Santos

South Australia Cooper Basin

Environmental Impact Report: Production and Processing Operations

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List of Abbreviations and Glossary

ABS	Australian Bureau of Statistics
AIMS	Asset Integrity Management System
ALARP	as low as reasonably practicable
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines (fresh and marine water quality)
Aquitard	A water-saturated sediment or rock whose permeability is so low it cannot transmit any useful amount of water. In a water drive reservoir, the oil zone is in communication with an aquifer that provides the bulk of the reservoir's drive energy
AS	Australian Standards
AWTS	Aerated Wastewater Treatment System - A system which uses the processes of aeration followed by clarification to achieve biological treatment of wastewater.
BDBSA	Biological Databases of South Australia
Block oil	Refers to petroleum crude oil that is characterised at Moomba for having little to no light ends and as such does not require stabilisation, though due to process design block oil is still processed through the crude stabilisation plant. Block oil is received at Moomba via several oil pipelines and road tankers.
BoM	Bureau of Meteorology
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulations
Crude oil	Untreated oil from an oil production well.
CSP	crude stabilisation plant
DAC	Direct Air Capture
DAWE	Department of Agriculture, Water and the Environment
DCWO	drilling, completions and well operations
DEHAA	Department for Environment, Heritage and Aboriginal Affairs (South Australia) (now DEW)
Depauperate	Lacking in numbers or variety of species (of flora, fauna or ecosystem).
DEM	Department for Energy and Mining
DIT	Department of Infrastructure and Transport (formerly (DPTI)
DSD	Department of State Development (now DEM)
DPTI	Department of Planning, Transport and Infrastructure
EHS	Environment, Health and Safety
EIR	Environmental Impact Report
EHR	enhanced hydrocarbon recovery
EPA	Environment Protection Authority (South Australia)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESP	Environmental Sensitivity Profile
ETP	ethane treatment plant
FFP	fitness for purpose
FIFO	fly in-fly out
FNPWA	Far North Prescribed Wells Area
FSA	formal safety assessment
GAB	Great Artesian Basin

Gathering system	Pipeline, flowline and trunkline network which takes oil and gas from wells to satellite facilities and Moomba Gas Plant.
GAS	goal attainment scaling
GIS	Geographic Information System
GRE	Glass Reinforced Epoxy
GTA	gas turbine driven alternator
HAZOP	hazard and operability study
HP	high pressure
IMS	Incident Management System
IMP	Integrity Management Plan
Inerts	A non-reactive and non-toxic gas.
Injectivity	In terms of waterflooding, means ability of fluids to be injected given its properties in relation to the reservoir.
ISO	International Organisation for Standardisation
IVMS	In Vehicle Monitoring System
JHA	job hazard analysis
LDB	Lower Daralingie Bed
LEMP	Landfill Environment Management Plan
Lunette	Crescent-shaped sand dune.
LNG	liquefied natural gas
LP	low pressure
LRP	liquids recovery plant
LSA Act	*Landscape South Australia Act 2019*
LT	low temperature
LTO	licence to operate
MBR	Membrane Bioreactor
MGP	Moomba Gas Plant
NEPM	National Environment Protection Measure
NGL	natural gas liquid
Nodal compressor	Compressors installed and operated at points within the gathering system to ensure flow of product.
NPI	National Pollutant Inventory
NPW Act	*National Parks and Wildlife Act 1972* (South Australia)
NRM	natural resource management
NRM Plan	Natural Resource Management Plan (prepared under the *Natural Resources Management Act 2004)*
NZS	New Zealand Standard
PCV	pressure control valve
PEL	Petroleum Exploration Licence
PFAS	Per- and Polyfluoroalkyl substances
PFW	produced formation water
Pig	A device inserted into a pipeline which travels freely through it, driven by the product flow to do a specific task within the pipeline.

Pigging	Use of pipeline inspection gauges or 'pigs' to perform various maintenance operations on a pipeline, including cleaning and inspecting the pipeline.
PIRSA	Primary Industries and Resources South Australia (now DEM)
PPL	Petroleum Production Licence
PPO	production and processing operations
PSV	pressure safety valve
PTW	permit to work
QA/QC	Quality Assessment and Quality Control
RAMMS	Reliability and Maintenance Management System
Raw gas	Untreated gas from a gas production well.
RGCP	raw gas conditioning plant
RO	reverse osmosis
Road	Roads (in comparison to tracks) are designed and constructed for operability following wet weather.
ROW	right of way
SAAL	South Australian Arid Lands
Sales gas	Gas, mainly methane, which has been treated so that it meets predetermined specifications.
Satellite or satellite facility	Remote operating plant where raw gas or crude oil is processed prior to relay to the Moomba Plant.
SCADA	Supervisory Control and Data Acquisition
SCP	spoolable composite piping
SDS	Safety Data Sheet
SEB	significant environmental benefit
SEO	Statement of Environmental Objectives
SMS	Santos Management System
SPU	Sewage Processing Unit: A primary or secondary treatment system as part of an on-site system (can be associated with fixed or mobile facilities).
STP	Sewage treatment plant: Fixed treatment plant operating at a temporary camp to primarily treat sewage from the associated camp, and may receive wastewater transported from mobile facilities.
TDS	total dissolved solids (measure of water salinity)
Track	Tracks (in comparison to roads) do not have wet weather access.
Trunkline	Hydrocarbon pipelines that connect satellite facilities to the Moomba Plant.
Unit oil	Refers to petroleum crude oil that is characterised at Moomba for having light ends and as such, requires stabilisation. Unit Oil is received at Moomba via several oil pipelines and road tankers.
UV	ultraviolet
Waste Management Facility (WMF)	A facility for the recycling, reprocessing, treatment, storage, incineration, conversion to energy or disposal of waste.
Waste Management Plan (WMP)	Provides details on the management of waste from the time of generation to the time of ultimate treatment and / or disposal. A WMP should provide the framework for addressing aspects of waste management, including but not limited to waste collection, transport, reuse, recycling, treatment and disposal (in line with the principles of the waste hierarchy).

Wastewater Treatment Plant (WWTP)	Fixed treatment plant operating at a permanent or satellite camp to primarily treat sewage from the associated camp, and may receive wastewater transported from mobile facilities.
WAP	Water Allocation Plan
WHS	Work Health and Safety
WIMS	Well Integrity Management System
WMF	Waste Management Facility
WTC	waste transfer certificate
WWTP	Waste Water Treatment Plant

Units of Measurement

bbls	barrels of oil
bcf	billion cubic feet
°C	degrees centigrade
°C/km	degrees centigrade per kilometre
CO_2-e	carbon dioxide equivalent (measure of greenhouse gas)
ha	hectare
Hz	hertz
kL	kilolitre
km	kilometre
kt	kilotonne
kV	kilovolt
kW	kilowatt
m^3	cubic metres
m^3/h	cubic metres per hour
mg/L	milligrams per litre
ML	megalitre
mm	millimetre
mmbbls	million barrels of oil
mol%	molar fraction
MW	megawatt
MWe	megawatt equivalent
PJ	petajoule
ppm	parts per million
psi	pounds per square inch
t	tonne
TDS	total dissolved solids
TJ	terajoule
tpd	tonnes per day
>=	greater than or equal to
<	less than

1 Introduction

This Environmental Impact Report (EIR) was developed prior to the commencement of the *Energy Resources Act 2000* (the ER Act) and as such, has been prepared to meet the requirements of section 99 and section 100 of the *Petroleum and Geothermal Energy Act 2000* (PGE Act). As this EIR was then submitted after the commencement of the ER Act, the document is subject to the transitional provisions under the ER Act and *Energy Resources Regulations 2013* (the ER Regulations); that an EIR that was developed prior to the commencement of the ER Act need only comply with the requirements of the previous Act (PGE Act).

1.1 About this Document

This document is a revision of the EIR for production and processing operations (Santos 2017a). It has been reviewed and updated by Santos in parallel with the review and update of the Statement of Environmental Objectives for production and processing operations (Santos 2017b) as discussed in Section 3 of this document.

Table 1-1 provided below gives a brief outline of the content of each section of this document. structure and content of this EIR.

Table 1-1:Environmental Impact Report outline

Section	Title	Content
1	Introduction	▪ Introduces the purpose and format of this document
2	Background	▪ Provides background, resource and operations information and identifies the location of Cooper Basin production and processing operations
3	Legislative Framework	▪ Provides a brief description of the relevant legislation and assessment process
4	Description of Production and Processing Operations	▪ Describes production and processing operations in detail
5	Existing Environment	▪ Describes the existing physical, biological, hydrogeological and social environment in the Cooper Basin
6	Consultation	▪ Documents consultation activities undertaken for development of the EIR and SEO, previous revisions and this current review
7	Environmental Risk Assessment	▪ Identifies hazards and their consequences and risk minimisation strategies ▪ Outlines risk assessment process and summarises results of the risk assessment
8	Management of Environmental Risks	▪ Outlines the Santos Management System and relevant management strategies
9	References	▪ Lists reference material used in the preparation of this document
Appendix A	Threatened Flora and Fauna Species in the Cooper Basin	▪ Provides a list of species listed under the *Environment Protection and Biodiversity Conservation Act 1999* and *National Parks and Wildlife Act 1972* that may occur in the region

Section	Title	Content
Appendix B	Moomba Gas Plant – Detailed Process Flow Diagrams	▪ Provides detailed process flow diagrams
Appendix C	Stakeholder Consultation	▪ Provides details on stakeholder comments on the revised EIR and SEO and Santos responses
Appendix D	Cooper Creek Surface Water Extraction Points	▪ Provides the locations of approved surface water extraction points
Appendix E	Environmental Sensitivity Profile Model	▪ Outlines the Santos Environmental Sensitivity Profile Model which identifies and maps Cooper Basin environmental values

1.2 Scope

Operations specifically covered by this EIR include:

- pipeline, trunkline and flowline construction, operation, maintenance and decommissioning
- plant and satellite construction, operation, maintenance and decommissioning
- produced formation water management
- enhanced hydrocarbon recovery
- road construction, maintenance and restoration
- waste management operations
- water resource management
- Moomba airport and fire training ground.

Activities specifically not covered by this EIR include:

- seismic exploration activities
- well site, campsite and access track construction
- well site, campsite and access track decommissioning
- drilling
- well completions and workovers (including hydraulic stimulation)
- gas and oil systems on well leases
- pre-wellhead production
- sub-surface well / reservoir activities (with the exception of the aspects relevant to enhanced hydrocarbon recovery that are covered in this EIR)
- well and zonal decommissioning
- underground carbon dioxide storage.

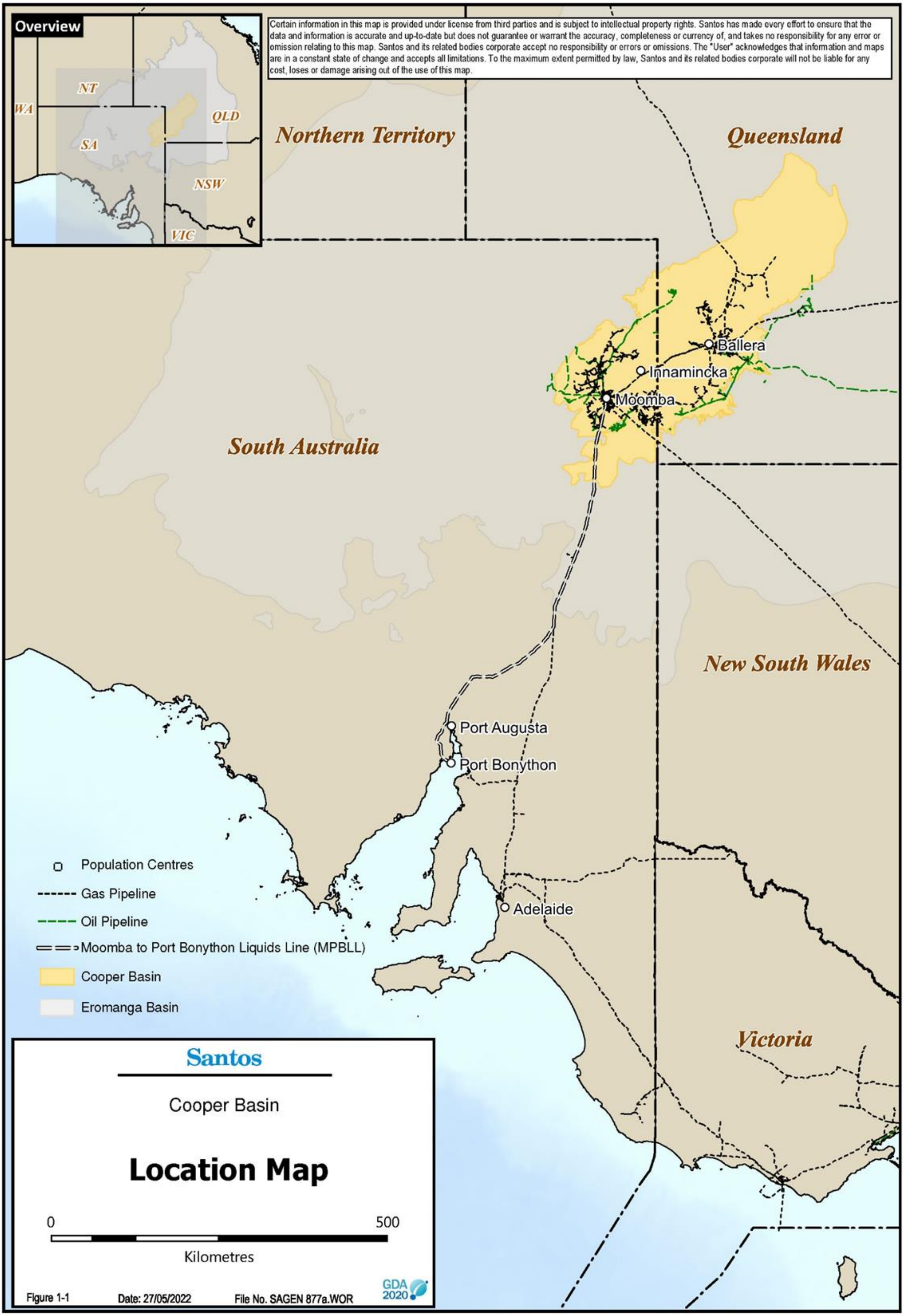
Seismic exploration is covered in the *South Australia Cooper / Eromanga Basin Environmental Impact Report: Geophysical Operations* (Santos 2018). Drilling, completions and well operations are covered in the *Drilling, Completions and Well Operations EIR* (Santos 2021a). Carbon storage[1] operations are

[1] Carbon storage operations are defined as the storage of measurable quantities of CO_2 in subsurface geological formations. They may also include carbon storage following the cessation of enhanced hydrocarbon recovery (EHR) activities. Carbon storage operations do not include carbon dioxide capture, treatment, transmission and injection (including utilisation for enhanced hydrocarbon recovery). These are covered in this (production and processing) EIR.

addressed in the *South Australia – Moomba Environmental Impact Report: Carbon Storage* (Santos 2021b).

Sales gas pipelines (which are not operated by Santos) and the liquids pipeline to Port Bonython are also covered by separate EIRs.

The original production and processing operations EIR (Santos 2003a) was developed by Santos to cover all 'South Australia Cooper Basin Operators'. Santos reviewed and updated this EIR in 2017 in the context of Santos' own practices in production and processing operations, rather than other operators' practices, over which Santos has no control. Consequently, the title and scope of the EIR refer to Santos operated activities rather than the South Australia Cooper Basin Operators.


Overview
NT
WA
QLD
SA
NSW
VIC
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Northern Territory
Queensland
Ballera
Innamincka
Moomba
South Australia
New South Wales
Port Augusta
Port Bonython
Adelaide
Victoria
Population Centres
Gas Pipeline
Oil Pipeline
Moomba to Port Bonython Liquids Line (MPBLL)
Cooper Basin
Eromanga Basin
Santos
Cooper Basin
Location Map
0
500
Kilometres
Figure 1-1
Date: 27/05/2022
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2 Background

A proudly Australian company, Santos is a leader of the Australian natural gas industry, with more than 60 years of responsible gas exploration development and production across the nation since its establishment in Adelaide in 1954.

Spanning the borders of north-east South Australia and south-west Queensland, the Cooper and Eromanga Basins house Australia's largest onshore oil and gas field development. Santos discovered the first commercial hydrocarbon resource (natural gas) in 1963 and first oil in 1970. Santos now produces sales gas, ethane, crude oil and gas liquids from these basins. The South Australian Cooper Basin currently meets a significant amount of the demand for domestic gas in eastern Australia, as well as producing crude oil and petroleum liquids for both Australian and overseas markets.

The Cooper Basin asset (which encompasses both the Cooper and Eromanga geological basins) is strategically important, housing key infrastructure at Moomba, approximately 800 km north-east of Adelaide in north-east South Australia (see Figure 1-1). This Santos operated infrastructure is integral to the processing and transportation of natural gas and ethane around the east coast of Australia, supported by substantial underground storage facilities suitable for natural gas, ethane and carbon dioxide. As operator of the Moomba facility, Santos provides services and facilities for personnel who operate and maintain the processing plant and field gathering facilities, as well as those involved in exploration, drilling and essential support activities.

Safety and sustainability are integral parts of Santos' operating ethos. Santos is committed to responsibly managing environmental impact, working in partnerships with the communities in which Santos operate and reliably managing the business.

Santos currently has an interest in over 180 Petroleum Production Licences (PPLs) in the South Australian Cooper Basin surrounding the Moomba processing facility (see Figure 2-1).

2.1 Moomba Plant and Facilities

At Moomba, Santos operates a purpose-built plant and facilities to enable the gathering and processing of natural gas and oil from the Cooper and Eromanga basins which has been brought to the surface by drilling into the hydrocarbon-bearing formations. Moomba accepts production from 26 oil facilities and 138 gas fields that when combined host more than 300 producing oil wells and more than 700 producing gas wells.

The oil and gas pumped to Moomba is refined and distributed via underground pipelines to markets in South Australia, New South Wales, Queensland, and other domestic and international markets. Crude oil and gas liquids (condensate and liquefied petroleum gases) are recovered via a refrigeration process in the Moomba Plant. Oil and gas together with stabilised crude oil and condensate is sent through a 659 km pipeline to Port Bonython near Whyalla, South Australia where they are separated for sale to domestic and international markets.

Sales gas is sent from Moomba to Adelaide via a 790 km pipeline, to Sydney via a 1160 km pipeline and from Moomba to Walumbilla through Ballera via a 920 km pipeline. Ethane is sent to Qenos in Sydney via a dedicated pipeline.

The Moomba processing facility also includes underground storage for processed sales gas and ethane.

Water for the Moomba processing facility and associated camp is sourced from dedicated bores and treated at a reverse osmosis plant. Electricity is provided by on-site power generators. Moomba is serviced by road and a jet-capable sealed airstrip.

Moomba is the first of a series of carbon capture and storage (CCS) hubs that Santos plans to develop around existing infrastructure. These hubs will deploy new emerging technologies like post-combustion and direct air capture (DAC). To develop direct air capture technologies, Santos has entered into a research and collaboration agreement with Australia's national science agency, CSIRO, to trial DAC and post-combustion capture technologies at Moomba. The trial will capture 1 tonne per day of CO_2 from the atmosphere ready for storage. If the trial is successful, the captured CO_2 can then be injected into the Moomba CCS facility for sequestration. Santos will also be looking to trial other direct air capture technologies in the future within the Cooper Basin.

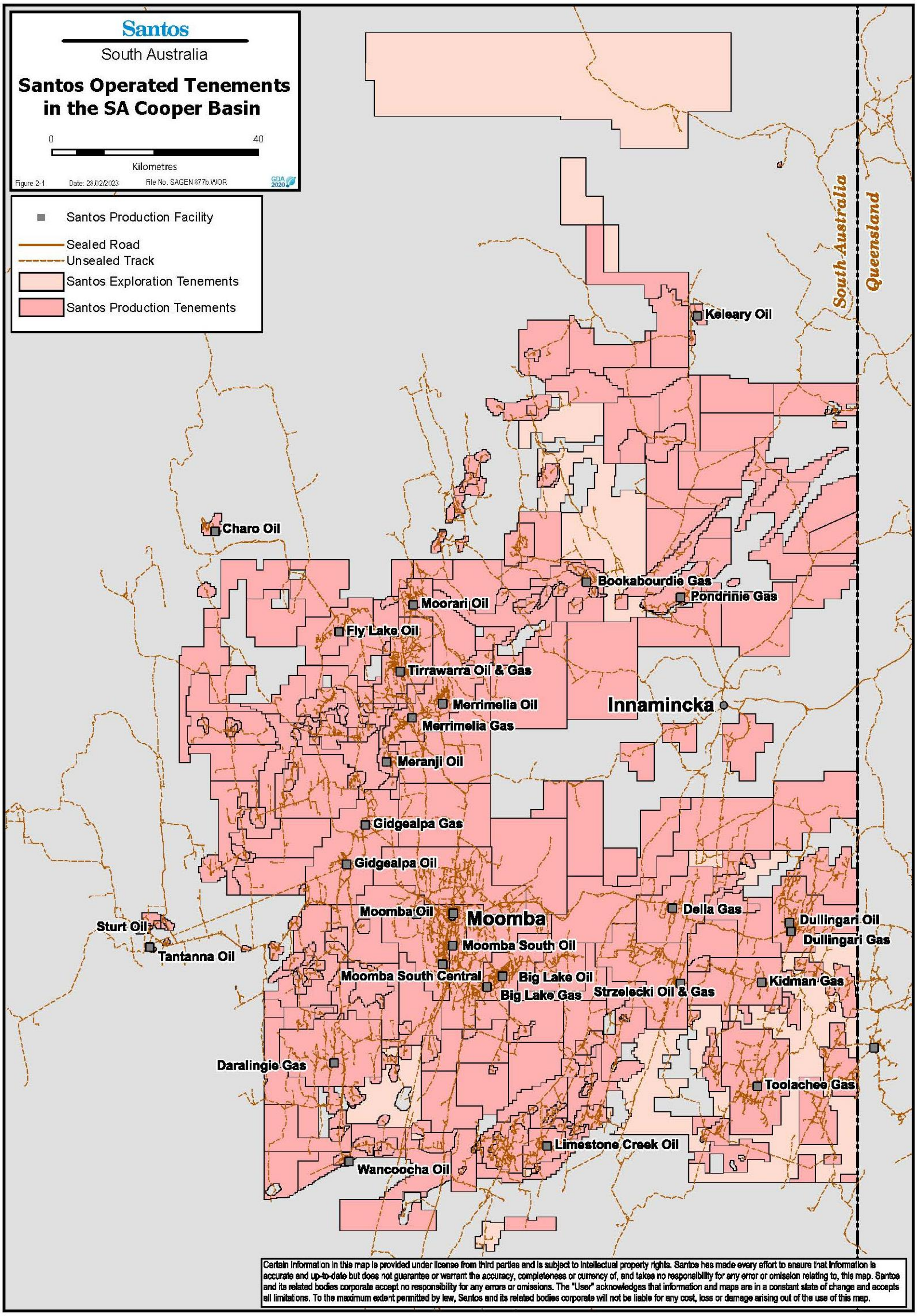


Figure 2-1: Santos operated tenements in the SA Cooper Basin

3 Legislative Framework

This section briefly describes the legislative framework applicable to petroleum licensing in South Australia.

The Department for Energy and Mining (DEM) is the government body responsible for the regulation of production and processing operations, to ensure that they occur in an environmentally, technical, and economically responsible manner and align with leading practice.

This EIR has been compiled in accordance with the *Petroleum and Geothermal Energy Act 2000* and the *Petroleum and Geothermal Energy Regulations 2013* (the Act and Regulations).

3.1 Petroleum and Geothermal Energy Act and Regulations

The Act and Regulations form the primary legislation governing onshore petroleum exploration and production in South Australia.

Key objectives of the legislation include:

- to create an effective, efficient and flexible regulatory system for exploration and recovery or commercial utilisation of petroleum and other resources.
- to create an effective, efficient and flexible regulatory system for the construction and operation of transmission pipelines for transporting petroleum and other substances.
- to minimise environmental damage from exploration and recovery or commercial utilisation of petroleum and other regulated resources.
- to minimise environmental damage from construction or operation of transmission pipelines for transporting petroleum and other regulated substances.
- to establish appropriate consultative processes involving people directly affected by regulated activities and the public generally.
- to ensure as far as reasonably practicable, security of supply for users of natural gas.
- to protect the public from risks inherent in regulated activities.

The Act and Regulations are objective-based rather than prescriptive (McDonough 1999). An objective-based regulatory approach principally seeks to ensure that industry effectively manages its activities by complying with performance standards that are cooperatively developed by the licensee, the regulatory authority and the community. This contrasts with prescriptive regulation where detailed management strategies for particular risks are stipulated in legislation.

Environmental objectives, as defined in Part 12 of the Act, are:

- to ensure that regulated activities that have (actually or potentially) adverse effects on the environment are properly managed to reduce environmental damage as far as reasonably practicable.
- to eliminate as far as reasonably practicable risk of significant long term environmental damage.
- to ensure that land adversely affected by regulated activities is properly rehabilitated.

Regulated resources, as defined in Part 1 of the Act, are:

- a naturally occurring underground accumulation of a regulated substance
- a source of geothermal energy
- a natural reservoir.

A reference in the Act to petroleum or another regulated substance extends to a mixture of substances of which petroleum or other relevant substance is a constituent part. Regulated substances, as defined in Part 1 of the Act, are:

- petroleum
- hydrogen sulphide
- nitrogen
- helium
- carbon dioxide
- any other substance that naturally occurs in association with petroleum
- any substance declared by regulation to be a substance to which the Act applies.

Regulated activities, as defined in Section 10 of the Act, are:

- exploration for petroleum or another regulated resource
- operations to establish the nature and extent of a discovery of petroleum or another regulated resource, and to establish the commercial feasibility of production and the appropriate production techniques
- production of petroleum or another regulated substance
- utilisation of a natural reservoir to store petroleum or another regulated substance (including in a case where a trace element naturally occurs with the petroleum or other regulated substance)
- production of geothermal energy
- construction of a transmission pipeline for carrying petroleum or another regulated substance
- operation of a transmission pipeline for carrying petroleum or another regulated substance.

3.1.1 Statement of Environmental Objectives

Pursuant to Part 12 of the Act, a regulated activity can only be conducted if an approved Statement of Environmental Objectives (SEO) has been developed. The SEO outlines the environmental objectives that the regulated activity is required to achieve and the criteria upon which the objectives are to be assessed.

The SEO is developed based on information provided in an EIR (unless activities are classified as 'high impact' refer to Section 3.1.3). The EIR contains an assessment of the potential impacts of an activity on the environment (refer to Section 3.1.3).

The SEO for Santos' production and processing operations in the Cooper Basin (Santos 2003b), was originally developed in 2003 and based on the *South Australia Cooper Basin Operators Environmental Impact Report: Production and Processing Operations* (Santos 2003a). The SEO was revised and updated in 2010 (Santos 2010a and 2010b) and 2017 (Santos 2017b) during five-yearly reviews undertaken in accordance with Regulation 14 of the Act and Regulations. It has been revised in parallel with the EIR (this document) as part of the 2022 five-yearly review.

3.1.2 Environmental Impact Report

In accordance with Section 97 of the Act, the EIR must:

- take into account cultural, amenity and other values of Aboriginal and other Australians in so far as those values are relevant to the assessment
- take into account risks to the health and safety of the public inherent in the regulated activities
- contain sufficient information to make possible an informed assessment of the likely impact of the activities on the environment.

In accordance with Regulation 10 of the Regulations the EIR must include:

- a description of the regulated activities to be carried out under the licence (including their location).

- a description of the specific features of the environment that can reasonably be expected to be affected by the activities, with particular reference to the physical and biological aspects of the environment and existing land uses.
- an assessment of the cultural values of Aboriginal and other Australians which could reasonably be foreseen to be affected by the activities in the area of the licence, and the public health and safety risks inherent in those activities (insofar as these matters are relevant in the particular circumstances).
- if required by the Minister, a prudential assessment of the security of natural gas supply.
- a description of the reasonably foreseeable events associated with the activity that could pose a threat to the relevant environment (including events during the construction stage (if any), the operational stage and the abandonment stage, events due to atypical circumstances (including human error, equipment failure or emissions, or discharges above normal operating levels) and information on the estimated frequency of events and an explanation of the basis on which these events and frequencies have been predicted).
- an assessment of the potential consequences of these events on the environment, including information on the extent to which these consequences can be managed or addressed, the action proposed to be taken to manage or address these consequences, the anticipated duration of these consequences, the size and scope of these consequences, the cumulative effects (if any) of these consequences when considered in conjunction with the consequences of other events that may occur on the relevant land (insofar as this is reasonably practicable),
- an explanation of the basis on which these consequences have been predicted.
- a list of all owners of the relevant land.
- information on consultation undertaken during preparation of the EIR.

3.1.3 Assessment and approval

Pursuant to section 98 of the Act, an environmental significance assessment is undertaken[2] by DEM to determine whether the activities described in the EIR are to be classified of ‘low’, ‘medium’ or ‘high’ impact. This in turn determines the level of consultation required prior to final approval of the SEO.

- Low impact activities do not require public consultation and are subject to a process of internal government consultation and comment on the EIR and draft SEO prior to approval.
- Medium impact activities require a public consultation process for the EIR and draft SEO, with comment sought for a period of at least 30 business days.
- High impact activities trigger the requirement to undergo an environmental impact statement (EIS) under the *Planning Development and Infrastructure Act 2016*. An SEO for high impact activities must be prepared on the basis of this EIS.

The level of impact of a particular activity is assessed on the basis of the predictability and manageability of the impacts on the environment. Where the environmental impacts are predictable and readily managed, the impact of the activity is considered low. Where the environmental impacts are less predictable and are difficult to manage, the impact of the activity is potentially high.

Once the approval process is complete, all documentation (including this EIR and its associated SEO) must be entered on an environmental register. This public Environmental Register is accessible to the community from the DEM website.

[2] DEM’s assessment is undertaken in accordance with the guideline *Criteria for classifying the level of environmental impact of regulated activities: Petroleum and Geothermal Regulatory Guidelines 004.* DEM 2019

3.1.4 Activity notification / approval process

Prior to commencing a regulated activity, Section 74(3) of the *Petroleum and Geothermal Energy Act* requires that:

- the Minister's prior written approval is required for activities requiring high level supervision (as per Regulation 19), and
- notice of activities requiring low level supervision is to be given at least 21 days in advance (as per Regulation 18).

To obtain written approval for activities requiring high level supervision, an application and notification of activities (in accordance with Regulation 20) must be submitted to the Minister at least 35 days prior to the commencement of activities.

The notification of activities must provide specific technical and environmental information on the proposed activity and include an assessment to demonstrate that it is covered by an existing SEO.

Consequently, the activity notification process provides an additional opportunity for DEM to ensure that the proposed activities and their impacts can be effectively managed and are consistent with the approvals obtained in the EIR and SEO approval process. This is particularly relevant for activities that are conducted under an SEO that applies to a broad geographical area, as it provides site-specific detail that is not usually contained in the generic documents.

3.2 Other Legislation

A variety of legislation applies to petroleum activities. Legislation of particular relevance to production and processing operations is listed below. (Note this is not a comprehensive list of all applicable legislation).

<u>Commonwealth Legislation</u>

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

Native Title Act 1993

Aboriginal and Torres Strait Islander Heritage Protection Act 1984

National Greenhouse and Energy Reporting Act 2007 (NGER Act)

National Environment Protection (National Pollutant Inventory) Measure 1998 (NPI NEPM)

<u>South Australian Legislation</u>

Aboriginal Heritage Act 1988

Crown Land Management Act 2009

Dangerous Substances Act 1979

Environment Protection Act 1993

Explosives Act 1936

Fire and Emergency Services Act 2005

Heritage Places Act 1993

Landscape South Australia Act 2019

National Parks and Wildlife Act 1972

Native Title (South Australia) Act 1994

Native Vegetation Act 1991

Pastoral Land Management and Conservation Act 1989

Radiation Protection and Control Act 2021

South Australian Public Health Act 2011

Work Health and Safety Act 2012.

Commonwealth Environment Protection and Biodiversity Conservation Act (EPBC Act)

Approval under the Commonwealth EPBC Act is required for activities that significantly impact matters of national environmental significance including World Heritage properties, National Heritage places, wetlands of international importance (listed under the Ramsar Convention), listed threatened species and ecological communities, migratory species and a water resource, in relation to coal seam gas development and large coal mining development.

There are no current approvals in place that affect production and processing operations in the South Australian Cooper Basin.

