



## Application for Licence Amendment

### Division 3, Part V *Environmental Protection Act 1986*

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<b>Licence Number</b>	L9102/2017/1
<b>Licence Holder</b>	Chevron Australia Pty Ltd
<b>ACN</b>	086 197 757
<b>File Number</b>	DER2017/001839
<b>Premises</b>	<p>Gorgon LNG Project</p> <p>Part of Crown Lease L007431 Certificate of Title Volume 3158 Folio 477, Part of CO<sub>2</sub> Injection Wells Licence 00564-2009-A1744377, and Portion of Lot 3000 on Deposited Plan 91514, being the subject of Easement shown on Deposited Plan 70903</p> <p>As defined by the coordinates in Schedule 1 of the Licence</p>
<b>Date of Report</b>	30 July 2019
<b>Status of Report</b>	Final

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# 1. Definitions of terms and acronyms

In this Decision Report, the terms in Table 1 have the meanings defined.

**Table 1: Definitions**

Term	Definition
ACN	Australian Company Number
AGRU	acid gas removal unit
aMDEA	activated methyl diethanolamine
BI Act Section 13 Approval	means the <i>Barrow Island Act 2003 (WA)</i> – Section 13 Approval to Dispose of Carbon Dioxide by Injection Into Subsurface Formation, inclusive of approved variations
BI Act	<i>Barrow Island Act 2003</i>
BTEX	Benzene, toluene, ethylbenzene and xylene
Category/ Categories/ Cat.	Categories of Prescribed Premises as set out in Schedule 1 of the EP Regulations
CO <sub>2</sub>	carbon dioxide
CO <sub>2</sub> Disposal Management Plan	means the most recent version of the Gorgon Project carbon dioxide disposal management plan approved by the BI Act Minister
CS Act	<i>Contaminated Sites Act 2003 (WA)</i>
Decision Report	refers to this document.
Delegated Officer	an officer under section 20 of the EP Act.
Department	means the department established under section 35 of the <i>Public Sector Management Act 1994</i> and designated as responsible for the administration of Part V, Division 3 of the EP Act.
DJTSI	Department of Jobs, Tourism, Science and Innovation
DomGas	domestic gas
DJTSI	Department of Jobs, Tourism, Science and Innovation
DMIRS	Department of Mines, Industry Regulation and Resources Safety
DWER	Department of Water and Environmental Regulation As of 1 July 2017, the Department of Environment Regulation (DER), the Office of the Environmental Protection Authority (OEPA) and the Department of Water (DoW) amalgamated to form the Department of Water and Environmental Regulation (DWER). DWER was established under section 35 of the <i>Public Sector Management Act 1994</i> and is responsible for the administration of the <i>Environmental Protection Act 1986</i> along with other legislation.
e6m <sup>3</sup> /d	million cubic metres per day
e9m <sup>3</sup>	billion cubic metres

<b>Term</b>	<b>Definition</b>
EIS/ERMP	Environmental Impact Statement/Environmental Review and Management Programme
EPA	Environmental Protection Authority
EP Act	<i>Environmental Protection Act 1986 (WA)</i>
EP Regulations	<i>Environmental Protection Regulations 1987 (WA)</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999 (Cth)</i>
Existing Licence	The Licence issued under Part V, Division 3 of the EP Act and in force prior to the commencement of, and during this amendment assessment
GTG	Gas turbine generator
GTP	Gas Treatment Plant
H <sub>2</sub> S	Hydrogen sulfide
Licence Holder	Chevron Australia Pty Ltd
LNG	liquefied natural gas
m <sup>3</sup>	cubic metres
MEG	monoethylene glycol
MMscf/d	million standard cubic feet per day
MRU	mercury removal unit
MS	Ministerial Statement
mtpa	million tonnes per annum
MW	Megawatts
mole	As defined in the International System of Units
NEPM	National Environmental Protection Measure
NMVOCs	Non-methane VOCs
Noise Regulations	<i>Environmental Protection (Noise) Regulations 1997 (WA)</i>
NO <sub>2</sub>	Nitrogen dioxide
NO <sub>x</sub>	Oxides of nitrogen
O <sub>3</sub>	Ozone
PGER Act	<i>Petroleum and Geothermal Energy Resources Act 1967</i>
PM	Particulate Matter
PM <sub>10</sub>	used to describe particulate matter that is smaller than 10 microns (µm) in diameter

Term	Definition
PP Act	<i>Petroleum Pipelines Act 1969</i>
ppm	parts per million
Prescribed Premises	has the same meaning given to that term under the EP Act.
Premises	refers to the premises to which this Decision Report applies, as specified at the front of this Decision Report
Primary Activities	as defined in Schedule 2 of the Licence
Reservoir CO <sub>2</sub>	as defined in Schedule 2 of Ministerial Statement 800 Reservoir CO <sub>2</sub> is a <i>gas stream that consists overwhelmingly of carbon dioxide and coming from the acid gas removal units of the Gas Treatment Plant located on Barrow Island. The carbon dioxide will contain incidental associated substances derived from the natural gas and the process used to separate the carbon dioxide from that natural gas.</i>
Risk Event	As described in <i>Guidance Statement: Risk Assessment</i>
SO <sub>x</sub>	Oxides of sulfur
Tcf	trillion cubic feet
TSEPP	Terrestrial and Subterranean Environment Protection Plan
TSEMP	Terrestrial and Subterranean Environment Monitoring Program
µg/m <sup>3</sup>	micrograms per cubic metre
µg/L	micrograms per litre
VOCs	volatile organic compounds
WHO	World Health Organisation
WHRU	waste heat recovery units
WWTP	wastewater treatment plant

## 2. Purpose and scope of assessment

Chevron Australia Pty Ltd (Chevron, the Licence Holder) operates the Gorgon LNG Premises (the Premises) under L9102/2017/1 (existing licence) located on Part of Crown Lease L007431, Barrow Island. The existing licence authorises operation of a three train gas treatment plant (GTP) including supporting infrastructure, power supply, a bridging wastewater treatment plant (WWTP), liquid waste facility, diesel storage facility, waste concrete storage area and waste transfer station under Categories 10, 34, 52, 54, 62 and 73 of the *Environmental Protection Regulations 1987* (EP Regulations).

On 9 May 2019, the Licence Holder submitted an application (the Application) to amend Licence L9102/2017/1 to allow for the operation of reservoir carbon dioxide (CO<sub>2</sub>) compression, transport and injection infrastructure (hereafter referred to as the CO<sub>2</sub> infrastructure), and extend the Premises boundary to include the CO<sub>2</sub> infrastructure locations within the Premises (Part of CO<sub>2</sub> Injection Wells Licence 00564-2009-A1744377 and Part of Lot 3000 on Deposited Plan 91514).

Reservoir CO<sub>2</sub> is the acid gas stream from the Gorgon GTP acid gas removal units (AGRU)

which is comprised overwhelmingly of CO<sub>2</sub> together with incidental associated substances derived from the natural gas and the process used to separate the CO<sub>2</sub> from the natural gas. This definition is taken from Ministerial Statement 800 (MS 800), the approval for the Premises granted under Part IV of the *Environmental Protection Act 1986* (EP Act) (refer to section 5.1 for further details).

Operation of the infrastructure will allow reservoir CO<sub>2</sub> (waste gas) extracted from the inlet gas via the AGRUs to be sequestered, through injection underground into the Dupuy Formation, a sandstone rock layer located at depths between 2,000 and 2,300 m below the surface of Barrow Island. The Licence Holder proposes to sequester the reservoir CO<sub>2</sub> in order to reduce the greenhouse gas (GHG) emissions associated with the operation of the Gorgon Project and address the requirements of conditions within MS 800 which require underground injection of reservoir CO<sub>2</sub>.

The Delegated Officer has determined that operation of the CO<sub>2</sub> infrastructure is an activity directly related to Category 10 and 34 therefore emissions and discharges associated with the operation of the infrastructure require assessment and inclusion within the scope of L9102/2017/1.

This Decision Report documents the Delegated Officer's risk assessment of emissions and discharges associated with the operation of the CO<sub>2</sub> infrastructure, and determination of the application consistent with the Department of Water and Environmental Regulation's (DWER) *Guidance Statement: Risks Assessment* and *Guidance Statement: Decision Making* respectively. Risks associated with activities, emissions and discharges already authorised to occur at the Premises under the Existing Licence have been assessed previously therefore these have not been considered as part of this assessment.

## 2.1 Application details

The Licence Holder has applied for a licence amendment. Table 2 lists the documents submitted during the assessment process.

### **Table 2: Documents and information submitted during the assessment process**

Document/information description	Date received
<p>Email titled <i>Submission: Chevron – Gorgon Licence Amendment (L9102/2017/1) to include CO<sub>2</sub> Facilities</i> including the following attachments:</p> <ul style="list-style-type: none"> <li>• Application form: works approval, licence, renewal, amendment, or registration (v11 Feb 2019) with: <ul style="list-style-type: none"> <li>Attachment 1A – Occupier Status</li> <li>Attachment 1B – Company Extract</li> <li>Attachment 2 – Premises Maps and Coordinates</li> </ul> </li> </ul>	9 May 2019 (A1787461)
<p>Email titled <i>Gorgon Submission: Revised RFI Response: L9102/2017/1 – LICENCE AMENDMENT APPLICATION</i> including the following attachments:</p> <ul style="list-style-type: none"> <li>• ABU190501191_DWER Revised RFI Response.Rev 0</li> <li>• Prescribed Premise Boundary Coordinates</li> <li>• CONFIDENTIAL ATTACHMENT</li> </ul>	17 June 2019 (DWERDT168589)
<p>Email titled <i>Mapping updates required for L9102/2017/1 Gorgon CO<sub>2</sub> Amendment</i> including the following attachments:</p> <ul style="list-style-type: none"> <li>• Infrastructure and equipment table</li> <li>• GORG_187A-Rev5_A3_TEN_PrimaryActivityInfrastructure</li> <li>• GORG_267A-Rev8_A3_TEN_CO2EmissionPoints</li> </ul>	1 July 2019 (DWERDT174567)

### 3. Background

The Premises is located on Barrow Island; an A-Class Nature Reserve (Crown Reserve 11648) situated 85 km north-west of Onslow. The Premises is operated by the Licence Holder on behalf of a joint venture comprising of the following companies:

- Chevron Australia Pty Ltd;
- Chevron (TAPL) Pty Ltd;
- Shell (Australia) Pty Ltd;
- Mobil Australia Resources Company Pty Limited;
- Osaka Gas Gorgon Pty Ltd;
- Tokyo Gas Gorgon Pty Ltd; and
- JERA Gorgon Pty Ltd.

Construction of the Gorgon LNG Plant and associated infrastructure commenced in 2009. Due to the size and complexity of the project, multiple works approvals and licences were granted to facilitate staged construction, commissioning and operation of the Premises and supporting infrastructure. Two works approvals (W4818/2010/1 and W5178/2012/1) were granted for construction of the GTP (refer to section 5.4.2 for full approvals history). Construction and commissioning of the CO<sub>2</sub> infrastructure was included within the scope of W5178/2012/1.

The first licence authorising operation of the GTP was granted for LNG Train 1 in July 2016 (L8952/2016/1). Subsequent to this, following completion of the commissioning of LNG Trains 2 and 3 and associated infrastructure, the first consolidated licence capturing all three LNG trains, and supporting infrastructure and facilities was granted on 30 July 2018 (L9102/2017/1).

The Licence Holder did not seek inclusion of the CO<sub>2</sub> infrastructure in the initial application for



L9102/2017/1 due to technical issues with the infrastructure which required rectification in order to ensure it could be operated safely. The existing licence therefore currently authorises the acid gas stream (reservoir CO<sub>2</sub>) from the AGRU's to be vented to atmosphere. The Licence Holder intends to steadily reduce the volume of acid gas vented from the AGRUs as the CO<sub>2</sub> infrastructure is progressively brought into operation, until there is no further routine venting of acid gas. Ad hoc venting of acid gas will however still occur from the AGRUs and the reservoir CO<sub>2</sub> venting system during process upsets, maintenance of the CO<sub>2</sub> infrastructure and start up/shut down events.

Table 3 lists the prescribed premises categories that are included on the Existing Licence together with the assessed production capacity. The Application relates only to the operation of the CO<sub>2</sub> infrastructure and extension of the Premises boundary therefore no changes to the prescribed categories or assessed production capacity have been proposed.

**Table 3: Prescribed Premises categories in the Existing Licence L9102/2017/1**

Classification of Premises	Description	Approved Premises production or design capacity or throughput
Category 10	Oil or gas production from well: premises, whether on land or offshore, on which crude oil, natural gas or condensate is extracted from below the surface of the land or the seabed, as the case requires, and is treated or separated to produce stabilised crude oil, purified natural gas or liquefied hydrocarbon gases.	LNG: 18 million tonnes per Annual Period DomGas: 300 TJ/day Condensate: 1 million tonnes per Annual Period
Category 34	Oil or gas refining: premises on which crude oil, condensate or gas is refined or processed.	
Category 52	Electrical power generation: premises (other than premises within category 53 or an emergency or standby power generating plant) on which electrical power is generated using a fuel.	585.5 MW
Category 54	Sewage facility: premises — (a) on which sewage is treated (excluding septic tanks); or (b) from which treated sewage is discharged onto land or waters.	1,385 m <sup>3</sup> /day
Category 62	Solid waste depot: premises on which waste is stored, or sorted, pending final disposal or re-use.	240,000 tonnes of stockpiled concrete Waste per Annual Period 52,050 tonnes of other solid Waste per Annual Period
Category 73	Bulk storage of chemicals, etc: premises on which acids, alkalis or chemicals that — (a) contain at least one carbon to carbon bond; and (b) are liquid at STP (standard temperature and pressure), are stored.	1,090 m <sup>3</sup>

## 4. Overview of Premises

### 4.1 Operational aspects

Natural gas is extracted from the Gorgon and Jansz-Lo gas fields (situated 65 and 130 km off the west coast of Barrow Island) and is transported to the Gorgon GTP located on the island for processing. The GTP produces LNG via three LNG processing trains with a maximum annual throughput of 18 mtpa. Lesser amounts of condensate and domestic gas (DomGas) are also produced.

Feed gas enters the GTP via inlet processing facility slug catchers which segregate the gas into three phases (gas, condensate and aqueous). The separated gaseous phase then undergoes acid gas removal to separate acid gases from the feed gas to prevent them from freezing at low temperatures during the LNG production process. The separated acid gas stream (reservoir

CO<sub>2</sub>) comprises predominantly CO<sub>2</sub> (at least 97% (mole)) with minor amounts of incidental associated substances which could include any or all of the following:

- Hydrocarbon (including traces of BTEX) - <3% (mole) during routine conditions and <10% (mole) during non-routine conditions;
- H<sub>2</sub>S - <400 ppm volume;
- Nitrogen - <1,000 ppm volume;
- Water - <3,000 ppm volume;
- corrosion inhibitor - < 5 ppm volume; and
- carryover of monoethylene glycol (MEG) injected into the compressor trains. Injection of MEG (80% MEG/20% water) is infrequent (during process upsets and start-up only) therefore the amount carried over is expected to be insignificant.

The composition of the reservoir CO<sub>2</sub> will vary over the life of the Gorgon Project due to variability within the gas fields and production within each gas field. The content of incidental substances listed above is the maximum expected to occur for each substance. Monitoring of the injection stream will be undertaken to determine the actual volume and composition of reservoir CO<sub>2</sub>.

The majority of the reservoir CO<sub>2</sub> is intended to be injected into the Dupuy Formation located between 2,000 and 2,300 m beneath Barrow Island with minor amounts being vented to atmosphere from the AGRUs and the reservoir CO<sub>2</sub> venting system during commissioning, process upset conditions, maintenance and start-up/shut down events.

The following sections further describe the acid gas removal stage and reservoir CO<sub>2</sub> compression, transport and injection.

#### 4.1.1 Acid gas removal

The gas stream from the GTP slug catcher and the condensate stabilisation unit is routed to the three AGRUs (one per processing train) for CO<sub>2</sub> and hydrogen sulfide (H<sub>2</sub>S) (collectively termed acid gas) removal using proprietary activated methyl diethanolamine (aMDEA) technology.

The AGRU is made up of three systems:

- An initial mercury removal unit (MRU) to remove mercury from the gas stream. Removal of mercury will ensure there is no mercury within the reservoir CO<sub>2</sub> which will be injected underground and vented to atmosphere;
- Absorber system, which is designed to remove CO<sub>2</sub> and H<sub>2</sub>S from the gas by absorption into an aMDEA solvent; and
- Regenerator system, which is designed to regenerate the aMDEA solvent for reuse by separating it from the acid gas components following absorption.

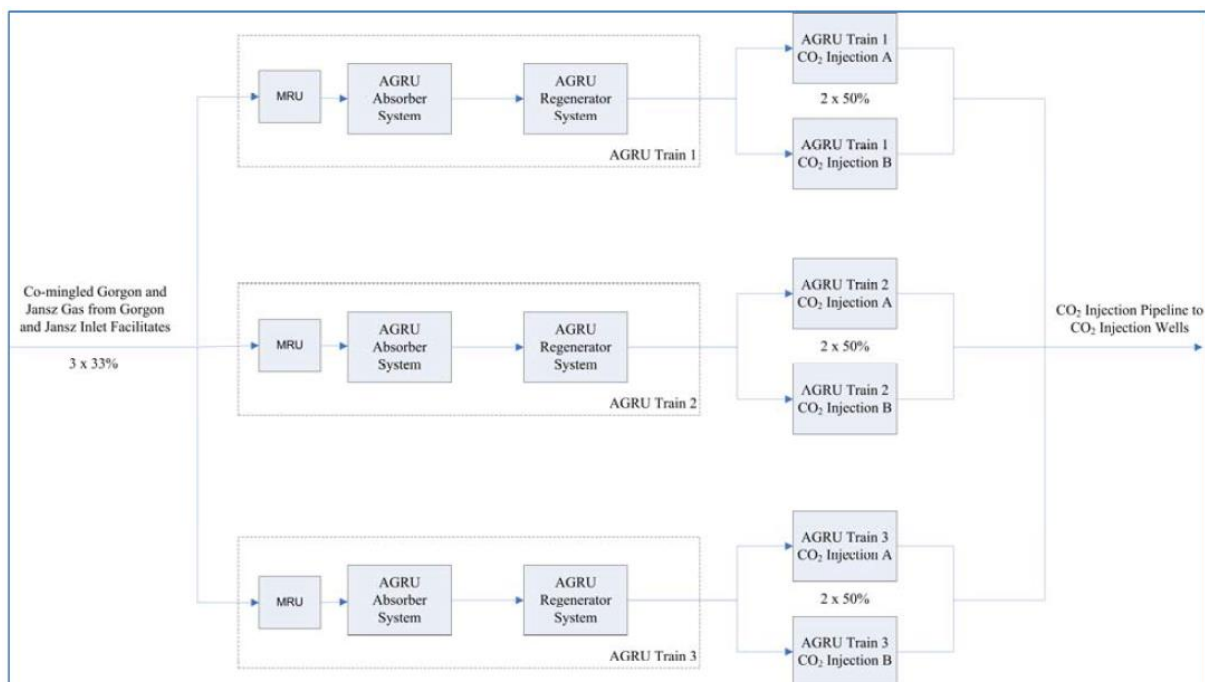
For additional liquid recovery, there is a series of inter-stage compressors, knockout drums, and coolers which recover liquids and re-route them back to the AGRU train. This enables additional resource recovery and efficiency.

