure 2.9-4**, emissions associated with the utilisation of natural gas are significantly larger than the emissions associated with the upstream and downstream aspects of the supply chain. In isolation, emissions associated with the use of natural gas seem considerable. However, consideration should be given to the potential for natural gas to reduce emissions globally through the displacement of coal and oil based power generation systems as demonstrated through the lifecycle emissions by fuel type in **Table 2.9-6** and **Table 2.9-7**.

A recent US study on the lifecycle emissions of LNG versus existing and future coal power generation identified that emissions from LNG based power generation using existing natural gas combined cycle (**NGCC**) technology were 38% of those from current American coal technology mix and 57% of the most efficient future coal technologies (Advanced Ultra Supercritical and Integrated Gasification Combined Cycle (**IGCC**). For comparison, the existing emission factor for electricity on the WA South West Interconnected System (**SWIS**) is 0.84t of CO_2-e per MWh, producing almost 1.8 times more emissions per unit of electricity than a system based on only natural gas combined cycle generation systems.



- **Figure 2.9-3 Supply Chain Greenhouse Gas Emissions for LNG.**



- **Figure 2.9-4 Supply Chain Lifecycle Emissions for Power Generation.**

- **Table 2.9-6 Lifecycle Greenhouse Gas Emissions for Power Generation in USA.**

Scenario	Lifecycle emission factor ($t\ CO_2$-e / MWh)
LNG	0.47
Current US coal technology	1.24
Advanced ultra supercritical	0.85
IGCC	0.82

Source: PACE, 2009.

An earlier study of power generation in Japan, Australia's largest LNG customer, based on existing Japanese power plants yielded similar results (**Table 2.9-7**). Differences between emissions factors for LNG can be attributed to technology changes which have improved the efficiency in the four years between when the two studies were published.

- **Table 2.9-7 Lifecycle Greenhouse Gas Emissions for Power Generation in Japan.**

Scenario	Lifecycle Emission Factor ($t\ CO_2$-e / MWh)
Coal fired	0.975
Oil fired	0.742
LNG fired	0.608
LNGCC	0.519

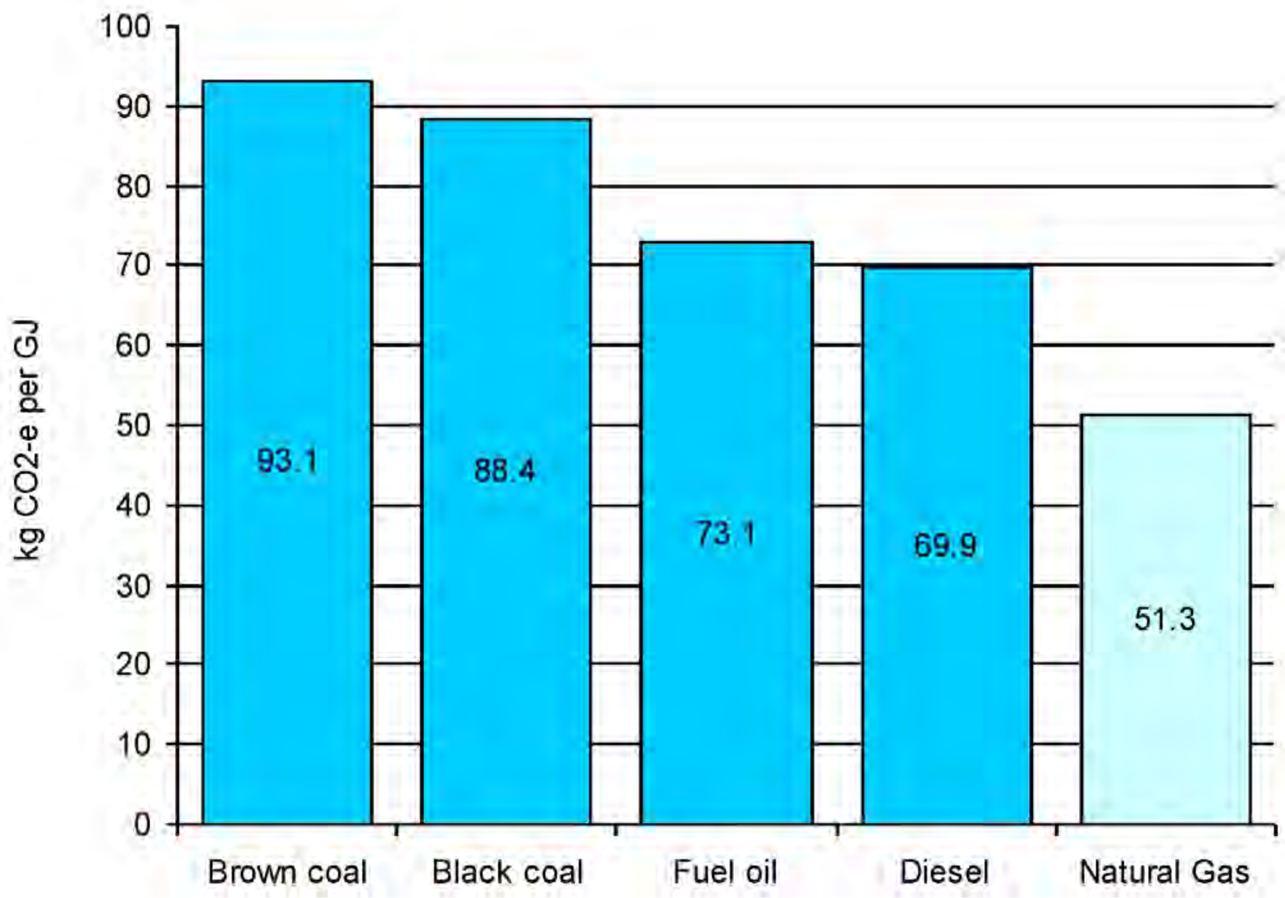
Source: Hondo, 2005.