Commonwealth National Greenhouse and Energy Reporting Act (NGER Act)

The NGER Act requires corporations that exceed a designated reporting threshold (25,000 tonnes CO_2-e) to report annually on the following emissions and energy data related to their Australian activities:

- greenhouse gas emissions comprising of:
  - direct emissions from the operation of a facility
  - indirect emissions from the consumption of an energy commodity produced outside of the facility (e.g. purchased electricity)
- energy production and energy consumption at a facility.

Commonwealth National Environment Protection (National Pollutant Inventory) Measure (NPI NEPM)

The NPI NEPM is the legislative framework underpinning the National Pollutant Inventory (NPI). The NPI is a public internet database of air, land and water emissions and transfers of the substances in waste, of 93 reportable substances that have been identified as important due to their possible effect on human health and / or the environment. Australian industrial facilities that meet defined thresholds for the 93 reportable NPI substances must estimate and report their emissions and transfers of substances in waste on an annual basis to their relevant state or territory environment agency.

Native Vegetation Act

The *South Australian Native Vegetation Act 1991* and the *Native Vegetation Regulations 2017* apply to vegetation clearance for petroleum operations. New activities authorised under the PGE Act including petroleum operations are permitted to clear vegetation, provided that:

- for work authorised under the PGE Act, the work is undertaken in accordance with an SEO under that Act (see Native Vegetation Regulation 14(1c)
- the clearance is undertaken in accordance with a management plan, approved by the Native Vegetation Council for implementation that results in a ‘significant environmental benefit’ (SEB) (see Regulation 14(1a)) or
- the person undertaking the clearance makes a payment into the Native Vegetation Fund of an amount considered by the Native Vegetation Council to be sufficient to achieve a SEB in the manner contemplate by section 21(6) or (6a) of the Act (see Regulation 14(2)).

Schedule 1, Part 5, Division 3, Clause 30 of the *Native Vegetation Act* also provides an exemption from the SEB requirement for operations authorised before 2003, provided that the clearance would reasonably be expected to have been required under the authorisation.

Guidelines[3] have been developed for the petroleum industry to provide a framework for determining the SEB requirement or the amount for payment into the Native Vegetation Fund. These guidelines are administered by DEM, who have delegated authority to approve SEBs.

Environment Protection Act (EP Act)

The EP Act imposes a general duty of care not to undertake an activity that pollutes, or might pollute the environment unless all reasonable and practicable measures have been taken to prevent or minimise any resulting environmental harm. Environmental authorisations are required to undertake activities prescribed under the Act. Santos holds an Environment Protection Authority (EPA) licence for its Cooper Basin production and processing operations (EPA Licence 2569). Under the EP Act and licence, approval from the EPA is required for changes to operating processes, alteration of buildings and structures or installation or alteration of plant and equipment in certain circumstances (e.g. where they have the potential to increase emissions, alter the nature of pollutants or waste or increase the risk of environmental harm).

The EP Act does not apply to wastes produced in the course of an activity (not being a prescribed activity of environmental significance) authorised by a lease or licence under the Petroleum and Geothermal Energy Act when produced and disposed of to land and contained within the area of the lease or licence.

Landscape South Australia Act 2019

The *Landscape South Australia Act* (which replaced the *Natural Resources Management Act 2004* in July 2020) applies to a range of aspects of natural resource management. Of particular relevance to the production and processing operations are provisions in the Act addressing activities which affect surface water and groundwater resources, as well as management of pest plants and animals.

Drilling of new water sourcing bores or conversion of petroleum wells to water supply wells requires a permit under the LSA Act. The Cooper Basin is located within the Far North Prescribed Wells Area which is covered by a Water Allocation Plan under the LSA Act (SAAL LB 2021a). Extraction of groundwater within the Far North Prescribed Wells Area generally requires a licence/allocation under this Act. Santos has a regulatory authorisation for groundwater extraction associated with production and processing activities.

This Act and the regional Water Affecting Activities Control Policy considers all water resources, including surface waters and set out a number of water-affecting activities that must not be undertaken without a permit.

The LSA Act also provides for the prevention or control of impacts caused by pest species of animals and plants that may have an adverse effect on the environment, primary production or the community.

National Parks and Wildlife Act (NPW Act)

The NPW Act provides for the establishment and management of reserves and the conservation of wildlife in a natural environment. Innamincka Regional Reserve is established under this Act which provides the Department for Environment and Water (DEW) rights as landowner and direct involvement in the approval process for licences and SEOs granted under the *Petroleum and Geothermal Energy Act* that are applicable to the regional reserve.

Work Health and Safety Act (WHS Act)

The WHS Act provides for the health, safety, and welfare of persons at work and other purposes. The main object of this Act is to provide a balanced and nationally consistent framework to secure the

[3] *MG16 Guide for a significant environmental benefit for the clearance of native vegetation associated with the Minerals and Petroleum Industry* (NVC 2017).

health and safety of workers and workplaces. Moomba Plant is considered a major hazard facility under the WHS Act which requires a safety case for a licence to operate.

4 Production and Processing Operations

This section provides an overview of the different phases of production and processing operations including pipelines, satellite facilities, enhanced hydrocarbon recovery facilities, Moomba Gas Plant operations and associated infrastructure. There have been more than 2,500 wells (cased and suspended, in production, decommissioned and suspended / inactive) drilled in the South Australian sector of the Cooper and Eromanga Basins.

Currently, the gas gathering system provides raw gas from more than 600 gas wells through to 12 gas satellite facilities. Similarly, the oil gathering systems provide crude oil from more than 100 oil wells through to seven oil satellite facilities. There are also nine nodal compressors, which increase the pressure of the gas / oil at the wellhead and maintain flow rates to the satellites. The outputs from the gas and oil satellites are directed to Moomba Plant for processing via a network of trunklines. The trunklines form part of the total pipeline network known as gathering systems. High-pressure transmission pipelines carry processed hydrocarbons from Moomba to regional centres, cities and other outlets. These transmission pipelines are operated by other companies and do not form part of this EIR.

4.1 Grouping of Operations

The operations considered in this EIR include the above ground facilities and pipelines in the Cooper Basin between the gas and oil well leases and the output from Moomba Plant.

To assess the environmental impact of production and processing operations, the activities have been grouped and considered as follows:

- pipelines (Section 4.2)
- satellite facilities (gas and oil) (Section 4.3)
- produced formation water facilities (Section 4.5)
- enhanced hydrocarbon recovery (Section 4.6)
- Moomba Gas Plant – process facilities (Section 4.7)
- Moomba Gas Plant – utilities (Section 4.8)
- supporting infrastructure and facilities (Section 4.9).

Drilling, completions and well operations, and seismic exploration activities, are addressed in separate EIRs (and accompanying SEOs) (refer Section 1.2).

4.2 Pipelines

A network of pipelines, consisting of smaller diameter flowlines and larger diameter pipelines, direct crude oil, condensate and gas from the production wells to the Moomba Gas Plant, via satellite facilities. These flowlines and pipelines are referred to as gathering systems. There are over 4,000 km of Santos flowlines and pipelines in the SA Cooper Basin.

Flowlines typically connect from the wellhead, to field manifolds, nodal compressors, pumps or a satellite facility. Flowlines are typically small diameter (typically 60 to 220 mm) and constructed from carbon steel. Materials such as Glass Reinforced Epoxy (GRE) and Spoolable Composite Pipe (SCP) can also be used.

Pipelines are generally larger diameter pipes (typically 270 to 400 mm) that receive crude oil, condensate and gas from flowlines, nodal compressors or satellite facilities for transfer to the Moomba Plant. Pipelines are generally constructed of carbon steel, but as with flowlines, they can also be constructed from GRE and SCP.

Smaller remote oil wells may not use flowlines to transfer produced fluids to a satellite facility, and instead use adjacent storage tanks for collection and transport by road tanker to a satellite facility or directly to Moomba Plant.

Smaller pipelines may also be installed to pipe CO_2 from nearby Direct Air Capture facilities to the inlet of a CCS facility.

A gathering system may consist of more than one network from several different gas or oil fields. Each well in each field can be individually operated or isolated depending on production demand and the condition of the well.

Raw gas and crude oil enter a satellite facility through one or more headers. Headers can be individually operated or isolated, adding to the control and flexibility of production in case of individual operational difficulties with wells, pipelines, networks or satellite facilities.

New and / or existing pipelines are required to transfer captured and treated CO_2 from the source to injection wells for storage. The configuration of these transmission systems will be similar to the existing gathering systems. Initially Moomba Plant will be the major source of CO_2 and will be connected to injection wells via smaller field facilities – comprising a manifold(s) and injection skids – located in existing satellites or the fields receiving CO_2. Injection wells and satellites will be capable of being individually controlled or isolated depending on injection demand or operational requirements.

Metering of produced gas is undertaken at various points in the existing gathering and processing system. CO_2 will be metered at junctions along the capture, transmission and injection flow process. It is anticipated that primary metering will be installed at the Moomba Plant CO_2 discharge with additional metering at field facilities and injection wells as required. Routine assessment of the CO_2 stream composition will take place at the discharge from Moomba Plant.

Pipelines may be above ground or buried. Pipeline markers are installed to identify the location of buried services. Santos' Geographic Information System (GIS) is used to capture buried and above ground pipeline routes. Plate 4-1 shows a photograph of a buried flowline during the construction phase, prior to restoration of the right of way.

Plate 4-1: Buried flowline prior to being laid in the trench during construction.

4.2.1 Pipeline design, operation and maintenance

The Australian Standard (AS) 2885 series of Standards establishes requirements for the safe design, construction, inspection, testing, operation and maintenance of pipelines intended for transporting petroleum fluids. All new Santos pipelines are designed, tested and constructed in general accordance with AS 2885 requirements to have sufficient strength, ductility, and toughness to withstand design loads to which they may be subjected during construction, testing and operation.

To ensure integrity and safe operation, Santos pipelines are maintained in accordance with the Santos Integrity Management System, which defines operational plans and procedures. This has been developed in general accordance with AS 2885.

All new Santos flowlines are designed, tested and constructed in accordance with Santos engineering standards to have sufficient strength, ductility, and toughness to withstand design loads which they may be subjected to during construction, testing and operation.

To ensure the integrity and safe operation of flowlines, they are maintained in accordance with the Santos Integrity Management System, which defines operational plans and procedures for flowlines.

Adherence to design standards minimises the risk of flowline / pipeline failure, which may pose a risk to the receiving environment, particularly in sensitive locations such as wetlands or floodplains. The fundamental principle of pipeline design is maintaining integrity and promoting operability throughout the operational life of the pipeline. This is achieved using the following prevention / detection controls, as appropriate:

- pipeline operability, including:
  - ‘pigging’ (cleaning and / or clearing the inside of a pipeline of oily sludges by running a ‘pig’ or slug / parcel of liquid through it). Pigging can typically only be used for larger diameter pipelines (e.g. 297 mm or above).
  - incorporating internal and external corrosion mitigation measures, such as external coatings and cathodic protection, and biocide batching and corrosion inhibitor injection where applicable.
  - incorporating overpressure protection systems, such as high-pressure shutdown valves and pressure safety valves (PSV).
- installing PSV or drain points with adequately sized containment vessels or vent stacks to direct discharge to an appropriate location. For liquid discharge this is to a bund or vessel and for gas this is to the atmosphere.
- launching and receiving facilities for pigs are constructed with a concrete pad including a sump to contain minor spills during removal / insertion of pigs.
- incorporating anti-corrosion controls (such as supporting above ground pipelines off-ground to minimise the potential for corrosion in specific areas) commensurate to the life of the pipeline.

4.2.2 Route selection, survey and site preparation

Santos employs a system to receive, assess and complete internal environmental approvals for proposals that include land disturbance, such as earthworks for pipeline construction. During this process, potential impacts to the environment are assessed and appropriate conditions / controls are implemented to minimise impact and facilitate compliance with the applicable legal and other requirements.

Prior to any on-ground works, desktop route selection and surveys are undertaken to evaluate the most appropriate route. The preferred route alignment is selected according to set evaluation criteria such as constructability, topography, environmental sensitivity (including cultural heritage sites), safety and cost.

The planning, scouting, assessment, design and construction process for a new pipeline typically involves:

- Santos selecting a proposed route, seeking appropriate approvals / notification and meeting regulatory requirements

- undertaking landholder and stakeholder liaison and ensuring appropriate notifications are made so that all parties are aware of the proposed alignment and can consider potential impacts to infrastructure and their operations
- scouting of the area to refine the route selection, evaluate access location(s) and to identify and minimise potential impacts associated with ground disturbance and infrastructure development
- cultural heritage clearances where internal approval for disturbance does not already exist
- environmental assessment using scout data, public / Santos databases, GIS information and field inspection (if required, for example for new areas or sites with potential for high environmental sensitivity)
- obtaining internal / external approvals for work programs (including final agreement of route alignment following cultural heritage and environmental sign-off)
- developing specifications / work packs (including site preparation) for the selected route alignment, access track and associated infrastructure construction and commissioning
- internal approval of the pipeline design
- provision of applicable notifications, and required documentation, to the regulator(s).

The requirements set out in the PPO SEO are incorporated into the approved construction program and pipeline design and must be accepted by the project manager prior to on-ground works being undertaken.

4.2.3 Pipeline construction

Pipeline construction techniques are subject to changes in technology and varying economic considerations.

Pipelines are designed and constructed based on operating pressure requirements. Pipelines are typically constructed of steel and non-spoolable materials with varying wall thickness and diameters (typically ranging from 60 mm up to 400 mm).

On floodplains and under creeklines, steel flowlines are sufficiently thick that they do not float and integrity management plan entries are made to have them inspected after flood periods.

Construction of buried pipelines requires trenching along the pre-prepared right of way (ROW) alignment to a specified depth (nominally minimum 750 mm of cover). Trenching to a depth of at least 2 m may be necessary in locations where pipelines pass through sand dunes, areas subject to inundation, washout areas or underneath main roads. Horizontal directional drilling (HDD) and ploughing of spoolable composite pipe (SCP) are two other methods of constructing buried pipelines.

In general, above ground flowlines require a narrower ROW than buried pipelines and therefore a reduced disturbance to vegetation and topsoil. During construction of above ground flowlines, the ROW may be rolled or cleared, but not necessarily graded.

For underground pipelines, the ROW area is cleared. Topsoil and vegetation are stockpiled separately for respread to facilitate revegetation once the pipe has been constructed and commissioned. Vegetation clearance is minimised and where possible trees are trimmed rather than removed.

Pipeline contractors may excavate up to 2 km of trench per day, depending on terrain, equipment and weather conditions. Trench breaks are installed to allow for wildlife movement across and / or out of open trenches.

Pipe is transported to the pipeline ROW in sections and laid end-to-end adjacent to the route on raised skids (typically wooden blocks with sandbags placed on top) to protect the pipe coating from damage and to facilitate construction. This process is known as ‘pipe stringing’. In the case of above ground flowlines, sections of pipe are laid out on raised skids adjacent to the pipeline supports.

Pipes are typically welded in 12 – 18 m lengths and several stages of welding are undertaken by qualified welders. Join welds are completed to the full thickness of the pipe. Welds are non-destructively tested in accordance with relevant standards.

Welded pipeline sections are lowered into the excavated trench, and where necessary, soil and / or padding from approved borrow pits is placed into the trench to protect and stabilise the pipe. The trench is then backfilled and compacted with previously excavated trench spoil material.

Above ground pipeline sections are placed onto pipe supports approximately 100 mm above the ground surface. Above ground pipelines are buried when they crossroads, floodplains and drainage channels.

4.2.4 Pipeline testing

Pipelines undergo ‘fitness for purpose’ testing in accordance with industry standards (e.g. AS 2885) prior to being put into service. Testing methods may include hydrostatic testing and X-ray.

Biocides and other chemicals such as corrosion inhibitors in hydrostatic test water are used to remove the potential for bacterial contamination and prevent internal corrosion of the pipeline. Hydrostatic test water is preferentially sourced from potable water sources at Moomba. Good quality water from Santos satellite ponds and existing Santos water bores may also be used.

Hydrostatic test water, which contains biocide and / or corrosion inhibitors may be discharged into existing satellite facility pond systems, or to other specifically constructed ponds (see Section 4.5).

4.2.5 Trench backfilling

Water that has accumulated in trenches during construction activities is allowed to dissipate or pumped out prior to backfilling. Trenches are left open for the shortest possible time to minimise the potential for impacts to native fauna and livestock. Open trenches are regularly inspected and where possible and safe to do so, trapped fauna will be released. Incidents involving livestock will initiate standard operational incident response protocols, see Section 8.6.

The general process for trench backfilling is as follows:

- excavated spoil is backfilled into the trench and compacted
- excess spoil is spread over the entire width of the ROW
- where subsidence occurs, it is remediated as soon as practicable.

4.2.6 ROW reinstatement

The ROW is reinstated and restored as soon as possible following pipe laying and backfill. This involves removal of construction waste and surplus materials, re-contouring of the site, re-establishment of natural drainage lines, dune or bank restoration (where required), respreading of topsoil (and embedded seed stock) and placement of specific native fauna habitat features (such as hollow logs), where required.

Ongoing management and maintenance of ROW is undertaken for both above and below ground flowlines based on the outcomes of regular ROW inspections.

4.2.7 Pipeline mothballing / decommissioning

Pipelines that are not in service are either mothballed or decommissioned depending on operational requirements at the time and AS 2885.3.

Where pipelines are to be mothballed, they will be cleaned using treated water to remove residual hydrocarbons and sludges. The pipeline will then be batch treated with a filming corrosion inhibitor that is hydrocarbon soluble. The pipeline will be left *in situ* and filled with mothball fluids (mixture of water, biocide and inhibitor), dry air or nitrogen at low pressure. Where present, cathodic protection functionality is maintained to ensure pipeline integrity for future use.

Where pipelines are decommissioned, the following process is observed:

- pipelines are cleaned with treated water to remove residual hydrocarbons and sludges
- above ground pipelines are cut into transportable sections and supports are removed and disposed of in accordance with applicable regulatory requirements and industry standards
- for buried pipelines, aboveground points are cut off and blinded below the surface
- remove above ground infrastructure as per Santos standards
- assess area for signs of impacted soil and remediate and validate where required
- relieve soil compaction (e.g. by ripping), where appropriate (except in gibber land systems)
- restore the site, as close as reasonably practicable, to pre-existing conditions (or as otherwise agreed with the regulator and / or stakeholders).

4.3 Direct Air Capture (DAC)

Carbon dioxide (CO_2) emissions are under increasing scrutiny as the world moves to net zero. There are considerable efforts globally to capture CO_2 from the atmosphere (direct air capture, DAC) for storage or utilisation. This will help to minimise CO_2 emissions in the atmosphere and has the potential to provide a low-cost source of industrial CO_2 gas.

Existing approaches for CO_2 capture have been known for over 50 years where liquid amines have been utilised in large, capital-intensive plants. These plants utilise aqueous amine solutions that require large energy usage to operate. This is because during the regeneration process when the solution is heated (and where CO_2 is released from the amine solution) the majority of the energy is used to heat the water in the solution rather than release the CO_2 from the amine.

In addition, the CO_2 capture efficiency of the aqueous solutions is inadequate to facilitate CO_2 capture from the atmosphere in direct air capture (DAC) because the contact area between the gas and the liquid is limited. As a result, there are global efforts to find alternative solutions primarily focused on porous solids because they offer the potential for lower energy requirements, higher CO_2 uptake / rate and a smaller footprint. Numerous porous solids projects show promise but currently there are no widespread applications for large scale CO_2 capture despite intense research effort as the materials are difficult to scale, are expensive and the performance is hindered by the presence of water and other contaminants in the air.

There are a limited number of materials that can efficiently capture CO_2 from air. Santos is planning on trialling multiple technologies throughout our assets. CO_2 in conjunction with our CCS facilities provide the opportunity to offset emissions by permanently removing atmospheric CO_2.

4.4 Satellite Facilities

Satellite facilities include oil and gas satellites and nodal compressors (pressure boosters). Oil and gas satellites are established to provide small scale localised production and processing operations for a given oil or gas field, before being transferred to Moomba Plant for centralised processing via pipeline or truck. Nodal compressors are large gas compressors which maintain flowrates at a reasonable level and boost gas pressures in pipelines.

Santos utilises a range of methods and technologies to manage operations at its facilities. While some larger facilities are staffed, other satellite facilities are monitored remotely and visited by field operators as required.

Santos operated South Australian gas and oil satellites and nodal compressors, are listed in Table 4-1 and shown in Figure 4-1. A typical satellite facility is shown in Plate 4-2.

Table 4-1: Cooper Basin nodal compressors and satellites

Nodal Compressors	Gas Satellites	Oil Satellites
Amyema	Big Lake	Charo
Brumby	Bookabourdie	Dullingari
Mawson-Kurunda	Daralingie	Fly Lake
Moomba South East	Della	Gidgealpa
Munkarie	Dullingari	Keleary
Strzelecki #15	Gidgealpa	Limestone Creek
Toolachee North	Kidman Gas	Meranji
Toolachee West	Merrimelia	Merrimelia
Meranji	Moorari	Moomba South Oil Facility
	Strzelecki	Moomba Oil Facility
	Tirrawarra	Moorari
	Toolachee	Narcoonowie
	Moomba South Central	Strzelecki
	Moomba North	Tantanna
		Tirrawarra

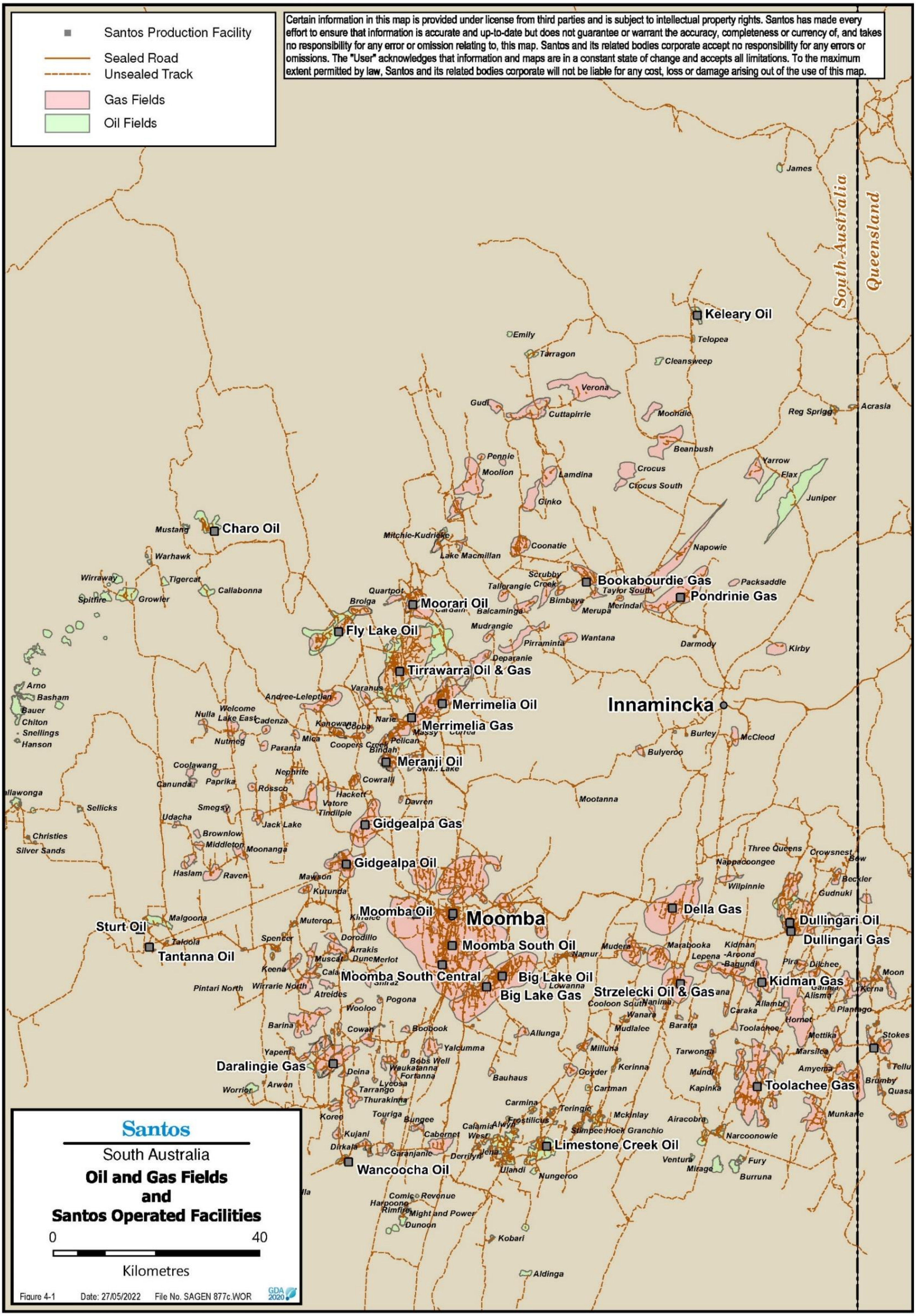
Plate 4-2: Typical satellite facility

4.4.1 Remote integrated operations

Santos utilises a range of technologies to remotely observe and manage production and processing operations in real-time at its facilities. The remote integrated operations system predominately consists of a Supervisory Control and Data Acquisition (SCADA) system, with human-machine interface (HMI) software to form a real-time information management system. SCADA utilises both hardware and software to centrally monitor and process real-time data supplied from a network of programmable microcomputers and sensors (e.g. pressure sensors) located at the Moomba facility, satellite facilities, compressor stations and individual well sites. Existing infrastructure can also be retrofitted with SCADA hardware (i.e. through installation of pressure sensors, valves, piping and cabling) to enable integration with the remote integrated operations system.

The SCADA system allows Santos to directly interact with infrastructure such that valves, pumps and motors can be remotely controlled through HMI software. This software centrally processes, distributes, and displays the data, which allows Santos to analyse the data and make decisions in real-time. Further, the system can alert Santos to process malfunctions, and allows for some infrastructure to be remotely started or shut-down. For example, an engineer receives a warning alarm from a production tank level or pressure sensor. The engineer pauses production operations and views the SCADA system data to determine the likely cause of the issue. If the issue is simple to rectify, and conditions are safe to do so, the engineer may be able to remotely restart production operations via the SCADA system. Alternatively, a field operator may be instructed to visit the site and inspect the infrastructure.

These systems provide a very high level of surveillance and control, leading to an increase in the safety of operations and improved response times. Santos is continuously expanding its remote operations capacity as technology allows.


Santos Production Facility
Sealed Road
Unsealed Track
Gas Fields
Oil Fields
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South Australia
Queensland
James
Keleary Oil
Telopea
Emily
Tarragon
Cleansweep
Verona
Gudi
Cuttapirrie
Moomdie
Reg Sprigg
Acrasia
Beanbush
Pennie
Moolion
Lamdina
Crocus
Crocus South
Yarrow
Flax
Juniper
Ginko
Charo Oil
Mustang
Mitchie-Kudriecke
Coonatie
Napowie
Warhawk
Lake Macmillan
Wirraway
Tigercat
Callabonna
Spitfire
Growler
Scrubby Creek
Tallerangie
Bookabourdie Gas
Packsaddle
Taylor South
Pondrinie Gas
Quartpot
Brolga
Moorari Oil
Bimbaya
Merupa
Merindal
Balcaminga
Mudrangie
Fly Lake Oil
Pirramimma
Wantana
Darmody
Kirby
Deparanie
Tirrawarra Oil & Gas
Arno
Basham
Bauer
Chiton
Snellings
Hanson
Andree-Leleptian
Varanus
Merrimelia Oil
Innamincka
Nulla
Welcome Lake East
Cadenza
Kanowana
Cooba
Narie
Merrimelia Gas
Massy
Correa
Burley
McCleod
Nutmeg
Paranta
Mica
Coopers Creek
Pelican
Bindah
Bulyeroo
Coolawang
Nephrite
Meranji Oil
Canunda
Paprika
Rossco
Cowralli
allawonga
Sellicks
Smegsy
Hackett
Vatore
Tindilpie
Davren
Mootanna
Udacha
Jack Lake
Gidgealpa Gas
Christies
Silver Sands
Brownlow
Middleton
Moonanga
Haslam
Raven
Gidgealpa Oil
Three Queens
Crowsnest
Bow
Nappacoongee
Beckler
Mawson
Kurunda
Wilpinnie
Gudnuki
Moomba Oil
Moomba
Della Gas
Dullingari Oil
Dullingari Gas
Sturt Oil
Malgoona
Muteroo
Taloola
Tantanna Oil
Spencer
Dorodillo
Arrakis
Muscat
Dune
Merlot
Moomba South Oil
Mudera
Marabooka
Kidman -Aroona
Lepena
Bagundi
Namur
Pira
Dilchee
Moomba South Central
Big Lake Oil
Big Lake Gas
Kidman Gas
Moon
Keena
Wirrarie North
Pintari North
Atreides
Pogona
Lowanna
Strzelecki Oil & Gas
Cooloon South
Nanima
Allambi
Alisma
Kerna
Wooloo
Wanara
Caraka
Plantago
Barina
Cowan
Boobook
Allunga
Mudlalee
Baratta
Toolachee
Hornet
Mettika
Stokes
Yalcumma
Milluna
Tarwonga
Marsilea
Yapeni
Bobs Well
Daralingie Gas
Waukatanna
Fortanna
Deina
Kerinna
Amyema
Tellu
Goyder
Mundi
Brumby
Arwon
Lycosa
Bauhaus
Kapinka
Toolachee Gas
Quasa
Worrior
Tarrango
Thurakinna
Cartman
Carmina
Teringie
Touriga
Koree
Bungee
Frostilicus
Mckinlay
Airacobra
Munkarie
Calamia
Alwyn
West
Cabernet
Stimpee Hock
Granchio
Kujani
Narcoonowie
Dirkala
Garanjanie
Derrilyn
Jena
Limestone Creek Oil
Ventura
Fury
Mirage
Wancoocha Oil
Ulandi
Nungeroo
Burruna
Comic
Revenue
Harpoono
Rimfire
Might and Power
Dunoon
Kobari
Aldinga
Santos
South Australia
Oil and Gas Fields
and
Santos Operated Facilities
0
40
Kilometres
Figure 4-1
Date: 27/05/2022
File No. SAGEN 877c.WOR
GDA 2020

4.4.2 Gas satellites

Raw gas, from a gas well, is directed into gathering lines via well lease pipework. As wells deplete and reservoir pressure drops, the flowrate from the wells also falls. To maintain flow rates with changing reservoir pressures, nodal compressors are used to boost gas pressure within the pipelines. Corrosion inhibitor may be injected at the nodal compressors to maintain pipe integrity.

Gas satellites deliver pressure-boosted raw gas from well fields to Moomba Plant for processing.

A typical gas satellite includes:

- gathering and manifold system from field gas wells
- inlet header system for raw gas
- gas, liquid hydrocarbon (condensate) and water separation facilities
- gas compression and cooling systems
- condensate handling facilities
- utility facilities (fuel gas system, fire detection, instrument air, evaporative coolers, power generation and washdown water)
- chemical injection system (including chemical storage) for corrosion prevention and emulsion breaking
- bulk fuel storage
- a flare system and vent facilities
- pipeline connection to a trunkline
- water treatment facilities, including interceptor and evaporation ponds
- telemetry and communications system
- emergency shutdown and control systems
- septic systems
- perimeter fencing.

Gas satellites include a fuel gas system and electrical power is provided from either Moomba Plant or on-site generation equipment.

Additional infrastructure such as compression, metering and monitoring facilities will be installed where required at satellites or fields where CO_2 injection is undertaken.

Once entering a gas satellite, raw gas is separated into gas, condensed hydrocarbon liquid (condensate) and water (produced formation water, PFW). The separation process occurs through a series of separator vessels. Separator vessels typically include inlet separators, filter separation systems and coalescers.

Once separated, the natural gas component undergoes compression and is cooled in after-coolers. Condensate remaining in process vessels (separators and after-coolers) is recovered and reinjected into the discharge header. The condensate is then added to the two-phase hydrocarbon mixture (i.e. gas and condensate) and sent to Moomba Plant via a trunkline.

Separated PFW is sent, via a drain system, to an adjacent engineered interceptor pond where hydrocarbons can be recovered by manual skimming or vacuum truck. See Section 4.5 for further detail on PFW and PFW facilities.

A flare system is provided for plant venting, emergency relief and process anomalies. Low pressure gas is directed to the flare, which is permanently alight. During any process anomalies or emergency situations, the gas can be sent directly to the flare.

Gas satellite waste management is detailed in Section 4.9.2.