#### 4.1.2 Carbon dioxide (CO<sub>2</sub>) compression, transport and injection

As described in the above section, acid gases (reservoir CO<sub>2</sub>) are recovered from feed gas through absorption into aMDEA solvent within three AGRUs located within the GTP. The recovered reservoir CO<sub>2</sub> then undergoes compression within CO<sub>2</sub> compression facilities. Each AGRU has two 50% CO<sub>2</sub> compression strings (total of six compressors). The reservoir CO<sub>2</sub> gas recovered by the AGRUs flows to the compressors and is dehydrated during the compression process until it is expelled as a hot supercritical fluid.

A supercritical fluid is any substance above its critical temperature and pressure. In this phase, the fluid will possess both gas and liquid like properties which allow it to fill the maximum pore space available (Chevron 2005). The supercritical fluid discharged from the CO<sub>2</sub> compression modules is commingled via a common header and routed, via an underground pipeline, to three injection drill centres (DC-A, DC-B, and DC-C) located approximately 1.2 km, 3.6 km, and 6.3 km north of the GTP. At each drill centre, reservoir CO<sub>2</sub> is sent via a common manifold to a series of injection wells and is injected into the Dupuy Formation.

Each drill centre has between two and four injection wells (there are a total of nine injection wells). Flow to the drill centres and injection wells is monitored and controlled from the central control room at the GTP. The injection wells will be brought into service in stages based on injection volumes from the compression modules and reservoir response. The reservoir CO<sub>2</sub> collection and compression process is illustrated in Figure 1 below.



**Figure 1 Gorgon reservoir CO<sub>2</sub> collection and compression process**

During routine operations all reservoir CO<sub>2</sub> removed from the incoming gas is proposed to be injected to the Dupuy Formation, a 300-500 m thick sandstone rock layer located 2,000 to 2,300 m below the surface of Barrow Island. Due to the depth of the formation, the higher pressure and temperature within allow for the injected reservoir CO<sub>2</sub> to remain in a supercritical phase, minimising the volume of rock which will be occupied by the injected gas. The reservoir CO<sub>2</sub> will be injected into pore spaces within the formation which normally contain saline water (formation water) or occasionally oil or gas.

Several geological sealing formations overlie the Dupuy formation which provide barriers to the migration of the reservoir CO<sub>2</sub> back to the surface. These include the Basal Barrow Group Shale (part of the Barrow Formation) which is anticipated to be a competent top seal over the injection area (Chevron 2005). Once injected, there are four mechanisms by which the host reservoir (Dupuy Formation) traps the injected gas. These include solution trapping, residual gas trapping, mineralogical trapping and large-scale geometric trapping.

Extensive investigation of the feasibility of disposal of reservoir CO<sub>2</sub> to the Dupuy Formation has been undertaken by Chevron to understand the subsurface geology and stratigraphy, injectivity, and capacity of the formation to store CO<sub>2</sub>, and the likely behaviour and movement of the injected reservoir CO<sub>2</sub> in the subsurface. Further detail of the investigations undertaken, and mechanisms by which the injected gas will be trapped within the Dupuy Formation, is included

in the draft Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Gorgon Development (EIS/ERMP) (Chevron 2005) and the Gorgon Gas Development Revised and Expanded Proposal Public Environmental Review (PER) (Chevron 2008) which are publicly available documents.

The CO<sub>2</sub> injection system has been designed to be capable of disposing of 100% of the volume of reservoir CO<sub>2</sub> expected to be removed during the life of the Gorgon Project. The injection volume will vary over the Project life due to the natural variability of CO<sub>2</sub> within the gas fields supplying input to the GTP. Chevron proposes that the injection volume will be less than a maximum daily rate of 9.9 e6m<sup>3</sup>/d (350 MMscf/d) and less than an annual average injection rate of 9.2 e6m<sup>3</sup>/d (325 MMscf/d). The maximum injected volume for the life of the Gorgon Project will be less than 87.5 e9m<sup>3</sup> (3.1 Tcf).

The rate of reservoir CO<sub>2</sub> which will be supplied for injection is a function of the production rate of the Gorgon gas field and the ability of the AGRUs to process that gas. The injection rate during the start-up phase will be limited by the availability of reservoir CO<sub>2</sub> compression capacity. The injection rate per injection unit is approximately 70 MMscf/d. When all compression trains are operational, the injection rate is anticipated to be approximately 210 MMscf/d MMSCFD, which is less than the maximum daily rate of 350 MMscf/d.

While the majority of the reservoir CO<sub>2</sub> is intended to be injected to the Dupuy Formation, ad hoc venting of the gas will still be required during the initial commencement of operation of the infrastructure, and when the infrastructure is fully operational for maintenance activities, start-up/shutdowns, and upset conditions. There are a number of valves within the Premises (relief, blowdown, depressurising) that form part of the reservoir CO<sub>2</sub> venting system and allow for venting to occur from the AGRUs. The volume of reservoir CO<sub>2</sub> expected to be vented has not been able to be accurately predicted as it is not known how often upset conditions requiring venting of the gas will occur. The volume of reservoir CO<sub>2</sub> vented will however be observed as MS 800 conditions restrict venting volumes as a percentage of total emissions by specifying a minimum volume (by percentage) of reservoir CO<sub>2</sub> which must be injected. Reporting of the reservoir CO<sub>2</sub> available for injection and the actual volume injected is also a requirement of MS 800 (see section 5.1.3 for details). The difference in reported values equates to the volume vented. Venting of reservoir CO<sub>2</sub> was also previously within the decision report for the Existing Licence. The outcomes of this assessment are included in Appendix 4.

## 4.2 Infrastructure

Additional infrastructure on the Premises associated with CO<sub>2</sub> compression, transport and injection is detailed in Table 4 with reference to the Site layout map in Schedule 1 of the amended Licence. The additional infrastructure has been specified in the infrastructure and equipment table (Table 13) in the amended licence.

**Table 4: Gorgon LNG Project CO<sub>2</sub> compression, transfer and injection infrastructure**

	Infrastructure	Site Plan Reference <sup>[1]</sup>
<b>Prescribed Activity Categories 10 and 34 directly related activities</b>		
Acid gases are separated from process gas via the AGRUs and directed to the reservoir CO <sub>2</sub> compression, transfer and injection system.		
1	3 x CO <sub>2</sub> compression modules each containing two compressors	37A, 37B, 37C
2	CO <sub>2</sub> transport pipeline	38
3	3 x CO <sub>2</sub> injection drill centres with associated injection wells as per below: <ul style="list-style-type: none"> <li>• Drill Centre A with 2 injection wells</li> <li>• Drill Centre B with 4 injection wells</li> <li>• Drill Centre C with 3 injection wells</li> </ul>	39A 39B 39C

Injection wells and pipelines have been designed and constructed for CO<sub>2</sub> transfer and a maintenance program established. Pipeline and well construction reports demonstrating sound design and construction were submitted to the Department of Mines Industry Regulation and Safety (DMIRS) in accordance with requirements of Pipeline Licence PL 93 which relates to the construction and operation of the CO<sub>2</sub> infrastructure (see section 5.3.2 for further details regarding this approval). The reservoir CO<sub>2</sub> transfer pipeline and injection wells are protected from corrosion (to prevent reservoir CO<sub>2</sub> leakage) via an impressed current cathodic protection system. Protection from internal corrosion is also provided for by dew point management of reservoir CO<sub>2</sub> entering the pipeline to meet the required operating conditions of the pipeline. Inspections, maintenance and repair activities (including pigging) of the CO<sub>2</sub> infrastructure is undertaken to ensure the integrity of the infrastructure is maintained.

In addition to the leak protection measures described above, the CO<sub>2</sub> infrastructure includes the following control measures intended to ensure reliable operation:

- Leak detection (based on mass balance algorithm);
- Fire and gas detection;
- Overpressure protection; and
- Emergency shutdown and isolation.

Chevron has also developed a Flow Management Tool to model and assist with predicting pipeline operating performance using real time information. The Flow Management Tool is designed to optimise the amount of reservoir CO<sub>2</sub> injected and minimise the amount vented for all operating scenarios, including system start-up and shutdown, pigging of pipeline, manifold and well start-ups. The Flow Management Tool system provides real time forecasts depending on the operating scenario and allows the Licence Holder to record and review operating data such as injection pressure, temperature and rate (as required by Pipeline Licence PL 93)

### 4.3 Exclusions to the Assessment

Potential environmental impacts associated with CO<sub>2</sub> emissions have been assessed under Part IV of the EP Act (Part IV) (EPA Reports 1221 and 1323) and are subject to the requirements

of conditions 26 and 27 of MS 800 (refer to section 5.1 for further details). The Delegated Officer has therefore determined not to duplicate this assessment and regulatory controls in accordance with the *Guidance Statement: Setting Conditions*.

The Delegated Officer has also determined that this assessment will not consider potential impacts associated with some of the incidental substances within the reservoir CO<sub>2</sub> (including nitrogen, water, corrosion inhibitor and clean MEG). The proposed maximum concentration of these substances within the gas stream is at levels not considered to present a risk of pollution occurring. They are therefore not considered in the risk assessment or specified as authorised emissions within the amended licence.

## 5. Legislative context

Table 5 summarises approvals relevant to the assessment.

**Table 5: Relevant approvals and tenure**

Legislation	Number	Holder	Approval
<i>Environment Protection and Biodiversity Conservation Act 1999 (Cth)</i>	EPBC 2008/4178	Chevron Australia Pty Ltd	Conditional approval was issued for the initial two train Gorgon LNG Project on 2 October 2007 (EPBC 2003/1294). Approval for the expanded Gorgon LNG Project was issued on 26 August 2009 (EPBC 2008/4178). Refer to section 5.3.3 for further details.
Part IV of the EP Act (WA)	Ministerial Statement Number 800 (MS 800) EPA Reports 1221 and 1323		MS 800 authorises the construction of facilities for the development of the Greater Gorgon Gas Fields on the North-West Shelf, and the processing and export of the gas at a liquefied natural gas plant to be constructed on Barrow Island. Refer to section 5.1 for further details.
<i>Barrow Island Act 2003</i> <i>Land Administration Act 1997</i>	L007431 Volume 3158; Folio 477		The <i>Barrow Island Act 2003</i> (BI Act) and the Gorgon Gas Processing and Infrastructure Project Agreement (Schedule 1 to the BI Act) allows for the implementation of the Gorgon Gas Development and makes provision for land within the Barrow Island Nature Reserve to be used for gas processing purposes under the <i>Land Administration Act 1997</i> . Refer to section 5.3.1 for further details.

Legislation	Number	Holder	Approval
<i>Dangerous Goods Safety Act 2004</i>  <i>Dangerous Good Safety (Major Hazard Facilities) Regulations 2007</i>	Dangerous Goods Licence DGS021356		<p>DGS021356 covers the storage of dangerous goods associated with the primary activities.</p> <p>The premises is also considered a Major Hazard Facility and is subject to the requirements of the <i>Dangerous Good Safety (Major Hazard Facilities) Regulations 2007</i>.</p>
<i>Petroleum Pipelines Act 1969</i>	Pipeline Licence PL 93	Gorgon Project JV partners	<p>PL 93 was granted on 1 December 2011 and authorises the construction and operation of the Gorgon CO<sub>2</sub> pipeline for the conveyance and disposal of CO<sub>2</sub> via injection into the sub-surface Dupuy Formation subject to the terms and conditions of the licence.</p> <p>Refer to section 5.3.2 for further details.</p>

## 5.1 Part IV of the EP Act

### 5.1.1 Background

The proposal to construct and operate the Gorgon Gas Development (two LNG processing trains), inclusive of reservoir CO<sub>2</sub> injection within the Dupuy formation, was initially referred to the Western Australian Environmental Protection Authority (EPA) under Part IV of the EP Act in 2003. Formal environmental impact assessment of the Proposal was undertaken through a draft EIS/ERMP assessment process. A bilateral assessment was undertaken under the EP Act and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

In June 2006, the EPA released its report and recommendations on the project (Report 1221), and Ministerial Approval for the Project was granted on 6 September 2007 subject to conditions outlined in Ministerial Statement 748 (MS 748).

Subsequently, in September 2008, the Applicant again sought both State and Commonwealth approval through a Public Environment Review (PER) assessment process for the revised and expanded Gorgon Gas Development, which included:

- Addition of a 5 mtpa LNG train, increasing the number of LNG trains from two to three;
- Expansion of the CO<sub>2</sub> injection system, increasing the number of injection wells and surface drill locations to account for increased reservoir CO<sub>2</sub> production due to the addition of a third LNG train; and
- Extension of the causeway and the materials off-loading facility into deeper water.

In April 2009, the EPA released its report and recommendations on the revised and expanded Gorgon Gas Development (Report 1323), and Ministerial Approval for the Project was granted on 10 August 2009 subject to conditions outlined in MS 800. MS 800 superseded MS 748 for the initial proposal, providing approval for both the initial Gorgon Gas Development and the revised and expanded Gorgon Gas Development.



The approval authorises the construction and operation of three 5 mtpa LNG processing trains, associated infrastructure and a CO<sub>2</sub> Injection System to inject reservoir CO<sub>2</sub> into the Dupuy Formation on Barrow Island.

Since the revised and expanded Gorgon Gas Development was approved, further minor changes have also been made and/or approved and updates to MS 800 made as necessary.

### 5.1.2 Assessment of CO<sub>2</sub> injection

Reservoir CO<sub>2</sub> injection and greenhouse gas (GHG) emissions were one of the key environmental factors included in the Part IV assessment for the Gorgon Proposal (EPA Reports 1221 and 1323). The reports state that a fundamental justification for the location of the GTP on Barrow Island was the need for access to a suitable location for long term reservoir CO<sub>2</sub> storage and that CO<sub>2</sub> injection is an important element of the Gorgon Project due to the significant GHG emissions associated with it.

The draft EIS/ERMP for the Proposed Gorgon Development (Chevron 2005) and the Gorgon Gas Development Revised and Expanded Proposal PER (Chevron 2008), which were the basis for the Part IV assessment, included detail relating to the suitability of the Dupuy Formation for reservoir CO<sub>2</sub> injection, and the anticipated volume and composition of the reservoir CO<sub>2</sub> gas stream which would be primarily injected, but also vented to atmosphere. It was anticipated up to 20% of the gas stream may require venting for maintenance, process upsets and start-up/shutdown scenarios.

The proposal documents identified that failures in the surface injection facilities or leakage of the injected reservoir CO<sub>2</sub> can create potential health, safety and environmental hazards. Reservoir CO<sub>2</sub> leaks can impact subterranean and terrestrial fauna through asphyxiation and can also cause necrosis of vegetation due to exposure to elevated CO<sub>2</sub> concentrations. The Part IV assessment relating to reservoir CO<sub>2</sub> injection (EPA Report 1323) found that while there is a risk of CO<sub>2</sub> leaks affecting the flora and fauna of Barrow Island the level of risk was sufficiently low to achieve the EPA's objectives.

The EPA also noted in Report 1221 its understanding that reservoir CO<sub>2</sub> injection would be subject to regulation under the BI Act and associated State Agreement, and other relevant legislation which would include responsibility for monitoring and management of the injected CO<sub>2</sub> during injection and after closure. The report also notes that the regulation should also address the environmental monitoring necessary to ensure any migration or escape of CO<sub>2</sub> did not result in any significant impacts to flora and fauna of Barrow Island.

Internal comment was sought from DWER's EPA Services on the Application to confirm injection of reservoir CO<sub>2</sub> is consistent with Part IV assessment of the Gorgon Project. EPA Services confirmed the gas stream proposed to be injected had been considered and assessed under Part IV and was consistent with this assessment. The advice also noted that the composition of the waste gas stream was not a ground of appeal for the two reports prepared as part of this assessment (EPA Reports 1221 and 1323).

### 5.1.3 Ministerial Statement 800

MS 800 contains conditions that need to be considered in the assessment of emissions and discharges from the Premises and the imposition of regulatory controls. Conditions relevant to the assessment of the activity of CO<sub>2</sub> compression, transport and injection are summarised in Table 6. The Statement also includes a Preamble which highlights that the Gorgon Project is subject to a number of requirements additional to the conditions and schedules of the Statement to ensure environmental protection. In this regard, the preamble makes specific reference to a number of matters covered by the BI Act and its Schedule 1 which are relevant to environmental management of Barrow Island, but are not duplicated within the conditions of MS 800. The matters include the approval to inject reservoir CO<sub>2</sub> which is granted under Section 13 of the BI Act (refer to section 5.3.1 below for further details). This approval must

also be considered in the assessment of emissions and discharges from the Premises and the imposition of regulatory controls.