2.9.3.2.1. Global Emissions Reductions from LNG Use in Power Generation Compared to Other Fossil Fuels

A considerable amount of available literature demonstrates that GHG emissions from power plants using LNG as a fuel source are considerably lower than those from plant using other fossil fuel sources.

The development of the BLNG Precinct represents a new source of GHG emissions for Australia. However, the project provides the opportunity for LNG to displace coal fired generation in the emerging economies in Asia. This has the potential to deliver a positive environmental outcome in terms of a reduction in net global GHG emissions. In practical terms, the development of the Browse Basin and the BLNG Precinct has the potential to enable emission reductions of 312Mt of CO_2-e per year if LNG displaces coal fired power generation, based on 15.15 tonnes LNG per MWh electricity, using Hondo (2005) averaged LNG (LNG fired and LNGCC) and coal emissions factors. This saving is equivalent to a 1.26% of global emissions referenced against a 2000 baseline year.

Figure 2.9-5 compares the direct emission intensities of selected fuels on the basis of greenhouse gas emitted per unit of energy. The figure shows that natural gas produces 51.3kg CO_2–e per gj compared with diesel, fuel oil and black coal which emit between 69.9 - 93.1kg CO_2 -e per gj. However, **Figure 2.9-5** does not include emissions associated with extraction, processing and transportation.



- **Figure 2.9-5 Comparative GHG Emissions Intensities of Common Fuels.**

2.9.4. Management Measures

Mitigation measures and safeguards that have been identified to manage potential impacts from greenhouse gases are outlined in **Table 2.9-8** and **Table 2.9-9**.

- **Table 2.9-8 Proposed Environmental Conditions for the Strategic Proposal that may affect Greenhouse Gas Emissions.**

Condition No.	Proposed Environmental Conditions for the Strategic Proposal
T9.1	Prior to commencement of commissioning of terrestrial LNG facilities, proponents of derived proposals shall prepare and submit a report demonstrating that currently applied best practice measures, in terms of greenhouse gas emissions, have been adopted in the design of the LNG processing facilities. Greenhouse gas emissions per tonne of LNG produced will be benchmarked against publically available data for other comparable national and overseas LNG processing facilities. This report will outline key measures that have been adopted in detailed design to ensure best practice emissions and associated efficiency gains have been achieved.
T9.2	Proponents of derived proposals shall submit a report annually, that addresses: • greenhouse Gas abatement measures undertaken during the reporting period; • greenhouse gas audits; • compliance with energy efficiency targets for managing greenhouse gases; and • reporting will be in accordance with Nationally legislated schemes for greenhouse gas reporting and disclosure.