4.4.3 Oil satellites

Oil satellites receive fluids from oil producing wells where the gas and water is separated from the oil through the use of dewatering tanks. Oil is then transferred to Moomba Plant via a trunkline or by truck. A typical oil satellite consists of:

- gathering and manifold system from field oil wells
- inlet manifold system
- dewatering tanks
- processed oil storage tanks
- oil transfer pumps
- utilities (instrument air, electric power generation, fuel gas and fuel oil systems)
- vent facilities
- water treatment facilities, including interceptor and evaporation ponds
- chemical injection system (including chemical storage) for corrosion prevention and emulsion breaking
- export facilities (pipeline connection to an oil trunkline or truck loading facilities)
- telemetry and communications system
- emergency shutdown and control systems
- perimeter fencing.

Additional infrastructure such as compression, metering and monitoring facilities will be installed where required at satellites or fields where CO_2 injection is undertaken.

Recovery of CO_2 from oil produced through CO_2 enhanced hydrocarbon recovery (EHR) may also be considered to enable reinjection of CO_2 (refer Section 4.6). Currently all CO_2 separation is performed at the Moomba Plant. This may occur at the satellite facility or Moomba Plant.

Electrical power for oil satellites, and nearby oil fields, is provided from Moomba Plant or on-site generation equipment.

Separated PFW is sent, via a drain system, to an adjacent engineered interceptor pond where hydrocarbons can be recovered by manual skimming or vacuum truck. See Section 4.5 for further detail on PFW and PFW facilities.

Oil satellite waste management is detailed in Section 4.9.2.

4.4.4 Nodal compressors

Nodal compressors are large gas compressors which maintain flowrates at a reasonable level and boost gas pressures. Corrosion inhibitor is injected at the nodal compressors to maintain pipe integrity.

4.5 Produced Formation Water and Associated Facilities

When extracted oil and gas reaches the surface through the well, it is accompanied by water, known as produced formation water (PFW) which is managed at satellite facilities and Moomba Plant. Once the petroleum products have been removed by various means of primary separation, the remaining water is managed either for the purpose of re-use (i.e. construction purposes, drilling and completions activities and / or enhanced hydrocarbon recovery) or disposal. A summary of PFW management facilities and their approximate sizes is provided in Table 4-2.

PFW can be saline and typically contains some residual hydrocarbons, naturally occurring heavy metals and other organic and inorganic compounds. These compounds are present in low concentrations in PFW and discharge to the environment is managed. A list of common compounds and elements present in PFW is presented in Table 4-3.

The Minister for Energy and Mining holds a water licence within the Far North Prescribed Wells Area which allocates 21,900 ML per annum (equivalent to 60 ML/day) for the purpose of taking produced formation water. The volume of PFW extracted by Santos is reported annually to DEM.

Table 4-2: South Australian Cooper Basin produced formation water treatment facilities

Facility Name	Area (m^2)	PFW Facility	Area (m^2)
Amyema Nodal Compressor	24,956	Moomba Oil Facility	134,000
Brumby Nodal Compressor	14,879	Moomba Plant evaporation ponds	284,200
Big Lake Gas Satellite	106,800	Moomba Plant	60,700
Bookabourdie Satellite	34,261	Moomba South Central Satellite	21,038
Charo	94,000	Moomba South East Nodal Compressor	8,450
Daralingie Gas Satellite	14,096	Moomba South Oil	29,700
Della Gas Satellite	162,494	Moorari Gas Satellite	N/A
Dullingari Gas Satellite	21,600	Munkarie Compressor	36,517
Dullingari Oil Satellite	234,800	Narcoonowie Oil Facility	176,400
Gidgealpa Gas Satellite	60,000	Strzelecki 15 Nodal Compressor	10,750
Gidgealpa Oil Satellite	1,067,520	Strzelecki Oil Satellite	532,861
Keleary Satellite	83,950	Tantanna Oil Satellite	538,500
Kidman Gas Satellite	126,725	Tirrawarra Gas Satellite	48,500
Limestone Creek Oil Satellite	896,529	Toolachee North Nodal Compressor	20,546
Mawson/Kurunda Nodal Compressor	728	Toolachee South Nodal Compressor	36,671
Meranji Oil Satellite	477,319	Toolachee Gas Satellite	169,425
Merrimelia Gas Satellite	16,904		
Merrimelia Oil Satellite	706,162		
Total Area of all PFW Facilities (m^2)			**6,251,981**

Table 4-3: Compounds commonly found in produced formation water

Key compounds		
Aluminium	Benzene	Ammonia-Nitrogen
Arsenic	Calcium carbonate	Nitrate-Nitrogen
Barium	Polycyclic aromatic hydrocarbons	Nitrite-Nitrogen
Beryllium	Toluene	Nitrogen
Boron	Total cyanides	Phosphorus
Cadmium	4-Bromofluorobenzene	Sulphate
Calcium	1.2-Dichloroethane-D4	
Chromium (Hexavalent)		
Chloride		
Cobalt		
Copper		
Iron		
Lead		

Key compounds		
Lithium		
Manganese		
Mercury		
Molybdenum		
Nickel		
Potassium		
Silica		
Strontium		
Vanadium		
Zinc		

Typically, PFW is managed via pond systems (see Section 4.5.2) but may also be reused (see Section 4.5.3). Once PFW is separated from oil and gas within the satellite or nodal facility, it is transferred to an interceptor pond to facilitate additional separation and then transferred through to a series of holding and / or evaporation ponds. A contemporary PFW management facility is shown in Plate 4-3. The stages of typical PFW management and treatment process are shown in Figure 4-3 and Figure 4-2, and are discussed further below.

Plate 4-3: Contemporary produced formation water management facility

4.5.1 PFW primary treatment

Primary PFW separation aims to maximise hydrocarbon recovery prior to discharge from the process stream. Primary treatment can be physical (gravity) or chemical treatment (emulsion breakers) or a combination of both.

Primary treatment is undertaken in vessels and tanks (the separation plant) proximal to a PFW pond system. Water is discharged from the base of the tanks to an interceptor pond to facilitate additional separation. Note that 'Polished water' in figure 4-2 is a generic term referring to water from the sludge processing plant following processing. This is where suspended solids and Biological oxygen demand (BOD) are removed from wastewater.

4.5.2 PFW pond systems

Satellite pond systems are the final recovery stage in hydrocarbon production. They are designed to maximise hydrocarbon recovery and achieve a water quality in the final stage pond that is commensurate with the sensitivity of the receiving environment, by progressively reducing the level of hydrocarbons present in PFW as it moves through the system.

An engineered interceptor pond is the first pond in a PFW system. It is lined to prevent seepage and fenced to prevent native fauna and livestock access.

Interceptor ponds are designed to manage primary-treated PFW and facilitate final recovery of hydrocarbons. Final recovery is undertaken by manual skimming or vacuum truck and is achieved by separation through residence time. The amount of hydrocarbon present in an interceptor pond is dependent on the efficiency of the primary treatment and the volume of PFW that flows through the system.

The level of separation or treatment achieved in an interceptor pond should be sufficient to minimise hydrocarbon carry-over to the first stage holding or evaporation pond (and / or subsequent ponds) and minimise the potential for impacts to the receiving environment.

Following separation in the interceptor(s), PFW is transferred through an underflow pipe to a bunded holding or evaporation pond, from where, depending on the quality of the water and / or the volume, it may be transferred (underflow pipe) to a secondary holding or evaporation pond. Holding and evaporation ponds are lined, either with clay or synthetic liners. Depending on the quality of the water in the holding or evaporation pond, PFW may be recovered for re-use via load out infrastructure (i.e. pump and a truck / tanker fill stand).

The number and size of holding and / or evaporation ponds present at a satellite facility will depend on the volume of PFW requiring management.

Bunded holding or evaporation ponds are considered engineered ponds as water quality and rate, minimum freeboard, bund height and appropriate construction materials are considered in the design and construction. New ponds are designed and constructed in accordance with EPA Wastewater Lagoon Guidelines.

Freeform evaporation pond systems use the natural topographical features of the landscape to capture PFW for final evaporation and / or beneficial use. Free form evaporation ponds most commonly use dune corridors, with bunds constructed where required to form the evaporation pond.

The concentration of residual contaminants in PFW ponds should take into account the type of pond (e.g. engineered or free-form) as well as the environmental setting, including environmental receptors.

Pond systems are designed in such a way that concentration of Total Recoverable Hydrocarbons (TRH) in the final-stage pond of any PFW pond system should not exceed:

- 30 mg/L in an engineered evaporation pond; or
- 10 mg/L in a free-form evaporation pond.

Santos commits to undertaking a review of PFW management across the Cooper basin to understand the risk and whether the current monitoring is adequate.

PFW monitoring is conducted in general accordance with relevant monitoring plans as required, and after PFW management review is complete to demonstrate compliance with appropriate water quality thresholds.

Monitoring of the pond systems, including visual inspection and / or water quality testing, is undertaken when required.

Evaporation ponds are designed to maximise water uptake and may be open or closed (i.e. fenced), bunded or free form. Open evaporation pond systems are not fenced and allow for access by native fauna and livestock. Closed evaporation pond systems are fenced to minimise the potential for access by native fauna and livestock. Whether a system is open or closed depends upon water quality considerations and consultation with landholders.

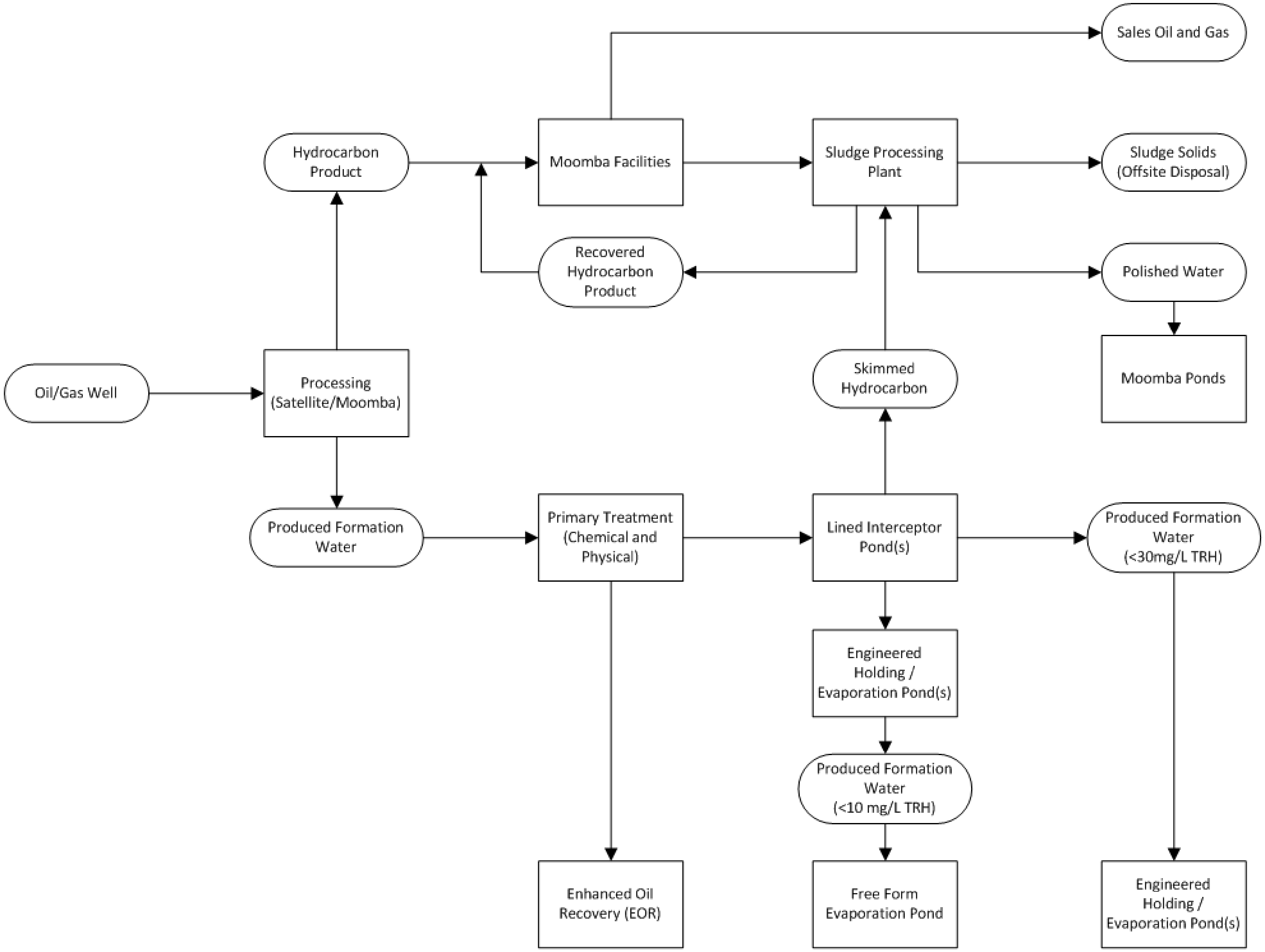


Figure 4-2: Flowchart of produced formation water treatment process

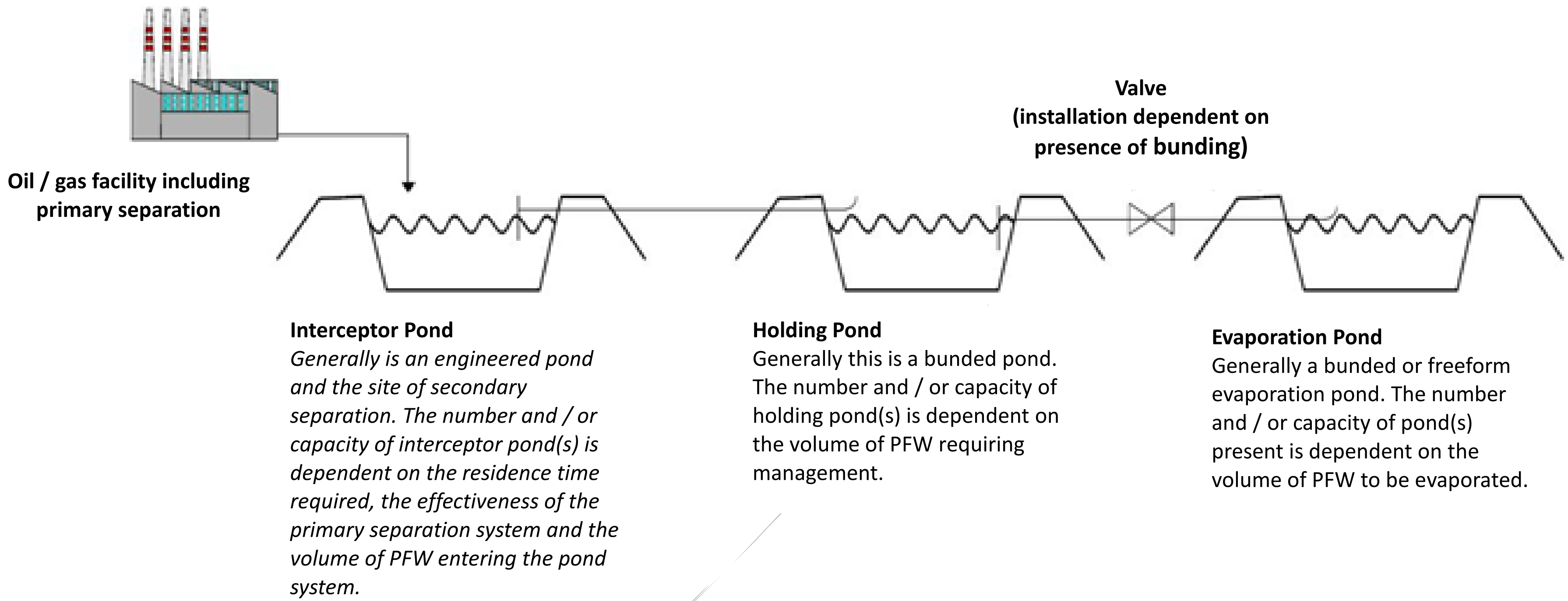


Figure 4-3: Typical produced formation water treatment pond system

4.5.3 PFW use

Santos may use PFW for secondary purposes including:

- road construction
- dust stabilisation
- drilling and completions activities
- hydrotest water
- enhanced hydrocarbon recovery
- ballast water for oil field tankers

PFW may also be provided to pastoralists for beneficial reuse (e.g. livestock watering).

Internal approval and conditions for activities that reuse PFW may be required in accordance with Santos standards. Where required, PFW monitoring may be undertaken to evaluate the quality of water in a pond system. Depending on beneficial use of PFW, monitoring results may be compared to applicable water quality criteria to evaluate suitability. Where monitoring results indicate that water quality is not suitable for the intended use, actions to meet applicable criteria may be undertaken, or an alternative water supply identified.

If a beneficial use option is identified that results in a discharge to the environment (i.e. irrigation), comparison against relevant water quality criteria and / or guidelines (e.g. ANZECC (2000) / ANZG (2018)) may be undertaken to inform a management strategy. Any water subject to beneficial reuse will be assessed to ensure suitability for the proposed reuse.

Where PFW is re-used in closed systems such as truck ballast or EHR, the risk to sensitive receptors is considered as low as reasonably practicable.

4.6 Enhanced Hydrocarbon Recovery

Improved and enhanced oil recovery (IOR / EOR) and enhanced gas recovery (EGR) can collectively be termed enhanced hydrocarbon recovery (EHR). These secondary and tertiary production techniques are used to increase the volume of hydrocarbons that can be recovered from a reservoir. Common techniques include waterflooding, gas injection, chemical injection and / or thermal processes.

Waterflooding

Waterflooding is a technique used to maintain or increase reservoir pressures and improve the displacement of oil through a reservoir. Fluid for waterflooding activities can be sourced from production wells, converted production wells or water supply bores or from PFW ponds from nearby satellites. The quality of water used for injection must be of similar quality to that of the target formation to minimise the potential for degradation of reservoir conditions. In each scheme, the water undergoes a level of treatment for removal of solids, biocide dosing and other chemical treatments.

Waterflood activities are currently undertaken in the Merrimelia and Charo fields and have demonstrated improved secondary oil recovery. Previously waterflood activities were carried out in the Dullingari, Gidgealpa and Jena fields.

Each waterflood scheme is subject to a reservoir specific study including applicability, suitability, injectivity and compatibility. Waterflooding schemes are implemented using the data obtained from pilot projects and historical waterflood activities. Waterflood activities are undertaken in liaison with the regulator, and where required, under applicable licences (e.g EPA licence 2569 and GWL 201800).

Gas injection

Gas injection is an alternative technique for EHR and serves the dual purpose of maintaining reservoir pressure and improving displacement of oil through the formation pore structure. Gas injection schemes can be immiscible or miscible depending on the purpose of the scheme. Immiscible schemes maintain reservoir pressure and displace oil. Miscible schemes involve dissolving injected gas into reservoir oil to improve the mobility of oil through a reservoir.

In the Cooper Basin, gas used in gas injection schemes is sourced from nearby satellites. Prior to injection into the reservoir, the gas is subject to biocide and corrosion inhibitor dosing and filtration. The gas for a dedicated CO_2 EHR scheme would be sourced from Moomba as described in Section 4.4.3.

Santos undertook miscible EOR in the Tirrawarra field from 1984 to 1996, during which time raw gas and ethane were used as the injection fluid. Tracer surveys were undertaken during the EOR scheme to monitor and evaluate EOR performance. In 1996 the Tirrawarra scheme was suspended for commercial reasons. Following the success of the Tirrawarra EOR scheme, a gas injection scheme was commissioned in the Fly Lake field (2008). The Fly Lake scheme is currently operational. Injection gas used at Fly Lake is raw gas sourced from a nearby satellite. Tracer surveys have also been undertaken at Fly Lake.

Injection wells for gas injection and waterflooding

Injection fluids for gas injection and water flooding are transferred through dedicated distribution flowlines and are injected into dedicated wells at pressures high enough to achieve the designed injection rates.

Factors considered for optimising the performance of an EHR scheme include:

- depth and thickness of the target zone
- lithology and temperature of target formation and bounding layers
- composition of the injected and reservoir fluids
- minimum horizontal stress across all layers (target and bounding)
- thickness of the ‘seals’ (aquitard layers) above and below the target reservoir formation
- porosity and permeability
- formation boundaries (as identified from seismic data)
- bedding planes, jointing and mineralisation
- natural fracture networks.

An injection well may be a converted production well or a well specifically drilled for water or gas injection. Injection wells are designed analogously to wells intended for production from the target formation(s). The location of injection wells within a field may change over the course of the life of an EHR scheme to ensure that optimum pressure gradients are maintained and hydrocarbon recovery is maximised through optimum sweep patterns.

Injection wells are managed using the same management system as production wells. The Santos Well Integrity Management System (WIMS) is used to maintain the asset in a ‘fit-for-purpose’ state and to protect people and the environment.

EHR schemes are designed to minimise the likelihood of souring of reservoir hydrocarbons. Reservoir souring can occur when there is an increase in the mass of hydrogen sulphide (H_2S) in produced fluids due to the activity of sulphate reducing bacteria. Consequently, the injected fluids are commonly treated with a biocide prior to injection.

Chemical and isotope tracers

Chemical or isotope tracers may be used to monitor the progress of injected water or gas through the reservoir. A small volume of the tracer is added at an injection well and subsequent sampling of the production stream at offset wells is monitored to observe tracer breakthrough. Selection of the tracer and survey design depends on the target geological and hydrogeological environment, the injection and production well locations and EHR history.

CO_2 storage

Following the completion of any EHR activity, CO_2 remaining in the reservoir could be viewed as permanently stored. This would be managed in line with the Carbon Storage SEO (Santos 2021b) and associated monitoring, verification requirements and international standards.

4.7 Moomba Gas Plant – Process Facilities

4.7.1 Moomba facilities

The Moomba facility or 'Greater Moomba Area' is located approximately 800 km north of Adelaide and includes:

- a fenced perimeter
- the Moomba Gas Plant, fenced oil and gas processing facilities
- Moomba North, a gas compression facility inside the northern boundary of Moomba Plant
- Moomba Camp, located approximately 250 m to the east of Moomba Plant fence line, providing camp facilities for Santos employees and contractors, including self-contained accommodation, mess facilities, and a medical centre (see Section 4.9.10)
- offices, located within the vicinity of Moomba Plant, comprising administration facilities for operational staff and support personnel, and the Moomba Communications Office
- maintenance workshops and plant control room (see Section 4.9.10)
- contractor yards, offices, stores, warehouse and workshops, located adjacent to Moomba Plant (see Section 4.9.10)
- APA Group Moomba Compressor Station and Epic Meter Station, containing pipelines, valving, filters and metering, situated approximately 700 m south of Moomba Gas Plant (covered under separate EIR / SEOs)
- fuel, explosives and hazardous materials storage outside of Moomba Plant confines (see Section 4.9.6)
- an aerodrome, located approximately 1 km from Moomba Plant (see Section 4.9.8)
- emergency services that provide dedicated resources (personnel and equipment) for fire and emergency response (see Section 4.9.9).

4.7.2 Moomba Gas Plant

The Moomba Gas Plant comprises of plant and equipment to receive and process raw gas, hydrocarbon condensate and crude oil from the gas and oil fields in the Cooper and Eromanga basins (refer Plate 4-4). A schematic of the Moomba process facilities is provided in Appendix B Figure B1.

There are nine gas trunklines feeding raw gas into the plant, including the sales gas reinjection / withdrawal line from the Moomba South Central Gas Satellite (refer Section 4.7.5). Condensate enters Moomba Plant through the gas trunklines as a two-phase mixture with the raw gases. Crude oil enters the plant through oil trunklines or by road tanker. There will also be pipelines transporting CO_2 out of Moomba Plant for injection.

The Moomba Gas Plant typically supplies:

- up to 250 TJ/day of sales gas to Adelaide and Sydney

- 240 m^3/hr of crude oil and natural gas liquids (NGLs) to Port Bonython
- 800 tonnes/day of ethane to Sydney.

From 2023, Moomba Gas Plant will also supply CO_2 for storage at several sites in the South Australian Cooper Basin.

Liquefied natural gas (LNG) supply to Queensland commenced in late 2015.

Moomba Gas Plant stores and handles several substances that are defined as Schedule 15 chemicals by the WHS regulations, including flammable liquids and compressed/liquefied gas.

Plate 4-4: Moomba Gas Plant
(Source: PACE Magazine Zenith Award 2008)

4.7.3 Site access

Due to its remote location, the main access to Moomba Plant is by air. Third party airlines provide charter services to and from Moomba, from Adelaide, Brisbane and Ballera. A light plane service and helicopter service provide access to remote sites and when roads are closed due to heavy rain or flooding.

Road access to Moomba is by public roads, principally from Adelaide via the partially sealed Strzelecki Track. Road access may be restricted or closed for short periods, especially following heavy rain.

4.7.4 Process overview

A schematic diagram which provides an overview of oil and gas processing at the Moomba Gas Plant and customer supply is provided in Appendix B.

Moomba Plant is self-sufficient in the production of potable water and boiler feedwater, fuel gas, instrument air, steam and electric power. There is a single, manned, main control room for the process areas and utility functions. In addition, there are five electrical switch-rooms, and five marshalling stations which house electrical distribution and control equipment.

Moomba Plant also provides energy for the greater Moomba facility utilities (see Section 4.9.5.).

4.7.5 Gas processing

Gas satellites in the Cooper and Eromanga Basin receive raw gas from nearby gas-producing wells and separate the gas into three component phases (gas, hydrocarbon liquid and water), in separator vessels. The separated gas is compressed and cooled, and then flows to Moomba Plant via nine gas trunklines which include the sales gas reinjection / withdrawal line from the Moomba South Central Gas Satellite.

Incoming raw gas streams are directed to the inlet separation section of Moomba Plant, which provides three-phase separation of gas, hydrocarbon-condensate and water.

Inlet separation facilities include the:

- raw gas inlet header
- slug catchers
- condensate / water coalescer
- high pressure (HP) separators.

Condensate is further processed in the crude stabilisation plant. The separated water is sent to the oily water system for treatment.

The separated gas is transferred from the HP separators to the Benfield Plants for carbon dioxide (CO_2) removal using continuous hot potassium carbonate solution to absorb CO_2. The potassium carbonate solution is regenerated allowing the potassium carbonate solution to be reused.

The CO_2 Removal Plant consists of four parallel Benfield trains which meet the CO_2 removal requirements for the current throughput of raw gas at Moomba Plant. Additional CO_2 removal capacity may be required depending on future CO_2 load forecasts.

For CO_2 injection and storage operations, CO_2 released from the Benfield trains will be captured and transferred through compressors to dehydration units that will remove any moisture before the CO_2 is piped out into the field.

The gas leaving the CO_2 removal plant, called 'sweet' gas, contains less than 3.0 mol% CO_2 and less than 1 ppm hydrogen sulfide (H_2S). This gas is fed to the Liquids Recovery Plant (LRP) via the dehydration facilities. The purpose of the LRP is to recover liquid hydrocarbons from Moomba Plant gas feed and is achieved by cryogenic distillation that separates ethane and heavier hydrocarbons.

Dehydration facilities are located upstream of the LRP, the aim of which is to:

- meet sales gas specifications
- reduce the moisture content of the feed gas
- remove mercury from the gas stream.

Moisture and mercury removal is achieved by a process of cooling and molecular sieve adsorption in the dew point control unit (DPCU) vessels before the gas passes into the LRP. After passing through the LRP, the residue gas (demethaniser overheads) is recompressed prior to entering the sales gas pipelines to Adelaide, Sydney and Wallumbilla.

During periods of low customer demand, gas can be sent to Moomba South Central satellite by pipeline to be reinjected (and stored) into underground storage formations, the Lower Daralingie Beds (LDB), which is located at Moomba South (10 km south of the plant). This reservoir has the capacity to hold up to 85 bcf of product for storage. During periods of high demand, the reinjected gases are withdrawn from the LDB to supplement processed sales gas.

Subsequent distillation of the liquid stream from the LRP de-ethaniser separates ethane from heavier components. The remaining liquids from this distillation (mainly propane and butane) are mixed with stabilised crude and condensate and are transferred to the Port Bonython Fractionation Plant.

Because of the high priority of maintaining continuous sales gas production, the plant can be switched to a simplified flow scheme should the cryogenic distillation plant be unavailable. In this flow arrangement, minimum liquid hydrocarbon is recovered by condensation, using refrigeration to decrease the hydrocarbon dew point of the gas product to a level that meets the sales gas specification. This operating mode is referred to as dewpoint control mode and is suitable for producing specifications for sales gas but not gas supply for LNG customers.

Ethane from the LRP de-ethaniser is fed to the Ethane Treatment Plant (ETP), to reduce the CO_2 content in ethane to <400 ppm, which is a suitable quality for petrochemical feedstock. The ETP utilises an amine adsorption process for CO_2 removal and a molecular sieve dehydration unit. Ethane is sent to Sydney via a dedicated ethane pipeline. Ethane from the LRP can also be directed to sales gas.

A pressure storage area within the plant contains a propane refrigerant bullet, which is located within an individual earthen bund, and two NGL vessels that are in a common earthen bund. Pumps are located outside the bunds.

4.7.6 Liquid processing

Liquid hydrocarbons at Moomba Plant are either recovered from the raw gas or are pumped / trucked to Moomba from the oil satellites. Oil satellites receive well fluids from nearby oil producing wells, separate water from the oil, dispose of the water and then transfer the oil to Moomba Plant via five trunklines.

Crude oil produced at the oil satellites is either sufficiently stable to store in tankage, i.e. ‘Block Oil’ in TK-1000, or requires processing through the Crude Stabilisation Plant (CSP) to remove volatile fractions, i.e. ‘Unit Oil’ from the northern oil satellites (e.g. Tirrawarra). The stored ‘Block Oil’ is directed to the CSP for processing, as required. The CSP removes volatile hydrocarbons and water from the crude oil and condensate. The CSP includes flashing vessels and a distillation column, with the lighter fractions primarily recovered as fuel gas.

A single pipeline transfers crude oil and natural gas liquids to the Liquids Processing Plant at Port Bonython.

4.7.7 Tank farm and truck load-in

A crude storage area contains two floating roof oil storage tanks (TK-1000 and TK-3000) within shared bunds. TK-1000 stores incoming ‘Block Oil’ from pipelines and the truck load-in while the ‘reduced’ or ‘stabilised’ crude from the CSP is stored in TK-3000. TK-1000 and TK-3000 have nominal capacities of 15,900 m^3 and 47,400 m^3, respectively.

The truck unloading facility enables transfer of ‘Block Oil’ from incoming road tankers to TK-1000 or TK-3000. The oil unloading facilities include a pair of parallel meter runs, each comprising a strainer, pump, water-in-oil analyser, mass flow meter and isolation valves.

4.7.8 Flare systems

The flare systems provide a means of safely managing uncontrolled and waste process hydrocarbons. Flare systems at Moomba include:

- high pressure (HP) flare, which collects the discharge from various equipment PSVs, pressure control valves (PCVs), and other manual vents and drains. A standby HP flare is used when maintenance work is being carried out on the main HP flare
- low pressure (LP) flare, which includes the CSP flare system, collects the discharge from various equipment such as PSVs, PCVs, and other manual vents and drains
- low temperature (LT) flare to handle light liquefied hydrocarbons such as ethane, propane and butane which can develop extremely low temperatures when released (vapourised) into a low-pressure system, such as a flare system.

4.7.9 Gas compression facility – Moomba North

Moomba North is located inside the northern fence of the Moomba Gas Plant. The Moomba North facility is integrated into the Moomba Plant, which includes systems for the management of wastewaters, oily waters and waste. The facility includes an inlet separator, several reciprocating compressors and carbon steel piping installations.

4.7.10 Sour water management

Sour water, by definition, is process water that contains H_2S. At Moomba Plant, 'sour water' is wastewater, which may not include H_2S in its makeup, generated from utilities or processes, and is characterised into two main flows:

- 'sour water east flow' – wastewater from utilities
- 'sour water west flow' – process wastewater, including PFW, oily water, raw gas conditioning plant (RGCP) wastewater.

Sour water west flow is managed by the Moomba interceptor pond system and tilted plate interceptor (TPI) separator. Sour water east flow is sent directly to the Moomba plant evaporation ponds.

4.8 Moomba Gas Plant – Utilities

4.8.1 Water supply

Water is essential to operations and is required for steam generation, process requirements, domestic purposes for the Cooper Basin camps and firewater.

Potable and demineralised water is supplied from the reverse osmosis (RO) plant at Moomba (see Section 4.9.3).

4.8.2 Fuel gas

Fuel gas is primarily provided from sales gas and is used to provide energy for steam generation, electric power generation, fired process facilities and gas turbine driven process compressors.

4.8.3 Compressed air

Compressed air is primarily required as 'instrument' air to drive pneumatic actuators on control valves. The instrument air system includes:

- three electrically driven, 50% capacity, screw compressors that provide spare capacity and normally operate with two on-line and one in stand-by
- one portable diesel driven compressor (for emergency back-up)
- two air dryer units and various air receivers. The dryers are refrigerant and desiccant units that can be regenerated in-situ.