**Table 6: Consideration of MS 800 conditions relevant to this application**

Condition	Overview	Delegated Officer considerations
5	<p>The condition requires the completion and submission of an annual Environmental Performance Report which includes reporting on a number of aspects, including the CO<sub>2</sub> injection system, Air Quality and Greenhouse gas abatement which are relevant to this assessment. Information to be included in the report is specified in Schedule 2, items 6, 7 and 10 of the statement and includes the following items of relevance:</p> <p><i>CO<sub>2</sub> Injection System</i></p> <ul style="list-style-type: none"> <li>• Volume of reservoir CO<sub>2</sub> and other acid gases removed from the incoming natural gas and available for injection</li> <li>• Volume of reservoir CO<sub>2</sub> and other gases injected</li> <li>• Results of environmental monitoring and any identified material or serious environmental harm resulting from seepage of injected CO<sub>2</sub> to the surface or near surface environments (including any that support subterranean fauna).</li> </ul> <p><i>Air Quality</i></p> <ul style="list-style-type: none"> <li>• Monitoring results and performance in relation to meeting emission targets.</li> </ul> <p><i>GHG Abatement</i></p> <ul style="list-style-type: none"> <li>• GHG intensity and annual average trend</li> </ul>	<p>The Delegated Officer notes that the annual reporting requirements do not specifically require reporting relating to venting of reservoir CO<sub>2</sub> to atmosphere. It is additionally noted that the Part IV assessment (EPA Reports 1221 and 1323) considered that air emissions (such as those vented from the CO<sub>2</sub> infrastructure) should be regulated under Part V of the EP Act. The Delegated Officer has considered this, in addition to the outcome of the risk assessment in determining regulatory controls relating to venting of the reservoir CO<sub>2</sub>.</p>
7	<p>Condition 7 requires the submission and implementation of a Terrestrial and Subterranean Environmental Protection Plan (TSEPP) which outlines management measures, including design commitments, to control potential impacts to the terrestrial and subterranean environment. The objectives of the plan are <i>'to reduce the adverse impacts from the construction and operation of the terrestrial facilities as far as practicable and to ensure that construction and operation of the terrestrial facilities does not cause Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint, including below the surface of the land.'</i></p> <p>The condition also requires reporting of any Material or Serious Environmental Harm detected outside the Terrestrial Disturbance Footprint.</p>	<p>The Delegated Officer has reviewed the TSEPP and determined that the Plan identifies the mechanical components of the CO<sub>2</sub> infrastructure required to manage the performance integrity of the injection facilities and Dupuy Formation. It also identifies the key impacts associated with reservoir CO<sub>2</sub> injection which are primarily associated with CO<sub>2</sub> leaks and migration to the surface or near surface environment. The Plan includes a preliminary description of the CO<sub>2</sub> Seismic Survey Program which will be implemented to monitor the position of the reservoir CO<sub>2</sub> plume but it is noted that TSEPP will be updated with further details of the Program prior to future Seismic Survey events.</p>

Condition	Overview	Delegated Officer considerations
8	<p>Condition 8 requires the submission and implementation of a Terrestrial and Subterranean Environmental Monitoring Program (TSEMP). The objective of the TSEMP is to <i>'establish a statistically valid ecological monitoring program to detect any Material or Serious Environmental Harm to the ecological elements outside the Terrestrial Disturbance Footprint'</i>. The TSEMP specifies procedures for monitoring vegetation, fauna (mammals and land birds), surface water landforms and groundwater, including monitoring locations, criteria, management triggers and reporting.</p> <p>The results from implementation of the TSEMP are required to be reported within the Annual Environmental Performance Report as per the requirements of Condition 5.</p>	<p>The plan specifies the monitoring methods which will be used to detect unexpected migration of injected CO<sub>2</sub>. These include:</p> <ul style="list-style-type: none"> <li>• Repeat seismic survey</li> <li>• Repeat Vertical Seismic Profiles</li> <li>• Passive Microseismic</li> <li>• Interferometric Synthetic Aperture Radar (InSAR)</li> <li>• Injection system well monitoring</li> <li>• Surface/near-surface monitoring (Groundwater, soil gas flux, aerial &amp; multispectral imagery).</li> </ul> <p>The Delegated Officer notes that the monitoring program will be implemented in accordance with the Carbon Dioxide Disposal Management Plan which is a requirement of the BI Act Section 13 Approval.</p> <p>Environmental monitoring programs described in the TSEMP have been considered in the determination of risk associated with potential emissions and discharges; however, conditions relating to environmental monitoring (e.g. flora, fauna or groundwater monitoring) will not be included on the licence to avoid duplication with MS 800.</p>
16	<p>A Long-term Marine Turtle Management Plan was developed in accordance with condition 16 and specifies commitments to minimise lighting and noise as far as practicable through design and operation to prevent impact on marine turtles. Procedures for monitoring lighting and impacts on turtle populations are also included.</p>	<p>The primary instrument for regulating the impacts on marine turtles from light and noise emissions is MS 800 and the Long-term Marine Turtle Management Plan. As such, no further assessment is required under Part V of the EP Act.</p>
26	<p>Condition 26 sets requirements for the injection of CO<sub>2</sub> to an underground reservoir. The condition specifies that all practicable means shall be implemented to inject all reservoir carbon dioxide removed during gas processing operations on Barrow Island and ensure that at least 80% of reservoir carbon dioxide that would otherwise be vented to atmosphere is injected (based on a 5 year rolling average).</p> <p>Reservoir carbon dioxide is defined in MS 800 as <i>'a gas stream that consists overwhelmingly of carbon dioxide and coming from the acid gas removal units of the Gas Treatment Plant to be located on Barrow Island. The carbon dioxide will contain incidental associated substances derived from the natural gas and the process used to separate the carbon dioxide from that natural gas.'</i></p>	<p>The Delegated Officer notes that reservoir CO<sub>2</sub> injection was included in the Part IV assessment of the Gorgon Project.</p> <p>The Delegated Officer also acknowledges the references made in MS 800 and the Part IV assessment (Report 1221) to regulation under the BI Act including responsibility for monitoring and management of the injected CO<sub>2</sub>, including environmental monitoring to detect potential leakage and impact. The Delegated Officer considers that MS 800 and the BI Act Section 13 Approval are the primary instruments for regulation of reservoir CO<sub>2</sub> injection.</p> <p>The Delegated Officer noted MS 800 does not include specific limits on the composition of reservoir CO<sub>2</sub> and therefore sought the advice of DWER's EPA Services to confirm that the proposed composition is consistent with EPA's assessment and approval under MS 800. See section 5.1.2 for further detail.</p>

Condition	Overview	Delegated Officer considerations
27	Condition 27 specifies that a Greenhouse Gas Abatement Program was to be prepared which demonstrates best practice in terms of greenhouse gas emissions have been adopted in the design and operation of the GTP and the Program is adopted. The Program is to include periodic review and, where practicable, adoption of technological advances intended to reduce GHG emissions per tonne of LNG produced.	<p>The Delegated Office considers that environmental impacts associated with GHG emissions have been assessed under Part IV of the EP Act and has not considered it further in this assessment (refer to section 4.3).</p> <p>The Delegated Officer has also noted that measurement and reporting of GHG emissions to the atmosphere is a requirement of the <i>National Greenhouse and Energy Reporting Act 2007</i> (Cwth).</p>
28	Condition 28 specifies that a Best Practice Pollution Control Design Report was required to be submitted as part of the Works Approval application for the Gorgon LNG Project. The purpose of the report is to demonstrate what best practice pollution control would be implemented for the Gas Treatment Plant.	<p>Commitments made in accordance with conditions 28 and 29 of MS 800 will be considered as part of this Decision Report noting that the Air Quality Management Plan includes emission targets for major point sources (GTGs and GTs) and ambient air quality monitoring.</p>
29	An Air Quality Management Plan was developed under condition 29. The purpose of the Air Quality Management Plan is to ensure that air quality meets appropriate standards for the protection of human health and does not cause environmental harm to flora and fauna on the island. Monitoring programs for ambient air quality and point source emissions, along with committed targets, are specified in the plan.	

**Key Findings:** The Delegated Officer notes that there is potential for regulatory duplication between Part IV and Part V of the EP Act. In setting regulatory controls, the Delegated Officer will consider the requirements of MS 800 conditions, and commitments made in Management Plans and Programs required by MS 800, and will avoid duplication in licence conditions.

Where emissions and discharges have been assessed in this Decision Report, the scope of these Management Plans and Programs required by MS 800 has been reviewed in order to avoid duplication and inconsistency in the conditions of the amended licence. Where the Delegated Officer has identified that environmental risk is not adequately regulated through other approvals, it may be regulated under Part V of the EP Act.

In consideration of the requirements of the Part IV approval relating to the Premises the Delegated Officer notes the following:

- MS 800 does not otherwise limit the composition or quantity of reservoir CO<sub>2</sub> which may be injected underground however DWER's EPA Services has advised that it considers that the composition of the reservoir CO<sub>2</sub>, including the incidental associated substances proposed to be injected, is consistent with the the previous Part IV assessments (EPA Reports 1221 and 1323) of the Gorgon LNG Project and the definition of Reservoir Carbon Dioxide in MS 800.
- MS 800 limits the volume of reservoir CO<sub>2</sub> which is able to be vented by virtue of the inclusion of a minimum limit on the volume of reservoir CO<sub>2</sub> which must be injected underground. The Statement does not limit the composition of the reservoir CO<sub>2</sub> which may be vented.
- The BI Act and associated BI Act Section 13 Approval are also primary instruments for regulation of the injection of reservoir CO<sub>2</sub>, particularly in relation to reservoir

## 5.2 Contaminated sites

Barrow Island Nature Reserve (BINR) is currently registered under the CS Act as *Contaminated – remediation required*. There are a number of areas on the BINR where contamination exists as a result of existing infrastructure, most significantly the terminal tank facility (operated as part of the Barrow Island Oil & Gas Processing Facility) located 1 km north of the Premises.

## 5.3 Other relevant approvals

### 5.3.1 Barrow Island Act 2003

The *Barrow Island Act 2003* (BI Act) ratifies and authorises the implementation of, an agreement between the State of Western Australia and the Gorgon joint venturers relating to a proposal to undertake offshore production of natural gas and other petroleum, and a gas processing and infrastructure project on Barrow Island. In addition to this, the BI Act makes provisions to enable land on Barrow Island to be used under the *Land Administration Act 1997* for gas processing project purposes. It also makes provisions as to the conveyance and underground disposal of CO<sub>2</sub> recovered during gas processing on Barrow Island.

Section 11 of the BI Act provides that the provisions of the *Petroleum Pipelines Act 1969* (PP Act) apply to pipelines on Barrow Island used for the conveyance of CO<sub>2</sub>. Further details relating to requirements under the PP Act are included in section 5.3.2.

Section 13 of the BI Act provides that a person must not inject CO<sub>2</sub> into an underground reservoir or other subsurface formation for the purpose of disposing of the CO<sub>2</sub> unless they have the BI Act Minister's approval to do so. Penalties apply for non-compliance with this requirement. The same penalty is taken to apply if the disposal of CO<sub>2</sub> is undertaken in a manner, other than in accordance with the conditions of an approval granted under Section 13.

An application was submitted in accordance with the requirements of Section 13 and the Minister's approval to dispose of CO<sub>2</sub> by injection into subsurface formation was subsequently granted to Chevron (and Joint Venturers) by the BI Act Minister in September 2009 (BI Act Section 13 Approval). The most recent variation to this approval was granted by the BI Act Minister in March 2019. The BI Act Section 13 Approval includes conditions which restrict the composition, daily and annual injection rate, and maximum volume of reservoir CO<sub>2</sub> which can be injected into the Dupuy Formation.

The BI Act Section 13 Approval conditions require Chevron to comply with a CO<sub>2</sub> Disposal Management Plan, approved by the BI Act Minister on advice from the Department of Jobs, Tourism, Science and Innovation (DJTSI) and DMIRS, which identifies the key subsurface risks associated with the CO<sub>2</sub> disposal and risk management options, together with the monitoring plan which will be implemented to address the risks and demonstrate the operation of the CO<sub>2</sub> injection is in accordance with the requirements of the approval. The monitoring program is designed to detect the general location of the CO<sub>2</sub> plume in the subsurface which will allow for detection of unexpected migration of injected reservoir CO<sub>2</sub> outside the Dupuy Formation. The program includes the following monitoring methods:

- Repeat seismic survey;
- Repeat Vertical Seismic Profiles;
- Passive Microseismic;
- Interferometric Synthetic Aperture Radar (InSAR);
- Injection system well monitoring; and

- Surface/near-surface monitoring (Groundwater, soil gas, and remote sensing).

Comment was sought from the Department of Jobs, Tourism, Science and Innovation (DJTSI) to confirm whether the Application for injection of reservoir CO<sub>2</sub> is consistent with the BI Act Section 13 Approval and current version of the CO<sub>2</sub> Disposal Management Plan. The DJTSI confirmed the application was consistent with these regulatory instruments.

The BI Act Section 13 approval conditions require submission of annual reports on compliance with the conditions as well as annual operational reports which report on performance of the CO<sub>2</sub> injection project including the details of injection rates, volumes and composition of injected CO<sub>2</sub> and the results of monitoring activities undertaken. There are also reporting requirements pertaining to non-compliance as well as identification of CO<sub>2</sub> leakage and significant risks associated with migration of the CO<sub>2</sub> plume.

The conditions of the BI Act Section 13 Approval allow for the BI Act Minister to require Chevron to rectify any failure to comply with conditions of the licence, or can require the cessation of CO<sub>2</sub> injection. If continued injection of CO<sub>2</sub> poses an unreasonable risk to health and safety, the environment or resources, the BI Act Minister can also suspend or revoke the approval.

**Key Findings:** The Delegated Officer considers that there is potential for regulatory duplication relating to reservoir CO<sub>2</sub> injection between the conditions of licence L9102/2017/1 granted under Part V of the EP Act, and the BI Act Section 13 Approval. Where emissions and discharges have been assessed in this Decision Report, the scope of the BI Act Section 13 Approval has been reviewed in order to avoid duplication and inconsistency in the conditions of the amended licence. Where the Delegated Officer has identified that environmental risk is not adequately regulated, it may be regulated under Part V of the EP Act.

The Delegated Officer has determined that the scope of the BI Act Section 13 Approval includes the following relating to reservoir CO<sub>2</sub> injection;

- Limits on the composition and quantity of reservoir CO<sub>2</sub> injected;
- Monitoring of the operational performance of the CO<sub>2</sub> infrastructure as well as composition and injection rates;
- Monitoring of the injected reservoir CO<sub>2</sub> and movement of the CO<sub>2</sub> plume within the injection reservoir (Dupuy Formation) intended to identify if there is a risk or occurrence of reservoir CO<sub>2</sub> leakage outside the formation; and
- Penalties for non-compliance and scope to stop the activity should there be a significant increase in risk to health and safety, the environment or resources associated with the activity.

The Delegated Officer has reviewed the composition and quantity of reservoir CO<sub>2</sub> proposed to be injected within the Application and, considers it to be consistent with the limits specified within the BI Act Section 13 Approval and this has been confirmed by the DJTSI.

The Delegated Officer has determined the primary instrument for regulating the composition and volume of reservoir CO<sub>2</sub> injected to the Dupuy Formation is the BI Act Section 13 Approval. However, to ensure the Licence does not authorise emissions beyond the scope of the BI Act Section 13 Approval, it is necessary to specify composition and volume limits for authorised emissions to land within the amended licence and associated monitoring and reporting to demonstrate the limits have been complied with. The Delegated Officer has therefore determined to include these within the licence.

The Delegated Officer has also determined that the CO<sub>2</sub> Disposal Management Plan, which is a requirement of the BI Act Section 13 Approval, is the primary instrument for specifying a

suitable monitoring program to demonstrate compliance with the approval, and identify any occurrence or increase in the risk of CO<sub>2</sub> leakage from the injection activity.

### 5.3.2 Department of Mines, Industry Regulation and Safety

DMIRS regulates pipeline operations in accordance with the *Petroleum Pipelines Act 1969* (PP Act) and associated regulations. In accordance with the requirements of this legislation, oil and gas operators must submit a Safety Case (including a Safety Management System) and an Environment Plan to DMIRS to obtain approval for pipeline activities. These documents are required to demonstrate that all safety, occupational health and environmental risks and impacts associated with a pipeline activity are reduced to As Low As Reasonably Practicable and are acceptable.

Section 11 of the BI Act requires that the provisions of the PP Act apply to pipelines on Barrow Island used for the conveyance of CO<sub>2</sub>. Construction, operation, maintenance and decommissioning of the reservoir CO<sub>2</sub> transport and injection infrastructure is therefore subject to the issue of a Pipeline Licence under the PP Act and all applicable requirements of the PP Act and associated regulations. Pipeline Licence PL 93 was granted to Chevron (and joint venturers) on 1 December 2011 under the PP Act to authorise the construction and operation of the Gorgon CO<sub>2</sub> pipeline for the conveyance and disposal of CO<sub>2</sub> via injection into the sub-surface Dupuy Formation (subject to the terms and conditions of the licence).

The conditions of the Pipeline Licence PL 93 require that the Licensee complies with the requirements of the BI Act Approved Proposal and Section 13 Approval which relate to the construction, operation, repair, maintenance and decommissioning of the licensed pipeline. The licensed pipeline includes the pipeline used for conveyance and disposal of CO<sub>2</sub> as well as the CO<sub>2</sub> disposal facilities.

The conditions also require the Licensee to comply with the approved Safety Case and Environmental Management Plan (EMP) (construction and operation) in force. The Safety Case identifies safety and occupational risks to people associated with the reservoir CO<sub>2</sub> injection pipeline (including impacts associated with leaks and venting of the reservoir CO<sub>2</sub>) and describes control measures in place to manage them. The EMP identifies environmental risks associated with CO<sub>2</sub> injection (including environmental impacts associated with leaks of reservoir CO<sub>2</sub> above and below ground) and describes control measures in place to manage them. The licence also includes requirements for the revision of these documents.

The current versions as approved by DMIRS for the operation of the reservoir CO<sub>2</sub> infrastructure are as follows:

- Pipeline Gorgon Carbon Dioxide Injection System Pipeline Operations Safety Case (GOR-COP-01277, Revision 4.0). conditionally accepted by DMIRS on 1 February 2019).
- Carbon Dioxide Injection System Pipeline and Wells Operations Environment Management Plan (GOR-COP-01489, Revision 2.3). Approved by the DMIRS on 15 January 2019.
- Carbon Dioxide Injection System Well Maintenance Environment Plan (GOR-COP-02232, Revision 2.0). Approved by DMIRS on 15 Jan 2019.

Other requirements of Pipeline Licence PL 93 include requirement to assess the integrity of the licensed pipeline and take any action as directed to correct any defects noted as well as monitoring, recording and reporting to DMIRS of CO<sub>2</sub> injection well data including, but not limited to injection pressure, temperature, rate, zone and depth. In accordance with the requirements of the PP Act, the Minister may cancel a licence if the Licensee fails to comply with conditions of the licence, the PP Act or the associated regulations.

In addition to the above legislative requirements overseen by DMIRS, the then Department of

Industry and Resources (now DMIRS) commissioned a series of three independent technical reviews of the proposal to dispose of reservoir CO<sub>2</sub> by subsurface injection to the Dupuy Formation to provide independent validation of the proposal and suggest areas for further investigation. The review outcomes indicated the Dupuy Formation appears to have adequate capacity for the volume of reservoir CO<sub>2</sub> that will be available for injection and that the basal Barrow Group Seal which overlies the Dupuy Formation should be adequate to contain the injected CO<sub>2</sub> for thousands of years.

**Key findings:** The Delegated Officer considers that there is potential for regulatory duplication relating to reservoir CO<sub>2</sub> injection between the conditions of licence L9102/2017/1 granted under Part V of the EP Act, and Pipeline Licence PL 93 granted under the *Petroleum Pipelines Act 1969*.

The Delegated Officer has determined that the Safety Case and Environmental Management Plans for the reservoir CO<sub>2</sub> Pipeline identify occupational health and safety risks to people from the reservoir CO<sub>2</sub> Pipeline operation, and the environmental risks associated with the reservoir CO<sub>2</sub> injection. These documents, together with the conditions of Pipeline Licence PL 93, include commitments and requirements to minimise the likelihood of these risks occurring.

Where emissions and discharges have been assessed in this Decision Report, the scope of these documents and Pipeline Licence PL 93 has been reviewed in order to avoid duplication and inconsistency in the conditions of the amended licence. Where the Delegated Officer has identified that environmental risk is not adequately regulated, it may be regulated under Part V of the EP Act.

In addition to the above, the Delegated Officer considers that the operation, maintenance and repair requirements necessary to minimise the risk of CO<sub>2</sub> infrastructure integrity issues have been assessed and approved through the BI Act Section 13 Approval and Pipeline Licence PL 93 processes and has determined not to specify conditions relating to these in the amended licence in order to avoid regulatory duplication and inconsistency.

### 5.3.3 Environment Protection and Biodiversity Conservation Act 1999 (Cth)

The initial Gorgon Gas Development was approved by the Commonwealth Minister for the Environment and Water Resources on 3 October 2007 (Reference 2003/1294). On 26 August 2009, the Commonwealth Minister for the Environment, Heritage and the Arts issued approval for the revised and expanded Gorgon Gas Development (Reference: 2008/4178) and varied the conditions for the initial Gorgon Gas Development (Reference: 2003/1294).