- **Table 2.9-9 Requirements to be Addressed via Development of a Management Plan to Support a Derived Proposal in regards to Greenhouse Gas Emissions.**

Derived Proposal Requirements	Timing
Prepare a Greenhouse Gas Abatement Plan, to the satisfaction of the Minister for Environment, that addresses the following: • targets for greenhouse gas emissions; • inventory of greenhouse gas emissions; • best practice measures to reduce greenhouse gas emissions including controls to maintain plant reliability and reduce venting and flaring; • strategies to incorporate greenhouse considerations in plant design, technology selection and operation, including defined targets and timeframes for achievement of no regrets measures such as energy efficiency programs; • evaluation of the feasibility of greenhouse gas emissions reduction opportunities; • compliance with any National scheme for reduction of CO_2-e emissions. The GGAP will be reviewed should future National or State schemes be enacted to appropriately respond to future requirements; • independent verification of emissions in line with National schemes for managing and reporting greenhouse gas emissions; • regular monitoring and external reporting, auditing of greenhouse gas emissions and performance; and • periodically review the effectiveness of improvement measures through the regular monitoring of greenhouse gas emissions and adaptive management of emissions, aimed at reducing the greenhouse gas emissions per tonne of LNG produced where practicable. It is expected that operators within the Precinct will provide a Continuous Improvement Report every five years to the Minister for Environment, outlining review of measures undertaken to date and practicability of measures for the next Reporting period. The GGAP for individual LNG facilities would be expected to include specific abatement targets and timeframes for achievement, including 'no regrets' measures such as energy efficiency programs. The Greenhouse Gas Abatement Plan will be subject to a period of public review prior to finalisation. Refer also **Part 4**, **Section 2.7** – for measures to establish Fire Management Strategy.	Prior to commissioning of LNG plant and updated for ongoing operational requirements

2.9.5. Environmental Outcome of Category A Activities

The BLNG Precinct may result in the emission of between 12Mt CO_2-e and 39Mt CO_2-e per year. The emissions, without abatement, represent between 15.7 and 51.1% of the total emissions for WA based on the 2007 estimate of 76.3Mt CO_2-e (DCC, 2009b) which is between 2.0 and 6.8% of Australia's total emissions estimate (DCC, 2009b) of 597.2Mt CO_2-e. Proponents of derived proposals would be expected to demonstrate best practice measures to further reduce GHG emissions through implementation of Greenhouse Gas Abatement plans and benchmarking to demonstrate GHG efficiency benefits.

Any proponents of derived proposals in the BLNG Precinct will be required to submit a Greenhouse Abatement Plan with any referral to EPA seeking a derived proposal under this Strategic Proposal. In addition, a condition would be proposed to require any proponents of derived proposals to submit a report annually to the EPA and publicly on the progress of the implementation of the abatement plan. A range of options to further reduce emissions are available, and will be the subject of further investigation to evaluate their feasibility as part of the greenhouse gas abatement plan.

The development of the BLNG Precinct provides the opportunity for LNG to displace coal fired generation in the emerging economies in Asia. This has the potential to deliver a positive environmental outcome in terms of a reduction in net global GHG emissions equivalent to a 1.26% of global emissions referenced against a 2000 baseline year.

2.9.6. Cumulative Impacts of the Proposal and Associated Activities

The cumulative emissions of the BLNG Precinct proposal and from emissions from indirectly facilitated or related projects in the region have been considered in this section.

2.9.6.1. Category B Emissions

Emissions from activities that may indirectly arise as a result of the development and operation of the BLNG Precinct (Category B activities) are largely driven by increases to the population base in Broome (approximately 60km from James Price Point) as result of the BLNG Precinct development. By using a *per capita* estimate of emissions, based upon the latest estimate of the greenhouse gas emissions and population for WA (DCC, 2009b and ABS, 2008a) it is possible to capture at a strategic level the emissions associated with the range of Category B activities which result in emissions (electricity, gas, water, wastewater, solid waste, transport as well as the incidental emissions associated with telecommunications) in a single emissions factor.

Population driven emissions, based on increased population due to construction activities represent a small percentage of emissions in comparison to annual BLNG Precinct emissions as shown in **Table 2.9-10**.

- **Table 2.9-10 Population Based Emissions Associated with Increased Population in Broome Due to Construction and Operation.**

	Scenario 2	Scenario 3A	Scenario 3B	Scenario 4
Total population increase in peak year	1309	8775	8655	11458
Year of peak population	2041	2034	2030	2036
Emissions in Mtpa	0.047	0.314	0.310	0.410
Percentage of BLNG precinct emissions	0.4%	1.6%	1.1%	1.0%

Similar to Category A activities, land clearing for Category B activities such as for residential and industrial development around Broome, will result in some greenhouse gases being lost to the atmosphere as CO_2 along with smaller amounts of CH_4 and NO_2. However, the scale of emissions associated with land clearing are minor compared to that generated from Category A activity operations. Whilst the carbon content of pindan vegetation is not available, a similar study based on savannahs in the NT determined a carbon content of approximately 75t/ha permanently cleared (Collins *et al.,* 2009). This is likely to represent an overestimate of the carbon content of the vegetation at James Price Point, but serves as a useful indicator of the emissions associated with the clearing. Conservatively assuming an indicative land area of up to 3,300ha may be cleared, and assuming a complete clearing of existing vegetation, one-off land clearing represents approximately 0.26Mt CO_2-e, or between 0.7 and 2.2% of annual BLNG Precinct emissions (50 and 15Mtpa scenarios respectively).