4.8.4 Boilers and steam

Steam is used to drive process steam turbines, produce electrical power and act as a medium for transferring energy around the plant. Steam is sourced from boilers inside the Moomba Gas Plant (see Section 4.9.4).

4.8.5 Electric power

Electrical power for the operation of Moomba Plant and associated facilities (such as camp, amenities and contractor facilities) is provided by steam and gas turbine driven alternators located at Moomba (refer to Section 4.9.5 for further detail on power generation and associated infrastructure).

4.8.6 Firewater facilities

There are three separate sets of firewater facilities strategically located around Moomba Plant. Each firewater facility consists of separate water storage and firewater pumps that are connected into the plant firewater distribution systems.

4.9 Supporting Infrastructure and Facilities

4.9.1 Road construction and maintenance

There are approximately 6,000 km of Santos constructed and maintained roads throughout the Cooper Basin (SA and south-west Queensland). These roads include approximately 1,000 km of main roads and approximately 4,500 km of minor roads and access tracks. There are five different road classes, the details of which are provided in Table 4-4.

Road safety requirements are taken into consideration and define the minimum design standards for road and access tracks. Roads are constructed to withstand heavy traffic volumes and vehicle weights. Where further developments are planned, access tracks will be upgraded to reflect the nature of the development and traffic loadings.

Table 4-4: Cooper Basin road classes

Road Class	Description
A	Plant and selected roads connecting plant to satellites
B	Selected satellite access roads and field spine roads to 'A' class network
C	Field access roads and spine roads with medium to low vehicle usage (3-30 trips per day) field access roads to wellheads. Construction method varies
D & E	Class D - field access roads to wellheads of lower priority and drilling lease access roads Class E - access tracks for drilling rig sites and production fields located in gibber areas

Roads and access tracks are designed and constructed in accordance with applicable Australian Standards and state legislation. Consideration is also given to the land system(s) through which they will pass. In most cases, the road easement is cleared and graded but under some circumstances the easement may be rolled (for example in gibber plains). Information on the road construction methods specific to particular land systems in the Cooper Basin is provided in Table 4-5.

Road construction methodology is based on estimated use and the environmental sensitivity of the area. Erosion controls are implemented during and after construction based on risk management principles with particular attention being given to flood and areas susceptible to water inundation. One example of attention to flood-prone areas is at Walkers Crossing on the Cooper Creek. After the inundation of the crossing had subsided in 2011, a bridge over the crossing was constructed to facilitate access to the Charo Field during flood events, whilst also minimising impact to surface water flows.

Following road construction, rehabilitation is undertaken to ensure that surrounding surface drainage is restored and erosion control structures are installed where required.

Table 4-5: Road construction methods for land systems in the Cooper Basin

Construction Method	Land System					
	Wetlands	Floodplains	Gibber Plains	Tablelands	Dunefields	Salt Lakes
Avoid construction on land system						●
Utilise naturally cleared areas	●	●	●	●	●	
Avoid steep slopes			●	●	Susceptible to erosion. Ensure controls are in place	
Weave road between trees and large shrubs	●	●	●	●	●	
Clear and grade easement	●	●	Refer to controls below		●	

Construction Method	Land System					
	Wetlands	Floodplains	Gibber Plains	Tablelands	Dunefields	Salt Lakes
			under 'Roads in gibber terrain'			
Roll easement			●	●		
Cap road surface with clay or similar borrow material	●	●	●	●	●	
Bridges, culverts or floodways installed on drainage line crossing as required	●	●	●	●	●	

Roads in gibber terrain

In sensitive gibber environments it is essential that surfaces have the stone cover layer maintained to control erosion. The following methods are considered to minimise disturbance and control erosion risk:

- roll gibber where surface is naturally smooth, stable and trafficable
- remove gibber mantle to windrows, grade underlying surface smooth, replace gibber mantle, water and roll
- leave existing natural surface, over-cap large rocks and wearing areas with borrow material that contains clay and stone
- construct erosion control berms, banks and drains where required
- undertake ongoing maintenance to prevent wheel rutting and water channelling.

Erosion controls are implemented where required based on a risk assessment, during and after construction, with particular attention given to flood and water flow areas. Culverts or other structures may be installed, where required to ensure that surface water flows are not impeded by the road. In some circumstances, structures such as raised roads or bridges may be installed to support production and processing activities.

Where relevant, a detailed hydrological assessment is undertaken for these structures to ensure that there are no significant impacts on surface water flows or aquatic fauna.

Borrow pits

Supplies of suitable construction material, such as gravel and soil, are generally excavated from sites referred to as borrow pits. The location of borrow pits will vary dependent on the land system and soil type required. Borrow pits vary in dimension, depending on the quality and quantity of material available.

Borrow pits are used to provide construction and maintenance fill material for:

- roads and access tracks
- satellite facilities (including ponds and bunds)
- permanent and mobile camp sites
- pipeline trench backfilling.

The location of new borrow pits will consider the following:

- avoid surface water flows into the pit, therefore minimising water retention
- minimisation of impacts to the environment (e.g. native flora and fauna, livestock and landforms)
- avoidance of cultural heritage sites
- stakeholder engagement to minimise impact to third party operations
- minimisation of visual impacts from construction activities by using native vegetation and landforms for screening
- maintenance of applicable clearance distances between borrow pits and infrastructure (e.g. facilities, fences, homesteads, roads and airstrips) to minimise risk associated with livestock, safety, erosion, and visual impacts.

Erosion is controlled by appropriate placement, batter slopes and construction of water flow diversion banks.

Site selection, environmental management and restoration of borrow pits is undertaken in accordance with Santos' procedures and the relevant SEO. Existing borrow pits are used in preference to new ones where appropriate. New borrow pits are subject to internal approval conditions and locations are recorded in the Santos GIS database.

Road, access track and borrow pit restoration

Restoration of a road or access track is undertaken if there are no longer operational requirements for its use. Final surface restoration involves:

- removal of capping from the access track or road and returning to the borrow pit
- ripping of the contour to promote revegetation and minimise erosion (gibber terrain is track rolled only)
- removing windrows to ensure that surface water flows are not impeded.

Borrow pits are restored in consultation with relevant stakeholders. Final restoration typically involves:

- battering slopes to prevent collapse
- constructing erosion control measures where appropriate
- returning overburden to the pit
- ripping the floor and sides of the pit
- spreading stockpiled topsoil and native vegetation
- ripping haul roads and tracks to relieve compaction.

In 2014 a study into the impacts of Cooper Basin borrow pits was undertaken by DEM to evaluate best practice for siting, construction, management and rehabilitation of borrow pits (Jacobs SKM, 2014). The results of the study are incorporated into the Goal Attainment Scaling (GAS) for Borrow Pit Construction and Rehabilitation (which forms part of the SEO for Production and Processing Operations) and Santos procedures.

4.9.2 Waste management

Santos recognises that waste management is an important part of the construction, operation and decommissioning phases of production and processing activities. Santos implements systems for waste management throughout the Cooper Basin to facilitate compliance to applicable Santos standards, legal and other requirements, and that waste is managed in accordance with the waste management hierarchy: avoid, reduce, reuse, recycle, treat, dispose. Santos operations or activities that generate, handle, store, or transport waste are required to have an appropriate management plan.

Santos employees and contractors that are involved in waste generation and / or management are responsible for ensuring that the relevant standards and procedures outlined in management plans are employed and maintained.

Waste types and a summary of management methods are outlined in Table 4-6 and Table 4-7 provides an overview of Santos' South Australian Cooper Basin waste management plans.

Table 4-6: Typical waste streams – operational waste from production and processing operations

Waste Type	Management Method	Point Source (where applicable)
Sludge	▪ Moomba Sludge Treatment Plant or recovered to process ▪ Sludge cake taken off-site for disposal at an approved facility	▪ satellite ponds ▪ tanks ▪ pig receivers and slug catchers
Biosolids	▪ Moomba Waste Management Facility (WMF)	▪ STP, septic systems
Contaminated soil	▪ Hydrocarbon contaminated soils stockpiled and / or treated at approved permanent or temporary landfarms	
Reverse Osmosis reject water	▪ Moomba Plant wastewater collection system then to evaporation ponds	▪ RO Plant
Stormwater run-off (plant) – open drains	▪ Moomba Plant wastewater interceptor and / or evaporation pond system	▪ Moomba Plant
Hydrotest water	▪ Nearest engineered pond system	▪ flowlines and pipelines
Blowdown waters	▪ Interceptor and evaporation pond system	▪ Moomba Plant boilers
Condensate from steam turbines	▪ Interceptor and evaporation pond system	▪ power generation (steam turbines)
200 L drums	▪ Moomba WMF for reuse or transport and recycling off-site, where possible	
Molecular sieves	▪ Moomba WMF	▪ Molecular Sieve Dehydration Unit
Chemical waste (including process Benfield/Potassium Carbonate Solution)	▪ Moomba WMF for disposal or transport off-site (to a licensed waste management facility)	
Scrap metal	▪ Moomba WMF for transport and recycling off-site, where possible	
Timber pallets (skids)	▪ Moomba WMF for transport and recycling off-site, where possible	
Vehicle tyres	▪ Moomba WMF for transport and recycling off-site	
Asbestos (e.g. building materials/insulations, etc.)	▪ Asbestos management facility	

Waste Type	Management Method	Point Source (where applicable)
Industrial bulky container (IBC)	▪ Moomba WMF for reuse or transport and recycling off-site, where possible	
Sewage and grey water	▪ Treated at Moomba WWTP and disposed of in evaporation ponds ▪ Satellite facility sewage and grey water is managed via septic systems ▪ Temporary camps' (e.g. for construction) sewage and grey water is managed via STP	▪ satellite facilities ▪ fixed and mobile camps ▪ office amenities
Putrescibles	▪ Moomba WMF	▪ fixed and mobile camps ▪ office amenities
Plastic, glass, cans, cardboard and paper	▪ Moomba WMF then recycled	▪ fixed and mobile camps ▪ office amenities
Oily rags and filters	▪ Moomba WMF	
Medical waste	▪ Moomba WMF	
Laboratory effluent	▪ Benfield solution and reagents are disposed to the grey water system (to WWTP) ▪ Other aqueous based wastes are disposed via grey water system (with appropriate neutralisation and dilution as necessary) to WWTP ▪ Crude oil and solvent wastes are disposed via the sludge treatment plant ▪ Vials are disposed of as broken glass ▪ EPA listed waste is transported off-site to an approved facility	▪ Moomba Laboratory
Gaseous waste (reported to the EPA via NPI)	▪ Flared to atmosphere - mainly propane, butane, methane, some ethane ▪ Vented – CO_2, H_2S, CO ▪ Carbon Capture and Storage ▪ Enhanced Oil recovery	▪ Moomba Plant ▪ field flares and venting ▪ power generation (gas turbine) ▪ boilers
Produced formation water	▪ Interceptor and evaporation ponds ▪ Beneficial reuse including construction and maintenance, drilling and completion activities, livestock watering and truck ballast water ▪ Waterflood (EHR)	▪ oil and gas fields
CCS condensed water	▪ Disposal at Moomba Eastern Evaporation Pond (Lake Brooks), or, ▪ Disposal at Moomba Western Evaporation Ponds, or ▪ Disposal at another suitable satellite water handling facility	▪ Recovered steam from the C02 trains

Table 4-7: South Australian Cooper Basin waste management plans

Title	Intent/Objective	Contents
Waste Management Plan	▪ Provide an overall coordination document for the management of the various waste streams that are generated by Santos' activities in the Cooper Basin ▪ To satisfy applicable legal (and regulatory) requirements, and any specific conditions set within the South Australian EPA Licence 2569 (Moomba General Operations)	▪ applicable legislative and other requirements ▪ types of waste generated ▪ Cooper Basin waste management facilities ▪ waste management processes and procedures ▪ waste storage requirements ▪ waste transport and tracking requirements ▪ general monitoring requirements ▪ audit and inspection requirements ▪ record keeping and reporting requirements ▪ identify opportunities for continuous improvement of the plan
Waste Management Plan – Wastewater	▪ Provide an overall coordination document for wastewater management of Cooper Basin Santos and Santos contractor facilities ▪ Wastewater is managed to minimise environmental and health risks to ALARP ▪ To satisfy applicable legal (and regulatory) requirements, and any specific conditions in the South Australian EPA Licence 2569 (Moomba General Operations)	▪ applicable legislative and other requirements ▪ types of wastewater generated ▪ wastewater management facilities ▪ wastewater management processes and procedures ▪ storage, treatment and disposal requirements ▪ transport and tracking requirements ▪ general monitoring requirements ▪ audit and inspection requirements ▪ record keeping and reporting requirements ▪ identify opportunities for continuous improvement of the plan
Moomba Landfill Environmental Management Plan (LEMP)	▪ Satisfy conditions in the South Australian EPA Licence 2569 (Moomba General Operations)	▪ defines wastes approved for disposal ▪ environmental monitoring and reporting requirements ▪ general facility details ▪ monitoring programs and reporting ▪ storage of materials not destined for disposal to the WMF landfill
Moomba Landfarm Management Plan	▪ To satisfy applicable legal (and regulatory) requirements, and any specific conditions in the South Australian EPA Licence 2569 (Moomba General Operations)) ▪ Responsible management of contaminated soils	▪ applicable legislative and other requirements ▪ landfarm management processes and procedures ▪ landfarm design requirements ▪ contaminated soil tracking requirements ▪ contaminated soil treatment objectives ▪ general monitoring requirements ▪ audit and inspection requirements

Title	Intent/Objective	Contents
		▪ record keeping and reporting requirements

Waste Management Facility

The Moomba Waste Management Facility (WMF) is regulated under the *Environment Protection Act 1993*. Santos holds South Australia EPA Licence 2569 (Moomba General Operations), for the Moomba WMF which includes provisions to allow Santos to accept waste from other generators in the Cooper Basin region. Requirements of the EPA licence are incorporated into management plans to facilitate compliance. The EPA Licence also specifically lists conditions for the overall management of the Moomba Wastewater Treatment Plant (WWTP).

The landfill is operated by Santos and its contractor(s) in accordance with the Moomba Waste Management Facility Landfill Environmental Management Plan (Moomba LEMP 2015, Santos 2015b). The WMF is designed to receive co-mingled waste and, in line with best practice, there are designated storage areas within the facility for the segregation of reusable / recyclable materials prior to transport off site. The Moomba asbestos waste depot (WF5 - also referred to as WD5) is a separate facility for disposal of friable and non-friable asbestos.

Wastes generated from activities associated with production and processing activities are generally segregated, stored and collected for transport by a licensed waste contractor to the WMF or off-site, for reuse, recycling or disposal. Licensed waste contractor/s are used for transport for treatment or disposal.

Landfarm operations

The management of hydrocarbon impacted soils at the Moomba Landfarm is regulated under the *Environment Protection Act 1993*. Santos EPA Licence 2569 (Moomba General Operations) authorises the operation of the Moomba Landfarm, subject to licence conditions, and includes provisions to allow Santos to accept hydrocarbon impacted soils from other generators in the Cooper Basin region. Conditions of the EPA licence are incorporated into the Landfarm Management Plan, developed to document potential risks, associated controls and compliance requirements. Hydrocarbon impacted material may also be stored temporarily at approved, pre-disturbed locations as required prior to treatment.

The Moomba Landfarm is operated by Santos and its contractor(s) in accordance with the Moomba Landfarm Management Plan (Moomba LMP, draft 2015). The Moomba Landfarm is designed to receive hydrocarbon impacted soils for the purposes of treatment using bioremediation techniques.

Once hydrocarbon impacted soils have been bioremediated to an appropriate level for a particular end-use, the soils could be beneficially reused for a range of purposes, including but not limited to clean fill in borrow pits, or for the construction of engineered structures e.g. capping material or bunds.

Wastewater management

Camp sites require systems for the management of sewage wastes. The main Moomba camp wastewater treatment plant (WWTP) comprises of aerated lagoons and a settling system, with treated effluent water evaporated or transferred to the Moomba plant evaporation ponds (‘Lake Brooks’).

Smaller permanent camps (Moomba Overflow, Moomba southern contractors’ area) use aerated wastewater treatment systems (AWTS) where treated effluent is irrigated to surface.

Permanent satellite camps (such as Dullingari, Tirrawarra and Limestone Creek) use a combined septic and single pond system septic systems known as a small ‘STED’ (septic tank effluent drainage) system with treated effluent evaporated or released to ground (soakage).

Wastewater (sewage and grey water) at temporary camp sites (such as mobile camps), is typically treated using a transportable aerated wastewater treatment system (AWTS) that have been approved under the *South Australian Public Health (Wastewater) Regulations 2013.* Treated wastewater effluent is typically irrigated to land.

Other measures (developed in consultation with the SA Health) may be implemented, for example in situations where excursions outside effluent quality guidelines may occur (e.g. start-up or system upset). All wastewater is treated and treated effluent is managed to ensure environmental and human health risks are minimised. Effluent management areas are set at appropriate separation distances between sewage disposal/irrigation areas and amenity buildings. Wastewater is not disposed to naturally occurring low-lying areas or watercourses.

4.9.3 Water supply

Groundwater

A water supply is required for production and processing operations, which includes activities such as steam generation, process requirements, domestic purposes and firewater.

Raw water is provided by artesian bores at Gidgealpa (27 km north-west of the Moomba Camp) approved under the DEW water licence 162791. Raw water is treated using a RO plant at Moomba and provides water suitable for potable use and production and processing operations (demineralised). The quality of the water required is dependent on the intended use. Steam generation and some process facilities require demineralised water to minimise the potential for gas souring and / or equipment corrosion.

Potable water is transported from the RO plant at Moomba in bulk water tankers for storage and use at areas remote to Moomba, as required. Construction and civil works may use specifically installed groundwater bores to source non-potable water for activities depending on the distance to suitable sources of PFW.

Where we have written agreements, Santos will provide advice to landholders regarding applicable legislation to them. PFW may also be used as a source of water as described in Section 4.5.3.

Cooper Creek extraction

Water extraction from the Cooper Creek is undertaken periodically to supplement available water supplies and meet project water demands. Extraction is undertaken subject to external and internal approval, which considers creek flow, alternative water sources, impacts to existing and / or future users and volumetric data. Cumulative extraction volumes are variable and are reported to DEM through annual reporting.

Internal authorisation for extraction from the Cooper Creek must consider the following:

- alternative water sources (e.g. PFW and / or groundwater) of acceptable quality within an economically viable haulage distance (maximum 2 hour return journey)
- the total volume of water required
- approved extraction occurs where potential risks to existing users downstream of Cullyamurra have been assessed and impacts mitigated
- any approved extraction occurs where water flow at Cullyamurra is >=2.15m (>= 0.1m flow at Innamincka Causeway) and rising
- water should not be extracted from permanent water refuges (e.g. Cullyamurra) (maps of approved surface water extraction points at Innamincka, Kudrieke and Mitchie Crossings are included in Appendix D). Extraction only occurs at these points and does not involve permanent pumping stations.
- cumulative extraction volume to be capped at 15 ML per year

- cumulative extraction volumes to be recorded in a monitoring database and included in annual regulatory reporting.

4.9.4 Steam supply

The Moomba facility has operational gas-fired boilers and process waste heat boilers that produce high pressure superheated steam. The steam is used to drive process steam turbines and to produce electric power via turbo alternators.

Steam is also used as a medium for transferring energy around Moomba Plant. The HP steam generated in the boilers is let-down to a LP steam system as it is used for heating in the plant processes.

Condensed steam is returned as boiler feedwater via a condensate recovery system.

4.9.5 Power generation and network

Electricity for the Moomba facility is provided by three steam turbine driven alternators and two gas turbine driven alternators. The combined output of these generators provides approximately 20 megawatts (MW) of electricity. These generators provide electricity to the Moomba facility, the main camp, and nearby satellite facilities including Moomba South, Moomba South Central and Big Lake. The Moomba main camp facilities also have a dedicated 400 kW emergency diesel generator. The control system for the generator is equipped with an uninterruptible power supply (UPS).

An additional 26 MW gas turbine was installed at Moomba in 2021 to provide power for the Carbon Capture and Storage (CCS) project. This turbine generates dedicated power for the CCS compressor station, which is required to compress and distribute CO_2 to satellite facilities for injection and storage (sequestration).

Additional gas driven generators (providing approximately 13 MW of electricity) are located at Moomba. These generators provide electricity to satellite facilities at Moomba North, Merrimelia and Tirrawarra. Remote satellite facilities (such as Della, Dullingari and Toolachee) also host small capacity gas and diesel driven generators to provide localised electricity, or to provide back-up power in the event of a network outage.

Power generated at Moomba and satellite facilities is distributed via several networks (microgrids) of high voltage (HV) infrastructure including overhead and buried powerlines and associated infrastructure e.g. transformers and switch rooms. These powerlines and associated infrastructure operate at voltages of between 33 to 66 kilovolts (kV). There is currently a total length of approximately 711 km of Santos overhead power lines and 273 km of buried power lines located in the SA Cooper Basin.

Given the remote location of oil and gas fields in the Cooper Basin, Santos currently operates several microgrids of HV infrastructure. Some of these microgrids are connected into centralised power generation infrastructure (such as those satellites located near Moomba), whereas others are isolated and rely on smaller scale localised power generation. Localised power generation is being phased out in preference for high efficiency centralised power generation facilities, and the development of additional HV overhead powerline coverage to connect isolated microgrids.

Further, some remote satellite facilities (such as Charo) are trialling the use of localised microgrids powered by solar arrays combined with Battery Storage Energy Systems (BESS) to provide baseload power. These microgrids still require small capacity gas and diesel driven back-up generators to ensure continuity of power supply, however they substantially reduce reliance on generators. Santos will continue to develop and utilise this technology across the Cooper Basin where it can provide suitable power solutions and reduce reliance on generators. These developments include solar arrays (solar panels and racking), transformers, battery storage, switchboards and supporting HV infrastructure i.e. buried and overhead powerlines.

Additionally Santos is investigating the use of wind turbines in the Cooper Basin and this may feature in the future.

Powerline planning, construction and decommissioning

Santos constructs overhead powerlines in accordance with AS/NZS 7000 and buried powerlines in accordance with AS/NZS 3000.

Route selection, survey and site preparation processes for overhead and buried powerlines are consistent with that described for gathering infrastructure in Section 4.2.2. The preferred powerline alignment is selected according to set evaluation criteria such as constructability, topography, environmental sensitivity (including cultural and heritage significance), safety and cost.

Construction of overhead and buried powerlines typically requires an installation ROW to be cleared of topsoil and vegetation, which are stockpiled separately to be respread following installation. Vegetation clearance is minimised and where possible trees are trimmed rather than removed. Powerlines and associated infrastructure are designed and constructed based on voltage operating requirements. Changes in technology and varying economic considerations will also impact powerline design and construction techniques.

Buried powerlines are typically installed into trenches as per buried pipelines, and they may be co-located with other buried linear infrastructure such as pipelines and communications lines. Trenching methods, backfilling and reinstatement for buried powerlines are generally consistent with those described for buried pipelines in Section 4.2.3.

Overhead powerline infrastructure is typically constructed of steel poles and cabling. A vehicle mounted auger is typically used to drill power pole installation holes, and the pole is then directly installed into the ground using a vehicle mounted crane. Depending on soil conditions soil, concrete or road base may be used to backfill and compact the hole to secure the pole in place. Power pole installation pits are typically open for a very short period of time prior to installation, and as such pose limited risk to wildlife or stock.

Power poles and cabling are transported to the prepared ROW and laid out end-to-end adjacent to the route to facilitate installation. Installation occurs in sections i.e. several power poles are installed and then cabling is strung into place, before moving onto the next section. Following installation, ongoing management and maintenance of the powerline ROW is undertaken based on the outcomes of regular ROW inspections. Overhead powerlines must be maintained to be clear of woody vegetation to ensure there is no potential for interaction with wires.

4.9.6 Fuel and chemical storage and handling

The areas within the Moomba facility where fuel, explosives and hazardous chemicals are stored include:

- a combination of above ground and below ground fuel storage tanks at the service station
- an explosives magazine, which is licensed to hold Class 1.1 explosives, located 2 km to the north-west of the oil storage tanks
- a licensed explosives storage in the wireline contractor’s yard for Class 1.2 explosives
- a licensed explosives storage at the Moomba airport for Class 1.1 explosives
- storage tanks of Jet A-1 fuel at the Moomba airport
- the Moomba stores located adjacent to the Moomba airport houses various hazardous chemicals.

Designated areas for fuel and chemical storage are located across the production and processing operations. The volumes and types of chemicals used will be dependent on the type of operation, minor storage for small volumes of chemicals or bulk storage of large quantities of fuel, for example.

Fuel, oil and chemicals are stored in appropriately designed systems that include bunding (in accordance with the Santos Management System (SMS) and AS 1940) and hardstand. A list of typical chemicals used in production and processing operations is included in Table 4-8.

Table 4-8: Typical chemicals used in production and processing operations

Production	Processing
corrosion inhibitor	corrosion inhibitor
biocide	biocide
soaps/detergent	lubricants
emulsion breakers	greases
urea	oils
lubricants	diesel
greases	Benfield Solution
oils (e.g. gear oil, engine oil, turbine oil)	emulsion breakers
diesel	Foamers/Pour point depressants/inhibitors
coolant	Wax dispersants/dissolvers/inhibitors
EHR polymers	Ashphaltene inhibitors
	Drag reducers

4.9.7 Other monitoring infrastructure

Santos may be required to install monitoring equipment and associated minor infrastructure from time to time to support authorised activities covered by this EIR.

Data and information collected by monitoring equipment is used to support and manage ongoing operations. Monitoring equipment is typically constructed within a small footprint (or within the disturbance area of an existing facility or well lease), with disturbance minimised as far as reasonably practicable. This monitoring equipment and associated minor infrastructure can include, but is not limited to:

- weather stations
- watercourse monitoring equipment (e.g. flood monitoring)
- groundwater monitoring infrastructure
- micro-seismicity monitoring equipment
- air monitoring equipment
- other monitoring equipment as required.

4.9.8 Moomba Airport

An aerodrome (licensed by the Civil Aviation Safety Authority (CASA) under CASR 139.050) is located approximately 1 km from Moomba Plant with charter flights and light plane services operated by commercial aviation companies from Adelaide, Brisbane and Ballera. Helicopter services are also currently operated by a commercial provider to assist in accessing remote sites and when roads are closed due to heavy rain or flooding.

Facilities are in a partially fenced compound. Grasses and other vegetation are restricted to prevent the attraction of native fauna (and in particular birds, e.g. Black Kites) to the area, which poses a safety hazard to aircraft.

4.9.9 Fire training ground

The fire training ground is located at Moomba and is used for emergency response training. The site is fenced and contains oil storage tanks and numerous training aids such as vehicles and chemical storage drums. Chemicals are stored on site in designated areas in liquid and / or dry form. Runoff from the site is directed to a lined pit adjacent to the fire training ground, prior to being pumped to the evaporation pond system.

4.9.10 Camps, offices and contractor facilities

The camp at Moomba houses Santos personnel and contractors that are associated with or support the operations of Moomba Plant and other Cooper Basin field facilities. The camp includes sleeping accommodation, mess and kitchen facilities, administration and recreational facilities, a lounge and a medical centre. Total camp capacity is approximately 1,000 people. The camp was built in 1982 and has undergone subsequent upgrades and extensions.

Santos satellite camps are located at Tirrawarra, Dullingari and Limestone Creek. These camps support operations for the outlying fields. Mobile camps and temporary construction camps are used for short-term projects or activities.

A range of Santos offices and buildings are at Moomba Plant, to house Moomba Plant operations, maintenance, engineering and administration personnel, Cooper Basin field operations, maintenance and engineering personnel, and emergency services.

Various contractor yards, offices and workshops are located adjacent to Moomba Plant. Contractor yards are provided by Santos to contractors under a Licence to Operate (LTO) agreement, which describes the respective obligations of each party.

4.9.11 Decommissioning and rehabilitation

Santos will progressively rehabilitate facilities that are no longer required (for example disused roads, production facilities and borrow pits). The rehabilitation of these sites can include, but is not limited to:

- removal of all infrastructure and rubbish
- testing for contamination of soil and groundwater (and remediating sites to the relevant regulated standard)
- re-contouring land surfaces to reinstate natural contours and drainage lines
- ripping compacted areas (except in gibber systems) to alleviate compaction and encourage revegetation.

Restoration of roads, access tracks and borrow pits is also discussed in Section 4.9.1.

Rehabilitation requirements are determined by the relevant regulatory obligations and / or to an agreed condition decided upon through stakeholder engagement.

Following construction, progressive rehabilitation is undertaken to ensure that surrounding surface drainage is restored, and erosion control structures are installed where required.

5 Existing Environment

This section outlines the regional climatic conditions, biophysical environments and social environments, including indigenous heritage and land use, relevant to Santos' production and processing activities in the Cooper Basin. The section also describes Santos Environmental Sensitivity Profile Model which is used to identify and map Cooper Basin environmental values.

The flora and fauna species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *National Parks and Wildlife Act 1972* that may occur in the Cooper Basin are provided in Appendix A.

5.1 Environmental Sensitivity Profile Model

Santos has developed an Environmental Sensitivity Profile (ESP) Model to identify and map Cooper Basin environmental values. The ESP was built using analogue and electronic data sets and enables characterisation and profiling of operational areas based on these values. The ESP is a spatial representation of Cooper Basin pathway and receiving environments and provides a platform for risk and impact assessment. The ESP was designed to meet regulatory site conceptualisation standards and requires input of source information (only) to meet the framework criterion of a source, pathway and receptor model (see Appendix E).

Analogue and electronic data sets were used to develop the ESP and field surveys were carried out to provide information for the model including, but not limited to:

- analysis of water quality, yield, depth and soil profiles (during installation) from 40 shallow groundwater monitoring bores across the South Australian Cooper Basin (and an additional 41 in south-west Queensland)
- analysis of known shallow landholder and Santos groundwater bore data (using WaterConnect database, where relevant)
- assessment and evaluation of vegetation type, community, wetland status, potential for EPBC-protected fauna and habitat and land systems across 107 analogue sites within the South Australian Cooper Basin and 127 sites in south-west Queensland Cooper Basin
- assessment of aerial photography and government databases to assist in extrapolating field measurements and data for the Cooper Basin.

The ESP Model supports the applicable regulatory objectives by providing a spatial resource which is integrated into existing Santos management systems and is used to inform the following processes:

- planning – identifying appropriate areas for new development, prioritising infrastructure upgrades and prioritising maintenance programs
- implementation – including environmental management plans and incident response
- measurement and evaluation – including monitoring programs
- review and implementation – including targeted auditing programs.

The ESP Model consists of a GIS database of environmental, land use, cultural and physical information which is overlaid by a sensitivity layer. The database includes government data as well as data collected by field investigations initiated by Santos. All Santos personnel have access to the database, which is actively maintained. A field validation program was undertaken to confirm the validity of assumptions used during the development of the model.

5.1.1 Planning and response

The ESP is a tool for informing forward process, planning, incident response and assessment.

In some instances, the information available to make informed and relevant decisions may be limited and in cases such as these additional data may be required. Additional information requirements will be documented using the Santos internal approval process and may include:

- applicable permits
- regulatory advice
- specific management actions required for compliance
- identification of specific activities that are prohibited in the subject area
- additional environmental management activities.

Environmental values

Environmental values in the model are defined by a sensitivity rating scale of one (very low) through to five (very high), which enables the user to understand the sensitivity of the receiving environment. The ranking is used in the disturbance decision making process and to evaluate the level of response in the event of an incident. The sensitivity ratings were developed using existing regulatory conditions, operator experience, historical risk assessments and existing hierarchy ratings in government data layers.

Groundwater sensitivity ratings also include an assessment of the potential beneficial use of the shallow groundwater resources.

Validation process

Field validation of model parameters is undertaken to ensure that the environmental constraints identified in the ESP Model are accurate. The validation process allows for identification of previously unknown sensitive receptors and / or other data gaps. Field validation may include groundwater investigations, ecological assessments and / or cultural heritage surveys. Where the environmental sensitivity is low, a site scout may be adequate to validate the model. The decision to undertake further investigations is based on Santos' experience with similar incidents and / or existing information, legislative requirements, regulator advice and current expectations.

5.2 Climate

The South Australian region of the Cooper Basin can generally be described as arid with a uniform climate.

The area is typically characterised by hot, dry summers and mild, dry winters. In summer, average daily maximum temperatures exceed 37°C and the average minimum is 23.7°C (BoM 2022). Average daily temperatures in winter range from 7.2°C to 20.8°C (BoM 2022). Both seasonal and diurnal temperature ranges vary considerably, with the Bureau of Meteorology recording a maximum temperature of 49.6°C and minimum temperature of -0.5°C.