Conditions imposed under the EPBC Act complement those imposed under Part IV of the EP Act relating to:

- Protection of the terrestrial and subterranean environment;
- Quarantine management;
- Fire management;
- Management of groundwater abstraction;
- Impacts associated with dredging, horizontal directional drilling and offshore pipeline installation;
- Impacts on turtles; and
- Solid and liquid waste management.

Conditions associated with CO<sub>2</sub> injection relate specifically to monitoring potential impacts to



the Blind Gudgeon (*Milyeringa verita*); a small subterranean fish if monitoring under the TSEMP identifies the reservoir CO<sub>2</sub> plume has migrated outside the injection zone to the near surface or surface environment.

## 5.4 Part V of the EP Act

### 5.4.1 Applicable regulations, standards and guidelines

The overarching legislative framework of this assessment is the EP Act and EP Regulations. The guidance statements which inform this assessment are:

- *Guidance Statement: Regulatory Principles (July 2015)*
- *Guidance Statement: Setting Conditions (October 2015)*
- *Guidance Statement: Licence Duration (August 2016)*
- *Guidance Statement: Publication of Annual Audit Compliance Reports (May 2016)*
- *Guidance Statement: Environmental Siting (November 2016)*
- *Guidance Statement: Decision Making (February 2017)*
- *Guidance Statement: Risk Assessments (February 2017)*

### 5.4.2 Works approval and licence history

Table 7 summarises the works approval and licence history for the Gorgon GTP.

**Table 7: Works approval and licence history for the Gorgon gas treatment plant**

Instrument	Issued	Nature and extent of works approval, licence or amendment
W5178/2012/1	23/08/2012	New works approval for the construction of the Gorgon Gas Project LNG (Trains 1 to 3), DomGas processing trains and support infrastructure such as GTGs, flares and CO <sub>2</sub> compression, transport and injection infrastructure.
	06/02/2015	Works approval amendment for the installation of additional mercury removal units, liquid mercury draw-off stations and slug catcher solids removal systems for managing higher than anticipated quantities of mercury in the feed gas.
	14/07/2016	Works approval amendment to extend the duration of the works approval to allow commissioning to be completed and to remove regulatory duplication of environmental risk associated with lighting.
W4818/2010/1	05/05/2014	New works approval for the construction of the LNG and condensate storage tanks, liquid waste facility and stormwater drainage system.
	10/04/2014	Works approval amendment to extend the duration of the works approval to allow completion of construction and commissioning.
	22/06/2016	Works approval amendment to extend the duration of the works approval to allow construction and commissioning to be completed and remove regulatory duplication of environmental risk associated with lighting.
L8952/2016/1	14/07/2016	New licence for the operation of the Gorgon Gas Project (Train 1) and support infrastructure including DomGas processing and LNG and condensate storage.

Instrument	Issued	Nature and extent of works approval, licence or amendment
	16/02/2017	Licence amendment to include Category 62 (solid waste depot) for the storage of waste concrete at the GTP site.
L8894/2015/1	15/10/2015	New licence for the operation of the liquid waste facility.
L9102/2017/1	30/07/2018	New licence for the entire Gorgon LNG Premises combining new infrastructure and existing licensed facilities onto a single licence for Category 10, 34, 52, 54, 62 and 73. The licence and premises boundary excluded CO <sub>2</sub> compression, transport and injection infrastructure as it had not been successfully commissioned at the time of the licence application.
W6199/2018/1	10/04/2019	Works approval to re-route air emissions associated with the MEG regeneration unit to the wet flare.
L9102/2017/1	30/07/2019	Licence amendment to include the operation of reservoir CO <sub>2</sub> compression, transport and injection infrastructure, and extend the Premises boundary to include the reservoir CO <sub>2</sub> infrastructure locations within the Premises.

### 5.4.3 Compliance inspections and compliance history

A Letter of Warning was issued to the Licence Holder in 2009 for the unauthorised clearing of 501 m<sup>2</sup> (0.05ha) of vegetation during the completion of geotechnical investigations. The incident was reported to the DWER by the Licence Holder.

There have been no other statutory notices issued or prosecutions in relation to the Premises. A small number of self-reported incidents have been recorded for the Premises

A site inspection in 2012 raised concern regarding poor management practices at the waste transfer station, which was operating as a temporary waste management facility to support temporary construction services (e.g. temporary accommodation). A lack of progress towards permanent waste infrastructure to support the commencement of construction of permanent facilities (i.e. the GTP) was also noted. In response, the Licence Holder applied to amend the works approval for the implementation of infrastructure improvements. The amendment was granted on 7 March 2013 and the upgraded facility is fully operational.

All other previous compliance inspections relating to the above licenses did not identify any significant compliance issues. During the most recent inspections undertaken in 2016, it was determined that all relevant licence conditions were complied with.

## 6. Consultation

The application for a licence amendment was sent to the following direct interest stakeholders for comment in May and June 2019:

- Department of Jobs, Tourism, Science and Innovation;
- Department of Biodiversity, Conservation and Attractions;
- Department of Mines, Industry Regulation and Safety;
- Shire of Ashburton; and
- Conservation Council of Western Australia.

Comment was also sought internally from the Department's EPA Services directorate. The stakeholder comments received are detailed in Appendix 2.

## 7. Location and siting

## 7.1 Siting context

The Premises is located on Barrow Island situated 85 km off the Pilbara coast, north-north-east of the town of Onslow and 140 km west of Karratha. Barrow Island is reserved under the Western Australian *Conservation and Land Management Act 1984* (CALM Act) as a Class A nature reserve for the purposes of 'conservation of flora and fauna' and is vested in the Conservation Commission. Day to day management of the reserve is undertaken by the Department of Biodiversity, Conservation and Attractions. The BINR is a unique remnant of Australia's natural ecology. The island's status as a Class A nature reserve reflects its importance as a refuge for wildlife species, with some endemic to the BINR and some extinct on the Australian mainland.

Oil production has occurred on the island since 1967. The Licence Holder also manages operations of the Barrow Island oil and gas facility on behalf of a separate joint venture, which includes Santos Offshore Pty Ltd, Mobil Australia Resources Company Pty Ltd, and Chevron (TAPL) Pty Ltd. The Barrow Island oil and gas facility is spread over a large portion of the island with a 4.5% footprint by land area. This facility is regulated under Licence L4467/1972/14.

## 7.2 Residential and sensitive Premises

The distances to residential and sensitive receptors are detailed in Table 8.

**Table 8: Receptors and distance from activity boundary**

Sensitive Land Uses	Distance from Prescribed Activity
Butler Park (Chevron operated worker accommodation camp)	2.5 km south of the GTP
Production Camp (Chevron operated worker accommodation camp)	2.5 km south of the GTP
Varanus Island oil and gas facility (including workers accommodation camp)	18 km north east of the GTP
Residential premises (Onslow)	~85 km south-west of the GTP

**Key finding:** In accordance with the *Guidance Statement: Risk Assessments*, the Delegated Officer has determined that this assessment will not consider the risk of potential impacts to people in accommodation camps occupied by the Licence Holder. Potential impacts to people at these locations are subject to requirements under occupational health and safety regulations and obligations.

The Butler Park and Production Camps are both operated by the Licence Holder (on behalf of the Gorgon Joint Venture and the Barrow Island Oil & Gas Joint Venture)); therefore, the Delegated Officer considers that people at both camps are excluded as potential receptors.

The Delegated Officer considers that there is no public community present on Barrow Island as it is a remote facility with no public access. The nearest public community is located on Varanus Island approximately 18 km north east of the GTP.

## 7.3 Specified ecosystems

Specified ecosystems are areas of high conservation value and special significance that may be impacted as a result of activities at or emissions and discharges from the Premises. The distances to specified ecosystems are shown in Table 9. Table 9 also identifies the distances

to other relevant ecosystem values which do not fit the definition of a specified ecosystem.

**Table 9: Environmental values**

Specified ecosystems	Distance from the Premises
Managed Lands and Waters	<p>The Gorgon Gas Project is located within the BINR, a Class A Nature Reserve</p> <p>Marine waters surrounding the north, west and south sides of Barrow Island form part of the Barrow Island Marine Management Area (including the Bandicoot Bay Conservation Area ~13 km to the south of the GTP). An exclusion zone exists on the east side of the island adjacent to the GTP for the Barrow Island Port Area.</p> <p>The Barrow Island Marine Park is located on the west side of the island (~10 km from the GTP) and incorporates the Western Barrow Island Sanctuary Area.</p>
Threatened Ecological Communities and Priority Ecological Communities	<p>The BINR is listed as a Priority Ecological Community. Smaller areas identified as Priority Ecological Communities are located at the GTP site as well as to the north, south and west of the Premises.</p>
Biological component	Distance from the Premises
Threatened / priority flora	<p>Three species of priority flora are located on Barrow Island west of the Premises.</p>
Threatened / priority fauna (terrestrial and marine)	<p>Barrow Island is recognised as an important refuge for native terrestrial mammal species that have either declined in numbers or become extinct on the mainland.</p> <p>A considerable number of threatened and priority fauna are known to occur on the island including a number species that are listed under the <i>Wildlife Conservation Act 1950</i> (WA) (WC Act) and the Threatened (Vulnerable) Species list of the EPBC Act. Some of these species are known to occur within or adjacent to the Premises.</p> <p>Green and flatback turtles (both listed as vulnerable under the WC Act and EPBC Act) nest on Barrow Island. Flatback turtle rookies are recorded near the Premises (300 m away).</p>
Threatened / priority fauna (subterranean)	<p>Barrow Island is recognized as being of high conservation significance for subterranean fauna communities at state, national and international levels. The subterranean fauna demonstrates high level of endemism and species diversity and includes one of only two stygal vertebrate species occurring in Australia (Blind Gudgeon). Twelve of the species are listed under the <i>Wildlife Conservation Act 1950</i> and the Blind Gudgeon is listed as vulnerable under the EPBC Act.</p> <p>13 stygofauna taxa were recorded in monitoring bores at the terminal tanks (approximately 1 km north of the GTP and 1 km east of Drill Centre A). The karstic limestone layer which is believed to be Giralia Calcarene is known to contain many cavities and solution tubes that provide habitat for stygofauna. It is located beneath the surficial soil layer at the premises. Beneath this layer is a band of siliceous silty sand which creates a barrier for subterranean fauna as there are no cavities or large pore spaces to allow movement. It is considered unlikely to encounter populations of subterranean fauna beneath this layer.</p>

## 7.4 Groundwater and water sources

The distances to groundwater and water sources are shown in Table 10.

**Table 10: Groundwater and water sources**

Groundwater and water sources	Distance from Premises	Environmental value
Groundwater	<p>There is one shallow unconfined fresh water aquifer on Barrow Island. This fresh water aquifer forms a lens of relatively fresh groundwater floating upon denser, saline ground water at depths between 9 m and 53 m.</p> <p>The aquifer is principally recharged from rainfall. Groundwater discharge is predominantly to the ocean, although given the high evaporation rates; loss of groundwater is expected to occur via evaporation in areas where the water table is shallower than two metres below the ground surface.</p>	<p>Domestic or industrial water supply for use on the island.</p> <p>The groundwater system is linked to the marine ecosystem (&lt;100 m from the Premises).</p> <p>Groundwater supports subterranean fauna which has high conservation significance.</p>
Barrow Group Formation	<p>The Barrow Group Formation is an underground saline aquifer situated at depths between 1,200 m and 1,900 m below the surface and is divided into three separate formations; the Flacourt and Malouet which are present beneath the BINR, and Flag Sandstone.</p> <p>The components of the Barrow Group Formation behave as a single, hydraulically connected unit; however, the Barrow Group Formation is hydraulically separated from the shallow unconfined Tertiary limestone by a thick sequence (more than 1,000 m) of low permeability material. Water quality is highly alkaline and saline (total dissolved solids concentration approximately &gt;30,000 mg/L), and is considered to be saturated with hydrocarbons. It is generally characterised as containing stable minerals with a very low proportion of soluble metals.</p> <p>A thick sequence of low permeability material (lower Gearle siltstone) hydraulically separates the Barrow Group Formation from the surface groundwater aquifer.</p>	No beneficial use.
Dupuy Formation	<p>The Dupuy Formation is a 300 to 500 m thick sandy silty unit located at depths between 2,000 to 2,300 m below the surface of Barrow Island. Water in the Dupuy Formation has a salinity of between 4,500 and 10,000 ppm sodium chloride (NaCl) equivalents and contains hydrocarbon in low concentrations.</p>	No beneficial use.

## 7.5 Meteorology

### 7.5.1 Wind direction and strength

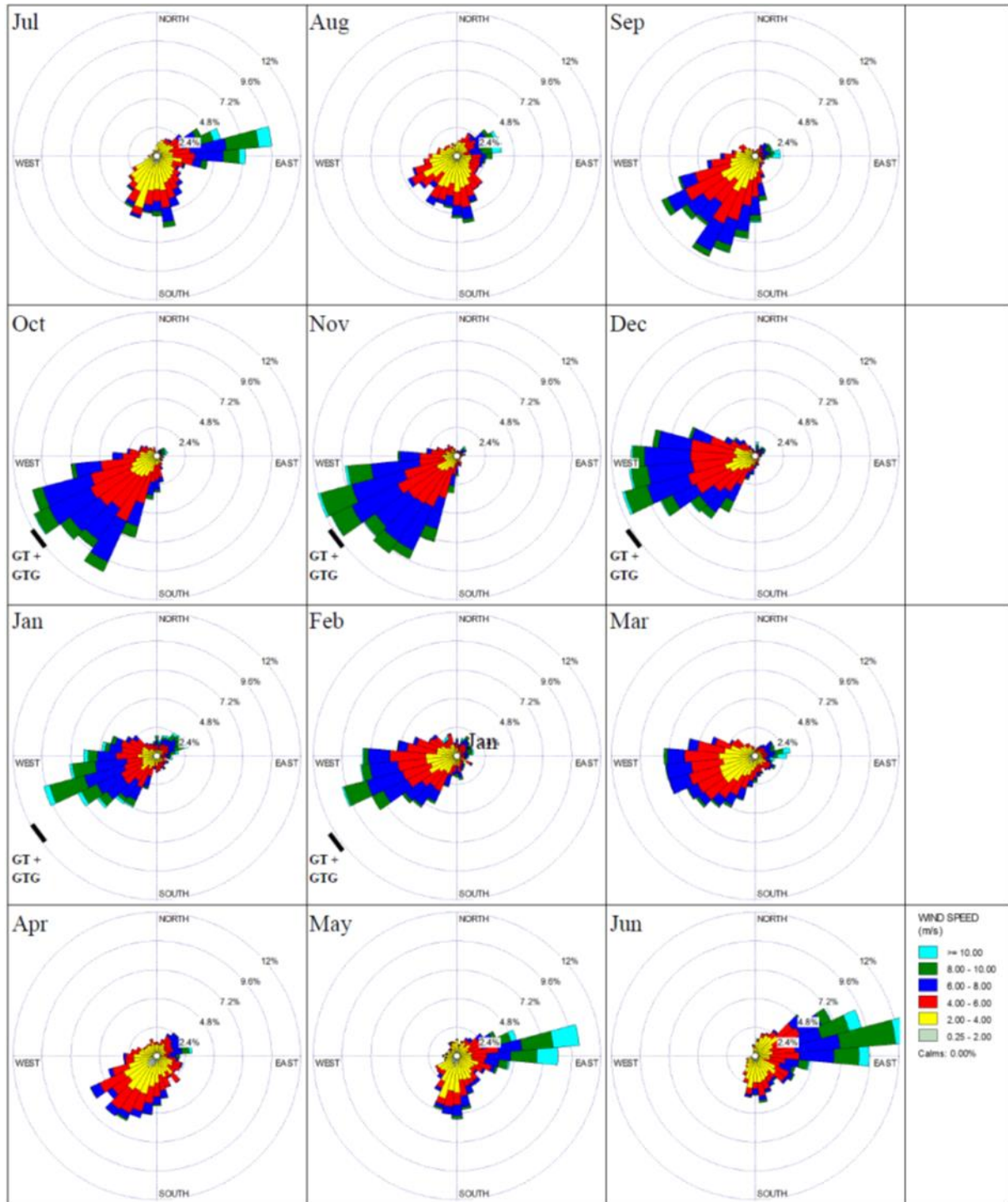
The Licence Holder maintains three meteorological monitoring stations on Barrow Island (Figure 2). Data measured at the P36 Well monitoring station between 2010 and 2014 indicates that the prevailing winds are from the south-west. During winter months (May – July), Barrow Island is subject to easterly winds.

It is important to note that these wind roses show historical wind speed and wind direction data

for the P36 Well station and should not be used to predict future data.

### 7.5.2 Regional climatic aspects

Barrow Island is characterised by an arid, sub-tropical environment with hot summers and moderate winters. Tropical cyclone activity occurs from November to April and can generate significant rainfall.



**Figure 2 Wind roses by month for P36 Well meteorological monitoring site for 2010 to 2014 (Chevron, 2017a)**

## **8. Risk assessment**

### **8.1 Determination of emission, pathway and receptor**

In undertaking its risk assessment, DWER will identify all potential emissions pathways and potential receptors to establish whether there is a Risk Event which requires detailed risk assessment.

To establish a Risk Event there must be an emission, a receptor which may be exposed to that emission through an identified actual or likely pathway, and a potential adverse effect to the receptor from exposure to that emission. Where there is no actual or likely pathway and/or no receptor, the emission will be screened out and will not be considered as a Risk Event. In addition, where an emission has an actual or likely pathway and a receptor which may be adversely impacted, but that emission is regulated through other mechanisms such as Part IV of the EP Act, that emission will not be risk assessed further and will be screened out through Table 11 and Table 12.

The identification of the sources, pathways and receptors to determine Risk Events are set out in Table 11 and Table 12 below.