2.9.6.2. Category C Emissions

Category C emissions include supply chain emissions associated with the gas production in the Browse Basin and the pipeline from the Browse to James Price Point. Supply chain emissions are those emissions which result from the production of gas at the Browse Basin and the transportation using undersea pipelines to James Price Point. This includes fugitive emissions and energy consumption associated with the platform and pipelines.

GHG emissions have been estimated for the Browse Upstream Development based on current knowledge of the reservoir gas composition and the level of engineering definition for the project. The estimate of emissions from the Upstream Development range from approximately 1.07Mtpa CO_{2e} for 15Mtpa production to 2Mtpa CO_{2e} for the expanded development of 25Mtpa. Main emissions of CO_{2e} are from export compression (36%), power generation (25%) and later in the life of the development, low pressure compression (24%). Emissions from flaring (12%), transport (<1%) and fugitive emissions (<2%) are anticipated to make up a small proportion of GHG emissions over the life of the development

The assessment of GHG emissions, and the proposed measures to manage GHG emissions, for the Browse Upstream Development, will be subject of a separate EIS.

- **Table 2.9-11 Impact Assessment Summary Table for Greenhouse Gas Emissions.**

<table>
<tr><th rowspan="2">Environmental Aspect</th><th rowspan="2">Potential Impacts</th><th colspan="2">Mitigation Measures</th></tr>
<tr><th>Proposed E nvironmental Conditions</th><th>Future Proponent Management Plans</th></tr>
<tr><td>Emission of Greenhouse Gases</td><td>Contribution to climate change through generation and emissions of greenhouse gases during operation and construction</td><td>Prior to commencement of commissioning of terrestrial LNG facilities, proponents of derived proposals shall prepare and submit a report demonstrating that currently applied best practice measures, in terms of greenhouse gas emissions, have been adopted in the design of the LNG processing facilities. Greenhouse gas emissions per tonne of LNG produced will be benchmarked against publically available data for other comparable national and overseas LNG processing facilities. This report will outline key measures that have been adopted in detailed design to ensure best practice emissions and associated efficiency gains have been achieved.

Proponents of derived proposals shall submit a report annually, that addresses:
• greenhouse Gas abatement measures undertaken during the reporting period;
• greenhouse gas audits; and
• compliance with energy efficiency targets for managing greenhouse gases.

Reporting will be in accordance with Nationally legislated schemes for greenhouse gas reporting and disclosure.</td><td>Prepare a Greenhouse Gas Abatement Plan, to the satisfaction of the Minister for Environment, that addresses the following:
• targets for greenhouse gas emissions;
• inventory of greenhouse gas emissions;
• best practice measures to reduce greenhouse gas emissions including controls to maintain plant reliability and reduce venting and flaring;
• strategies to incorporate greenhouse considerations in plant design, technology selection and operation, including defined targets and timeframes for achievement of no regrets measures such as energy efficiency programs;
• evaluation of the feasibility of greenhouse gas emissions reduction opportunities;
• compliance with any National scheme for reduction of CO_2-e emissions. The GGAP will be reviewed should future National or State schemes be enacted to appropriately respond to future requirements;
• independent verification of emissions in line with National schemes for managing and reporting greenhouse gas emissions;
• regular monitoring and external reporting, auditing of greenhouse gas emissions and performance; and
• periodically review the effectiveness of improvement measures through the regular monitoring of greenhouse gas emissions and adaptive management of emissions, aimed at reducing the greenhouse gas emissions per tonne of LNG produced where practicable. It is expected that operators within the Precinct will provide a Continuous Improvement Report every five years to the Minister for Environment, outlining review of measures undertaken to date and practicability of measures for the next Reporting period.

The GGAP for individual LNG facilities would be expected to include specific abatement targets and timeframes for achievement, including ‘no regrets’ measures such as energy efficiency programs.

The Greenhouse Gas Abatement Plan will be subject to a period of public review prior to finalisation.

Refer also **Part 4**, **Section 2.7** – for measures to establish Fire Management Strategy.</td></tr>
</table>

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