Rainfall variability in the Cooper Basin is among the highest in Australia, while average annual total rainfall records are among the lowest. Annual rainfall is generally less than 250 mm and average evaporation can be up to 3500 mm annually. However, when it does rain, it can be localised, very heavy and in some instances the average annual rainfall can fall in one rainfall event.

Although the prevailing winds throughout the year are from the south-east, wind direction is more southerly in the south of the Basin and more easterly in the north of the Basin. Light winds (<20 km/h) are most common from May to July, while the greatest frequency of strong winds (41 to 61 km/h) is from September to January.

A summary of climate records for Moomba airport (Station 017123; BoM 2022) is provided in Table 5-1.

Table 5-1: Temperature and rainfall records for Moomba

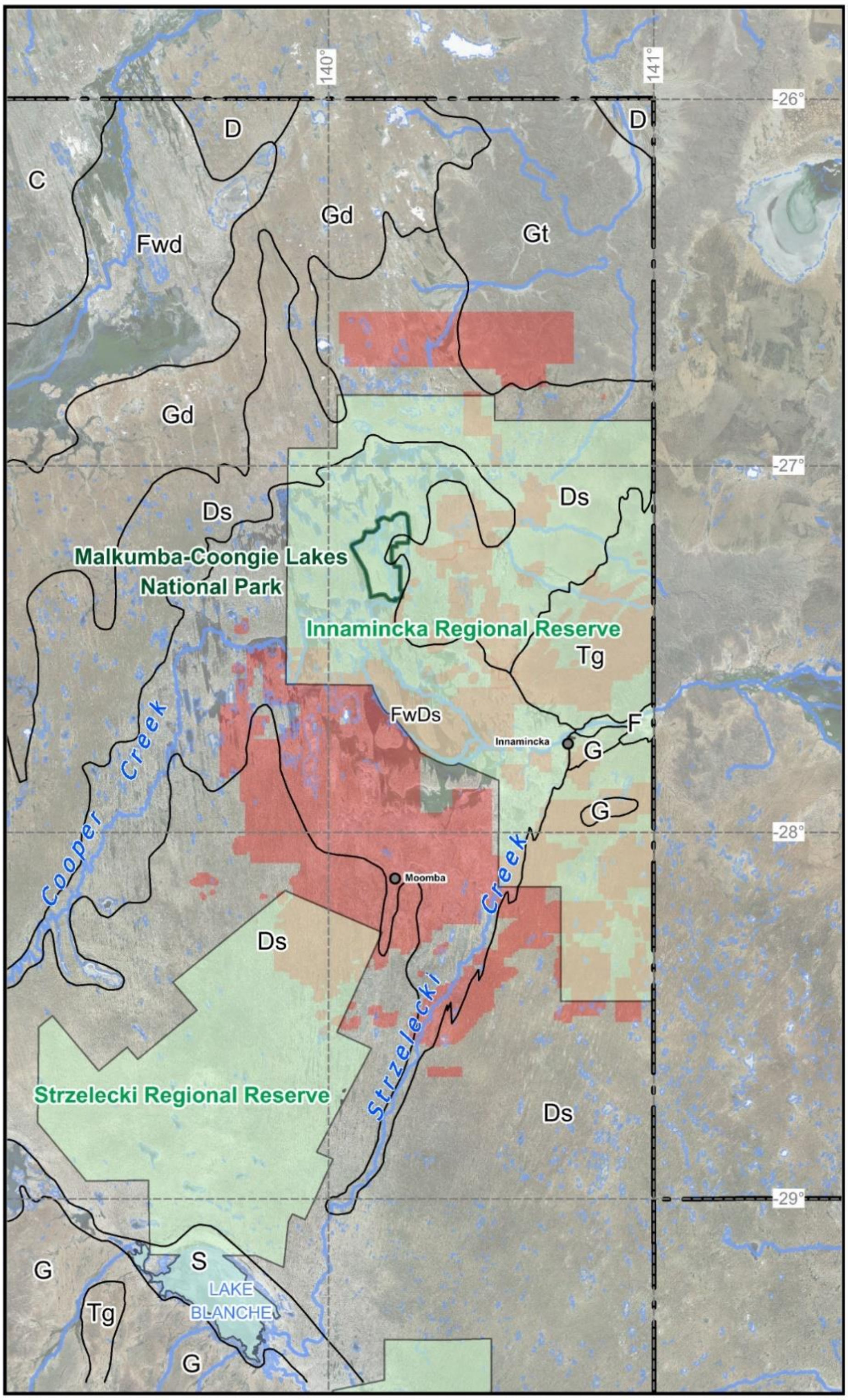
Weather and rainfall data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily max (°C)	38.9	37.0	34.0	29.3	23.8	19.9	19.9	22.5	27.3	30.9	34.2	36.9	29.6
Mean daily min (°C)	24.9	23.6	20.5	15.7	10.6	7.3	6.3	7.9	12.0	15.8	19.5	22.6	15.6
Mean rainfall (mm)	17.6	24.1	25.3	7.8	9.6	10.2	11.9	5.1	14.9	9.4	18.1	14.0	166.2
Median rainfall (mm)	3.4	4.0	3.0	0.8	3.7	5.8	0.8	0.8	1.6	3.0	7.2	6.2	157.6

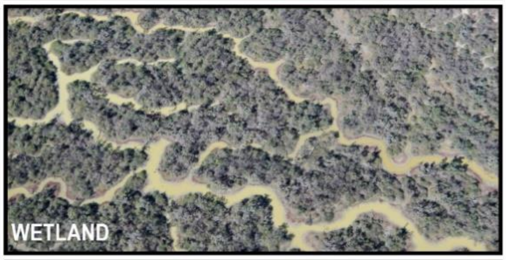
5.3 Biophysical Environment

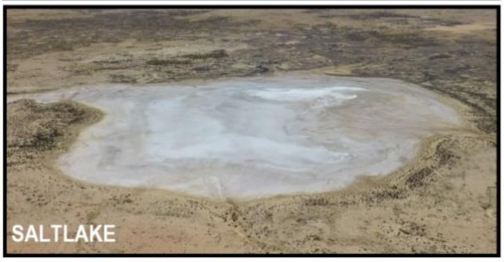
Six major types of land systems are found in the Cooper Basin licence areas (see Figure 5-1):

- dunefields
- floodplains
- wetlands
- salt lakes
- tablelands
- gibber plains.

The sensitivity of each system to disturbance depends on its basic characteristics including geology, landform, soils, hydrology, flora and fauna.







Santos Tenements

Exploration / Production Tenements

Drainage

Major Drainage

Land Systems

C............Channels and floodplains

D............Dunefields

Ds...........Dunefields dominant / Saltlake sub-dominant

Fwd.........Flood Plain dominant / Wetlands sub-dominant / Dunefields sub-dominant

FwDs.......Flood Plain dominant / Wetlands sub-dominant, Dunefield dominant / Saltlake sub-dominant

G............Gibber Plain

Gd...........Gibber Plain dominant / Dunefields sub-dominant

Gt............Gibber Plain dominant / tableland sub-dominant

S.............Saltlake

Tg...........Tableland / Gibber Plain sub-dominant

Santos

South Australia

Cooper Basin
Land Systems

0 100

Kilometres

Figure 5-1 Date: 30/05/2022 File No. SAGEN 877d.WOR GDA 2020

5.3.1 Dunefields

The dunefields of the Tirari and Strzelecki deserts dominate the Cooper Basin licence areas. These dunefields mainly occur in the far north-west, south-west and south-east regions of the Cooper Basin (see Figure 5-1).

Geology, soils and landform

The development of the dunefields commenced approximately 18,000 years ago when a combination of low lake levels and extremely dry windy conditions created large, mobile dunes of lakebed and floodplain material (Twidale and Wopfner 1990). This process of dune development continues today with sediment from river channels, floodplains and salt lakes being transported by the wind and shaped into dunes.

The Cooper Basin dunefields are characterised by parallel dunes of red, yellow or white aeolian sands of the Simpson Sand (Drexel and Preiss 1995), dominated by single crested linear sand ridges. Dunes are separated by flat interdune corridors (swales), which usually consist of either sandy flats or claypans (Twidale and Wopfner 1990, Santos 1997a). They range in height from 5 m to 35 m and trend approximately north-east (Twidale and Wopfner 1990). Sand cover rarely exceeds 30 m and a stony base may be exposed in interdune areas.

Sand dunes have the potential to be affected by wind erosion as a result of disturbances brought about by production activities (particularly earthworks). In sandy desert areas, the potential for wind erosion to affect soils disturbed by operations (particularly earthworks) poses a significant environmental hazard. Red dunes are generally considered to be more susceptible to wind erosion than grey/brown sand dunes.

Water erosion is less likely on dunes as rainfall generally infiltrates rapidly into the sands before creating enough force to cause surface erosion. However, where there is a high proportion of clay in the sand, as for example at the base (or toe) of a dune, rilling and sheet erosion can occur (Santos 1997a).

In those parts of the basin where clay pan lakes, salt lakes and distributary channels occur in interdune corridors, the soils between dunes are dominantly grey and brown clays. Elsewhere, the common interdune soils are solonised brown soils, calcareous red earths and earthy sands (Wright *et al*. 1990).

Hydrology and groundwater

The dunefields are extremely arid and generally lack any permanent surface water. However, following heavier localised rainfall events, some areas, particularly those areas with clay rich soils such as clay pan lakes, can hold surface water for extended periods of time (several weeks to months) depending on seasonal conditions and evaporation rates.

In some areas good quality groundwater can be found at shallow depths in dunefield areas adjacent to major watercourses (for example the Strzelecki and Cooper Creeks). This water is non-artesian and contained within unconfined aquifers that are primarily recharged from surface stream flows.

Flora

Vegetation types alternate between the upper slopes and crests of dunes, and interdune areas. Dune crests are often sparsely vegetated (depending on seasonal conditions) with tussock grassland species (for example Canegrass), Needlebush, herbs and ephemeral forbs (Santos 1997a). Dune flanks are characterised by:

- tussock grasses in the Tirari Desert
- Lobed Spinifex grassland in the Strzelecki Desert
- shrubland consisting of Sandhill Wattle in all dunefield areas
- shrubland species such as Whitewood and Narrow-leafed Hopbush more commonly in the Strzelecki Desert.

Vegetation in interdune areas depends largely on dune spacing. Narrowly spaced areas contain similar vegetation to dune flanks. Widely spaced dune areas, where gibber or floodplain soils are exposed, may contain low shrubland of Saltbush or Bluebush (Santos 1997a). Interdune claypans are typically bare other than at their margins, however some claypans support Swamp Cane-grass, Old-Man Saltbush, Cottonbush, Bristly Love-grass and Lignum. In general, interdune vegetation may consist of hummock grassland, Chenopod shrubland, open shrubland or low open woodland.

Fauna

Despite the lack of free water, dunefields provide important habitat for a range of wildlife including a variety of small mammals, reptiles and birds.

Thirteen species of mammals, including exotic species, have been recorded in the dunefields in north-east South Australia. Common wildlife species include the Fat-tailed Dunnart, Striped-faced Dunnart, White-winged Wren, White-backed Swallow, Richards' Pipit and the Brown Falcon. Common reptiles include geckos, skinks, dragons, blind snakes, elapid snakes and pythons (Tyler et al. 1990).

The Dusky Hopping-mouse is a nationally vulnerable species (EPBC Act) and occurs in sand dunes in the region. The entire known range of the Eyrean Grasswren is circumscribed by the limits of the Simpson, Tirari and Strzelecki deserts. The species habitat requirements are tied to Sandhill Canegrass, which it uses for food, shelter and nesting (Reid et al. 1990).

5.3.2 Floodplains

The Cooper Creek floodplain is a major feature of the South Australian section of the Cooper Basin. It covers the central third of the basin and includes the Coongie Lakes system to the north and the Strzelecki Creek floodplain that feeds Lake Blanche in the south (see Figure 5-1). The Cooper Creek floodplain occurs in close association with the dunefields of the Basin.

Geology, soils and landform

The Cooper Creek and Strzelecki floodplains consist of intricately braided channels, swamps and extensive outwash plains. Floodplain topography is relatively flat and consists of an extensive and extremely variable system of rivers and creeks (Blackley et al. 1996). Soils are characterised by deep, grey, self-mulching clays derived from fluvial mudstone and siltstone, and occasional fluvial sand and conglomerates in river and creek beds.

Geological units include undifferentiated fluvial and lacustrine sands of the Eurinilla Formation, clays and fine sands of the Tingana Clay, clays of the Milyera Formation and fluviatile sands of the Yandruwantha Sand (Drexel and Preiss 1995).

Hydrology

The floodplains of the Cooper Basin are primarily associated with the Cooper Creek drainage system. The Cooper Creek originates in the moister catchments of south-west Queensland and channels water through the Basin to Lake Eyre. Copper Creek still has the hydrologic character of an unregulated arid zone river with an extremely variable flow regime and, although it flows every year, several months often pass without flow (Puckridge et al. 1999). Annual flow volumes for the Cooper Creek are presented in Figure 5-2 and are based on readings from the Cullyamurra gauging station near Innamincka (approximately 140 km upstream from Coongie Lakes).

Puckridge et al. (1999) developed nine flood classes for the lower Cooper Basin floodplain based on the 25-year Cullyamurra record. Table 5-2 provides expected frequencies and volumes for each of these flood classes. The predicted extent of flooding for each class is based on satellite imagery of previous flood events in the Cooper Basin region (Puckridge et al. 1999).

Upper catchments of the Cooper Creek provide virtually all flows to the South Australian section of the Cooper Basin floodplain, as local rainfall makes only a small contribution to the hydrology of the region (Puckridge et al. 1999). Data from the Cullyamurra gauging station therefore provides flow data that is representative of total flows in the lower Cooper Basin floodplain. Eighty seven percent of flow at Cullyamurra is from the upstream catchment of the Cooper Creek.

Strzelecki Creek receives inflow only during large Cooper Creek flood events (e.g. 2010 floods). Strzelecki Creek, is in the centre of the reserve, which is an overflow of the Cooper Creek and a major feeder stream of Lake Blanche (a shallow freshwater ephemeral lake).

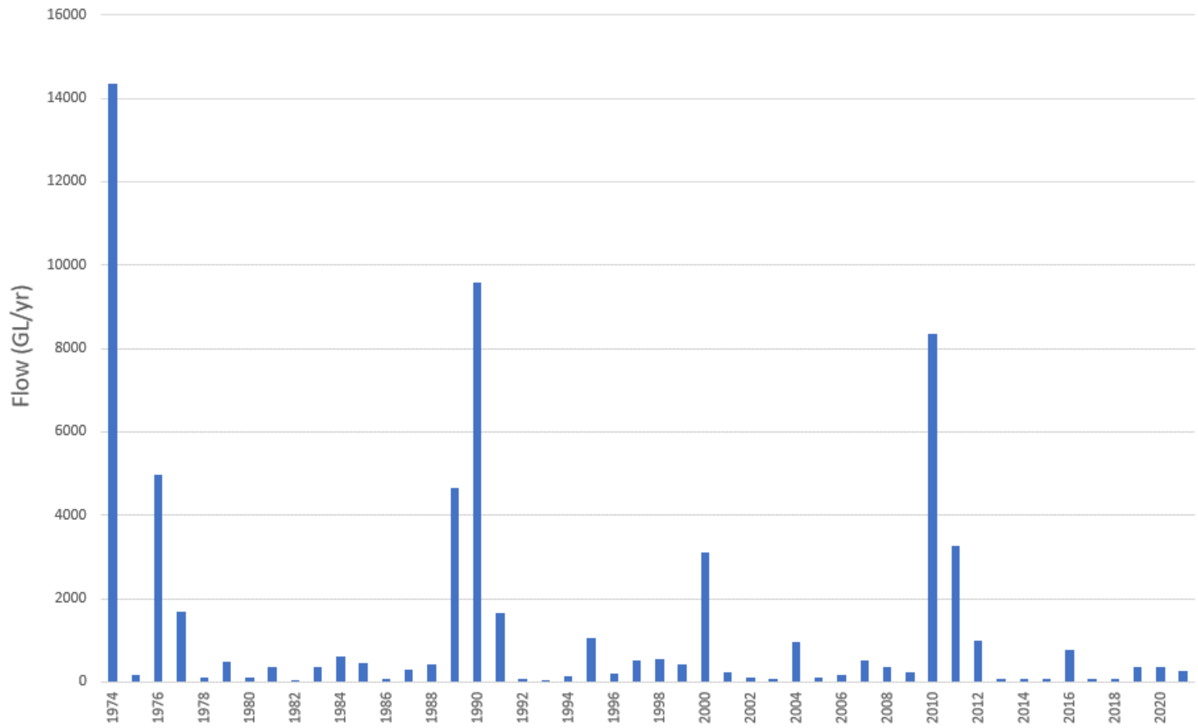


Figure 5-2: Annual flow volumes of Cooper Creek, Cullyamurra gauging station 1974 to 2021
(Source: Water Connect https://www.waterconnect.sa.gov.au/Pages/Home.aspx Site A0030501)

Table 5-2: Cooper Creek flood classes, volumes and frequency

Flood Class	Daily flow volume (ML/day)	Total volume (ML)	Frequency	Comment
1	600–1200	14,000–40,000	Annual	Since 1973 there have been Class 1 floods, or larger, every year. All water flows into the north-west branch of Cooper Creek.
2	1200–2500	40,000–130,000	1–2 years	Most water flows into the north-west branch, but a proportion flows into the main branch of Cooper Creek.
3	2500–5400	130,000–220,000	1–2 years	Significant part of flows into the main branch as far as Embarka Swamp.
4	5400–18,000	220,000–400,000	2 years	Significant flow enters the main branch, to the lower main branch and the lower Cooper Creek.
5	18,000–40, 000	400, 000–1,400,000	2–5 years	Significant flow occurs out of Coongie Lakes into the lower Cooper Creek as far as Lake Hope.

Flood Class	Daily flow volume (ML/day)	Total volume (ML)	Frequency	Comment
6	40,00–100,000	1,400,000–2,400,000	5 years	Results in flows into Wilpinnie Creek. Flow into this area can disrupt gas field installations.
7	100,000–180,000	2,400,000–4,500,000	10 years	Results in flows into Strzelecki Creek but not as far as Lake Blanche. Flows occur along the lower Cooper Creek. Class 7 flood was largest in 2005.
8	180,000–450,000	4,500,000–10,750,000	20 years	Flow into Lake Eyre North and fill Lake Blanche. Class 8 flood was the largest flood in 1990.
9	>450,000	>10,750,000	100 years	A Class 9 flood occurred in 1974, but no satellite images are available to determine flood extent.

(Source: Puckridge et al. 1999 & http://www.bom.gov.au/qld/flood/brochures/cooper/cooper.shtml)

Flora

Woodland, often with a tall shrub layer, is characteristic of the major intermittent watercourses in the Cooper Basin. Woodlands of River Red Gum, Coolibah, Gidgee, Whitewood, and Bean Tree fringe the floodplains, channels and semi-permanent waterholes (Santos 1997b). Groundcover on floodplains has a high ephemeral component, with very rapid growth after flooding.

In frequently flooded areas, open Coolibah woodland with a shrub or ephemeral understorey is common. Further out onto floodplains, tall shrubland consists of Broughton Willow or Prickly Wattle.

Old Man Saltbush and scattered Coolibah are the main cover of tributary streams. Shrubland of Lignum, Old Man Saltbush or Queensland Bluebush extends into the Coolibah woodlands but tends to be characteristic of outer floodplains (Santos 1997a).

Fauna

Within the arid zone, the most important environmental areas are those connected with sites of permanent water. They provide permanent habitat for a variety of native flora and fauna and are especially important as a refuge during drought conditions. For example, the Cooper drainage system is thought to be an important refuge for the Long-haired Rat during particularly dry conditions (Morton et al. 1995, Kemper 1990).

Watercourse habitat supports more native mammal species than other habitat types in the Basin. Thirty-five species have been recorded in the floodplain areas of the greater north-east region of South Australia. Notable species in South Australia include Forrest's Mouse and the Yellow-bellied Sheath-tailed Bat (Kemper 1990).

Birdlife along major watercourses is prolific, especially in River Red Gum woodlands of the upper Cooper to which the Barking Owl and endemic Mallee Ringneck are restricted. Floodplains support a highly significant population of raptors. Breeding densities, calculated along Strzelecki Creek, are among the highest in the world. Especially significant is the occurrence of the Grey Falcon, Black-breasted Buzzard and Letter-winged Kite.

Aside from the terrestrial avifauna, floodplain areas also support varied and abundant waterbird populations. The Cooper floodplain and associated wetlands are a preferred breeding area for the Freckled Duck, Black-tailed Native-hen and Red-necked Avocet, all of which are endemic to Australia (Reid et al. 1990).

The Cooper Creek wetlands support the richest amphibian fauna within the South Australian Cooper Basin. However less than 3% of the known frog fauna of Australia occurs in this region (Brandle and Hutchinson 1997).

5.3.3 Wetlands

Despite its aridity, the Cooper Basin contains an array of wetlands. The Coongie Lakes and the Strzelecki wetland systems are included in the Directory of Nationally Important Wetlands. The Coongie Lake system is also listed under the Ramsar Convention as a Wetland of International Importance in recognition of its important role in providing refuge for the conservation of migratory and nomadic birds (Morton et al.1995; Blackley et al. 1996).

The Coongie Lakes Ramsar wetland covers the floodplain, lake and channel system of the upper Cooper Creek in South Australia, as well as large areas of dunefield with no hydrological connection to Coongie Lakes or the Cooper Creek. It is estimated that the Coongie Lakes Ramsar Wetlands area covers 30% of the known oil and gas resources within the South Australian portion of the Cooper Basin (DEHAA 1999).

The Coongie Lakes National Park, situated within the Coongie Lakes Ramsar Wetland, forms the core of the extensive Coongie Lakes system of wetlands and near-permanent freshwater lakes.

Geology, soils and landform

Wetlands in the South Australian section of the Basin most commonly occur within floodplain and dunefield land systems. These include ephemeral shallow lakes, waterholes, swamps, flooded woodlands and grasslands, deep permanent channel reaches and samphire claypans. Soils generally consist of deep, cracking clays and occasional siliceous sands and conglomerates.

Geological units include undifferentiated fluvial and lacustrine sands of the Eurinilla Formation, clays and fine sands of the Tingana Clay, clays of the Milyera Formation and fluviatile sands of the Yandruwantha Sand (Drexel and Preiss 1995).

Hydrology

Wetlands may be perennial or ephemeral and are considered to contain water more often, or be subjected to more frequent inundation, than surrounding areas of floodplain (Santos 1997a).

The Cooper Creek intermittently discharges into a vast area of swamps, lakes and overflows (Morton et al. 1995). Most wetlands in the Basin receive flows from this system which carries floodwaters throughout the basin and occasionally, during major flooding events, to Lake Eyre. Wetlands are also filled intermittently by heavy rainfall. Flooding is considered the most crucial factor in the recharge of many wetlands in the Basin.

Flora

The presence of water in an otherwise arid environment has allowed the development of a diversity of plant habitats and communities (Reid et al. 1990). The close association between floodplains and wetlands results in similar flora being present in both systems. Woodlands of River Red Gum, Coolibah, Gidgee and Bean Tree often border the margins of wetland areas. The aquatic environment consists of several macrophyte species including *Ludwigia peploides, Azolla filiculoides and Myriophyllum verrucosum* (Blackley et al. 1996).

Fauna

The wetlands associated with the north-west branch of the Cooper Creek, including Coongie Lakes, are recognised as a region of exceptional ecological value. The aquatic invertebrate fauna is abundant and diverse and includes an array of insects, crustaceans, and gastropods (Reid and Puckridge 1990). Aquatic vertebrates include the Water Rat and Cooper Creek Short-necked Tortoise.

The fish community of this system is also one of the most significant in South Australia as it is close to its original composition, with only two exotic species present (Reid and Puckridge 1990).

The Coongie Lakes system supports significant numbers and diversity of water birds. These wetlands have been recognised as internationally significant under the Ramsar Convention, providing a feeding, resting, and breeding site for large numbers of migratory and nomadic birds. The lakes also support a great variety of aquatic fauna, including Desert Rainbow Fish, shrimp, the Cooper Creek Tortoise, and a diverse frog population.

5.3.4 Salt lakes

The Basin is dotted with numerous salinas, or salt lakes and salt pans, of varying sizes (see Figure 5-2). In these lakes, excess evaporation in interior basins leads to the concentration of soluble salts as a surface crust. The salts themselves are derived from the weathering of rock and are transported to the lakes via the movement of surface water (e.g. rivers and streams). The larger salt lakes in the area include Lake Blanche, Lake Hope, Lake Gregory, Lake Etamunbane and Lake Uloowaranie (Santos 1997a).

Geology, soils and landform

Salt lakes usually have a low topography and dry surface covered with a gypsum (salt) crust. Salt lakes typically have saturated mud below the salt crust that is incapable of supporting ground pressure i.e. the salt crust will typically give way under foot to reveal a dark black muddy subsurface. Lunettes are found along parts of the eastern shores of lakes. Little is known about the physical attributes of many salt lakes.

It should be noted that salt lakes differ from clay pan lakes (as described in Section 5.3.1), which can appear similar in appearance to salt lakes on occasion. Clay pan lakes have a hard clay surface, and they do not have a surface crust of gypsum (salt) or saturated mud below the salt crust.

Hydrology

Salt lakes are predominantly dry but are occasionally filled by floodwaters from the major river systems. During flooding, water may remain fresh and can support abundant fish populations. Lakes become increasingly saline as they dry. The frequency of flooding and inundation is highly variable.

Flora

Although the surface of salt lakes is devoid of vegetation, the immediate surrounds are usually fringed with Samphire and occasional Nitre Bush shrubland. Samphire eventually grades to low open Chenopod shrubland in the outer surrounds (Reid et al. 1990).

Fauna

Dry salt lakes form a harsh environment with a complete absence of surface water and extremes in daily temperature. Consequently, they support relatively few native fauna species.

Salt lakes are particularly depauperate in bird species. Salt lakes in the region constitute highly ephemeral aquatic habitat for birds and, as such no species is restricted to salt lakes alone (Reid et al. 1990). Surrounding Chenopod shrublands support common species such as the Orange Chat and Richard's Pipit.

While birds are almost entirely absent from the lakebed when dry, during flooding fish populations can flourish and consequently a variety of waterbirds (such as pelicans, terns and cormorants) can be found.

5.3.5 Tablelands

Tableland areas are commonly known as dissected residuals or breakaways. They are characterised by a silcrete surface that has been eroded to form low but steep escarpments, mesas, buttes and extensive gibber covered footslopes (Santos 1997b). Tableland areas in the north and east of the Cooper Basin in South Australia include Wadi Wadi or Innamincka Dome, Mount Kingsmill and Kertietia Hill (see Figure 5-1).

Geology, soils and landform

Uplift in the Lake Eyre Basin has led to erosion and dissection of the silcrete surface and formation of low steep escarpments, small mesas and extensive gibber covered footslopes. Tableland areas generally have moderately deep clay rich soils of aeolian origin, and a fine crystalline gypsum-rich horizon.

Geological units present in tableland areas include gibber surfaces, which consist of recent deposits of silcrete pebbles on sandy soils, gypsiferous soils or Callabonna Clay plus Tertiary age fluviatile sands and shales of the Eyre Formation and Cretaceous age Winton Formation (Drexel and Preiss 1995). The Eyre Formation is generally silicified, as are portions of the Winton Formation.

Hydrology

Permanent surface water is scarce in elevated areas of tablelands. Minor drainage channels occur in lowland plains and can contain permanent waterholes. Temporary surface water can also be found lying in pools after rain in lowland plain areas.

Flora

Landforms that dominate the tablelands support a variety of low open woodlands, shrublands and low open Chenopod shrublands (Santos 1997b). Areas of relatively high relief support low Acacia woodlands, and occasionally on calcareous soils an uncommon *Eucalyptus socialis* Mallee formation (Brandle 1997a). The most heavily wooded areas occur along drainage lines with River Red Gums and Coolibahs fringing more permanent waterholes.

Fauna

Due to close association and similar environmental characteristics, tableland and gibber plain fauna is very similar (see Section 5.3.6).

5.3.6 Gibber plains

Throughout Cooper Basin licence areas, there are vast expanses of flat to gently undulating gibber covered plains and downs such as the Sturt Stony Desert and the Innamincka or Wadi Wadi Dome (Santos 1997a) (see Figure 5-1).

Geology, soils and landform

Gibber plains are extremely flat to undulating plains that were formed during the breakdown and gradual recession of former tablelands. Soils typically consist of red and brown clays that are mantled by stone or gibber (Brandle 1994 to 1997). As stated above, gibbers are recent deposits of silcrete pebbles on sandy soils, gypsiferous soils or Callabonna Clay. Gibbers form a stable pavement that protects underlying soil from erosion. Gibber plains commonly contain gilgai or low surface relief structures.

While gibber plains are generally considered to be a stable environment, disturbance or removal of the surface layer of stones (gibbers) and the exposure of clay soils can result in significant erosion by either wind or water. Even in gently sloping areas, water can gather enough force to cause erosion gullies in exposed soils (Santos 1997a). The erosive potential of these soils is clearly evident in areas where grading or removal of gibber has resulted in severe erosion and long-term scarring on the landscape. For example, creation of windrows during seismic activities can remove the protective layer of gibber and result in gully and sheet erosion.

Hydrology

Permanent surface water sources are generally lacking, but temporary pools of water often form after rain in low depressions or gilgai. Minor drainage channels occur throughout lowland plain areas.

Flora

There is a range of native vegetation throughout gibber country. On the southern and south-western margins, relatively dense low open shrubland of Bladder Saltbush, Low Bluebush and Cotton Bush are common. Further north, much of the area is naturally bare, but Mitchell Grass tussock grasslands become more frequent. In other gibber areas, the main cover may be short-lived Copperburrs and ephemeral grasses. There is still further variation caused by hills and drop-offs where small trees or tall shrubs, particularly Emu Bush, may form a tall open shrubland.

Fauna

Gibber plains have a poor native fauna assemblage compared to other land systems in the region.

Only a minority of the bird assemblage of the South Australian Cooper Basin is resident (Brandle and Reid 1997). Gibber areas are an important habitat for a number of bird species including the Chestnut-breasted Whiteface, the Inland Dotterel and the Gibber Chat. The Chestnut-breasted Whiteface is unusual amongst birds in being endemic to the gibber plain area (Reid et al. 1990).

Common mammal species include the Stripe-faced Dunnart, Fat-tailed Dunnart, dingo and Forrest’s Mouse. Less common species include the Fawn-Hopping mouse and Gile’s Planigale, which is common in habitats with cracking clay soils. The Kowari is endemic to the stony deserts and considered vulnerable to extinction. It appears to be restricted to the north-east region of South Australia (Brandle 1997b).

5.3.7 Pest plants and animals

The density of most of the weed species in the Cooper Basin is relatively low, however across the region there are several large areas of infestation (Hodges 2014). The majority of the introduced plants that occur are naturalised or widespread species of limited concern to the environmental or pastoral values of the region. Introduced plant species recorded as occurring in the region include, but are not limited to:

- Athel Pine (*Tamarix aphylla*)
- Black Nightshade (*Solanum nigrum*)
- Caltrop (*Tribulus terrestris*)
- Colocynth (*Citrullus colocynthis*)
- Common Sow-thistle (*Sonchus oleraceus*)
- Common Verbena (*Verbena officinalis*)
- Creeping Heliotrope (*Heliotropium supinum*)
- Grain Sorghum (*Sorghum bicolor*)
- Mimosa Bush (*Acacia farnesiana*)
- Noogoora Burr (*Xanthium strumarium*)
- Prickly Acacia (*Acacia nilotica*)
- Ruby Dock (*Acetosa vesicaria*)
- Wandering Speedwell (*Veronica peregrina ssp. xalapensis*)
- Mediterranean Turnip (*Brassica tournefortii*).

Also found, and of particular concern as an invasive species are Buffel Grass (*Cenchrus ciliaris* and *C. pennisetiformis*) which has the potential to outcompete native species and reduce habitat (Hodges

2014). Buffel Grass, Athel Pine, Caltrop, Noogoora Burr and Prickly Acacia are declared weeds under the SA LSA Act.

Pest animals in the region include rabbits, feral cats and foxes, feral pigs, donkeys, horses and camels.

Santos recognises that the introduction and / or spread of pest plants and animals can impact the biodiversity of a region and therefore appropriate management is important. To ensure a consistent approach, Santos has developed Pest Plant and Animal Management Plans (PPAMP) to reduce the risk of environmental and / or stakeholder impacts. In addition, Santos has developed and implemented a Buffel Grass Control Plan (appended to the PPAMP) to minimise the potential for spread outside of Santos Cooper Basin operational areas.