**Table 11: Identification of emissions, pathway and receptors during operation**

Risk Events					Continue to detailed risk assessment	Reasoning
Sources/Activities	Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
<p><b>Category 10 and 34</b></p> <p><b>LNG processing trains</b></p>	<p>CO<sub>2</sub> compression, transport and injection</p>	<p>Emissions to land - point source</p> <p>H<sub>2</sub>S and Hydrocarbon (including BTEX) within reservoir CO<sub>2</sub></p>	<p>Dupuy Formation</p> <p>Barrow Formation</p>	<p>Direct injection of reservoir CO<sub>2</sub> to a subsurface formation (via injection wells)</p>	<p>Groundwater contamination restricting use</p>	<p>No</p> <p>There is potential for reservoir CO<sub>2</sub> to cause contamination, in particular acidification, of groundwater where it is injected, or in areas the CO<sub>2</sub> plume migrates to.</p> <p>The Delegated Officer has however determined that the Dupuy Formation where reservoir CO<sub>2</sub> will be injected, and the overlying Barrow Formation, have no beneficial use and do not support any significant environmental values due to their saline nature and presence of residual hydrocarbons. Assessment and approval for reservoir CO<sub>2</sub> injection to the Dupuy Formation has already occurred and been granted under Part IV of the EP Act (MS 800), BI Act Section 13 Approval and Pipeline Licence PL 93 under the PP Act, supporting this determination.</p> <p>The Delegated Officer considers the risk of groundwater contamination has been previously assessed and is sufficiently regulated through the requirements of Pipeline Licence PL 93, the BI Act Section 13 Approval and the associated CO<sub>2</sub> Disposal Management Plan. The CO<sub>2</sub> Disposal Management Plan includes monitoring of the reservoir CO<sub>2</sub> plume within the subsurface environment. Additionally, groundwater monitoring commitments within the TSEMP (MS 800, Condition 8) will detect any migration of contamination to the near surface environment.</p> <p>Although the risk of groundwater contamination is sufficiently regulated, the amended licence will be required to authorise emissions to land associated with reservoir CO<sub>2</sub> injection via wells. The Delegated Officer has determined that the BI Act Section 13 Approval sets limits on the composition, rate and quantity of reservoir CO<sub>2</sub> injected to the Dupuy Formation and, given the EP Act under which the licence is granted prevails over other legislation, any authorisation within the licence relating to reservoir CO<sub>2</sub> emissions via injection must not be additional to, or of a higher degree of regulatory control than these limits. The Delegated Officer considers only Hydrocarbon (including BTEX) and H<sub>2</sub>S within the reservoir CO<sub>2</sub> are waste emissions needing to be specified within the licence.</p>



Risk Events					Continue to detailed risk assessment	Reasoning
Sources/Activities	Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
		Groundwater (shallow unconfined fresh water aquifer) and groundwater dependant ecosystems (subterranean fauna)	Leakage from the CO <sub>2</sub> injection facilities or leakage of injected reservoir CO <sub>2</sub> from the sub-surface environment	Groundwater contamination (acidification) causing impact to or loss of conservation significant subterranean fauna  Asphyxiation (CO <sub>2</sub> ) of significant subterranean fauna	No	<p>The potential impact to groundwater and subterranean fauna was considered in the Part IV assessment of the Gorgon Project (EPA Reports 1221 and 1323). The risk of unpredicted leakage or migration of reservoir CO<sub>2</sub> to the near surface or surface environment was considered and was a key consideration within the draft EIS/ERMP and the subsequent PER for the Gorgon Project.</p> <p>The shallow surface formations and the water table identified as subterranean fauna habitat are geologically isolated from the deeper Dupuy Formation which receives injected reservoir CO<sub>2</sub>. The Part IV assessment found the level of risk associated with reservoir CO<sub>2</sub> affecting the shallow aquifer and subterranean fauna within the aquifer is sufficiently low to meet EPA objectives.</p> <p>The Delegated Officer considers the risk of groundwater contamination within the shallow aquifer, and associated impacts to subterranean fauna, has been previously assessed and is sufficiently regulated through the requirements of Pipeline Licence PL 93, the BI Act Section 13 Approval and the associated CO<sub>2</sub> Disposal Management Plan. The CO<sub>2</sub> Disposal Management Plan includes monitoring of the reservoir CO<sub>2</sub> plume within the subsurface environment. Additionally, groundwater monitoring commitments within the TSEMP (MS 800, Condition 8) will detect any migration of contamination to the near surface environment.</p> <p>As per the above the Delegated Officer has determined to include emission to land limits consistent with the BI Act Section 13 Approval to ensure authorisation for discharges to land relating to reservoir CO<sub>2</sub> emissions via injection is not additional to, or of a higher degree of regulatory control, than the existing BI Act Section 13 Approval.</p>

Risk Events					Continue to detailed risk assessment	Reasoning
Sources/Activities	Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
		Flora and fauna within the Class A Nature Reserve		Survival and health impacts to flora and fauna	No	<p>The potential impact to flora and fauna was considered in the Part IV assessment of the Gorgon Project (Reports 1221 and 1323). The risk of unpredicted leakage or migration of reservoir CO<sub>2</sub> to the surface environment was considered and was a key consideration within the draft EIS/ERMP and the subsequent PER for the Gorgon Project.</p> <p>The Dupuy Formation which receives injected reservoir CO<sub>2</sub> is geologically isolated from the surface environment. The Part IV assessment found the level of risk associated with reservoir CO<sub>2</sub> affecting flora and fauna is sufficiently low to meet EPA objectives.</p> <p>The Delegated Officer considers the risk of reservoir CO<sub>2</sub> leak or migration to the surface, and associated impacts to flora and fauna, has been previously assessed and is sufficiently regulated through the requirements of Pipeline Licence PL 93, the BI Act Section 13 Approval and the associated CO<sub>2</sub> Disposal Management Plan. The CO<sub>2</sub> Disposal Management Plan includes monitoring of the reservoir CO<sub>2</sub> plume within the subsurface environment. Additionally, environmental monitoring commitments within the TSEMP (MS 800, Condition 8) will detect impacts which may result from reservoir CO<sub>2</sub> leaks or migration to the surface.</p> <p>As per the above the Delegated Officer has determined to include emission to land limits consistent with the BI Act Section 13 Approval to ensure authorisation for discharges to land relating to reservoir CO<sub>2</sub> emissions via injection is not additional to, or of a higher degree of regulatory control, than the existing BI Act Section 13 Approval.</p>

Risk Events					Continue to detailed risk assessment	Reasoning
Sources/Activities	Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
		Noise	Licence Holder operated accommodation camps (Butler Park and Production Camp) Varanus Island Onslow	Air / wind dispersion	Amenity impact	<p>In accordance with the <i>Guidance Statement: Risk Assessments</i>, worker accommodation camps are not considered a potential receptor.</p> <p>The BINR is considered a single premises for the purpose of the <i>Environmental Protection (Noise) Regulations 1997</i> (Noise Regulations). The Noise Regulations specify that noise emitted from any premises must not cause or significantly contribute to noise which exceeds the assigned levels when received at another Premises. Therefore, the assigned noise levels within the Noise Regulations, do not apply to any location within the BINR, inclusive of the accommodation camps, as the BINR is a single Premises.</p> <p>The Delegated Officer has determined that there is sufficient separation distance to the closest public sensitive receptors for there to be no source-pathway-receptor link.</p> <p>The Delegated Officer has determined that potential noise impacts on marine turtles are regulated under MS 800 (condition 16) through the Long Term Marine Turtle Management Plan.</p> <p>The Delegated Officer has determined that impacts on marine turtles from artificial light from the Premises are regulated under MS 800 (condition 16) via the Long Term Marine Turtle Management Plan.</p>
		Light	Turtle nesting beaches located 300m away		Disruption to turtle nesting behaviour.	

**Table 12 Identification of emissions, pathway and receptors during upset conditions**

Risk Events					Continue to detailed risk assessment	Reasoning
Sources/Activities	Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
<p><b>Category 10 and 34</b></p> <p><b>LNG processing trains</b></p>	<p>Ad hoc venting from the AGRUs and miscellaneous vents within the CO<sub>2</sub> compression, transfer and injection system</p>	<p>Air emissions - point source</p> <p>H<sub>2</sub>S and Hydrocarbon (including BTEX)</p> <p>O<sub>3</sub> (secondary pollutant)</p>	<p>Licence Holder operated accommodation camps (Butler Park and Production Camp)</p> <p>Varanus Island</p> <p>Onslow</p>	<p>Air / wind dispersion</p>	<p>Health and amenity impacts to sensitive receptors</p>	<p>No</p> <p>In accordance with the <i>Guidance Statement: Risk Assessments</i>, worker accommodation camps are not considered a potential receptor.</p> <p>The Delegated Officer has determined that there is sufficient separation distance to other sensitive receptors for there to be no source-pathway-receptor link.</p> <p>The Delegated Officer has determined that the CO<sub>2</sub> Pipeline Safety Case, required to be implemented as per conditions of Pipeline Licence PL 93, identifies occupational health and safety risks to people working on Barrow Island and risk mitigation measures to minimise the likelihood of these risks occurring. The Delegated Officer therefore considers that potential impact to persons working on Barrow Island, associated with venting of reservoir CO<sub>2</sub>, is regulated under Pipeline Licence PL 93.</p>

			Flora and fauna within the Class A Nature Reserve (BINR)		Survival and health impacts to flora and fauna	<p>No – previously assessed (refer to sections 2.1 and 2.2 of Appendix 4)</p>	<p>Venting of the reservoir CO<sub>2</sub> (acid gas, Hydrocarbon (including BTEX) and H<sub>2</sub>S) from the AGRUs was assessed in the initial assessment of the application for Licence L9102/2017/1 (see sections 2.1 and 2.2 of Appendix 4 for the risk assessment). The risk of health impacts to flora and fauna as a result of Hydrocarbon (including BTEX) and H<sub>2</sub>S emissions was determined to be low, and as a result of the secondary pollutant O<sub>3</sub> was determined to be medium.</p> <p>The venting scenario considered in the assessment was based on simultaneous venting from all three AGRU's due to unavailability of the CO<sub>2</sub> injection system. This is considered to be the most significant venting scenario for the Premises as these vents have the highest emission rates, particularly when venting simultaneously. It is noted that the different vent heights, flow rates and emission volumes of the vents within the reservoir CO<sub>2</sub> injection system may impact emission and dispersion characteristics of the vented gas, however the emission rates from the vent system are lower. DWER's Air Quality technical experts consider the venting of reservoir CO<sub>2</sub> from the Premises is unlikely to pose an unacceptable risk to non-occupational receptors.</p> <p>Venting from the AGRUs and reservoir CO<sub>2</sub> venting system will occur during initial commencement of operation of the infrastructure, and, when the infrastructure is fully operational, for maintenance activities, start-up/shutdowns, and upset conditions. Venting is expected to be infrequent and short-term with approximately half expected to have a duration between 15 minutes and an hour and remaining events lasting between four hours and one week. The volume of reservoir CO<sub>2</sub> expected to be vented has not been able to be accurately predicted as it is not known how often upset conditions requiring venting of the gas will occur. As the CO<sub>2</sub> infrastructure is progressively brought into operation the venting undertaken as per the current licence from the AGRUs is expected to significantly reduce.</p> <p>The Delegated Officer has determined that the ongoing ambient air quality monitoring undertaken in accordance with the Air Quality Management Plan developed under MS 800 will continue to verify ambient air quality, including H<sub>2</sub>S, VOCs (BTEX) and O<sub>3</sub> levels, are meeting relevant air quality criteria during venting events and other operational scenarios for the GTP.</p> <p>The TSEMP will be implemented in accordance with the requirements of Condition 8 of MS 800 to measure impacts on flora and fauna. The Delegated Officer considers this regulatory control is suitable for detecting and responding to</p>
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Risk Events					Continue to detailed risk assessment	Reasoning
Sources/Activities		Potential emissions	Potential receptors	Potential pathway		
						<p>potential impact to flora and fauna resulting from the CO<sub>2</sub> venting.</p> <p>The Delegated Officer has determined that there are no limits within MS 800 or the BI Act Section 13 Approval applicable to emissions to air during venting of reservoir CO<sub>2</sub>. However, as per the risk assessment, there is a low risk associated with venting of acid gases, and sufficient regulatory controls in place to detect impacts which may result from emissions to air, therefore the Delegated Officer has determined not to include limits or monitoring of emissions to air from the venting system. The vent locations will be included on the licence as authorised emission points for H<sub>2</sub>S and Hydrocarbon (including BTEX).</p>

## 9. Determination of amended Licence conditions

The conditions in the amended Licence have been determined in accordance with the *Guidance Statement: Setting Conditions* and the *Guidance Statement: Risk Assessments*. The DWER notes that it may review the appropriateness and adequacy of controls at any time and that, following a review, DWER may initiate amendments to the licence under the EP Act.

### 9.1 Emissions to air

The assessment has determined that there will be point source emissions of Hydrocarbon (including BTEX) and H<sub>2</sub>S (incidental substances within the reservoir CO<sub>2</sub>) to air from the reservoir CO<sub>2</sub> infrastructure venting system. Condition 2, Table 3 has been updated in the amended licence to include the reservoir CO<sub>2</sub> infrastructure vents as authorised emission points for these substances. The remaining substances within the reservoir CO<sub>2</sub> have not been included as they were excluded from the assessment as per section 4.3.

The risk assessment found the risk associated with Hydrocarbon (including BTEX) and H<sub>2</sub>S emissions to air is low therefore the Delegated Officer has determined that monitoring of emissions and/or establishing emission limits for emissions to air from the venting system is not required. The composition of the reservoir CO<sub>2</sub> which is discharged to land via injection, which will have emission limits and monitoring, is anticipated to reflect the composition of the reservoir CO<sub>2</sub> stream that may be vented.

Condition 26 of MS 800 includes a minimum limit on the quantity of reservoir CO<sub>2</sub> which must be injected, and therefore also limits the quantity which can be vented. The Delegated Officer has therefore determined not to include a limit on the quantity which can be vented to avoid regulatory duplication.

Ambient monitoring is a requirement of the Air Quality Management Plan implemented in accordance with Condition 29 of MS 800. Ambient monitoring requirements (and related targets) specified in the Plan are not duplicated in the Licence conditions. DWER may request copies of ambient air quality monitoring data to review trends in ground level concentrations and ensure that the risk assessment and Licence conditions remain appropriate and relative to the environmental risk.

Other environmental monitoring programs, such as the TSEMP, are implemented as per the conditions of MS 800, to detect impacts to flora and vegetation if these occur as a result of reservoir CO<sub>2</sub> venting.

### 9.2 Emissions to land

The assessment has determined that there will be point source emissions of Hydrocarbon (including BTEX) and H<sub>2</sub>S, (incidental substances within the reservoir CO<sub>2</sub>) to land from the reservoir CO<sub>2</sub> injection wells. Condition 7, Table 4 has been updated to include the reservoir CO<sub>2</sub> drill centre injection wells as authorised emission points for these substances. The remaining substances within the reservoir CO<sub>2</sub> have not been included as they were excluded from the assessment as per section 4.3.

The risk assessment outcomes demonstrate that potential impacts to groundwater, flora and fauna, from emissions of Hydrocarbon (including BTEX) and H<sub>2</sub>S to land from the reservoir CO<sub>2</sub> injection wells are sufficiently regulated through the conditions and requirements of Pipeline Licence PL 93, the BI Act Section 13 Approval and the associated CO<sub>2</sub> Disposal Management Plan. Additionally, groundwater, flora and fauna monitoring commitments within the TSEMP (MS 800, Condition 8) will detect impacts which may occur.

However, the Delegated Officer has determined that the BI Act Section 13 Approval establishes limits for the composition, rate and quantity of reservoir CO<sub>2</sub> which will be injected to the Dupuy Formation. Given the EP Act under which the Licence is granted prevails over

other legislation, any authorisation within the Licence relating to reservoir CO<sub>2</sub> emissions must not be additional to, or of a higher degree of regulatory control than these limits. The Delegated Officer has therefore determined to include limits for discharges to land from the reservoir CO<sub>2</sub> injection wells within Condition 8, Table 5. The limits have been extracted from the BI Act Section 13 Approval (and variation of conditions) for Hydrocarbon (including BTEX), H<sub>2</sub>S and the daily injection rate. The remaining substances within the reservoir CO<sub>2</sub> have not been included as they were excluded from the assessment as per section 4.3.

### 9.2.1 Monitoring

Monitoring requirements have been specified within Condition 9, and Table 16 in Schedule 3 to monitor and record data which will verify whether the emission limits specified in Condition 8 have been complied with. The monitoring requirements have been based on those specified in the CO<sub>2</sub> Disposal Management Plan to provide for consistency in requirements between the different regulatory instruments.

Monitoring of the operation of the reservoir CO<sub>2</sub> injection wells and the associated CO<sub>2</sub> plume is specified within the conditions and requirements of Pipeline Licence PL 93, the BI Act Section 13 Approval and the associated CO<sub>2</sub> Disposal Management Plan therefore to avoid regulatory duplication no process monitoring or ambient monitoring associated with emissions to land has been specified within the amended Licence.

As per the above section groundwater, flora and fauna monitoring commitments within the TSEMP (MS 800, Condition 8) will detect impacts which may occur and no further monitoring has been specified in the amended licence.

### 9.2.2 Reporting

Monitoring data collected in relation to discharges to land (as per requirements of Condition 9) is required to be reported and interpreted to DWER in the Annual Environmental Report required by Condition 19.

Existing Condition 16 also requires reporting of any non-compliance with the conditions of the Licence within the specified timeframe. This condition is applicable to exceedance of any of the limits set in Condition 8.

DWER may request copies of monitoring data relevant to the discharge of reservoir CO<sub>2</sub> to land recorded and reported under the Pipeline Licence PL 93, the BI Act Section 13 Approval and the associated CO<sub>2</sub> Disposal Management Plan to review the performance of the reservoir CO<sub>2</sub> injection system, and migration of the CO<sub>2</sub> plume, to ensure that the risk assessment and Licence conditions remain appropriate and relative to the environmental risk.

## 9.3 Maps

The Premises boundary required extension to include the CO<sub>2</sub> infrastructure therefore the Premises map and boundary coordinates have been updated in the amended Licence.

A new site layout map has also been included to illustrate the location of the CO<sub>2</sub> infrastructure and an additional map of the reservoir CO<sub>2</sub> discharge points has been included to specify their location within the premises.

## 10. Applicant's comments

The Applicant was provided with the draft Decision Report and draft amended Licence on 24 July 2019. The Applicant provided comments which are summarised, along with DWER's response, in Appendix 3.



## 11. Conclusion

This assessment of the risks of operation of reservoir CO<sub>2</sub> compression, transport and injection infrastructure on the Premises has been undertaken with due consideration of a number of factors, including the documents and policies specified in this Decision Report (summarised in Appendix 1).

Based on this assessment, it has been determined that the Amended Licence will be granted subject to conditions commensurate with the determined controls and necessary for administration and reporting requirements.