5.4 Geology and Hydrogeology

The Cooper and Eromanga basins are in central and eastern Australia. The Cooper Basin is a sedimentary geological basin located in north-eastern South Australia and south-west Queensland. The saucer-shaped Eromanga Basin (which overlays the Cooper Basin) is a large Mesozoic sedimentary basin and extends over 1,000,000 m^2 covering parts of Queensland, the Northern Territory, South Australia, and New South Wales.

5.4.1 Geology

The Eromanga Basin is overlain by the Lake Eyre Basin, a succession of Tertiary and Quaternary age sediments occurring extensively throughout central Australia. In the north-east of South Australia, the Lake Eyre Basin consists of the sediments described in the preceding sections on floodplains, wetlands, tablelands, gibbers, salt pans. At depth, units include the Yandruwantha Sand (medium to coarse grained sand), the Namba Formation (deltaic and lacustrine clay, silt and sand), and the Eyre Formation (sandstone and shale). The thickness of Lake Eyre Basin sediments in the Moomba area is generally in the range 200 m to 300 m (Drexel and Preiss 1995).

Eromanga Basin sediments were deposited during the Jurassic-Cretaceous period and reach a maximum thickness of between 1200 m and 2700 m over the Cooper Basin (Gallagher and Lambeck 1989). These sediments were deposited under fluvial, lacustrine and (later) shallow-marine conditions, and are broadly continuous across the basin (Vine 1976) (see Figure 5-4). These sediments are gently folded in some areas and contain a succession of aerially extensive sandstone formations that serve as oil reservoirs and regional aquifers. The Eromanga Basin is the largest of the group of basins that constitute the Great Artesian Basin (GAB). It is the only part of the GAB that lies within South Australia, the other sections being in Queensland and in part in New South Wales.

Beneath, and entirely covered by the Eromanga Basin, is the Permian–Triassic Cooper Basin, limited in its distribution by bounding faults and pinch-out edges. The Cooper Basin extends over a much smaller area than the Eromanga and covers about 153,000 km^2 in north-east South Australia and south-west Queensland (Stanmore 1989) (see Figure 5-3).

Total Cooper Basin sediment accumulations exceed 1500 m in places and are characterised by fluvial, deltaic and swamp deposits that include some coal measures (Thornton 1979). These sediments contain petroleum reservoirs (mainly gas) and limited aquifers. The South Australian end of the Cooper Basin includes several north-east to south-west-trending depocentres, including the Patchawarra and Nappamerri troughs. In the deepest and most central portion of the Cooper Basin (the Nappamerri Trough), high-pressure gas cells with reservoir pressures more than 7,000 pounds per square inch (psi) are present.

The tectonic history of the Cooper and Eromanga basins is complex and has been characterised by several periods of rift-related subsidence and compressional uplift and erosion. This history has resulted in the Cooper Basin being subdivided into several large-scale sub-troughs separated by fault-bounded ridges. The historical evolution of the Cooper and Eromanga basins is discussed by Kuang (1985), Finlayson et al. (1988), Gallagher (1988), Hunt et al. (1989), and Stanmore (1989).

The groundwater flow in the region is described in terms of the GAB (Habermehl 1980). From 10 to 5 million years ago a phase of structuring in the Eromanga uplifted the margins of the basin (particularly in the east), raising the ground surface to a slightly higher level than the present-day elevation and instigated the groundwater flow pattern within the GAB, which is described in detail by Habermehl (1980 and 1986).

Geothermal gradients in the Cooper and Eromanga range from 30°C/km on the margins to 60°C/km in the Nappamerri Trough – some of the highest recorded gradients worldwide in hydrocarbon-bearing basins. Temperatures in the basal Cooper sediments reach approximately 250°C.

The Cooper and Eromanga basins are currently subjected to a regionally compressive stress regime. Motion along fault-bounded basement blocks results in strong local stress variations. Evidence from well bore geomechanics shows that conditions for movement on faults are present and that the structural evolution of the area is ongoing. The relative stress magnitudes and orientations that make up the stress regime are an important consideration in hydraulic stimulation as they define the direction of fracture propagation and its vertical extent.

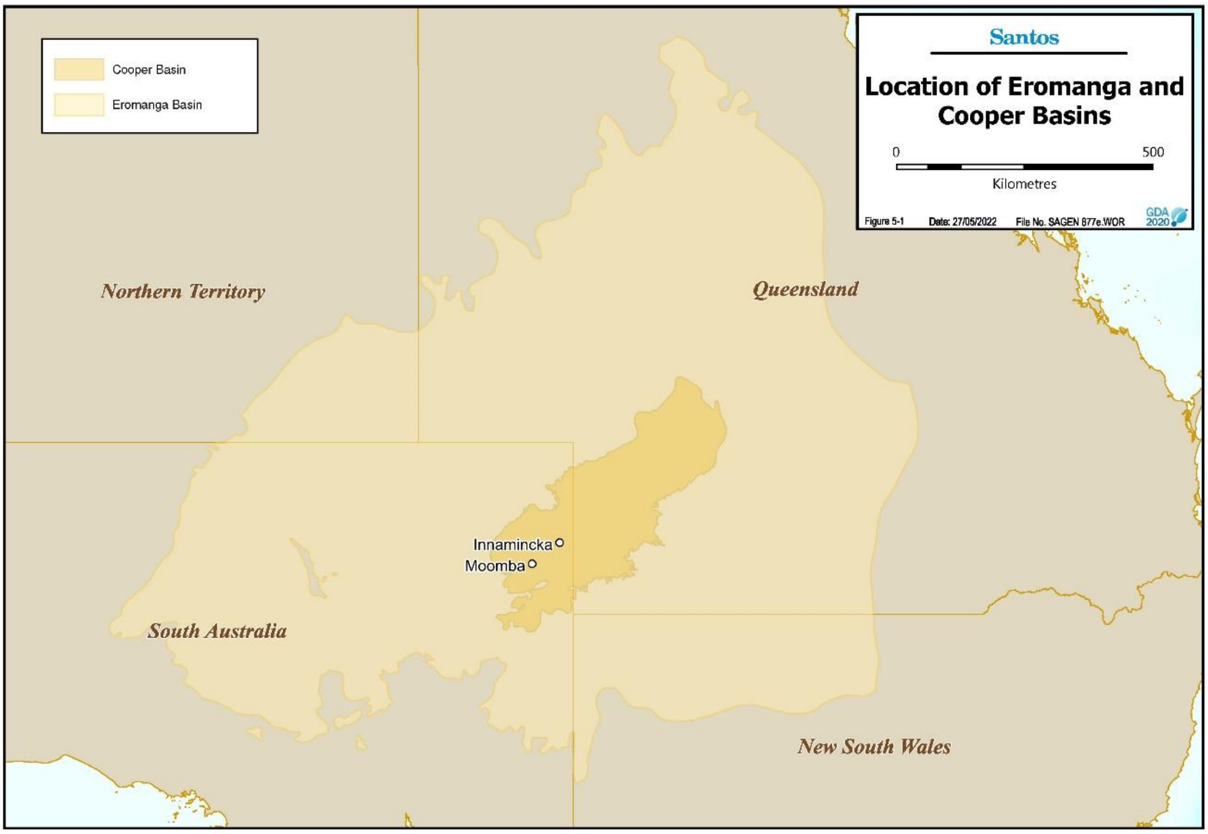


Figure 5-3: Location of Eromanga and Cooper Basins

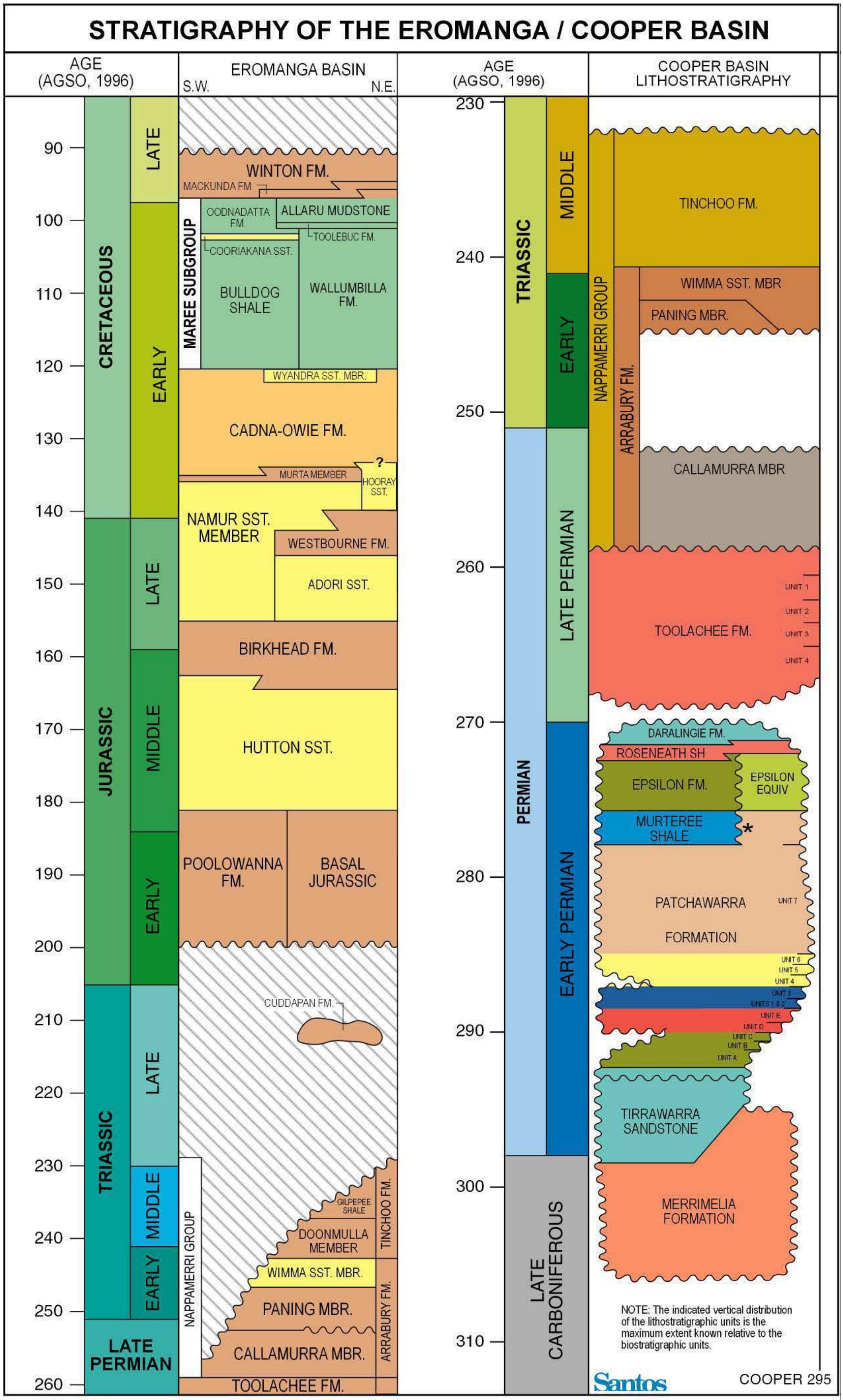


Figure 5-4: Stratigraphy of the Cooper and Eromanga Basins

5.4.2 Hydrogeology

The Eromanga and Cooper basins can be broadly subdivided into aquifers and confining beds (aquitards and seals). Aquifers are porous and permeable units that can store and transmit water and are generally analogous to the petroleum reservoirs in that they have storage capacity for fluids as well as permeability which enables the passage of fluids through them. In several instances, porous-permeable units are both aquifers and petroleum reservoirs.

Confining beds (aquitards) are rock units that impede the movement of water, and in general have low hydraulic conductivities or permeability. In some Cooper Basin aquitards, the conductivity is so low that no fluid permeates them under natural pressure conditions. Seals are proven by their ability to trap and hold gas under pressure.

The pressure of an aquifer can be described as a pressure or hydraulic head. In general, the hydraulic head drives the flow of water from one part of an aquifer to another, (i.e., from high to low). The head distribution can be used to create a potentiometric surface map that links locations of equal head potential by the construction of equipotential contours. Flow paths are constructed perpendicular to these contours to show the direction of lateral groundwater flow.

Differences in hydraulic head between aquifers occur when a confining layer is present and the flow in each aquifer occurs independent of the other. In this situation, the hydraulic head difference will drive water through the confining bed until equilibrium is established. The volume of water moving through a confining bed is generally very small compared with the lateral flow in the aquifers. The rate of movement through the confining bed depends on its thickness, its vertical hydraulic conductivity (related to lithology) and the head difference. Flow through confining beds can also occur along faults. Under normal conditions, fluid flows from high pressure (hydraulic head) to low pressure. If the pressure is the same in two aquifers that are separated by a confining bed or seal, fluids between the aquifers will not mix even if the aquifer is breached. Where the hydraulic head is different and there is a breach in the confining bed, fluid will flow from the aquifer with the higher hydraulic head to the aquifer with the lower head.

In general, aquifers and aquitards are assigned in relation to geological formations, which is the basic rock unit used to describe a stratigraphic succession. A geological formation can contain both aquifers and aquitards. For example, the Cadna-owie Formation has been described as one of the main aquifers of the GAB. However, the bottom three quarters of the Cadna-owie Formation is siltstone and shale and acts as an aquitard while the upper quarter of the unit is a sandstone that may act as an aquifer where it is not cemented or too silty. Large parts of the Poolowanna, Birkhead, Murta and Westbourne formations and most of the Wallumbilla Formation and the Bulldog Shale, Allaru, Toolebuc and the Oodnadatta formations are aquitards within the Eromanga Basin.

Within the Cooper Basin, trapping of gas indicates that most of the aquitards are seals. The entire Murteree Shale and Roseneath Shale are seals. The Patchawarra, Epsilon and Toolachee formations are composed of sandstone-shale-coal cycles each of which contain potential aquifer / reservoir systems and a seal or aquitard. In these systems the formations as a whole act as seals. The Nappamerri Formation, which overlies the coal measures, is a regional seal to the gas sands of the Cooper Basin, except around the eastern, southern and western margins of the Cooper where it has been eroded. As a seal, it prevents the vertical movement of gas and oil, diverting the hydrocarbons laterally until they reach the eroded edge of the Nappamerri, where the hydrocarbons can resume their vertical movement.

The hydraulic conductivities of these beds have been estimated by numerical model calibration to be about 10^{-4} m/day (Audibert, 1976). Despite the low hydraulic conductivities, over geological time, the aquitards have allowed hydraulic communication between aquifers such that most are in hydraulic equilibrium and have the same hydraulic head. In addition, many aquitards have been breached naturally, either by erosion or by faulting. Where this occurs, large scale mixing of the aquifers has taken place and hydraulic equilibrium has or is being reached.

Aquifers include the Eyre Formation of the Lake Eyre Basin, some parts of the Winton, Coorikiana, Cadna-owie, Murta, Birkhead formations, and large parts of the Mackunda, Namur, Adori, Hutton, Poolowanna and Cuddapan formations, and all the Eromanga Basin. In the Cooper Basin, parts of the Nappamerri Group, Toolachee, Daralingie, Epsilon, Patchawarra and Merrimelia formations, and all the Tirrawarra Sandstone, may act as aquifers. Hydraulic conductivities measured within aquifers range between 0.1 and 10 m/day (Audibert, 1976). Porosity values of most Jurassic and Early Cretaceous aquifers range from 10 to 30 percent, diminishing with increasing depth (Senior and Habermehl, 1980).

Table 5-3 provides a summary of the pressure, permeability and salinity characteristics of these aquifers. Regional geological cross-sections are shown in Figure 5-5 and

Figure 5-6. Based on the geological data available, the aquifers can be grouped into seven largely regional hydrogeological cells, labelled from the top down as follows:

- the Meteoric Recharge Zone (top water table or unconfined aquifer)
- the Eyre Formation, which in places overlaps and is coincident with the surface Meteoric Recharge zone
- parts of the Winton and most of the Mackunda Formations (non-flowing, uppermost GAB aquifer system (K aquifer of Habermehl 1980)
- Coorikiana Sandstone (non-flowing aquifer restricted to western parts of the Eromanga Basin)
- uppermost part of the Cadna-owie Formation, parts of the Murta Formation, a large part of the Namur Sandstone, parts of the Westbourne and Birkhead formations and most of Hutton Sandstone and Poolowanna Formations – all within the GAB and collectively called the J Sands by Habermehl (1986)
- the Cooper Basin (normal pressure) largely shallower parts of the Basin and around its margins
- the Cooper Basin (abnormal pressure) largely deeper, hotter parts of the Basin such as the deep Nappamerri Trough.

Whilst the data strongly supports this interpretation, it is recognised that in some areas the data to prove the regional interpretation is unavailable. Where this occurs, well data obtained during drilling activities provides adequate delineation of the cells within a well bore.

The distribution of these cells across the Cooper and Eromanga basins shows how in several areas the aquifer/reservoirs are in direct communication. However, all cells do not necessarily exist in all parts of the basins. Towards the margins of the Cooper Basin and along some intra-basin highs, the GAB and Cooper Basin cells are in connection. It is also noted that the Coorikiana Sandstone is only known from the southern and western Eromanga Basin[4].

[4] Further information on the hydrogeology of the Central Eromanga Basin can be found in Smerden BD and Ransley TD (eds) (2012) Water resource assessment for the Central Eromanga region. A report to the Australian Government from the CSIRO Great artesian Basin Water Resource Assessment. CSIRO Water for a Healthy Country Flagship, Australia.

Table 5-3: Summary of aquifer salinity, pressure and permeability characteristics

Reservoir / Aquifer	Use	Extent	Salinity	Pressure System	Permeability
Phreatic aquifer comprising dunes of Simpson Sand plus associated older dunes, inter-dunes, lakes and channels.	Generally limited to stock watering and petroleum exploration	Basin wide, except where older, underlying units are exposed	Highly variable, 1,000 up to 2,0000 ppm or more	Fully unconfined	High
Eyre Formation	Limited use for petroleum exploration	Basin wide, except where eroded on topographic highs	Unclear, probably variable, like the phreatic aquifer above (1,000 – 2,0000+ ppm)	Uppermost aquifer. Unknown, but less than GAB	High
Winton Formation (multiple sands and aquitards)		Basin wide, but sands may be of limited extent	As above	As above	High
Mackunda Formation		Basin wide	Unclear, probably high (>9,000 ppm)	Uppermost GAB or K aquifer. Known to be less than GAB J aquifer (Della 20 evidence)	High
Coorikiana Sandstone	Potential hydrocarbon reservoir	Restricted to southern marginal and eastern areas of Basin	Unclear, probably high (>9,000 ppm) dataset, may be high or low	Aquifer between Bulldog Shale and Oodnadatta Formation. One data point apparently less than GAB. Not in communication with GAB in Cooper area	Generally low but local areas up to moderate
Cadna-owie Formation (aquifer in the Wyandra SS at top of formation)	Known aquifer in uppermost part of formation only	Basin-wide	Limited data – possibly 2,000 – 5,000 ppm	Part of main GAB J aquifer system, on a common water pressure system	Often low, locally high
Murta Formation (multiple sands and aquitards)	Known hydrocarbon reservoir	Basin wide, but sands may be limited in extent	Limited data (3,000-4,000 ppm) for Murta sands	Part of main GAB J aquifer (Algebuckina Sandstone equivalent). Data pressures variable and source not verifiable. May be issues with mixing McKinlay Member data.	High
Namur Sandstone (includes McKinlay member of Murta Fm)	Known aquifer and hydrocarbon reservoir	Basin wide	300-4,000 ppm	Part of main GAB aquifer (Algebuckina Sandstone equivalent). May have local depleted zones	High
Adori Sandstone	Known aquifer and hydrocarbon reservoir	Restricted to northern part of basin	300-4,000 ppm	Part of main GAB aquifer (Algebuckina Sandstone equivalent). May have local depleted zones	High
Birkhead Formation (multiple sands)	Known hydrocarbon reservoir	Basin wide but sands separated by aquitards	300-4,000 ppm	Part of GAB J aquifer. May have local depleted zones	Highly variable
Hutton Sandstone	Known aquifer and hydrocarbon reservoir	Basin wide	300-4,000 ppm	Part of main GAB aquifer (Algebuckina Sandstone equivalent). May have local depleted zones	High
Poolowanna Formation	Known hydrocarbon reservoir	Basin wide	3,000-4,000 ppm in Cooper Basin area, but more than 9000 ppm in northern areas	Part of GAB J aquifer. May have local depleted zones.	High

Reservoir / Aquifer	Use	Extent	Salinity	Pressure System	Permeability
Cuddapan Formation	Known hydrocarbon reservoir	Local channels only between Nappamerri and Jurassic units	Unknown		High
Nappamerri Group (multiple sands and seals)	Known hydrocarbon reservoir	Extensive with erosion from the top to the west south and east of Moomba, but sands of local extent. Degree of interconnection across basin unclear	3,000-7,000 ppm. Local variations appear to depend on connection with GAB	May be same or greater or less than GAB. May have local depleted zones	Highly variable
Toolachee Formation (multiple sands and seals)	Known hydrocarbon reservoir	Extensive, top eroded on structural highs, but sands of local extent. Complex interconnections across basin.	1,500 to 15,000 ppm apparently depending on connection with GAB. Data set combined with Daralingie.	Potential for very high pressures in centre of basin. May be same or greater or less than GAB. May have local depleted zones. Can prove connection with GAB in Munkarie Brumby area.	Highly variable
Daralingie Formation (multiple sands and seals)	Known hydrocarbon reservoir	As above	Data combined with Toolachee.	Potential for very high pressures in centre of basin. May be same or greater or less than GAB. May have local depleted zones.	Highly variable
Epsilon Formation (multiple sands and seals)	Known hydrocarbon reservoir	As above	Limited dataset, 2,000 to 10,000 ppm apparently depending on connection with GAB.	As above	Highly variable
Patchawarra Formation (multiple sands and seals)	Known hydrocarbon reservoir	As above	2,000 to 18,000 ppm. Low salinities in Weena / Tinga Tingana Trough	As above	Highly variable
Tirrawarra / Merrimelia Formation	Known hydrocarbon reservoir	Basin wide except for south-east and around local highs	Limited dataset for Tirrawarra 5,000 to 17,000 ppm no data for Merrimelia	As above	Highly variable
Pre Permian Basement	Known hydrocarbon reservoir	Basin wide	Unknown	Potential for very high pressures in centre of basin. May be same or greater or less than GAB	Highly variable, may include natural fractures

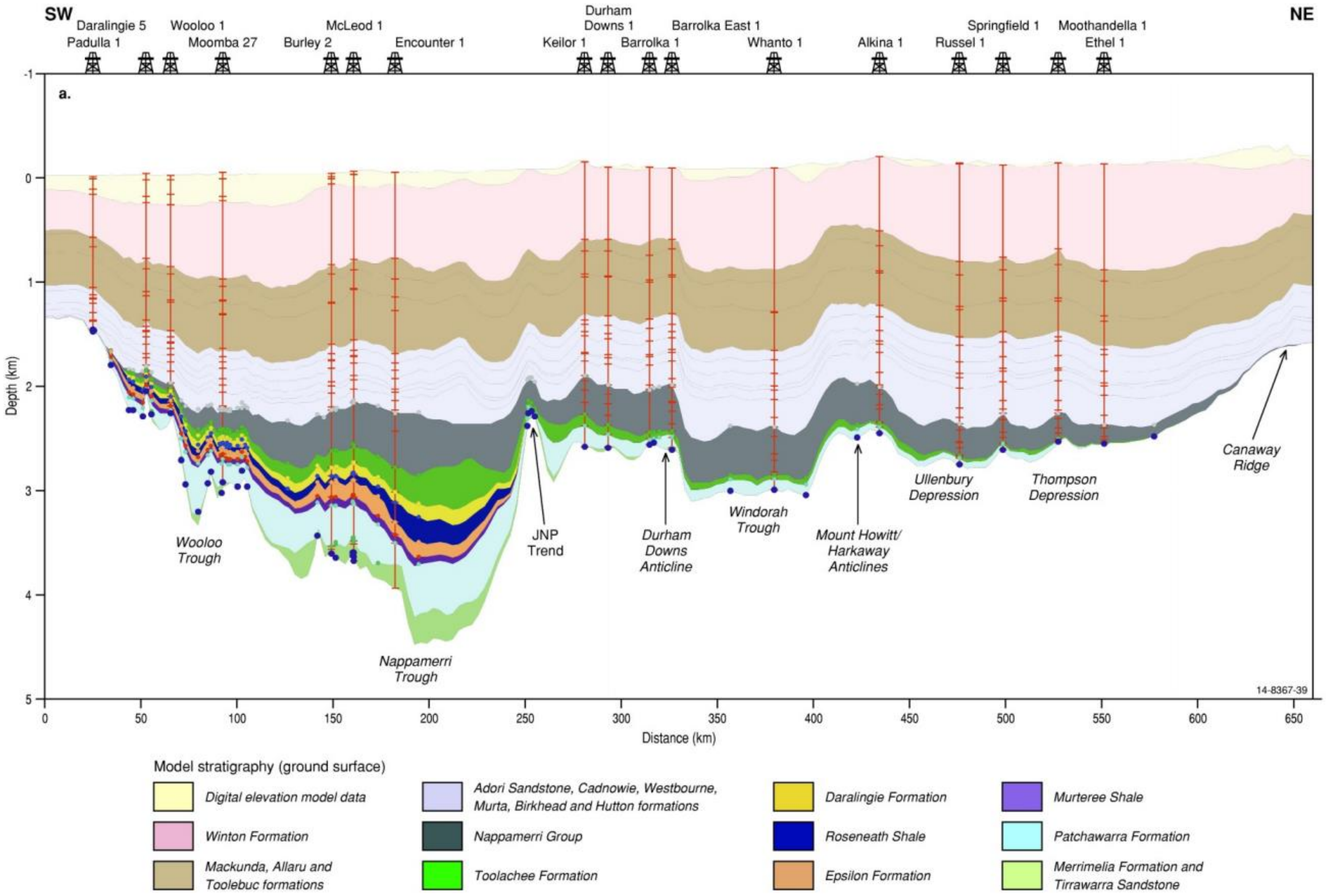


Figure 5-5: Regional geological cross-sections of the Cooper Basin extracted from Geoscience Australia - Cooper Basin Architecture and Lithofacies 2015 (GeoCat 87832)

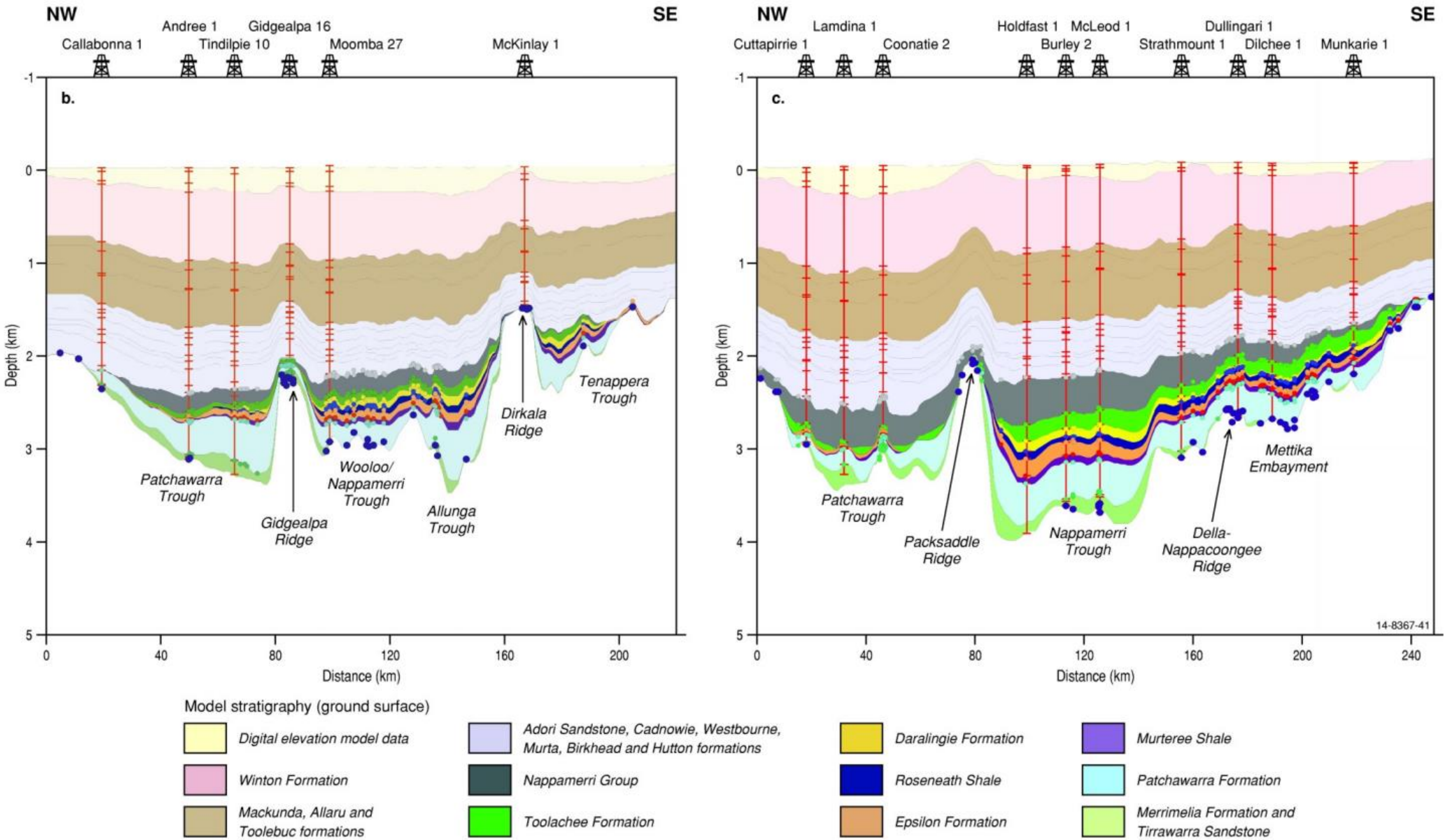


Figure 5-6: Regional geological cross-sections of the Cooper Basin extracted from Geoscience Australia - Cooper Basin Architecture and Lithofacies 2015 (GeoCat 87832)

5.4.3 Groundwater use

Due to the dry climate of the region, groundwater is an important resource. Land use is generally restricted to low intensity stock grazing, and where accessible and of acceptable quality, groundwater is used for domestic and stock watering purposes. It is noted however, that in most cases groundwater for domestic use is treated using reverse osmosis (RO) to improve quality.

Other industries reliant on groundwater resources in the region include oil and gas exploration and production and other mining. The quality of the water required for these activities is variable, and accessibility to water of appropriate quality may restrict land uses in some locations. The socio-economic value of these oil and gas and mining industries is discussed further in Section 5.5.5.

The GAB aquifer supports the GAB springs which occur around the margins of the Eromanga Basin. The Namur and Hutton sandstones (Algebuckina Sandstone equivalents) are thought to be among the primary sources of groundwater to GAB springs (Priestley *et al.* 2020). There are several GAB springs that occur near the southern extent of the Cooper Basin. Hydrochemical evidence has suggested multiple aquifer sources for some of these springs (Keppel et al. 2020). The communities that are dependent on the GAB water are listed under the EPBC Act list of Threatened Ecological Communities.

In accordance with water bore licences, Santos can extract approved volumes of water for petroleum activities from shallow aquifers, GAB aquifers and other deeper aquifers. Most oil producing reservoirs in the Cooper and Eromanga Basins are classified as ‘water drive’ reservoirs. Oil pools are usually found in formations that also contain considerable quantities of water. As a result of the different physical properties of oil and water over time, the oil tends to rise up and sit above the water. These formations usually exist under pressure and so when they are accessed (by drilling a borehole), the oil will flow to the surface. Eventually, water will take the place of the produced hydrocarbons and rise up the borehole with the oil. As production from the reservoir continues, this water content will gradually increase until it is a significant proportion of the total production. This water is considered a by-product, is separated from the oil stream in satellite stations and either managed through produced formation water pond systems or reused, depending on its quality and the reuse activity.

Due to the depth of the artesian aquifers at the centre of the Basin, most pastoral water use from these aquifers in South Australia occurs along the southern and western margins where bores intersect artesian aquifers at less than 600 m (GABCC 1998). On the western margin, these bores coincide approximately with the Oodnadatta Track and there are several flowing artesian bores used for stock watering along the Birdsville Track. The use of artesian water in the central portions of the Cooper Basin is generally limited to converted petroleum wells (due to the expense associated with drilling bores to the depth required to intersect freshwater aquifers).