**James Milne**

**A/ Senior Manager, Process Industries**

Delegated Officer under section 20 of the *Environmental Protection Act 1986*

## Appendix 1 Key documents

	Document title	In text ref	Availability
1.	Application form: Works Approval / Licence / Renewal Amendment / Registration and associated attachments	Chevron 2019a	DWER records (A1787461)
2.	Chevron's Revised response to DWER's request for further information	Chevron 2019b	DWER records (DWERDT168589)
3.	Chevron's mapping updates for Gorgon CO2 Amendment	Chevron 2019c	DWER records (DWERDT174567)
4.	Gorgon Project Emissions Verification Report: LNG Trains 1, 2 and 3 and Associated Facilities (W5178/2012/1)	Chevron 2017a	DWER records (A1505078)
5.	Works Approval W5178/2012/1 – Gorgon Gas Development Gas Treatment Plant Part 2 (and attached Environmental Assessment Report)	W5178/2012/1	DWER records (A538236, A538237)
6.	Licence L9102/2017/1 – Gorgon Gas LNG Project (and attached Decision Report)	L9102/2017/1	DWER records (A1708213)
7.	Ministerial Statement 800	MS 800	Accessed at <a href="http://www.epa.wa.gov.au">www.epa.wa.gov.au</a>
8.	EPA, 2006. Gorgon Gas Development Barrow Island Nature Reserve, Chevron Australia. Report and Recommendations of the Environmental Protection Authority (Bulletin 1221)	Report 1221	
9.	EPA, 2009. Gorgon Gas Development Revised and Expanded Proposal: Barrow Island Nature Reserve, Report and Recommendations of the Environmental Protection Authority (Bulletin 1323)	Report 1323	
10.	Chevron Australia Pty Ltd, 2014. <i>Gorgon Gas Development and Jansz Feed Gas Pipeline: Terrestrial and Subterranean Environment Protection Plan</i>	Chevron 2014a	Accessed at <a href="http://www.chevronaustralia.com">www.chevronaustralia.com</a>
11.	Chevron Australia Pty Ltd, 2014. <i>Gorgon Gas Development and Jansz Feed Gas Pipeline: Terrestrial and Subterranean Environment Monitoring Program</i>	Chevron 2014b	

	Document title	In text ref	Availability
12.	Chevron Australia Pty Ltd, 2016. <i>Gorgon Gas Development and Jansz Feed Gas Pipeline: Air Quality Management Plan</i>	Chevron 2016a	
13.	Draft Environmental Impact Statement/ Environmental Review and Management Programme for the Proposed Gorgon Development	Chevron 2005	
14.	Gorgon Gas Development, Revised and Expanded Proposal, Public Environmental Review  EPBC Referral 2008/4178, Assessment No. 1727	Chevron 2008	
15.	Gorgon Project Carbon dioxide disposal management plan	Chevron 2019	Confidential
16.	Barrow Island Act 2003 (WA) – Section 13 Approval to Disposal of Carbon Dioxide by Injection Into Subsurface Formation, inclusive of approved variations	BI Act	Confidential
17.	Petroleum Pipeline Act 1969 Pipeline Licence No. PL 93	Pipeline Licence PL 93	Confidential
18.	DER, July 2015. <i>Guidance Statement: Regulatory principles</i> . Department of Environment Regulation, Perth.	DER 2015a	
19.	DER, October 2015. <i>Guidance Statement: Setting conditions</i> . Department of Environment Regulation, Perth.	DER 2015b	
20.	DER, February 2017. <i>Guidance Statement: Risk Assessments</i> . Department of Environment Regulation, Perth.	DER 2017a	
21.	DER, February 2017. <i>Guidance Statement: Decision Making</i> . Department of Environment Regulation, Perth.	DER 2017b	
22.	Department of Environment and Conservation (NSW), 2005. <i>Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales</i> , Department of Environment and Conservation, Sydney	DEC NSW 2005	Accessed at <a href="http://www.environment.nsw.gov.au">http://www.environment.nsw.gov.au</a>

accessed at [www.dwer.wa.gov.au](http://www.dwer.wa.gov.au)

	<b>Document title</b>	<b>In text ref</b>	<b>Availability</b>
23.	WHO, 2000. <i>Air Quality guidelines for Europe, 2nd Edition</i> , WHO Regional Publications, European Series, No. 91, WHO Regional Office of Europe, Copenhagen, Denmark	WHO 2000	Access at <a href="http://www.euro.who.int">http://www.euro.who.int</a>
24.	WHO, 2005. <i>Air Quality Guidelines, Global Update 2005</i> , WHO Regional Office of Europe, Copenhagen, Denmark	WHO 2005	Access at <a href="http://www.euro.who.int">http://www.euro.who.int</a>

## Appendix 2 Summary of comments on the application for amendment from stakeholders

Summary of comments	DWER response
<p>The stakeholder has submitted that regulation of GHG emissions falls within the scope of Part V of the EP Act and therefore should be fully assessed and conditioned under the Licence. They have further submitted that this is an appropriate regulatory response and must be applied to all GHG emissions associated with the Gorgon LNG Project.</p> <p>The stakeholder also comments that licence conditions must place enforceable limits and trigger points on GHG emissions associated with the CO<sub>2</sub> Injection System and that specific conditions on the manner in which geosequestration will occur, must be imposed to prevent environmental harm from emissions associated with the CO<sub>2</sub> Injection System and the Gorgon LNG Project as a whole.</p>	<p>The Delegated Officer has determined that potential environmental impacts associated with GHG emissions (which include CO<sub>2</sub>) have been assessed under Part IV of the EP Act (EPA Reports 1221 and 1323) and are subject to the requirements of conditions 26 and 27 of MS 800. The conditions specified in MS 800 relating to the control (reservoir CO<sub>2</sub> injection) and minimisation (Greenhouse Gas Abatement Program) of GHGs are directly derived from this assessment. The Delegated Officer therefore considers that regulation of GHG emissions is within the scope of the Part IV assessment for the Gorgon Project.</p> <p>While the Part IV assessment and regulation of GHG emissions does not preclude the Department from also regulating these emissions under Part V, duplication of regulation is inconsistent with the Department's published guidance in relation to setting conditions. Guidance Statement: Setting Conditions states that "<i>Conditions [on a licence] will not unnecessarily duplicate requirements imposed on licenses directly by the EP Act or another written law</i>".</p> <p>The Delegated Officer has also noted measurement and reporting of greenhouse gas emissions to the atmosphere is a requirement of the <i>National Greenhouse and Energy Reporting Act 2007</i> (Cwth).</p> <p>In addition to regulation and assessment under Part IV of the EP Act, the injection of reservoir CO<sub>2</sub> is also subject to approval under the BI Act and the PP Act (see sections 5.3.1 and 5.3.2 for further detail).</p>
<p>The stakeholder has submitted that the CO<sub>2</sub> Injection System has not yet been subject to appropriate environmental impact assessment and therefore DWER should refer the CO<sub>2</sub> Injection System to the EPA for assessment. The submission states that the EPA assessments of the Gorgon Project did not address the environmental impacts of the CO<sub>2</sub> injection system in detail and that MS 800 does not describe the</p>	<p>The Delegated Officer requested internal advice from EPA Services during the assessment of the amendment application seeking confirmation whether the proposed operation of the reservoir CO<sub>2</sub> infrastructure, including the composition of the reservoir CO<sub>2</sub>, was consistent with what had been assessed during the Part IV assessment of the Gorgon Project.</p> <p>The advice provided by EPA Services was that the reservoir gas stream, including incidental substances was considered and assessed in Bulletins</p>

Summary of comments	DWER response
<p>injection process or condition the volume or composition of reservoir CO<sub>2</sub> to be injected.</p> <p>The stakeholder further submits that emissions other than CO<sub>2</sub> associated with the CO<sub>2</sub> Injection System and the Gorgon LNG Project as a whole, in particular MEG gas (including flaring of flash gas vapours) and other hydrocarbons, have similarly not been subject to Part IV assessment and may properly be the subject of a s 38(5) referral.</p>	<p>1221 and 1323 and that the proposal is consistent with the previous assessment under Part IV for the Gorgon Project and subsequent approval under MS 800.</p> <p>As the reservoir CO<sub>2</sub> injection system has previously been referred under Part IV of the EP Act, as part of the Gorgon Gas Development, it is not able to be referred to the EPA again in accordance with s38(5j) of the EP Act.</p>
<p>The scope of Part V assessment must encompass the volume and composition of reservoir carbon dioxide and account for the Proponent's information as to variability and "worst case" scenarios.</p>	<p>The risk assessment in section 8.1 (Table 11 and Table 12) discusses the Delegated Officer's determination in relation to assessment and regulation of emissions to air and land associated with the reservoir CO<sub>2</sub> injection proposal. The risk assessment found the BI Act Section 13 Approval already specifies limits to the injection rate and composition of the reservoir CO<sub>2</sub>. Due to the EP Act prevailing over this approval, the Delegated Officer determined to include the same limits within the amended licence for discharges to land. The limits only apply to substances authorised to be emitted from the injection system.</p> <p>This assessment found there are no regulatory restrictions applicable to the composition of reservoir CO<sub>2</sub> which is vented from the AGRUs and reservoir CO<sub>2</sub> venting system. The risk associated with venting was determined through this assessment to be low. In accordance with the Department's Guidance Statements additional control and monitoring of the venting is therefore not required. MS 800 restricts venting volumes as a percentage of total emissions by specifying a minimum volume (by percentage) of CO<sub>2</sub> which must be injected.</p>
<p>Other approvals do not justify any lack of regulation through controls and limits on greenhouse gas emissions associated with the Gorgon LNG Project</p> <p>Regulation of emissions under the BI Act is not sufficient. as section 5 of the EP Act provides that it overrides other legislation, and the BI Act specifically states that there must be compliance with the EP Act (Schedule 1, Clauses 2(3) and 14).</p> <p>While the Barrow Island Act provides that it is an offence for a person to</p>	<p>DWER Guidance Statement: Setting Conditions states that "<i>Conditions [on a licence] will not unnecessarily duplicate requirements imposed on licenses directly by the EP Act or another written law</i>".</p> <p>The Delegated Officer has considered the scope and applicable penalties of the regulatory instruments which relate to the operation of the reservoir CO<sub>2</sub> infrastructure on the Premises (inclusive of associated Management Plans or Programs) within this assessment. The scope of the various regulatory instruments is discussed in section 5. Where appropriate the Delegated</p>

Summary of comments	DWER response
<p>inject CO<sub>2</sub> into a reservoir without the permission of the Minister (which has been provided via the Section 13 Approval), the Act makes no specific provision for compliance with conditions imposed under a Section 13 Approval.</p> <p>It is therefore unclear whether any 'compliance consequences' will arise from a failure by the Proponent to inject reservoir CO<sub>2</sub> consistently with the terms of the approval, what such consequences might be, or whether efforts by regulators to impose such consequences would be enforceable. Such vague and uncertain compliance arrangements are not commensurate with the environmental risks posed by the operation.</p>	<p>Officer has avoided regulatory duplication as per the DWER Guidance Statement: Setting Conditions.</p> <p>This is with the exception of setting limits and monitoring requirements for discharges to land for the composition and injection rate of reservoir CO<sub>2</sub>. As discussed in sections 8.1 and 9.2, limits and monitoring have been specified within the amended licence to align with the BI Act Section 13 Approval composition and injection limits. As the licence includes authorised emissions from the reservoir CO<sub>2</sub> injection wells, without the inclusion of limits the licence could potentially authorise higher levels than the BI Act Section 13 Approval given the requirements of the EP Act prevail over other legislation.</p> <p>The review of other regulatory instruments identified that there are penalties for non-compliance with the requirements of the conditions of MS 800, BI Act Section 13 Approval and the Pipeline Licence PL 93. The most notable of these is the scope to require rectification of non-compliance or to remove or restrict the approval to inject reservoir CO<sub>2</sub> in the event there is an increased risk of significant environmental impact or the Proponent has not conducted activities in accordance with the requirements of the approval. There are also other penalties which apply. There is provision within the BI Act Section 13 Approval requiring timely reporting of significant risks and other incidents such as CO<sub>2</sub> leakage and non-compliance. The Delegated Officer considers there is sufficient regulation and penalties within the legislative framework and considered these in making this decision.</p>
<p>The application does not include disposal of gaseous MEG waste (as well as mercury, BTEX, etc) from the Gorgon LNG Project more broadly. These emissions do not appear to be authorised under Part V and should be incorporated into the Licence after full assessment of relevant risk and environmental impact</p>	<p>The Delegated Officer has only considered the content of the amendment application within the assessment. The application did not seek to include disposal of gaseous MEG waste via the reservoir CO<sub>2</sub> injection system. The Licence Holder has also confirmed in the application details that there is no mercury within the reservoir CO<sub>2</sub> gas stream, mercury is removed by mercury removal units during the acid gas removal stage. Disposal of gaseous MEG waste is currently authorised within the scope of W6199/2018/1.</p>
<p>DBCA has reviewed the proposal and notes that no specific information was provided that highlights any potential additional impacts associated with this proposal on matters relevant to the <i>Conservation and Land</i></p>	<p>No response required.</p>

Summary of comments	DWER response
<p><i>Management Act 1984</i> (CALM Act) or the <i>Biodiversity Conservation Act 2016</i> (BC Act). DBCA notes the Gorgon Project and activity of carbon dioxide compression and injection has been assessed and approved under Part IV of the EP Act.</p> <p>DBCA does not propose any specific comment in regards to the amendment to licence.</p>	
<p>In relation to advice requested relating to the Application the DJTISI confirmed the Application was consistent with the BI Act Section 13 Approval and associated CO<sub>2</sub> Disposal Management Plan.</p>	<p>The Delegated Officer noted the advice provided.</p>
<p>DMIRS provided confirmation that the Application was generally consistent with the Pipeline Licence PL 93 but did not include some additional infrastructure for managing pressure within the application.</p>	<p>The Delegated Officer noted the advice provided.</p>
<p>In relation to advice requested regarding the Application, DWER's EPA Services confirmed MS 800 allows for CO<sub>2</sub> and some incidental substances to be injected to the Dupuy Formation. The composition of the reservoir CO<sub>2</sub> was assessed by the EPA and the composition of reservoir CO<sub>2</sub> in the Application is consistent with what has been assessed under Part IV of the EP Act.</p> <p>EPA Services confirmed there is no approval to dispose of mercury through injection and a detailed submission to the EPA would be required to determine the assessment pathway to make such a change.</p>	<p>The Delegated Officer noted the advice provided.</p>



## Appendix 3 Summary of applicant's comments on risk assessment and draft conditions

Condition	Summary of Licence Holder comment	DWER response
2 (Table 3)	<p>The Licence Holder requested minor amendments to the nomenclature of the discharge points and the number of vents specified in the table. The Licence Holder also provided discharge point heights for the discharge points added to the table.</p> <p>The Licence Holder requested LNG be removed from the description of the AGRU discharge points in the table as the AGRUs are separate trains from the LNG trains.</p>	Accepted.
7 (Table 4)	The Licence Holder requested minor amendments to the nomenclature of the discharge points specified in the table.	Accepted.
8 (Table 5)	The Licence Holder requested amendment to the emission to land parameter Hydrocarbon (including BTEX) and the inclusion of a million standard cubic feet per day (MMscF/d) daily injection rate in addition to the cubic metres per day limit to ensure consistency with the BI Act Section 13 Approval values.	Accepted. The emission to land limits have been extracted from the BI Act Section 13 Approval and therefore have been amended to ensure consistency with the approval.
Schedule 1 - Map of reservoir CO <sub>2</sub> discharge and monitoring points	The Licence Holder provided a revised map which included discharge to land monitoring locations.	Accepted.
Schedule 3 (Table 15)	The Licence Holder provided clarification of the parameters, monitoring locations, frequency and methods for monitoring of the reservoir CO <sub>2</sub> discharges to land.	Accepted.

## Appendix 4 L9102/2017/1 Previous risk assessment and modelling summary relevant to the amendment application

### 1. Determination of risk events through emission, pathway and receptor

A summary of the previous risk assessment undertaken during the assessment of the application for L9102/2017/1, which is of relevance to the amendment application (air emissions) is set out in Table 1 below.

Identification of emission sources, pathways and receptors has been undertaken in accordance with the *Guidance Statement: Risk Assessments* (DER 2017a).

**Table 1 Identification of emissions, pathway and receptors during operation**

Risk Events					Continue to detailed risk assessment	Reasoning
Sources/Activities	Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
<b>Category 10 and 34</b>  <b>LNG and DomGas processing trains and storage facilities</b>	LNG, DomGas and condensate processing and storage	Air emissions - point source  Combustion gases and mercury (Hg): GTs, heating medium heaters and ground flares  Hg, H <sub>2</sub> S and BTEX: AGRU venting  O <sub>3</sub> (secondary pollutant)	Applicant operated accommodation camps (Butler Park and Production Camp)  Varanus Island  Onslow		N/A	No  In accordance with the <i>Guidance Statement: Risk Assessments</i> , worker accommodation camps are not considered a potential receptor.  The Delegated Officer has determined that there is sufficient separation distance to other sensitive receptors for there to be no source-pathway-receptor link.
			Flora and fauna within the Class A Nature Reserve	Air / wind dispersion	Survival and health impacts to flora and fauna	Yes  See section 2.1 (H <sub>2</sub> S and BTEX) and 2.2 (O <sub>3</sub> )  (note: combustion gases and Hg are not relevant to the assessment of the current licence amendment Application (to allow for the operation of reservoir CO <sub>2</sub> compression, transport and injection infrastructure). Therefore the previous risk assessment relating to these emissions has not been included in this appendix).

Risk Events					Continue to detailed risk assessment	Reasoning	
Sources/Activities	Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts			
<b>Category 52 Power Generation</b>	Gas turbines generators	Air emissions - point sources Combustion gases and Hg O <sub>3</sub> (secondary pollutant)	Applicant operated accommodation camps (Butler Park and Production Camp) Varanus Island Onslow	Air / wind dispersion	N/A	No	In accordance with the <i>Guidance Statement: Risk Assessments</i> , worker accommodation camps are not considered a potential receptor.  The Delegated Officer has determined that there is sufficient separation distance to other sensitive receptors for there to be no source-pathway-receptor link.
			Flora and fauna within the Class A Nature Reserve		Survival and health impacts to flora and fauna	Yes	See section 2.1 (H <sub>2</sub> S and BTEX) and 2.2 (O <sub>3</sub> )  (note: combustion gases and Hg are not relevant to the assessment of the current licence amendment Application (to allow for the operation of reservoir CO <sub>2</sub> compression, transport and injection infrastructure). Therefore the previous risk assessment relating to these emissions has not been included in this appendix).

## 2. Risk assessment

An extract of DWER’s previous assessment of the consequence, likelihood and acceptability of risk events which are relevant to the operation of the CO<sub>2</sub> infrastructure is included in the following sections.

Determination of the consequence, likelihood, acceptability and treatment of each event were determined in accordance with the *Guidance Statement: Risk Assessments* (DER 2017a).

### 2.1 Risk assessment – acid gas venting (BTEX and H<sub>2</sub>S)

#### 2.1.1 Description of emissions from acid gas venting

The acid gas containing CO<sub>2</sub> and minor residual amounts of VOCs (BTEX) and H<sub>2</sub>S is vented to atmosphere via the AGRU vents. Each AGRU has its own acid gas vent (three in total). Secondary releases of acid gas are also emitted through other vents (see Table 2).

#### 2.1.2 Identification and general characterisation of emission

Due to delays in the operation of the CO<sub>2</sub> compression and injection system, all acid gas from the three LNG trains is currently vented from the AGRUs. Continuous acid gas venting is expected to be temporary and will progressively decrease as the CO<sub>2</sub> compression and injection system is progressively commissioned.

Once the CO<sub>2</sub> compression and injection system is operational it is planned that all acid gas will be compressed and injected into the subsurface geological formation beneath the BINR. After this point, acid gas venting will only occur in the event of a failure of the CO<sub>2</sub> compression and injection system, process trip, maintenance, or during other process upset conditions. It is anticipated that approximately half of these events will occur from 15 minutes to one hour, with most remaining events lasting between four hours and one week (cumulative total 73 days per year).

Condition 26.2 of MS 800 specifies that all practical measures must be taken to inject acid gas with a target of 80% of acid gas injected (calculated over a 5 year rolling average). Chevron’s long-term performance target is to inject 95% of acid gas into the Dupuy Formation per year.

Estimated emission rates are provided in Table 2. These rates represent the maximum pollutant emissions during upset conditions (i.e. CO<sub>2</sub> compression and injection system failure). Measured emissions rates are the results of compositional analysis undertaken as part of emissions verification.