Water quality requirements for industries vary depending on specific needs. Salinity is used as a guide to the suitability for water use and is usually expressed as total dissolved solids (TDS), a measure of the weight of dissolved solids in water. Groundwater quality in the shallow (water table) aquifers in the Moomba region is generally not suitable as potable or livestock water due to its high salt content. Water of up to 5,000 mg/L TDS is considered acceptable for stock watering, with levels of TDS higher than this possibly resulting in a loss of production and decline in animal health (ANZECC, 2000). The salinity of shallow groundwater in the north-east of South Australia is often significantly higher than this. Likewise, the salinity of water in the uppermost GAB aquifer (Eyre, Winton and Mackunda formations) is also generally too saline for use. However, the salinity level of the main flowing GAB aquifer is much lower (600–2,000 mg/L TDS) in the eastern part of South Australia and is suitable for livestock watering purposes.

5.4.4 Historical land and groundwater impact

Santos has undertaken production and processing operations that have resulted in impacts to soil and groundwater within the Moomba and Cooper Basin region. These impacts are either associated with known discrete loss of containment events or historical impacts, attributable to former petroleum hydrocarbon and produced fluid management and storage practises, authorised at the time of installation and construction and operated under current relevant approvals.

Sites, where impact associated with known discrete loss of containment events or historical activities has been identified, are subject to assessment and ongoing monitoring as required under relevant approvals or via agreed monitoring programs developed in consultation with DEM and the EPA. Several sites have historically been subject to detailed or site-specific risk assessment, in accordance with the ASC NEPM.

Discussion of the assessment and management of the historical land and groundwater impacts is provided in Section 8.8.

5.5 Social Environment

The Cooper Basin area has Aboriginal cultural and European historical significance, with many Aboriginal and non-Aboriginal heritage sites present in the landscape. There are a range of current land use types throughout the area including conservation, tourism, and oil and gas production with pastoral activities. While the regional permanent population has decreased, commercial and tourist numbers have increased. From 2009 to 2013 the number of vehicles crossing the border from Queensland into South Australia increased from 22 to 105 per day and average annual daily traffic volume recorded in 2015 was 120 vehicles per day (DPTI/DIT 2019). It is noted however, the region remains generally undeveloped in terms of infrastructure and roads.

5.5.1 Aboriginal cultural heritage

The north-east desert region historically sustained a significant Aboriginal population, particularly in the area surrounding Cooper Creek and its many channels (Santos 1998). Sites of Aboriginal heritage are present throughout the region and include features of archaeological, anthropological, historical and / or traditional importance, for example, middens, artefact scatters, rock engravings, arrangement sites, burial sites and quarries (Blackley et al. 1996). These are summarised in Table 5-4.

Table 5-4: Land system and site types

Land system	Site types	Location of sites
Sand dunes	Burial sites	Eroding out of deflated dunes
	Shell midden	Near sources of permanent water such as Cooper Creek and Coongie Lakes
Floodplains	Burial sites	Isolated dunes and sandy rises
	Open camp sites/scatters	Isolated dunes and elevated land close to a natural watercourse
	Shell middens	Near lakes and along rivers and creeks
	Rock art	Near lakes and rivers
	Culturally modified trees (rare)	Along natural watercourses or in isolated stands of old growth native trees
Gibber plains	Stone tool quarries	Mesa caps
	Stone arrangements	Gibber country Often associated with cleared pathways

Sand dunes have been found to contain the largest and most important archaeological sites in the Cooper Basin region. For example, stones found on sand dunes may be representative of sites of Aboriginal cultural significance. Burial sites are relatively common and are often found in eroding sand dunes. Shell middens are another common feature, particularly near sources of permanent water such as Cooper Creek and Coongie Lakes.

Clay covered floodplains contain small numbers of Aboriginal sites. Camp sites and burial sites have been found on sandy rises and isolated dunes in floodplains, while stone artefact scatters, shell middens and rock art are found near lakes and rivers (particularly Cooper Creek). Although relatively uncommon, culturally modified trees can be found along creeks and rivers. Boomerang scars can also be found on trees of various types, including Acacias and Eucalypts.

Aboriginal heritage sites are also found in the pebble-covered gibber country. The dense bands of stone that cap mesas were often extensively quarried for making stone tools. Stone arrangements can be recognised from the combination of regular patterns of larger rocks in lines, circles and cairns. Cleared pathways near these stone arrangements are also common.

The Cooper Creek region has been proclaimed a State Heritage Reserve because of its association with Aboriginal and European history as well as its environmental significance. The area encompasses Innamincka and a 1 km strip either side of Cooper Creek, totalling 120 km^2. There are a number of sites of Aboriginal heritage including relics, camp sites, quarries and engravings with several unique designs located around Cullyamurra waterhole.

5.5.2 Non-Aboriginal cultural heritage

Non-Aboriginal cultural heritage in the region dates to European exploration during the 1840s. Pastoral development rapidly followed exploration and by the mid-1880s all available pastoral leases in the region had been taken up.

This rapid pastoral expansion was due in part to the presence of Afghan cameleers who first arrived in the north-east desert region in the 1860s. They were employed on survey expeditions into the arid interior and transported supplies from the railhead to remote settler areas. From 1884, Marree was the hub of a vast pack-camel transportation network.

Most historical sites in the region are associated with exploration, including the failed Burke and Wills expedition of 1860–61 (the Dig Tree and grave sites), the establishment of transport routes, expansion of pastoralism throughout the north-east deserts and subsequent settlement of inland South Australia and Queensland (DEW 2022; DAWE 2022a).

Locations around Innamincka are incorporated in the Innamincka/Cooper Creek State Heritage Area. Several sites in the region are listed on the State Heritage Register, including the Australian Inland Mission Nursing Home at Innamincka and the Innamincka/Cooper Creek State Heritage Area (a section 1 km either side of the Cooper Creek channel from the Queensland border to 14 km west of Innamincka).

Historical sites in the far north-east of South Australia listed on the State Heritage Register or the National Heritage List in 2022 are:

- The Burke, Wills, King and Yandruwandha National Heritage Place (incorporating the Dig Tree and Fort Wills Site, Howitt's Site, Burke's Tree, King's Site and Wills' Site)
- Innamincka – Cooper Creek State Heritage Area
- Tree possibly marking the burial site of Charles Gray (Innamincka Regional Reserve)
- Horse Capstan Pump and Well, Merty Merty Station
- Well and Whim, Coochilara Waterhole, Merty Merty Station
- Cordillo Downs Station Homestead and Woolshed
- Australian Inland Mission Nursing Home (former)

- Cadelga Homestead (Ruin).
- Blanchewater Homestead on the Strzelecki Track
- Tinga Tingana Homestead (Ruin)

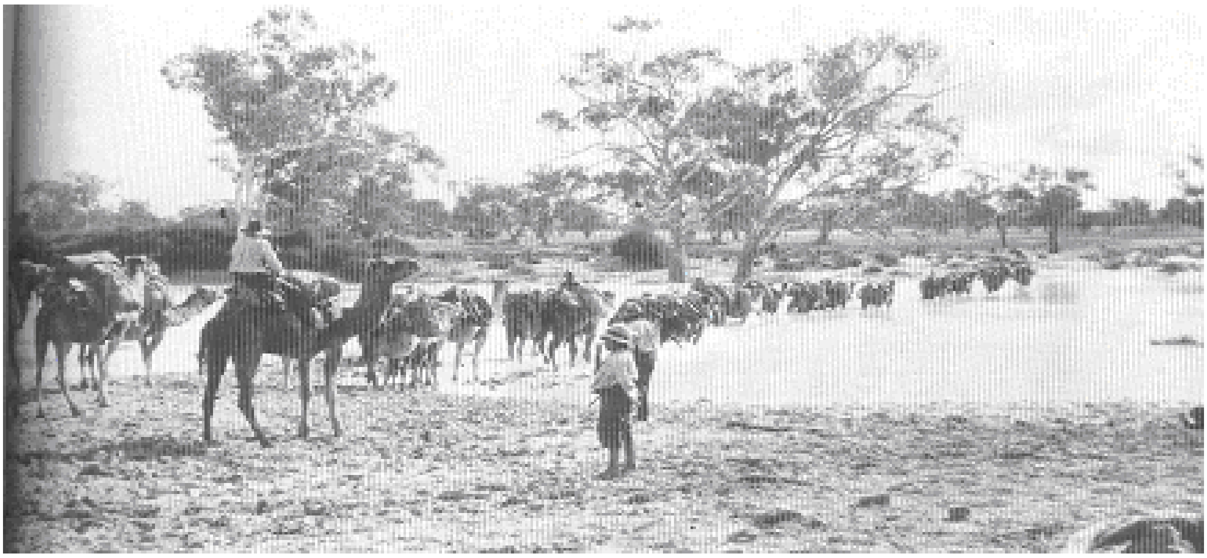


Plate 5-1: Camel train carrying supplies to Cordillo Station at Innamincka c1926 (Tolcher 1986)

5.5.3 Native Title

There are currently three native title claim groups in the South Australian Cooper Basin. Details of each claim are presented in Table 5-5.

Table 5-5: Native title claims in the South Australian Cooper Basin

Title	Location	Status
Yandruwandha/ Yawarrawarrka Native Title Claim	North east corner of South Australia (SA) extending south to Lake Blanche	Determined SCD2015/003
Dieri Native Title Claim	From Marree in the south to Cameron Corner in the east, to Hadden Corner in the north-east, following the Queensland border to Lake Teetatobie, south-west of Gypsum Cliff, west to Lake Eyre, south to Marree	Determined SCD2012/001

The Dieri and Yandruwandha/Yawarrawarrka Native Title Groups are Santos' two primary Aboriginal stakeholders in the South Australian Cooper Basin. The Dieri are recognised as native title holders for an area of Santos operations that includes the Tirrawarra and Charo fields. The Yandruwandha / Yawarrawarrka are recognised as native title holders for an area that incorporates the Dullingari, Moomba (South and East) and Limestone Creek fields and most of the Nappa Merrie Trough Unitisation Zone.

Santos has cultural heritage agreements in place with the relevant Traditional Owner parties. Santos is working with the Native Title holders within the footprint of the SEO to establish native title agreements in respect of the impact of the operations on native title rights and interests.

5.5.4 Land use and tenure

The primary land uses in the Basin are pastoralism, oil and gas exploration and production, conservation and tourism. Sixty percent of the region is used for pastoral production and most of the remainder falls within Regional Reserves.

Pastoral land use

The main pastoral enterprise in the region is beef cattle production on native pasture. Pastoral properties located within the South Australian Cooper Basin include:

- Merty Merty
- Gidgealpa
- Cordillo Downs
- Innamincka
- Clifton Hills
- Mungeranie
- Bollards Lagoon
- Mulka
- Lindon.

Sections of pipeline operations in the South Australian Cooper Basin are carried out on properties that are certified under programs such as the Livestock Production Assurance On-Farm Quality Assurance (LPAQA) program. Some properties may also be certified as organic/biodynamic through recognised certifying bodies.

Conservation

The region contains some of South Australia's largest conservation reserves dedicated under the *National Parks and Wildlife Act 1972*. The main parks and reserves of the broader region include the Innamincka Regional Reserve, Strzelecki Regional Reserve, Simpson Desert Regional Reserve and Conservation Park, and the Malkumba-Coongie Lakes National Park.

Regional Reserves are areas proclaimed for the purpose of conserving native fauna, natural or historical features while allowing responsible use of the area’s natural resources (including oil and gas production). Together, the Innamincka and Strzelecki Regional Reserves account for just over 2,000,000 ha of land within the Cooper Basin while the Simpson Desert Regional Reserve, located on the western margin of the region is one of the largest protected areas in South Australia and plays an important role for landscape-scale conservation of central Australian arid environments.

In 1987, part of the Cooper Creek system was proclaimed as the Coongie Lakes Wetland of International Importance under the Ramsar Convention. The Ramsar wetland is defined by Lake Moorayepe to the north, the Queensland border at the crossing of Cooper Creek to the east, and a point south-west of Lake Hope. It is estimated that the Coongie Lakes Wetlands Ramsar area covers 30% of the known oil and gas resources within the South Australian portion of the Cooper Basin (DEHAA 1999).

The Malkumba-Coongie Lakes National Park was proclaimed to conserve significant wetlands, provide tourism experiences and ensure that the core component of the Coongie Lakes system is protected from grazing, petroleum and mining activities. Three special management zones (the No Mining Zone, Walk-In Zone and Controlled Access Zone) have also been established to provide additional protection to key riparian and wetland zones adjacent to the Park.

Oil and gas production

The area of land used for oil and gas production is small, but the supporting infrastructure extends throughout much of the central and north-east portion of the Cooper Basin in South Australia.

Productive oil and gas fields are distributed across pastoral lands, Regional Reserves and the Ramsar wetland.

Santos is the largest petroleum company in the area, operating a total of 28 gas and oil satellites, Moomba processing plant and associated infrastructure. Other operators, including Beach Energy, operate smaller production facilities in the region, which generally deliver produced oil or gas to Moomba via road or pipelines.

5.5.5 Socio-economic context

The Cooper Basin region is sparsely populated, with a small number of residents working in the pastoral industry and over 2,000 petroleum industry workers, largely based (on FIFO rosters) at Moomba and surrounding areas. Moomba and Innamincka are the main population centres.

Santos operates and maintains:

- Moomba airport (with contracted air services) to transport the workforce and small freight to and from Adelaide
- several workforce accommodation villages in the Cooper Basin at Moomba, Dullingari, Tirrawarra in South Australia and Ballera and Jackson Operating Villages in QLD
- a waste management facility, licenced to receive waste from the greater Cooper Basin.

The population of Innamincka was recorded as 44 in the 2016 census (ABS 2022). The population of Statistical Level 1 4114107 which covers the north-east of South Australia (including Innamincka and incorporating Leigh Creek to the south and Lake Eyre National Park to the west) was 661 in the 2016 Australian Census (ABS 2022). Most of the residents were male (70.3%) with a median age of 40. Aboriginal and / or Torres Strait Islander people made up 16.4 % of the population.

Based on DIT (formerly DPTI) traffic counts (J Gerblich, DPTI, 2015, pers. comm., 9 July), it is estimated that more than 20,000 tourists visit the region annually. The Strzelecki Track, Innamincka Regional Reserve and Coongie Lakes wetlands are tourist attractions. Online booking information for the Innamincka Regional reserve indicates that 1103 people visited the park in 2018-2019, and 2039 people also had access to this park through purchase of a Desert Parks Pass. These numbers are considered an underestimation of visitors as they do not include other visitation information such as camping and accommodation in the town of Innamincka. Vehicle traffic counters on the road to the Malkumba Coongie Lakes National Park estimated there were approximately 5,000 vehicle trips on the access road in 2018 (NPWS 2019).

Infrastructure in the region is minimal. The Strzelecki and Birdsville tracks are the major transport routes through the region. Unsealed roads service the district and most roads and tracks associated with oil and gas fields have no public access. The first 50 km of the 472 km Strzelecki Track was sealed during 2021 and the project to seal priority sections of the track is proposed to be completed by mid-2025 (DITRDC 2022; DIT 2022).

Santos contributes significant investment in the Cooper Basin region, including maintaining and upgrading roads, road and tourism signage, fencing, the Moomba Waste Management Facility, the Moomba Airport, emergency response and associated medical facilities.

The Cooper Basin operations contribute over $50 million in royalties to South Australia each year.

6 Consultation

Effective consultation allows for an exchange of information and provides an opportunity to promote understanding and reconciliation of competing interests.

Santos has been operating in the Cooper Basin for over 60 years and recognises the importance of working with stakeholders. Santos is an active member of regional bodies such as the SA Arid Lands Natural Resources Management Group and continually engages with local pastoral, landholder, community and traditional owner groups as well as other relevant stakeholder groups based outside of the Cooper Basin.

The following sections outline the consultation that has been undertaken in the development of this EIR and the accompanying SEO from 2003 to the 2022 review.

6.1 Development of the EIR and SEO (2003)

Santos undertook a formal stakeholder consultation process during the original development of the Production and Processing Operations EIR and SEO (Santos 2003a and 2003b). This involved stakeholder workshops in Adelaide and Moomba and the draft EIR and SEO were also released for public comment during this time.

Key stakeholders consulted during this process included the Commonwealth environment department, state government agencies and Ministers, land management boards, non-government environment and conservation organisations, petroleum and geothermal energy companies and pastoral landholders.

Issues raised by stakeholders included roads (dust, vehicle movements), borrow pits, cultural heritage, spill management and emergency response, impacts to pastoral operations and stock disturbance, pest plants and animals, rehabilitation, and public safety (fire and explosion). Santos responses are provided in full in the 2003 EIR (at Appendices C and D) and SEO (at Appendices 6 and 7). The EIR and SEO were updated following the consultation process to ensure that they addressed the issues raised during the process.

6.2 SEO Review (2009)

Santos undertook targeted consultation during the review and revision of the EIR and SEO in 2009. This included:

- meetings with the regulator (then Primary Industries and Resources, South Australia (PIRSA) now Department for Energy and Mining (DEM))
- a meeting with PIRSA, Department for Water, Land and Biodiversity Conservation (DWLBC now Department for Environment and Water (DEW)) to discuss potential changes to aquifer definitions and grouping in the SEO
- circulation of the draft SEO and EIR addendum to government agencies for comment (coordinated by PIRSA).

Information provided by the Santos Stakeholder Adviser regarding ongoing landholder and stakeholder liaison and potential concerns was also addressed in the SEO review and revision.

Written feedback was received from the following agencies and incorporated into the SEO:

- Environment Protection Authority
- Department for Environment and Heritage
- Department of Health
- Department of Primary Industries and Resources, South Australia.

6.3 EIR and SEO Review 2016-2017

During the 5-yearly review and revision of the EIR and SEO in 2016-2017 targeted consultation included:

- discussions and meetings with the regulator DSD
- meetings and site visits with DSD in relation to new borrow pit GAS criteria (2014).
- provision of draft documents to DSD for review
- circulation of the draft EIR and SEO to key stakeholders and government agencies for comment (coordinated by Santos).

Feedback from ongoing consultation with pastoral stakeholders, traditional owner groups, regional bodies and other oil and gas operators was also incorporated in the review and revision of the EIR and SEO.

Written feedback on the EIR and SEO was received from the following agencies and incorporated into the SEO:

- Environment Protection Authority
- Department of Environment, Water and Natural Resources
- Department of State Development – Aboriginal Affairs and Reconciliation Division
- Department of Health
- South Australian Arid Lands Natural Resources Management Board.

Stakeholder comments were addressed in the EIR and SEO and are summarised in Section 6 of the EIR. Santos detailed comments and responses were provided in the Appendix D of the 2017 EIR.

6.4 EIR and SEO Review 2023

Stakeholder Consultation commenced 28th of April 2023 for a period of 30 business days. Feedback from ongoing consultation with pastoral stakeholders, traditional owner groups, regional bodies and other oil and gas operators has been incorporated in the review and revision of the EIR and SEO.

Santos has undertaken targeted consultation during the current review and revision of the Production and Processing Operations EIR and SEO. To date this has included:

- discussions and meetings with the regulator DEM
- circulation of the draft EIR and SEO to key stakeholders and government agencies for comment (coordinated by Santos).

Appendix C provides full details of written responses received following circulation of the EIR and SEO to key stakeholders facilitated by Santos. Table 6-1 summarises the key issues raised and where they have been addressed in the EIR and SEO.

Table 6-1: Key issues raised during consultation - EIR and SEO (2023)

Category	Issue	Addressed in SEO/EIR section (s)
Water affecting activities	▪ Request for Santos to note that the Water affecting control policy (WAACP) considers all water resources, including surface waters.	Page 13 (SEO)
Water affecting activities	▪ Request by SA Arid Lands Landscape board that water affecting activities be undertaken with adequate permitting and review as required.	Whole document (SEO) and (EIR)

Category	Issue	Addressed in SEO/EIR section (s)
Water affecting activities	▪ Clarity requested as to how sensitive areas are defined and request to consider the definition against water resources.	Section 5.1 and 5.11 (SEO)
Waste water management	▪ Clarification provided on waste facilities located at Moomba, as defined by the Department of Health & Wellbeing (SA)	Page 44 (SEO)
Waste water management	▪ Clarification provided and updates made to descriptions of Dullingari and Tirrawarra waste water management.	Page 44 (SEO)
Waste water management	▪ Request from the Department of Environment and Water to clearly define Lake Brooks and distinguish this name from an actual lake. This term refers to the Moomba waste water facility rather than an actual lake	Whole document (SEO) and (EIR)
Administering authorities	▪ Request made by the Department of Environment and Water to replace DEW with Landscape SA Act as administering instrument.	Section 7.11.3 (SEO)
Legislation review	▪ Replace Radiation Protection and Control Act 1982 with Radiation Protection and Control Act 2021	Whole document (SEO and EIR)
Environmental Risk assessment	▪ The cumulative impacts from activities in the Basin needs to be included in the Environmental Risk Assessment	Section 7.2 (SEO)
Native Title references	▪ AAR is no longer within Department of Premier and Cabinet. Santos to remove all references to DPC-AAR in any project document.	Table 1 (SEO) and whole document (SEO and EIR)
Cumulative impacts	▪ Queries raised in relation to how Santos manage the documents for seismic, well site, campsite, track construction ad decommissioning as well as drilling as these activities can have large environmental impacts.	Reference to DEM website with full list of SEO's and EIR's relating to each of the activities requested.

7 Environmental Risk Assessment

This section identifies and discusses the potential hazards and consequences associated with Cooper Basin production and processing operations including:

- public and third party safety
- environmental (including biophysical, social and cultural)
- security of supply of natural gas

7.1 Identification of Potential Hazards and Consequences

A hazard is considered any source (or cause) of potential harm (or impact). To identify hazards, the various activities associated with each stage of operations (flowline construction, production operations and decommissioning) were considered along with the events that could lead to impact. The possible consequences of such events were also identified and assessed.

Where possible, environmental hazards and potential consequences have been identified and assessed based on existing information on the magnitude and / or frequency of activities associated with production and processing operations in the Cooper Basin. However, this information is not available for all activities and associated potential hazards. Where this is the case, environmental hazards and subsequent consequences have been identified based on the experience of petroleum industry personnel.

The environmental hazards that are considered to have potential to result in the most significant environmental consequences include:

- storage and disposal of process wastes (for example, oil sludge)
- loss of containment associated with pipeline failure or storage, handling and disposal of oil, fuels and chemicals
- disposal of general and chemical waste and contaminated soil
- emissions vented from satellite facilities and the Moomba Plant
- earthworks associated with pipeline/flowline and road construction
- vehicle movements.

Potential consequences associated with the above hazards include:

- contamination of soil, shallow groundwater resources and / or watercourses
- soil erosion and disturbance to natural drainage patterns
- loss of native vegetation and habitat
- introduction and / or spread of pest plants, animals and / or pathogens
- atmospheric pollution
- disturbance to Aboriginal and non-Aboriginal heritage sites
- impacts to public safety
- disturbance of, or injury, to native fauna or livestock
- impacts to stakeholder business reputation
- disruption of natural gas supply.

Potential environmental hazards and consequences associated with the operations are discussed in Sections 7.3 to 7.11.

7.2 Risk Assessment Process

Environmental risk is a measure of the likelihood and consequence of environmental harm occurring from an activity. Environmental risk assessment is used to differentiate minor acceptable risks from major risks, and to provide a basis for further evaluation and management of major risks.

An environmental risk assessment of activities involved with production and processing operations has been undertaken using the risk assessment framework set out in the Santos Management System (SMS). This framework is based on the principles of Australian Standard AS/NZS ISO 31000:2018 Risk Management.

The risk assessment process is outlined in Figure 7-1.

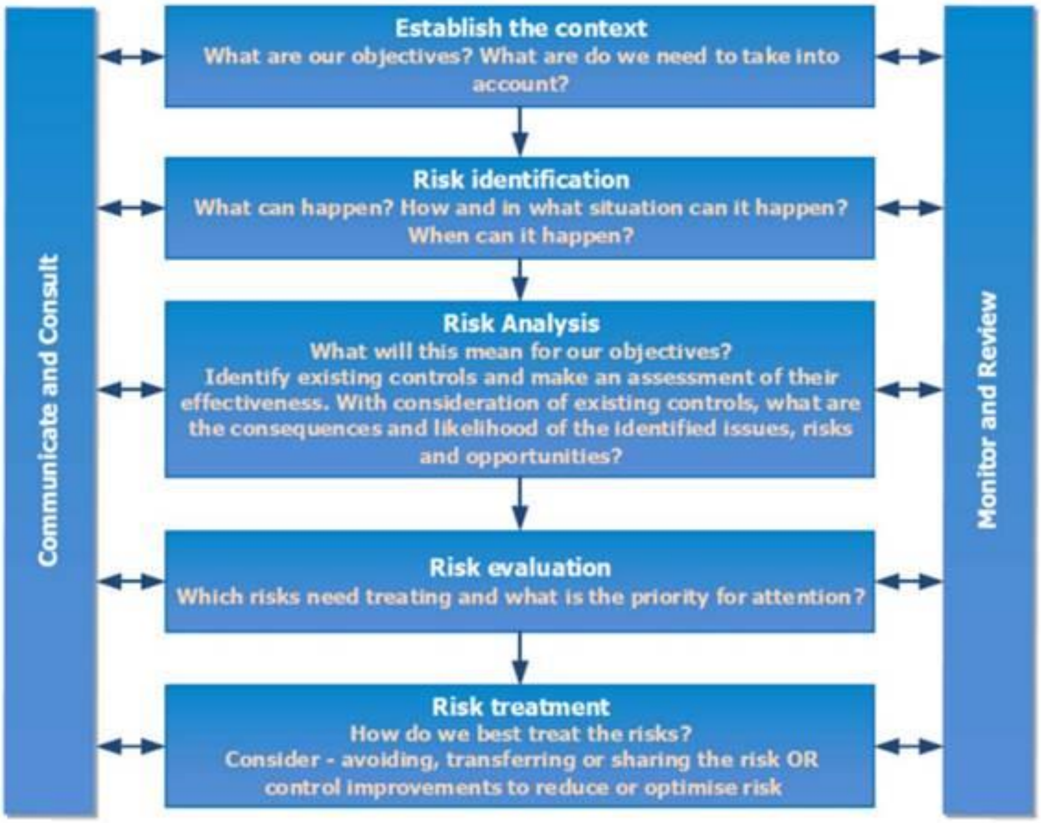


Figure 7-1: Framework for environmental risk assessment

The environmental risk assessment for production and processing operations has been undertaken based on the assumption that the management practices identified in this EIR are in place (i.e., the risk assessment presents the residual risk).

The risk assessment has been developed by Santos personnel, based on knowledge of the Cooper Basin environment and operating experience in the Cooper Basin. The Cooper Basin operation is an existing operation and environmental hazards and existing management measures are well understood.

The potential for risk to the environment as a result of production and processing operations has been evaluated using the Santos Operational Risk Matrix. This uses:

- six levels of environmental consequence to describe the severity, scale and duration of potential impacts
- six levels of likelihood of potential environmental consequences occurring. The likelihood refers to the probability of the particular consequences eventuating, rather than the probability of the hazard or event itself occurring, and
- a risk matrix to characterise the resultant risk into one of five levels.

Table 7-1 presents the Operational Risk Matrix used to evaluate risk.

The extent of the consequence is determined by the character of the receiving environment (i.e. gibber, dunefields, floodplain, etc.) the size and nature of the hazard (for example, road construction, pipeline failure, explosion, etc.) effectiveness of Santos' controls, procedures and guidelines in minimising potential impacts and past experience of Santos personnel or in the industry.

Santos also recognise that our activities may contribute to cumulative effects of the consequences of existing (or other party's) impacts in the Cooper Basin. Potential cumulative effects, or stakeholder concerns, may exist for aspects such as flora and fauna (through clearing of vegetation), groundwater (with using a natural resource), pest plants and animal species (with traversing numerous oil / gas fields and landholdings), and air quality (with fugitive and point source emissions).

Sections 7.3 to 7.11 discuss the potential hazards and consequences that may result from production and processing operations. Table 7-3 to Table 7-18 provide the details of controls implemented to mitigate risks associated with identified potential hazards and present the results of the risk assessment.

Table 7-1: Operational risk matrix

Consequence	Safety		**Negligible Harm** + No bodily damage or minimal harm or impairment (hours to days)	**Minor Harm** + Short term impairment (days to weeks)	**Moderate Harm** + Temporary disablement or medium term impairment (weeks to months)	**Severe Harm** + Long term/life altering disablement or impairment	**Single Fatality OR Critical Life Threatening Injuries**	**Multiple Fatalities**
	Environment		+ No impact to Environmental Value (EV).	+ Small-scale impact to EV(s) of conservation significance + Potential surface or groundwater impact.	+ Moderate-scale impact to EV(s) of conservation significance + Localised surface or groundwater impact.	+ Large-scale impact to EV(s) of conservation significance + Moderate-scale surface water impact; + Localised impact to groundwater with potential or known beneficial use.	+ Extensive population or community scale impact to EV(s) of conservation significance + Extensive impact to other EV(s).	+ Irreversible impact to EV(s).
	Community & Reputation		+ No actual or potential community criticism + Details remain within Santos sites and/or offices	+ Minor level local community criticism (< week) + No reputation impact	+ Local community criticism (> week) or one-day community protest + Local company reputation impacted	+ State-level community criticism or protest over multiple days/locations + State-based company reputation impacted + Very short-term share price impact (< week)	+ National community criticism or large scale protest + Company reputation and approvals impacted + Shareholder intervention or short-term share price impact (< month)	+ Sustained national community criticism or widespread protest + Industry reputation and approvals impacted + Changes at executive/board level or long-term share price impact (> month)
	Financial (A$)		< $30k	$30k to $300k	$300k to $3m	$3m to $30m	$30m to $300m	> $300m
	Workforce		+ Will require some staff attention over several days. + No actual or potential impact to culture	+ Will require several days local management time. + Minor impact to employee engagement and limited staff turnover	+ Will require head office staff and take several weeks of site management time. + Moderate impact to employee engagement and staff turnover above industry average with some key roles	+ Will require several weeks of senior management time + Impact to employee engagement (< 6 months), moderate turnover of key roles and no succession	+ Will require several months of senior management time + Impact to employee engagement (< 18 months), high staff turnover and attraction issues	+ Will require more than a year of senior management involvement and operations severely disrupted + Impact to employee engagement (> 18 months), significant key role turnover and attraction issues
	Compliance		+ Non-conformance with legislation, instruments (e.g. tenure licence) or contract + No regulatory or punitive action	+ Minor breach of legislation, instruments or contract + Notification/report to; request for information by; and/or administrative/ warning notice from the regulator + LOCI Tier 3 or non-hydrocarbon releases notifiable to the regulator	+ Limited number of minor breaches of legislation, instruments or contract + Statutory notice from the regulator + LOCI Tier 2 or non-hydrocarbon releases immediately reportable to the regulator	+ Systemic minor breaches (or one moderate breach) of legislation, instruments or contract + Company charged with an offence with minor penalty/fine + LOCI Tier 1 or cumulative regulator notification of non-hydrocarbon releases	+ Systemic moderate breaches (OR single material breach) of legislation, instruments or contract + Company charged with an offence with moderate penalty/fine	+ Material breaches of legislation, instruments or contract + Company or officers charged with an offence with material penalty/fine, or loss of tenure/operatorship
			I	II	III	IV	V	VI
Likelihood	ALMOST CERTAIN (< 4 monthly) Occurs in almost all circumstances OR could occur *within days to weeks*	f	Low	Medium	High	Very High	Very High	Very High
	LIKELY (4 monthly - 1 yearly) Occurs in most circumstances OR could occur *within weeks to months*	e	Low	Medium	High	High	Very High	Very High
	OCCASIONAL (1 - 3 yearly) Has occurred before in Santos OR could occur *within months to years*	d	Low	Low	Medium	High	High	Very High
	POSSIBLE (3 - 10 yearly) Has occurred before in the industry OR could occur *within the next few years*	c	Very Low	Low	Low	Medium	High	Very High
	UNLIKELY (10 - 30 yearly) Has occurred elsewhere OR could occur *within decades*	b	Very Low	Very Low	Low	Low	Medium	High
	REMOTE (30 - 100 yearly) Requires exceptional circumstances and is unlikely even in the long term OR only occurs as a *"one in 100 year event"*	a	Very Low	Very Low	Very Low	Low	Medium	Medium

7.3 Incident Response

In the event of an incident (such as an uncontrolled release), incident response will be implemented consistent with Santos standards and procedures. Further details of each stage of the Incident Response Framework are outlined below:

Immediate response following an incident

Upon becoming aware of an incident, actions must be initiated to:

- ensure safety of all persons in the area and site
- make the site safe and secure
- notify the person responsible for the site or activity and the relevant supervisor as soon as reasonably practicable
- minimise risk of further impact or incidents.