**Table 2 Estimated base emission rates and actual emissions from AGRU vents.**

Source <sup>[1]</sup>	Vent description and location	Pollutant base emission rate (g/s)			Measured emission rate (g/s) <sup>[2]</sup>	
		NM VOC	BTEX	H <sub>2</sub> S	BTEX	H <sub>2</sub> S
Vent 1	The main low-pressure acid gas vent stack from the discharge of the Amine Regenerator Reflux Drum Vent in each of the AGRUs (three in total)	8.04	104.9	8.1	52.6	1.1 – 2.7
Vent 6	Low-pressure vent upstream of MEG flash gas compressor (one in total)	2.03	6.05	0.65	Flow rates too low to allow sampling for compositional analysis	

Note 1: Only Vents 1 and 6 were operational at the time of the assessment as remaining vents relate to CO<sub>2</sub> compression and injection infrastructure.

Note 2: NMVOC emissions were not determined.

### 2.1.3 Description of potential adverse impact from the emission

BTEX compounds are toxic and can potentially cause a wide range of significant health effects impacting the neurological and respiratory systems. Benzene is also a known carcinogen.

Hydrogen sulfide has a pungent odour at low concentrations; however, there are few detectable toxicological health hazards at concentrations less than 1 ppm (1.5 mg/m<sup>3</sup>) even with exposure for long periods. Eye irritation can occur between 10 to 20 ppm. Respiratory difficulties can be experienced above 320 ppm (WHO, 2000).

### 2.1.4 Criteria for assessment

Assessment criteria for BTEX compounds are provided in the NEPM and are detailed in Table 3.

**Table 3 NEPM (Air Toxics) standards for BTEX**

Pollutant	Averaging period	Monitoring investigation level		Goal (Maximum allowable exceedance)
		ppm	µg/m <sup>3</sup>	
Benzene <sup>[2]</sup>	1 year	0.003	9.6	-
Toluene <sup>[2]</sup>	1 day	1.0	3780	-
	1 year	0.1	380	-
Xylene <sup>[2]</sup>	1 day	0.25	1085	-
	1 year	0.2	870	-

The NSW DEC *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW DEC, 2005) sets residential criteria for H<sub>2</sub>S based on population density. Criteria range from 4.83 µg/m<sup>3</sup> for a population of less than two, to 1.38 µg/m<sup>3</sup> for populations greater than 2,000 (1 hour averaging period).

The WHO provides a criteria for H<sub>2</sub>S of 7 µg/m<sup>3</sup> (30-minute average) which is based on odour annoyance (WHO, 2000). The recommended guideline for eye irritation is 150 µg/m<sup>3</sup> (24-hour average) (WHO, 2000).

In the absence of residential receptors on the island, the WHO criteria of 150 µg/m<sup>3</sup> (24-hour average) has been adopted as a surrogate to assess health impacts to fauna as it represents actual health impacts rather than nuisance odour.

### 2.1.5 Licence Holder controls

The location of vents, size, overall stack height and anticipated flow rates of exit gas all promote the dispersion of the acid gas vented. Ground level concentrations will be reduced as a result of the design features and the operating philosophy.

Venting of acid gas is considered temporary until the CO<sub>2</sub> compression and injection system is functioning. It is expected that once the CO<sub>2</sub> compression and injection system is operational, all acid gas will be compressed and injected. Some venting is expected to occur during process trips or with process upset conditions however these events will be infrequent and short term.

Environmental monitoring will continue in accordance with the TSEMP to identify potential impacts to fauna and flora.

### 2.1.6 Key findings

**The Delegated Officer has reviewed the information regarding acid gas emissions and**

#### has found:

1. Condition 26 of MS 800 specifies an injection target for acid gas of 80% (calculated of a 5 year rolling average) and compliance with this target is managed under Part IV of the EP Act.

### 2.1.7 Consequence

The predicted ground level concentration of H<sub>2</sub>S and BTEX at selected sensitive receptor locations were below the relevant assessment criteria (section 4.1).

A screening level ERA was also undertaken to assess impacts on marine and terrestrial flora and fauna, which concluded that predicted ground level concentrations of H<sub>2</sub>S and BTEX under all modelled acid gas venting scenarios showed no potential for material or serious environmental harm (Section 4.2). Worst case conditions, considered to be simultaneous venting of acid gas from three AGRUs, may result in short-term reversible impacts to susceptible flora and fauna; however, the likelihood of this event occurring has been calculated to be 0.07%. The Delegated Officer notes that the ERA does not consider the current operating scenario where simultaneous venting will occur from all three AGRUs for an extended period (at least 1 year).

Modelling of BTEX emissions considered six scenarios, including the unavailability of the CO<sub>2</sub> compression and injection system due to planned maintenance or a process trip resulting in venting from the AGRU. The maximum annual average concentrations of benzene outside the GTP were predicted to be 40% of the assessment criteria while toluene and xylene were predicted to be less than 5% of the criteria. The maximum 1-hourly concentrations of BTEX were predicted to be 11% of the assessment criteria at Butler Park. Although emissions modelling did not explicitly consider the current scenario of 100% venting from three AGRU trains on a long term continuous basis, the Delegated Officer considers that BTEX levels will remain low and that ambient air quality assessment criteria will be met.

Ambient air quality monitoring data indicates that there were seven exceedances of the H<sub>2</sub>S criteria (7 µg/m<sup>3</sup>) at the communications tower monitoring location attributable to GTP emission sources (section 4.3). However, this criteria is set for odour annoyance to human receptors. The maximum measured concentration of H<sub>2</sub>S (24-hour average) was 1.2 ppb (approximately 18 µg/m<sup>3</sup>) which is significantly less than the WHO guideline for health impacts.

Despite modelling under-predicting concentrations of H<sub>2</sub>S, the Delegated Officer considers that there will be minimal on-site impacts from BTEX and H<sub>2</sub>S emissions and therefore has determined the consequence of BTEX and H<sub>2</sub>S emissions to be **Slight**.

### 2.1.8 Likelihood of Risk Event

The Delegated Officer has determined that the likelihood health impacts to fauna occurring will be **Rare**.

### 2.1.9 Overall rating of acid gas venting

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (DER 2017a) and determined that the overall rating for the risk of BTEX and H<sub>2</sub>S emissions is **Low**.

## 2.2 Risk assessment – ozone

### 2.2.1 Description of ozone emissions

Ozone is a secondary pollutant produced by the reaction of NO<sub>x</sub>, VOCs and sunlight. Emissions of NO<sub>x</sub> and VOCs from various sources including the GTGs, GTs, flares and acid gas venting all contribute to the creation of ground level ozone. Ozone is also a naturally occurring pollutant.

## 2.2.2 Description of potential adverse impact from the emission

Ozone can be toxic with potential health effects including eye and throat irritation and exacerbation of existing respiratory problems. Impacts to vegetation from ozone exposure include visible foliage injury, growth retardation, and increased sensitivity to stress (WHO, 2000).

## 2.2.3 Criteria for assessment

Assessment criteria for ozone are provided in the NEPM and are detailed in Table 4.

**Table 4 NEPM standards for ozone**

Pollutant	Averaging period	Monitoring investigation level		Goal (Maximum allowable exceedance)
		ppm	µg/m <sup>3</sup>	
O <sub>3</sub>	1 hour	0.10	214	1 day a year
	4 hours	0.08	171	1 day a year

## 2.2.4 Licence Holder controls

The location of vents, size, overall stack height and anticipated flow rates of exit gas all promote the dispersion of the pollutants via their source. A summary of controls for reducing NO<sub>x</sub> and VOC emissions was provided in the Decision Report for the original issue of L9102/2017/1.

Venting of acid gas is considered a temporary emission until the CO<sub>2</sub> compression and injection system is functioning. It is expected that once the CO<sub>2</sub> compression and injection system is operational, all acid gas will be compressed. Some is expected to occur during process trips or with process upset conditions; however, these events will be infrequent and short term.

Ambient air quality monitoring will continue in accordance with the *Air Quality Management Plan* to monitor for assessment criteria exceedances and to identify any potential impacts.

## 2.2.5 Key findings

### **The Delegated Officer has reviewed the information regarding ozone and has found:**

1. Ozone is not a direct emission but is created by the reaction of NO<sub>x</sub> and VOC emissions in the atmosphere.
2. Ongoing ambient monitoring will be carried out in accordance with requirements of MS 800.

## 2.2.6 Consequence

The 2008 modelling studies indicated that ground level concentrations of ozone could reach 93.5% of the assessment criteria at the accommodation facilities (0). It is noted that this was based on a worst case scenario of all three AGRUs venting simultaneously. Further modelling was undertaken in 2010 to improve the accuracy of these predictions. Results showed a significant reduction in ozone concentrations with the maximum ground level concentrations of ozone anywhere on Barrow Island predicted to be 78% (1 hour average) and 70% (4 hour average) of the assessment criteria (0).

Ambient air quality monitoring data indicates that ground level ozone concentrations will meet the assessment criteria. There is some evidence that high ozone events occur due to recirculation of NO<sub>x</sub> emission plumes from the GTP; however, for these events the peak 1-hour ozone concentration was estimated to be 0.052 ppm (52% of the criteria). Although one exceedance of the 1-hour criteria and three exceedances of the 4-hour criteria were recorded

(section 4.4.1), these all occurred on the same day and were attributed to regional sources (i.e. bushfires) rather than the operation of the GTP.

The Delegated Officer has determined that consequence criteria for ozone are at risk of being met, due to potential exceedances associated with regional sources (i.e. bushfires). Low-level off-site impacts from O<sub>3</sub> may occur and wider scale off-site impacts will be expected to be minimal. The Delegated Officer has determined the consequence of ozone emissions to be **Moderate**.

### 2.2.7 Likelihood of Risk Event

The Delegated Officer has determined that the likelihood of health impacts to vegetation and fauna occurring will be **Rare**.

### 2.2.8 Overall rating of ozone

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (DER 2017a) and determined that the overall rating for the risk of ozone emissions is **Medium**. Ozone levels will continue to be monitored in accordance with commitments of the *Air Quality Management Plan*.

## 2.3 Summary of acceptability and treatment of Risk Events

A summary of the risk assessment and the acceptability or unacceptability of the risk events set out above, with the appropriate treatment and control, are set out in Table 5 below. Controls are described further in Section 3.

**Table 5 Risk assessment summary**

	Description of Risk Event			Licence controls	Holder	Risk rating	Acceptability with controls (conditions on instrument)
	Emission	Source	Pathway/ Receptor (Impact)				
1.	H <sub>2</sub> S and BTEX compounds	AGRU vents	Air/wind to sensitive receptor causing environmental impacts	Infrastructure and management controls		Slight consequence Rare <b>Low risk</b>	Acceptable subject to regulatory controls (MS 800)
2.	Ozone (O <sub>3</sub> )	Secondary pollutant (not a direct emission)	Air/wind to sensitive receptor causing environmental impacts	Infrastructure and management controls		Moderate consequence Rare <b>Medium risk</b>	Acceptable subject to regulatory controls (MS 800)

## 3. Regulatory controls

A summary of regulatory controls determined to be appropriate for the identified Risk Events is set out in the following sections. Controls were determined having regard to the adequacy of controls proposed by the Licence Holder and the *Guidance Statement: Setting Conditions* (DER 2015b).



### 3.1 Licence controls – H<sub>2</sub>S and BTEX compounds and O<sub>3</sub>

Ambient air quality monitoring will continue in accordance with MS 800 to confirm ambient air quality criteria are being achieved. The DWER may review this data to inform future risk assessments. No stack testing is required on the AGRU vents, however the volume of gas vented to atmosphere is required to be monitored under condition 18 and reported in the Annual Environmental Report to verify outputs align with those predicted and assessed.

## 4. Key modelling and monitoring data

A summary of key modelling and monitoring data which has informed previous risk assessment of the Premises is included in the following sections.

### 4.1 Air quality modelling

The Licence Holder carried out the following air quality modelling studies to assess the potential effects on air quality from emissions to air:

- 2008 - Modelling to estimate emissions of oxides of nitrogen (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), particulates (PM<sub>10</sub>), and ozone (O<sub>3</sub>) during routine and non-routine operation of the GTP for both startup and operation phases. Non-routine (or upset conditions) included cold startup, emergency shutdown, and CO<sub>2</sub> venting. In addition, modelling was carried out to estimate emissions of H<sub>2</sub>S during acid gas venting, and estimate nitrogen and sulphur deposition over the adjacent terrestrial and marine environments (TAPM-GRS model used).
- 2010 - Modelling and sensitivity testing to further improve the accuracy of predicted ground level concentrations of NO<sub>x</sub> and O<sub>3</sub> by refining assumptions made in the 2008 modelling study (TAPM-CTM model used).
- 2010 - Modelling to estimate ground-level concentrations of H<sub>2</sub>S and organic compounds (BTEX) during acid gas venting for six selected release scenarios under a complete set of probable weather conditions (Canary model used).
- 2014 - Modelling to estimate ground-level concentrations of mercury and deposition on Barrow Island and in the adjacent ocean (CALPUFF model used).

Modelling studies were reviewed by DWER's air quality experts as part of the assessment of the Air Quality Management Plan, which was developed under condition 29 of MS 800. It was determined that appropriate model selection, input data, and assumptions were used to ensure reliable conclusions on the predicted concentrations of pollutants.

The modelling assessed ambient air quality against various air quality criteria to assess impacts on human health, occupational health exposure effects, non-occupational health exposure effects (impacts on human health from exposure outside of working environments), and effects on the terrestrial environment of the BINR. Due to the remote location of the BINR (85 km from the mainland), with the exception of accommodation camps, there are no significant residential receptors in the vicinity of the Premises. In their assessment (EPA Report 1323), the EPA noted the lack of data available on the effects of air pollutants on fauna and flora. In the absence of standards, the EPA considered that limits for humans were the only available surrogate standards for mammals and that the deposition limits described in the World Health Organisation Air Quality Guidelines for Europe (WHO, 2005) were an appropriate surrogate for assessing the impact of air pollutants on vegetation.

The results of the modelling compared to relevant air quality criteria are presented in the following tables (Table 6 to Table 13).

**Table 6 Summary of maximum predicted pollutant concentrations against assessment criteria (2008 model results)**

Pollutant	TAPM-GRS grid	Maximum on grid ( $\mu\text{g}/\text{m}^3$ )	Averaging period	Assessment criteria		Percentage of assessment criteria
				ppm	$\mu\text{g}/\text{m}^3$	
<b>Background conditions</b>						
NO <sub>2</sub>	1 km	30.9	1 hour	0.12	246	12.5
		0.49	Annual	0.03	62	0.8
SO <sub>2</sub>	1 km	1.08	1 hour	0.20	571	0.2
		0.19	24 hour	0.08	229	0.1
		0.02	Annual	0.02	57	0.1
O <sub>3</sub>	10 km	130.9	1 hour	0.10	214	61.2
		108.8	4 hour	0.08	171	63.6
<b>Routine operating conditions</b>						
NO <sub>2</sub>	1 km	42.6	1 hour	0.12	246	17.3
		0.7	Annual	0.03	62	1.2
SO <sub>2</sub>	1 km	14.6	1 hour	0.20	571	2.6
		2.6	24 hour	0.08	229	1.2
		0.2	Annual	0.02	57	0.3
PM <sub>10</sub>	1 km	0.9	24 hour	--	50	1.8
O <sub>3</sub>	10 km	131.9	1 hour	0.10	214	61.6
		109.6	4 hour	0.08	171	64.1
<b>Cold startup</b>						
NO <sub>2</sub>	1 km	341	1 hour	0.12	246	139
SO <sub>2</sub>	1 km	14.8	1 hour	0.20	571	2.6
PM <sub>10</sub>	1 km	1	24 hour	--	50	2
O <sub>3</sub>	10 km	132.2	1 hour	0.10	214	61.8
<b>Emergency shutdown</b>						
NO <sub>2</sub>	1 km	37.5	1 hour	0.12	246	15.3
SO <sub>2</sub>	1 km	9.1	1 hour	0.20	571	1.6
PM <sub>10</sub>	1 km	0.7	24 hour	--	50	1.3
O <sub>3</sub>	10 km	133.2	1 hour	0.10	214	62.2
<b>Acid gas venting</b>						
NO <sub>2</sub>	1 km	42.6	1 hour	0.12	246	17.3
SO <sub>2</sub>	1 km	14.9	1 hour	0.20	571	2.6

Pollutant	TAPM-GRS grid	Maximum on grid ( $\mu\text{g}/\text{m}^3$ )	Averaging period	Assessment criteria		Percentage of assessment criteria
				ppm	$\mu\text{g}/\text{m}^3$	
PM <sub>10</sub>	1 km	2.3	24 hour	--	50	4.7
O <sub>3</sub>	10 km	272	1 hour	0.10	214	127

**Table 7 Summary of maximum predicted pollutant concentrations at sensitive receptor locations (Chevron Camp and Butler Park) as percentage of assessment criteria (2008 model results)**

Pollutant	Averaging period	Percentage of assessment criteria (%)				
		Background	Routine operations	Cold startup	Emergency shutdown	Acid gas venting
<b>Chevron Camp</b>						
NO <sub>2</sub>	1 hour	6.1	8.1	33.3	6.5	7.7
SO <sub>2</sub>	1 hour	0.1	0.9	0.7	0.5	0.9
PM <sub>10</sub>	24 hour	n/a	0.6	0.6	0.6	1.6
O <sub>3</sub>	1 hour	n/a	n/a	n/a	n/a	93.5
<b>Butler Park</b>						
NO <sub>2</sub>	1 hour	7.3	8.5	33.3	8.5	8.5
SO <sub>2</sub>	1 hour	0.1	1.1	1.1	0.5	1.1
PM <sub>10</sub>	24 hour	n/a	0.6	0.7	0.6	1.6
O <sub>3</sub>	1 hour	n/a	n/a	n/a	n/a	93.5

**Table 8 Summary of maximum predicted pollutant concentrations against national occupational health exposure standards (under all modelled operating conditions) (2008 model results)**

Pollutant	Maximum on grid ( $\mu\text{g}/\text{m}^3$ )	Averaging period	TWA ( $\mu\text{g}/\text{m}^3$ )	Percentage of assessment criteria
<b>Routine operating conditions</b>				
NO <sub>2</sub>	14.1	8 hour	5600	0.25
SO <sub>2</sub>	6.3	8 hour	5200	0.12
<b>Non-routine operations – cold startup</b>				
NO <sub>2</sub>	86.6	8 hour	5600	1.5

Pollutant	Maximum on grid ( $\mu\text{g}/\text{m}^3$ )	Averaging period	TWA ( $\mu\text{g}/\text{m}^3$ )	Percentage of assessment criteria
SO <sub>2</sub>	5.7	8 hour	5200	0.11
<b>Non-routine operations – emergency shutdown</b>				
NO <sub>2</sub>	12.2	8 hour	5600	0.22
SO <sub>2</sub>	4.4	8 hour	5200	0.08
<b>Non-routine operations – acid gas venting</b>				
NO <sub>2</sub>	15.7	8 hour	5600	0.28
SO <sub>2</sub>	6.3	8 hour	5200	0.12
H <sub>2</sub> S	1774	8 hour	14 000	12.7

**Table 9 Summary of maximum predicted O<sub>3</sub> and NO<sub>2</sub> concentrations against assessment criteria (2010 TAPM model results)**

		Maximum predicted O <sub>3</sub> concentrations			Assessment Criteria ( $\mu\text{g}/\text{m}^3$ )
		Base case	Base case plus one AGRU	Base case plus three AGRUs	
One-hour Averaging Period	Maximum on Grid ( $\mu\text{g}/\text{m}^3$ )	140	147	167	214
	Percentage of Criteria (%)	65%	69%	78%	214
Four-hour Averaging Period	Maximum on Grid ( $\mu\text{g}/\text{m}^3$ )	119	119	125	171
	Percentage of Criteria (%)	70%	70%	70%	171
<b>Averaging Period</b>		<b>Maximum Predicted NO<sub>2</sub> Concentration (<math>\mu\text{g}/\text{m}^3</math>)</b>		<b>Assessment Criteria (<math>\mu\text{g}/\text{m}^3</math>)</b>	
		<b>Base Case</b>			
One-hour Averaging Period		20		246	

**Table 10 Maximum predicted pollutant concentrations during acid gas venting at sensitive receptors (Chevron Camp and Butler Park) compared to assessment criteria (2010 canary model results)**

Pollutant	Averaging period	Maximum ground-level concentrations (ppb)		Assessment criteria (ppb)
		Butler Park	Chevron Camp	
Benzene	1 hour	1	<1	9

Pollutant	Averaging period	Maximum ground-level concentrations (ppb)		Assessment criteria (ppb)
		Butler Park	Chevron Camp	
Toluene	1 hour	2	1	90
Ethylbenzene	1 hour	<1	<1	1 800
Xylene	1 hour	<1	<1	40
H <sub>2</sub> S	Peak Concentration	<1	<1	1.0 – 3.5 <sup>1</sup>

Note 1: The impact assessment criterion for H<sub>2</sub>S varies with population size (e.g. 2 people – 3.5 ppb; 10 people – 3.0 ppb; ~30 people – 2.5 ppb; ~125 people – 2 ppb; ~500 people – 1.5 ppb; >2000 people – 1.0 ppb).

**Table 11 Summary of maximum predicted pollutant concentrations during acid gas venting compared to assessment criteria (2010 Canary model results)**

Pollutant	Maximum Ground-level Concentrations (ppb)						Assessment criteria – TWA <sup>1</sup> (ppb)
	GTP	Permanent Operations Facility	MOF	Terminal Tanks Site	Jetty	WA Oil Base	
Benzene	89	8	5	4	<1	<1	1000
Toluene	120	15	9.5	8	1	<1	100 000
Ethylbenzene	6	<1	<1	<1	<1	<1	100 000
Xylene	50	3	2	1	<1	<1	80 000
H <sub>2</sub> S	28	6	4	3	<1	<1	5000

Note 1. The TWA concentration is measured over a normal eight-hour work day and a 40-hour work week, and is the concentration of an atmospheric contaminant to which nearly all workers may repeatedly be exposed, day after day, without adverse effect.

**Table 12 Estimated annual atmospheric pollutant concentrations for benzene, toluene, and xylene (acid gas venting) (2010 Canary model results)**

Pollutant	Annual average ground-level concentrations (ppb)		Assessment criteria (ppb)
	Worst-case (outside the GTP)	Residential Locations <sup>1</sup>	
Benzene	1.2	0.2	3
Toluene	2.3	0.3	100
Xylene	0.45	0.2	200

Note: The residential locations considered as part of the modelling study included the Chevron Camp and Butler Park.

**Table 13 Summary of maximum predicted mercury concentrations at sensitive receptor locations (under all modelled operating conditions) (2014 model results)**

Sensitive receptor	Assessment criteria ng/m <sup>3</sup>	Averaging period	Maximum ground-level concentrations <sup>[1,2,6,7]</sup> (ng/m <sup>3</sup> ) (Percentage of Criteria [%])			
			Routine operations <sup>[3]</sup>	Routine operations <sup>[3]</sup> (including background levels) <sup>[4]</sup>	Non-routine operations with 20% CO <sub>2</sub> venting <sup>[5]</sup>	Non-routine operations with 20% CO <sub>2</sub> venting <sup>[5]</sup> (including background Levels) <sup>[4]</sup>
<b>Residential Criteria</b>						
Chevron Camp	1800	1-hour <sup>[5]</sup>	0.68 (0.038%)	2.68 (0.15%)	21 (1.2%)	23 (1.3%)
	200	Annual	0.0055 (0.0055%)	1.256 (0.63%)	0.04 (0.02%)	1.29 (0.65%)
Butler Park	1800	1-hour <sup>[5]</sup>	0.9 (0.0021%)	2.9 (0.16%)	34 (1.9%)	36 (2.0%)
	200	Annual	0.009 (0.05%)	1.259 (0.63%)	0.08 (0.04%)	1.33 (0.67%)
<b>Occupational criteria</b>						
GTP	25 000	8-hour	2.2 (0.0088%)	4.2 (0.017%)	100 (0.4%)	102 (0.408%)
Permanent Operations Facility			1.7 (0.0068%)	3.7 (0.015%)	35 (0.14%)	37 (0.148%)
MOF			0.5 (0.002%)	2.5 (0.01%)	15 (0.06%)	17 (0.068%)
Terminal Tanks Site			0.65 (0.0026%)	2.65 (0.011%)	38 (0.15%)	40 (0.16%)
Jetty Head			0.23 (0.0009%)	2.23 (0.0089%)	10 (0.04%)	12 (0.048%)
WA Oil Base			0.18 (0.0007%)	2.18 (0.0087%)	20 (0.08%)	22 (0.088%)

Note 1: Concentrations and assessment criteria are presented in ng/m<sup>3</sup> to aid in presentation of results, as the predicted ground-level concentrations are very low.

Note 2: Concentrations are the total of elemental Hg, divalent Hg, and particulate Hg. More than 99% of the Hg emissions are associated with elemental Hg.

Note 3: Routine operations do not include any CO<sub>2</sub> venting.

Note 4: Background Hg levels are determined based on global emissions and comprise primarily elemental Hg. For the region near Barrow Island, anthropogenic sources should be minimal, with the largest local sources being emissions from soils, vegetation, and fires. Estimates of background levels across Australia were presented in a modelling study that included all known sources including industrial emissions and natural sources. Annual predictions from this study

indicate that for a location near Onslow a typical value is 1.25 ng/m<sup>3</sup>; with a shorter-term peak concentration of 2 ng/m<sup>3</sup> being considered reasonable.

Note 5: Non-routine operations include 20% CO<sub>2</sub> venting (as a conservative estimate). To provide worst-case estimates of the 1-hour and 8-hour Hg concentrations, predictions were obtained from the model run assuming CO<sub>2</sub> venting occurs for every hour over a 3-year period. This ensured CO<sub>2</sub> venting would occur at the time of worst-case dispersion. The annual average concentration is based on 80% of the non-CO<sub>2</sub> venting model run and 20% of the result from the model run with CO<sub>2</sub> venting.

Note 6: The 1-hour criteria are the 99.9th percentile.

Note 7: Non-routine shutdown and black-start conditions were also modelled; however, maximum ground-level concentrations at any grid point increased by a maximum of 0.10% from the modelled routine operations case. Therefore, the results have not been included.

Note 8: Annual Hg deposition rates were also modelled, with a maximum rate of 55 µg/m<sup>2</sup>/year occurring within the GTP footprint (associated with non-routine operations with 20% CO<sub>2</sub> venting), without taking into account the re-emission of the highly volatile elemental Hg.

## 4.2 Environmental Risk Assessment Studies

In addition to the air quality modelling studies outlined above, the Project was also subject to the following risk assessments:

- Screening-level health risk assessment (HRA) to evaluate potential human health risks specifically associated with acid gas venting;
- Screening-level terrestrial and marine ecological risk assessments (ERA) to assess potential environmental impacts to terrestrial and marine flora and fauna; and
- Screening-level HRA and ERA to evaluate potential human health risks and environmental impacts specifically associated with mercury emissions.

The ERAs were based on effects (where known) of respective atmospheric pollutants and air toxics on the likely exposure pathways to identified sensitive ecological receptor species. The assessments considered the environmental setting (e.g. physical and climatic conditions), and the effects of air pollutants at certain dose concentrations in comparison to modelled concentrations to determine the potential risk to fauna and flora.

The ERA determined that routine emissions from the GTP are '*unlikely to result in anything more than short-term reversible impacts on terrestrial and marine flora and fauna*' and that the likelihood of this occurring was low. Risks associated with mercury deposition were also considered negligible.

Risks associated with acid gas venting were further investigated to determine potential effects of H<sub>2</sub>S and BTEX emissions. The ERA considered that acid gas venting from all three AGRUs would occur infrequently (i.e. once in five years over a maximum period of five days due to pigging of the CO<sub>2</sub> injection pipeline). In this situation, it was estimated that there is potential for ground level concentrations of benzene to cause short-term reversible impacts to susceptible fauna within 50 m of the northern fence line of the Premises. Provided suitable atmospheric conditions (i.e. wind and weather stability) were experienced, the ERA predicted that the probability of this occurring was 0.07%. It is noted that the predicted 50 m impact zone is within the approved terrestrial disturbance footprint.

## 4.3 Ambient air quality monitoring

Ambient air quality monitoring is undertaken in accordance with the Air Quality Management Plan. Monitoring commenced in 2012 with the aim of capturing baseline data and continued through commissioning, startup, and operation of the GTP. Details of the ambient monitoring program are provided in Table 14 and the location of ambient monitors shown in Figure 1. The communications tower monitoring station was relocated in August 2016 from the terminal tanks. It is understood that the monitoring locations are indicative and may be subject to further changes to support meeting the objectives of the Air Quality Management Plan approved under MS 800.

**Table 14 Ambient Air Quality Monitoring Program**

Monitoring location	Monitoring equipment <sup>[1]</sup>	Parameters	Frequency
Butler Park <sup>[2]</sup> Monitoring Station	Chemiluminescence Analyser (1)	NO NO <sub>x</sub> NO <sub>2</sub>	Continuous <sup>[3]</sup>
	Tapered Element Oscillating Microbalance (TEOM) (1)	PM <sub>10</sub>	Continuous <sup>[3]</sup>
	UV Fluorescence Analyser (2)	SO <sub>2</sub> H <sub>2</sub> S	Continuous <sup>[3]</sup>
	Passive Diffuse Samplers <sup>4</sup> (1)	NM VOC	Continuous (but sample collected fortnightly)
	Gas Filter Correlation/Infra-red (GFC/IR) Analyser (1)	CO	Continuous <sup>[3]</sup>
	UV Absorption Analyser (1)	O <sub>3</sub>	Continuous <sup>[3]</sup>
	Automated Weather Station (1)	Wind speed and direction Ambient temperature Relative humidity	Continuous <sup>[3]</sup>
Communications Tower Monitoring Station <sup>[5]</sup>	Chemiluminescence Analyser (1)	NO NO <sub>x</sub> NO <sub>2</sub>	Continuous <sup>[3]</sup>
	TEOM (1)	PM <sub>10</sub>	Continuous <sup>[3]</sup>
	UV Fluorescence Analyser (2)	SO <sub>2</sub> H <sub>2</sub> S	Continuous <sup>[3]</sup>
	Passive Diffuse Samplers <sup>[4]</sup> (1)	NM VOC	Continuous (but sample collected fortnightly)
	GFC/IR Analyser (1)	CO	Continuous <sup>[3]</sup>
	UV Absorption Analyser (1)	O <sub>3</sub>	Continuous <sup>[3]</sup>
	Automated Weather Station (1)	Wind speed and direction Ambient temperature Relative humidity	Continuous <sup>[3]</sup>
Reference Site - South of the GTP (e.g. at a suitable location near the Barrow Island Airport)	Passive Diffuse Sampler (1)	NM VOC	Continuous (but sample collected fortnightly)



Monitoring location	Monitoring equipment <sup>[1]</sup>	Parameters	Frequency
Barge (WAPET) Landing	Passive Diffuse Sampler (1)	NMVOC	Continuous (but sample collected fortnightly)
P36 Well Site	Automated Weather Station	Wind speed and direction Rainfall Ambient and differential temperature Solar radiation Barometric pressure Relative humidity	Continuous <sup>[3]</sup>
	Passive Diffuse Sampler (1)	NMVOC	Continuous (but sample collected fortnightly)
Relocatable Monitoring Stations <sup>[6]</sup>	Electrochemical Cell (1)	H <sub>2</sub> S	Continuous <sup>[3]</sup>
	Infra-red (1)	CO <sub>2</sub>	
	Photo Ionisation Detector <sup>7</sup> (1)	NMVOC	

Note 1: For each type of monitoring equipment, the numbers in brackets represent the total number of monitoring equipment located at the monitoring site.

Note 2: A monitoring station was located at Butler Park as this is considered the closest permanent sensitive receptor to the GTP.

Note 3: Monitoring data from continuous monitoring equipment is downloaded daily using remote modem access to a data storage server located in Perth.

Note 4: This monitoring is for screening exercise purposes only to determine whether additional more rigorous monitoring is required. Depending on the NMVOC monitoring results at the two monitoring stations, there is potential for escalation of NMVOC monitoring from the Passive Diffuse Samplers to either:

- Fourier Transform Infra-red (FTIR) Spectrophotometry, or
- Gas Chromatograph with either a Photo Ionisation Detector or Flame Ionisation Detector (GC/FID, GC/PID), or other open path analyser.

Note 5: A monitoring station will be located at the Communications Tower based on technical considerations including air quality modelling, wind direction and proximity to other emissions sources.

Note 6: This monitoring is meant as a screening exercise only, so as to determine whether additional more rigorous monitoring is required. The four proposed relocatable monitoring stations are expected to be located in low-lying areas so as to assess any potential impacts to receptors (e.g. fauna) during acid gas venting events. Therefore, the locations of relocatable monitoring stations are subject to change.

Note 7: Depending on the NMVOC monitoring results at the four relocatable monitoring stations, there is potential for escalation of NMVOC monitoring from the Photo Ionisation Detector to either:

- Passive Diffuse Samplers, or
- TO-14A Passivated Canisters.



**Figure 1** Location of ambient air quality monitoring sites

## 4.4 Emissions Verification Monitoring

Condition 5 of Works Approval W5178/2012/1 required the submission of an Emissions Verification Report (EVR) following commissioning of the GTP. A partial EVR was submitted in April 2016 capturing emissions from LNG Train 1 and facilities approved under Licence L8952/2016/1.

A final EVR was submitted on 14 August 2017 following commissioning of LNG Trains 2 and 3, and GTGs 4 and 5. The purpose of this report was to verify emissions from the whole Premises. Verification testing included monitoring of both point source emissions and ambient air quality.

### 4.4.1 Ambient monitoring

The results of ambient air quality monitoring were reviewed by DWER's air quality experts who verified that the data was valid. The data, which consisted of measured results from 2011 up to May 2017 (where available), indicated that the relevant assessment criteria had been met with the exception of PM<sub>10</sub>, NO<sub>x</sub>, H<sub>2</sub>S and O<sub>3</sub> (Table 15).

**Table 15 Summary of exceedances of ambient air quality criteria**

Pollutant	Averaging period	Guideline	Terminal tank/ comm. tower	Butler Park
			No. of exceedances	
PM <sub>10</sub>	1 day	50ug/m <sup>3</sup> [1]	39	263
	1 year	25ug/m <sup>3</sup> [1]	1	0
NO <sub>2</sub>	1 hour	0.12ppm [1]	19	0
	1 year	0.03ppm [1]	0	0
O <sub>3</sub>	1 hour	0.10ppm [1]	1	1
	4 hours	0.08ppm [1]	3	1
SO <sub>2</sub>	1 hour	0.20ppm [1]	0	0
	1 day	0.08ppm [1]	0	0
	1 year	0.02ppm [1]	0	0
H <sub>2</sub> S	30 minutes	7ug/m <sup>3</sup> [2]	7	7
CO	8 hours	9ppm [1]	0	0
Hg <sub>E</sub>	8 hours	0.003ppm [3]	0	0
Benzene	1 year	0.003ppm [1]	0	0
Toluene	1 day	1ppm [1]	0	0
	1 year	0.1ppm [1]	0	0
Xylene	1 day	0.25ppm [1]	0	0
	1 year	0.2ppm [1]	0	0

Note 1: NEPM

Note 2: Elemental Mercury and Inorganic Mercury Compounds: Human Health Aspects, Concise International Chemical Assessment Document 50 (WHO, 2003). Equates to 4.6ppb.

### Hydrogen sulfide (H<sub>2</sub>S)

Ground level concentrations of H<sub>2</sub>S were relatively low while the GTP was processing Janzs feed gas. However, concentrations increased following the introduction of Gorgon feed gas in March 2017 and the commencement of venting from all three AGRUs. Since then, concentrations of H<sub>2</sub>S were shown to be higher than predicted by the modelling with ambient monitoring data showing seven exceedances of the assessment criteria (7 µg/m<sup>3</sup>) at the communications tower monitoring location attributable to GTP emission sources.

Seven exceedances were also recorded at Butler Park between March 2015 and February 2016 (prior to the introduction of Gorgon feed gas). These were attributed to onsite sources (i.e. blockages at the WWTP). Since then, no additional exceedances have been recorded at Butler Park.

### Ozone (O<sub>3</sub>)

One exceedance of the criteria for O<sub>3</sub> was recorded in 2012 (Figure 2). An investigation into this exceedance determined it was from regional sources such as bushfires.

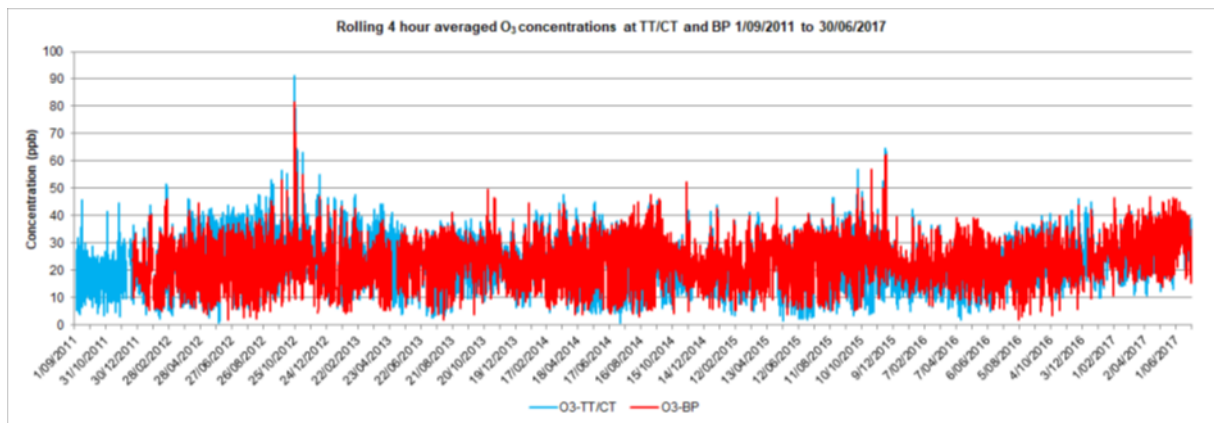


Figure 2 Rolling 4 hour O<sub>3</sub> concentrations between September 2011 and June 2017 (Chevron, 2017a).