In the event of an environmental incident, such as a loss of containment, the SMS requirements will be implemented as follows:

- follow existing emergency response procedures
- preliminary assessment of risks posed (environmental, safety, stakeholder)
- complete a preliminary environmental assessment (PEA), including:
  - assessment of site topography and soil type(s)
  - identification of presence and proximity to any sensitive receptors in incident area, including:
    - surface water bodies including creeks, wetlands, depressions, drainage channels (wet or dry), tidal flats, ponds, springs
    - flora and fauna, including habitat (e.g. large trees, endangered species)
  - desktop groundwater assessment (approximate depth, if known)
  - livestock (presence and access to)
  - nearby building and other infrastructure
  - cultural heritage sites
  - other notable sources of risk.

Depending on the scale of an incident, response works may include:

- contain release:
  - use absorbent boom
  - construct downstream containment bund
- remove free fluids (where possible):
  - vacuum truck
  - sump pump
  - absorbent pads
  - spill kits
- remove contained fluids to alternative storage (i.e. above-ground tank or tanker)
- installation of fencing around impacted areas
- obtain clearances/permits if required (e.g. excavation, cultural heritage, environmental)
- clean up:
  - excavate impacted material
  - remove soil from site to an appropriate location (i.e. landfarm) in accordance with applicable regulatory requirements.

Incident notification and classification

Once the site is secured and the initial response actions implemented, the relevant supervisor must notify relevant persons (e.g. Health and Safety Representatives (HSRs), Environmental Advisers, Safety Advisers).

As part of this notification process the relevant supervisor must:

- ensure details of the incident are entered into the Santos Incident Management System (IMS) as soon as reasonably practicable
- classify the incident in accordance with Santos and relevant Regulatory requirements.

Internal incident investigation

As soon as practicable following notification and classification, an internal investigation is to be undertaken in accordance with Santos' standards and procedures.

Recommended actions and reporting

In order to appropriately learn from incidents and prevent reoccurrence, the following incident recommendations and reporting requirements are to be implemented:

- recommended actions from incident investigations must be reviewed by the responsible person
- recommended actions from investigations must be assigned via the IMS
- outcomes from investigations must be communicated to the workgroups involved.

Following initial notifications, completion of the PEA and response activities, an assessment to determine if the site has resulted in impact will be undertaken. Pending the outcomes of this assessment, further site assessment may be undertaken in accordance with Santos and regulatory requirements e.g. *National Environment Protection (Assessment of Site Contamination) Measure 1999*, amended 2013 (NEPC, 2013) and where required, remediated in line with relevant guidelines.

External reporting requirements, in accordance with the *Petroleum and Geothermal Energy Act 2000*, are stipulated in the SEO reporting table, which is developed by DEM in consultation with industry.

7.4 Pipelines

7.4.1 Pipeline construction

Environmental hazards associated with pipeline construction include:

- movement of heavy vehicles
- earthworks, including clearing and excavation
- storage and handling of fuels and chemicals
- generation of waste.

Pipelines are designed and constructed in accordance with applicable standards (e.g., AS 2885) to minimise potential for long term, adverse impacts to public and third-party safety and sensitive receiving environments. Construction activities are undertaken to comply with a Safety Management Study (developed at the design phase), the intent of which is to identify and address location and non-location specific threats, and implement the appropriate level of controls, commensurate with the level of risk.

The decision to construct either an above or below ground pipeline is influenced by existing infrastructure, the type of well that will be connected into the gathering system (oil or gas), the properties of produced fluid (i.e., temperature) and the anticipated flow rate.

Above ground pipelines traverse lands systems at the surface but are buried at road and / or creek crossings (with increased depth of cover) to minimise the potential for impacts to pipeline integrity.

Below ground pipelines are buried at a minimum depth of cover 750 mm, or greater, depending on the outcomes of the Safety Management Study. The Safety Management Study takes into consideration the land system, land use, topography and other surface features such as drainage lines or creek crossings across which the pipeline will be traversing.

Prior to commissioning new pipelines (above and below ground), lines are hydrotested in accordance with AS 2885 to test the integrity of the new infrastructure. If the newly constructed pipeline fails the hydrotest process, a repair is undertaken and the line is retested.

Flooding (as part of a natural flood event of the Cooper Creek floodplain and associated watercourses) and fire are also considered to be potential environmental hazards associated with pipeline construction and maintenance activities.

Land disturbance impacts associated with pipeline construction are managed in accordance with the relevant Santos standards. Important environmental values may be near Santos pipeline activities, therefore, prior to Greenfield disturbance, or subsequent re-disturbance, a Santos Environmental Adviser and / or ecologist inspects the site for potential sensitive receptors. The assessment, and any recommendations for mitigation, is managed via Santos systems. Approval conditions are in accordance with the relevant Santos standards, the PPO SEO and other relevant regulatory requirements must be accepted by the relevant project proponent prior to any on-ground works being undertaken.

Further to this, Santos implements an Environmental Sensitivity Profile (ESP) tool which identifies the environmental value(s) within the Cooper Basin and creates profiles of environmental sensitivity for specific areas based on these values (refer Section 5.1). The values are defined based on a sensitivity rating scale and enable the user to understand the sensitivity of the receiving environments in the Cooper Basin. Areas of sensitivity are defined by geographic location and identified spatially within a hierarchical layer over the Cooper Basin operational areas.

Movement of heavy vehicles

Movement of heavy vehicles (for example trucks, excavators and graders) during construction activities may present a hazard to native vegetation, soils and / or cultural heritage sites. Potential impacts include vehicles inadvertently causing damage to native flora and / or fauna habitat, introducing or spreading pest plants, compaction of soil (other than what is required operationally) and / or generating dust if not appropriately managed.

Earthworks

Earthworks, such as trenching, can result in consequences similar to the movement of heavy vehicles as well as potentially disturbing cultural heritage sites, altering surface water flows and exposing soils to wind and water erosion.

The type and severity of potential impacts associated with earthworks is dependent on the land system in which the activities are being carried out (see Table 7-2). Disturbance to soils in some land systems, such as gibber plains and tablelands, can result in uncontrolled erosion by water (Fatchen and Woodburn 2000, Woodburn and Fatchen 2008) while other systems, such as dunefields, are generally more resilient and less likely to be subjected to long-term impacts. More sensitive land systems, such as wetlands and salt lakes, require a higher level of control on activities. In most cases pipelines are not constructed in these land systems. Sensitive land systems can be difficult to reinstate and restore as they are susceptible to scarring.

The steeper slopes and escarpments of tableland land systems are avoided, where possible, for the construction of flowlines and access tracks due to their instability and the potential for erosion. Potential impacts specific to earthwork activities in the different Cooper Basin land systems are summarised in Table 7-2.

Construction activities also have the potential to introduce pest plant and animal species as a result of movement of vehicles and construction equipment mobilising from affected areas outside the region.

Construction activities along the ROW, such as clearing and site preparation, can result in short-term impacts to native vegetation and fauna habitat, which can potentially lead to:

- siltation of natural drainage lines and watercourses
- destabilisation of creek crossings
- introduction or spread of pest plant or animal species
- damage to cultural heritage sites
- impedance of native fauna movement within the construction zone, particularly small mammals or reptiles.

Most land systems in the Cooper Basin are naturally bare or unsheltered, and for this reason, the impedance of native fauna movement in terms of exposure (in cleared and open areas) to predators is unlikely (Moss and Low 1996).

Sand may be used during pipeline construction and backfilling. This material is generally not moved over large distances, however there is the potential for pest plants to be moved along with the construction material.

To minimise the potential impacts associated with earthwork and construction activities, Santos uses an internal assessment process to identify site-specific sensitivities. These sensitivities may include priority vegetation species or communities, vulnerable native fauna habitat, land systems (i.e. dunes or salt lakes) or drainage/creek systems. Once identified, a series of work program conditions will be developed to address the risk and minimise impact. Work program conditions may include, but not be limited to:

- ROW to be limited to a specified width
- clearance of vegetation to be minimised where possible and include scraping at the surface rather than uprooting the plants
- rootstock to remain in place to facilitate regeneration
- where practicable, clearing should be undertaken progressively to avoid erosion of topsoil
- vehicles entering the Cooper Basin to be free from weeds; pest plant control to be undertaken in accordance with relevant Santos biosecurity procedures
- branches and logs from felled trees (where relevant) be relocated to nearby undisturbed areas (i.e. moved with a bulldozer and bucket) to provide alternative habitat for fauna species
- avoid disturbance and destruction of warrens, burrows and hollow logs where possible
- topsoil to be removed and stockpiled for rehabilitation purposes
- stockpiled vegetation shall be spread over the disturbed area after construction for the purpose of preserving and regenerating native vegetation, erosion control and providing animal habitat
- minimise the duration of time trenches are left open
- provide trench exit structures for fauna self-egress
- during construction activities, pipe to be strung with gaps to enable fauna movement across the pipeline
- where relevant, construction activities not to occur when low lying areas and the drainage channels are inundated
- construction management procedures to be implemented to minimise the risk of spills or leaks of chemicals or contaminated water

- spillages of wastes or contaminants that may cause environmental harm to be effectively contained and cleaned up.

Table 7-2: Impacts associated with pipeline-related earthworks in Cooper Basin land systems

Land System	Activity and Associated Impacts			
	Grading (ROW for buried and above ground pipelines)	**Trenching and backfilling**	**Excavation / digging (e.g. borrow pits)**	**Soil stockpiling**
Wetlands	N/A	N/A	N/A	N/A
Floodplains	▪ Vegetation clearance ▪ Soil erosion (wind and water) ▪ Soil compaction ▪ Disturbance of natural drainage systems restricted at creek crossings where practicable ▪ Disturbance to cultural heritage sites (generally low density of sites in floodplains) Note: Higher level of controls employed where required in sensitive areas	▪ Disturbance of natural drainage systems restricted at creek crossings where practicable) ▪ Inversion of the soil profile ▪ Disturbance to cultural heritage sites (generally low density of sites in floodplains) ▪ Impeded wildlife movement (for the duration that the trench is open) Note: Higher level of controls employed where required in sensitive areas	▪ Vegetation clearance ▪ Soil erosion (wind and water) ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites (generally low density of sites in floodplains) Note: Higher level of controls employed where required in sensitive areas	▪ Disturbance of natural drainage systems (e.g. siltation) ▪ Soil erosion (wind and water) Note: Higher level of controls employed where required in sensitive areas
Gibber plains	*(Grading is generally not undertaken on gibber plains)* ▪ Soil erosion (particularly susceptible to water erosion, e.g. severe gullying) ▪ Disturbance of natural drainage systems (e.g. siltation) ▪ Inversion of the soil profile ▪ Disturbance to cultural heritage sites	▪ Soil erosion (particularly susceptible to water erosion, e.g. severe gullying) ▪ Disturbance of natural drainage systems (e.g. siltation) ▪ Inversion of the soil profile ▪ Disturbance to cultural heritage sites ▪ Impeded wildlife movement (for the duration that the trench is open)	▪ Vegetation clearance ▪ Soil erosion (particularly susceptible to water erosion, e.g. severe gullying) ▪ Disturbance of natural drainage systems (e.g. siltation) ▪ Inversion of the soil profile ▪ Disturbance to cultural heritage sites	▪ Soil erosion (wind and water) ▪ Disturbance of natural drainage systems ▪ Inversion of the soil profile

<table>
<tr><th rowspan="2">Land System</th><th colspan="4">Activity and Associated Impacts</th></tr>
<tr><th>Grading
(ROW for buried and above ground pipelines)</th><th>Trenching and backfilling</th><th>Excavation / digging
(e.g. borrow pits)</th><th>Soil stockpiling</th></tr>
<tr><td>Tablelands</td><td>N/A
(Grading is generally not undertaken on tablelands)</td><td>▪ Soil erosion (particularly susceptible to water erosion, e.g. severe gullying)
▪ Soil compaction
▪ Disturbance of natural drainage systems (e.g. siltation)
▪ Inversion of the soil profile
▪ Disturbance to cultural heritage sites
▪ Impeded wildlife movement (for the duration that the trench is open)
Note: Construction avoided on steeper slopes and escarpments</td><td>N/A</td><td>▪ Soil erosion (wind and water)
▪ Disturbance of natural drainage systems
▪ Inversion of the soil profile
Note: Construction avoided on steeper slopes and escarpments</td></tr>
<tr><td>Dunefields</td><td>▪ Vegetation clearance
▪ Soil erosion (wind and water erosion)
▪ Disturbance to cultural heritage sites (dunefields near waterholes are typically of high Aboriginal cultural significance)</td><td>▪ Soil erosion (wind and water erosion)
▪ Disturbance to cultural heritage sites (dunefields near waterholes are typically of high Aboriginal cultural significance)
▪ Inversion of the soil profile
▪ Impeded wildlife movement (for the duration that the trench is open)</td><td>▪ Vegetation clearance
▪ Soil erosion (wind and water erosion)
▪ Disturbance to cultural heritage sites (dunefields near waterholes are typically of high Aboriginal cultural significance)
▪ Inversion of the soil profile</td><td>▪ Soil erosion (wind erosion)
▪ Inversion of the soil profile</td></tr>
<tr><td>Salt Lakes</td><td>N/A
(No construction on salt lakes)</td><td>N/A
(No construction on salt lakes)</td><td>N/A
(No construction on salt lakes)</td><td>N/A
(No construction on salt lakes)</td></tr>
</table>

Storage and handling of fuel and chemicals

Chemical and fuel storage areas and refuelling of construction equipment are potential point sources for loss of containment. The primary consequence of a loss of containment is the potential for localised contamination of soil and / or shallow groundwater resources at the construction site. Management strategies such as minimising the volume of fuel and chemical stored on site, storage in accordance with the Safety Data Sheet (SDS) and relevant Australian Standards or guidelines (such as AS 1940 and / or EPA Bunding Guidelines) and ensuring that appropriate spill response procedures are in place, are implemented to ensure that the residual risk to the environment is as low as reasonably practicable.

During pipeline commissioning, there is a potential for hydrotest water that may contain biocides and / or corrosion inhibitors to be released to grade resulting in localised soil and / or shallow groundwater resource contamination.

Hydrostatic test water, free of chemical additives and sourced from water bores (not of PFW make-up), may be released to ground adjacent to the construction area, provided it meets discharge guidelines (e.g. ANZECC (2000), ANZG (2018)). Hydrotest water, that contains additives, is released to existing lined evaporation ponds (generally PFW facilities) or to specifically constructed ponds sited to prevent impacts to surface or shallow groundwater.

Generation of waste

Waste generated during construction activities includes:

- minor volumes of general and / or putrescible waste associated with work crews
- construction and demolition waste, including pipe ends / off-cuts, rope spacers and timber skids and pallets
- waste oils, oily rags and chemicals
- hydrotest water.

If wastes are not managed, contamination of soil, waterways and / or shallow groundwater resources could occur. Litter is an aesthetic issue and can be a hazard to fauna.

Wastes generated as part of site works programs are managed in accordance with relevant Santos standards and applicable regulatory requirements. In general, waste will be segregated and stored securely on site for collection and transport to the Moomba WMF for recycling or disposal.

Flood or fire

The occurrence of a natural flood event or fire during pipeline construction and / or maintenance has the potential to result in soil erosion, loss of stockpiled topsoil and contamination of soil and watercourses with fuel, oils or chemicals that are used during the construction process.

Project planning, emergency response and flood watch procedures are management strategies employed to minimise the potential for environmental impacts associated with flooding events. During periods of high rainfall, monitoring of upstream weather conditions is undertaken to pre-empt downstream flooding, and where possible, provide early advice for demobilisation.

The potential consequences of fire resulting from pipeline construction and / or maintenance activities include loss of native vegetation and native fauna habitat, impacts to livestock and the production of particulate air emissions.

The hazards, potential consequences, management strategies and level of residual risk associated with pipeline construction are summarised in Table 7-3.

7.4.2 Pipeline operation

Environmental hazards associated with pipeline operation include:

- loss of containment of pipeline products
- handling and storage of fuels and chemicals
- generation of waste as part of inspection and maintenance activities
- potential disturbance to cultural heritage sites
- fire or explosion and other public safety risks.

Loss of containment of gas may cause reduced localised air quality or negatively impact greenhouse gas emission abatement. Loss of containment could potentially result in the development of clouds of unburnt gas which poses a safety risk if it encounters an ignition source, or for CCS pipelines, could potentially result in the concentration of CO_2 in low lying structures or topographic lows which could impact people, stock or fauna in those areas.

Loss of containment of oil and / or PFW may result in impacts to soil and / or shallow groundwater, surface waters, native vegetation and / or fauna habitat and health.

High pressure losses may lead to soil disturbance resulting in alteration of drainage lines, erosion and siltation.

The severity of impacts from loss of containment is dependent on:

- land systems
- proximity to sensitive receptors (i.e. native vegetation, native fauna and / or fauna habitat and livestock
- third party groundwater users.

To minimise the risk of impact to public and third-party safety and the environment, pipelines are operated in accordance with relevant engineering standards.

As discussed in Section 4.2.1, all new Santos pipelines and flowlines are designed, tested and constructed in general accordance with AS 2885 and Santos engineering standards, respectively. To ensure the integrity and safe operation of Santos pipelines and flowlines, they are maintained in accordance with the Santos Integrated Management System.

The primary hazard associated with pipeline operation is the loss of containment (of oil, gas or PFW) through:

- corrosion of the pipeline (external or internal)
- line strike (i.e. unintentional contact with buried pipeline during excavation)
- heavy vehicle traffic (i.e. inadequate depth of cover to protect buried pipelines from vehicle weight and soil compaction at crossing locations)
- vehicle impact (i.e. collision with an aboveground pipeline)
- natural events which stress the pipeline (e.g. flooding, bushfire)
- overpressure events
- metallurgical, material or construction faults
- aging infrastructure (i.e. corrosion).

With the exception of construction, maintaining pipeline integrity is the primary control for minimising the potential for failure. The risk of pipeline failure during operations is generally subject to the following threats:

- Internal:

  - over pressure / pressure cycling
  - acid gas (CO_2 / H_2S) corrosion
  - microbiologically influenced corrosion (MIC)
  - erosion.
- External:
  - soil / atmospheric corrosion / coating disbondment / CP level / water ingress
  - environmental stress corrosion cracking
  - impact damage
- mechanical joint failure
- low cycle (thermal) fatigue.

Whilst there are other threats that can affect pipeline integrity, they are generally considered and mitigated during design and construction, e.g. through the Safety Management Study process (refer to Section 7.4.1).

To minimise the potential for failure and optimise pipeline longevity, Santos uses an Integrity Management Plan (IMP). The IMP provides a systematic approach to pipeline operation and maintenance activities in conjunction with the application of appropriate standards to minimise risk to public and third-party safety, and the environment.

IMPs have been developed for existing pipelines, and IMPs are developed for new pipelines as part of the design phase. IMPs are periodically reviewed and updated as required. The intent of the IMP is to:

- identify relevant threats to the pipeline whilst operational
- determine the mitigation, monitoring and inspection activities and associated frequencies
- support program planning to achieve the required life of each line.

The condition of protection barriers (i.e. corrosion / erosion allowance, coatings, pressure / temperature / velocity limits) is evaluated to forecast the operational life of each pipeline. The monitoring, mitigation and inspection activities undertaken to maintain integrity and minimise the risk of failure include, but are not limited to:

- monitoring:
  - pressure, temperature and flowrate monitoring
  - corrosion rate monitoring (ER probe / weight-loss coupon)
  - water sampling and analysis
  - pig trash sampling and analysis
  - chemical injector checks
  - CP transformer rectifier checks
  - CP test post potential checks
- mitigation:
  - pigging
  - corrosion inhibitor injection
  - batch chemical treatment
  - cathodic protection (CP)
  - lifting and supporting
  - coating maintenance
  - ROW maintenance
- inspection:
  - in-line inspection (ILI) by intelligent pig
  - direct assessment: visual inspection and non-destructive testing

- direct current voltage gradient (DCVG) coating defect surveys
- ROW Surveys

Santos collates the results from the monitoring, mitigation and inspection activities and uploads the information to the Santos Integrated Management System database/s. These databases store pipeline data including, but not limited to:

- operational status
- design specifications
- risk profile
- test and audit information
- maintenance and repair history.

The information stored in the Integrated Management System databases is used to support the IMP. The Integrated Management System databases form part of the greater Santos Management System.

Land systems

In dry environments, such as dunefields and gibber, the potential for early containment of fluids because of a loss of containment is higher than in wet and / or more sensitive environments, such as wetlands or floodplains. In dry environments access and therefore release containment is generally more manageable and therefore environmental impacts are more likely to be localised and of lower consequence.

The release of fluids to grade in wet and more sensitive environments, such as the Cooper and Strzelecki Creeks (and surrounding floodplains and wetlands) poses a higher environmental risk than in drier environments. Incident response including containment and recovery in sensitive areas is generally more difficult and therefore the overall consequence may be higher. Additional controls, such as modified casing design for creek crossings, are employed to minimise the risk in these areas.

During periods of high rainfall and / or flooding, the challenges associated with containment and recovery may be exacerbated with the potential for released fluids to spread over large areas (and distances away from the source), throughout sensitive ecosystems.

Sensitive environments

The Coongie Lakes Ramsar wetland covers approximately 1.9 million hectares of the Cooper Basin floodplain and comprises a series of perennial and / or ephemeral freshwater wetlands, lakes, interdune corridors, channels floodplains and swamps with limited connection to the Cooper Creek system. It also covers extensive areas of dunefields with no hydrological connection to Cooper Creek and Coongie Lakes. Hundreds of oil and gas wells currently operate within the designated Ramsar area.

New and / or re-disturbances are subject to an environmental assessment process which is undertaken in accordance with the Santos Environmental Approvals Procedure, the SEO and recommendations made based on field observations. Ramsar wetlands are recognised as a matter of international environmental significance under the EPBC Act.

As detailed above, Santos has control measures in place to minimise potential impacts to soil and surface water systems from pipeline construction, maintenance and operation of the pipeline and does not undertake activities within one km of the Coongie Lakes National Park.

Pipelines are a potential hazard within sensitive environments.

Proximity to native fauna, livestock and vegetation

Potential impacts to livestock, native fauna and vegetation are primarily due to:

- loss of containment from the storage and handling fuels, chemicals, gas or produced fluids (e.g. PFW)

- use of roads and movement of vehicles and machinery
- activity outside of operational areas
- fuel, chemical and waste storage and transport.

Livestock and native fauna access to fuel, chemicals and fluid storage areas is managed in accordance with the SMS, EPA Bunding Guidelines and AS 1940.

Specific controls include:

- ecological assessment of new pipelines to evaluate sensitivity, including habitat assessment
- storage of fuels and chemicals in designated areas
- scheduled (and / or upon request) removal of waste from operational sites
- spill response for fuel or chemical loss of containment
- erection of fencing around infrastructure to limit access by livestock and native fauna, where required
- regular and ongoing inspections by site operators to ensure integrity of site controls, such as fencing.

Increased vehicle trafficking associated with pipeline operations has the potential to impact livestock, native fauna and vegetation.

The risk to native vegetation associated with driving outside of cleared areas includes impact to or destruction of rare or endangered species and associated habitat and degradation of important flora communities. There are also potential cultural heritage consequences. Santos implements the relevant safety standard to reduce the risk of vehicle collisions with livestock and native fauna. Controls within the standard include:

- no unapproved off-road driving
- adherence to specified speed limits
- use of In Vehicle Monitoring System (IVMS) to track speed, route and harsh braking
- minimising night-time driving to the greatest extent practicable
- driver education programs.

Off-road driving by Santos personnel and contractors is prohibited, without prior approval. The risk to native vegetation associated with driving outside of cleared areas includes impact to or destruction of rare or endangered species and associated habitat and degradation of important flora communities. Where areas of sensitive vegetation are identified they will be made obvious with flagging and signposted to indicate that restricted access applies.

Gathering system operations may introduce hazards associated with the introduction of pest plants or animals, or pathogens, leading to impacts to native vegetation and fauna.

Windblown litter and scavenger access has the potential to impact livestock, native fauna and vegetation.

As outlined above, prior to new pipeline disturbance, an assessment is undertaken to evaluate the sensitivity of a proposed location. The results of the assessment are used to inform the internal approvals process from which a set of conditions is generated. The objective of these conditions is to provide a set of guidelines for pipeline construction and operation and to minimise the likelihood of impacts to the environment outside of the area cleared for operation.

Third-party groundwater users

Beneficial use of groundwater in the region is generally limited to livestock watering and construction activities, see Section 5.4.3. Pastoral bores in the region are generally less than 200 m deep and intersect unconfined and semi-confined aquifer formations. Hazards with the potential to impact third party groundwater users include water extraction for construction or hydrotest activities and / or loss of containment resulting in shallow groundwater resource contamination.

Storage and handling of fuel and chemicals

Loss of containment of fuels and chemicals may result in contamination of soils, shallow groundwater resource and / or waterways.

The storage and handling of fuel and chemicals is undertaken in accordance with the Safety Data Sheet (SDS), the SMS, EPA Bunding Guidelines and AS 1940 to minimise impacts to soil and / or shallow groundwater. This includes, but is not limited to:

- fuels and chemicals stored with appropriate secondary containment such as double skinned tanks (fuel storage)
- storage of fluids in systems with 110% bunded capacity
- training personnel in emergency spill response
- chemical and dangerous goods handling and
- use of spill kits.

Waste management

Waste, if not managed, may result in impacts to soil, shallow groundwater resource and / or waterways, or may impact native vegetation, native fauna or livestock.

Pipeline / equipment maintenance operations generate relatively limited waste streams such as:

- oily rags
- spent packaging and containers
- redundant equipment, pipe off-cuts and other plant/materials from repair and maintenance activities
- wastewater and sludge.

Waste management is undertaken in accordance with Santos standards and the Cooper Basin Waste Management Plan. These promote the application of the waste management hierarchy.

Aboriginal and non-Aboriginal cultural heritage sites

Activities associated with production and processing, in particular excavation activities associated with construction, may impact Aboriginal and non-Aboriginal heritage sites.

Most frequently, cultural heritage is encountered during initial field scouting and line-of-sight surveys, or during cultural heritage clearances. Less frequently, cultural heritage is identified during operational activities and after cultural heritage assessment approvals have been obtained.

Activity outside of a cleared area is strictly controlled, and measures such as signage or fencing are installed (where required) to delineate restricted access to cultural heritage sites. Consequently, the potential for impacts to cultural heritage is low.

Workforce awareness training and incident response provide a level of control for the discovery of cultural heritage items and / or sites.

Where cultural heritage is discovered, the person discovering the cultural heritage must undertake the following actions immediately, even if an approved cultural heritage assessment is in place:

- stop all activity that could, in any way, interfere with or disturb the discovered cultural heritage
- declare and place a 50 m radius exclusion zone around the cultural heritage discovery
- notify the site supervisor and Cultural Heritage Team.

Santos Cultural Heritage Standards and Procedures outline the process, requirements and those responsible for managing the discovery. No activity can be undertaken within the exclusion zone until the stop work order is removed by the Cultural Heritage Team.

Public safety

Most sites in the Cooper Basin are relatively remote from public roads and have little or no public access. Potential sources of risk to the public, landholders and other third parties principally arise from unauthorised access resulting in exposure to site hazards and the use of roads and movement of vehicles and heavy machinery. Fire and explosion may also increase risks to public safety.

Unauthorised access to operational areas is prevented through the use of signage, fencing, and liaison with stakeholders (e.g. through landholder liaison processes).

Pipeline operations can result in short term and localised increase in vehicle traffic on public roads from time to time. The existing road network in the Cooper Basin is heavily used by the oil and gas industry and the incremental increase is not considered to be significant. Santos employs controls, outlined in relevant standards, to manage the risks of road use. Controls include adherence to specified speed limits, use of In Vehicle Monitoring System (IVMS) to track speed, route and harsh braking, minimising night-time driving and driver education programs.

Fire (natural or as a result of Santos activities) and / or explosion are possible hazards associated with pipeline operation. A fire or explosion along a pipeline poses a potential risk to public safety and third party assets (such as livestock) and could produce atmospheric emissions. Santos procedures aim to reduce the potential for explosion or fire and loss of containment.

The hazards, potential consequences, management strategies and level of residual risk associated with pipeline operation are summarised in Table 7-3.

7.4.3 Pipeline decommissioning

The potential consequences associated with pipeline decommissioning are similar to the construction phase and may include:

- impacts to native fauna, vegetation and drainage patterns
- soil compaction, erosion and siltation
- injury to native fauna or livestock
- potential damage to third party assets or cultural heritage sites
- impacts to soil, waterways and / or shallow groundwater resource from loss of containment, or chemical and fuel storage and handling or management of wastes.

The key steps in decommissioning and restoration are described in detail in Section 4.2.7.

Plans for decommissioning and restoration are developed in consultation with DEM and relevant stakeholders.

In the event of a fire or explosion during decommissioning activities, release of particulate emissions to air and generation of waste materials may pose a risk to the environment.

The hazards, potential consequences, management strategies and level of residual risk associated with pipeline decommissioning are summarised in Table 7-3.

Table 7-3: Pipelines - pipeline construction, operation and decommissioning risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Pipeline construction	Impacts to native vegetation and fauna, erosion and siltation of watercourses	Vegetation clearing	▪ Impeded native fauna movement through construction zone ▪ Loss of native vegetation and fauna habitat ▪ Significant damage to native vegetation ▪ Siltation of watercourses ▪ Erosion ▪ Short to medium term loss of visual amenity ▪ Introduction and / or spread of pest plants	**Design** ▪ Minimise vegetation disturbance, and plan construction to avoid areas of sensitive vegetation. ▪ Use existing routes / disturbed ground where practicable. ▪ Sensitive environments and Ramsar sites are considered during route selection. ▪ Avoid important or 'priority' native vegetation[5] where possible. ▪ Facilities are designed and constructed to minimise impacts to native fauna. ▪ Undertaking a Safety Management Study during the design process to address location and non-location specific threats and develop adequate controls to mitigate environmental and public/third party safety risk **Systems** ▪ Use of Santos systems for vegetation clearance approvals, which triggers further assessment where required. ▪ Prior to greenfield disturbance, or subsequent re-disturbance, a Santos Environmental Adviser and / or ecologist undertakes an environmental assessment in accordance with the relevant Santos standards, the SEO and recommendations based on field inspections, which includes a site inspection for potential sensitive receptors. ▪ Relevant internal and external approvals in place before work undertaken. ▪ Implementation of the Environmental Sensitivity Profile (ESP) tool to assess proposed pipeline routes for rare, vulnerable and endangered flora and fauna species before the commencement of construction and implement appropriate avoidance or mitigation measures. ▪ Stockpile and clear vegetation and respread following construction works to facilitate revegetation. ▪ Where possible trim vegetation rather than clearing. ▪ Unauthorised off-road or off-lease driving or creation of shortcuts is unacceptable. ▪ Implementation of the Cooper Basin Pest Plants and Animals Management Plan.	**E** **C&R** **C**	**II**	**c**	2
Pipeline construction and decommissioning	Impacts to soil, natural drainage lines, native vegetation and fauna, and third party assets (livestock and infrastructure)	Earthworks, including grading, trenching, backfilling, reinstating and stockpiling	▪ Contamination of soil, surface water and / or shallow groundwater resources ▪ Inversion of soil profile ▪ Dust generation ▪ Soil compaction ▪ Soil erosion ▪ Impacts to natural drainage patterns ▪ Siltation of watercourses ▪ Impacts to native vegetation ▪ Impeded native fauna movement through construction/decommissioning zone ▪ Injury or loss of native fauna or livestock ▪ Loss of visual amenity ▪ Introduction and / or spread of pest plants ▪ Damage/disturbance to landholder/stakeholder infrastructure and activities and business reputation	**General** ▪ Undertaking a Safety Management Study during the design process to address location and non-location specific threats and develop adequate controls to mitigate environmental and public / third party safety risk. ▪ Relevant internal and external approvals (Notice of Entry) in place before work undertaken. ▪ Consider alternate routes, locations and construction methods during construction phase planning and scouting to minimise environmental impacts. ▪ Implementation of the ESP tool to assess proposed pipeline routes for rare, vulnerable and endangered flora and fauna species before the commencement of construction and implement appropriate avoidance or mitigation measures. ▪ Minimise impact by restricting earthworks to the minimum area necessary. Use existing routes/disturbed ground where practicable. ▪ Minimise the time trench lines and excavations remain open, with a corresponding increase in the frequency of native fauna exit structures. ▪ Observation of procedures for location of services and infrastructure. ▪ Obtain excavation permits where required. ▪ Minimise vegetation disturbance, and plan works to avoid sensitive vegetation areas and significant or "priority" vegetation. ▪ Removal of waste to minimise visual impact and attraction of pests.	**S** **E** **F** **C**	**II**	**c**	2

[5] In the Cooper Basin, important vegetation typically includes:

- Plants of Priority 1 or 2 species as defined in the *Field Guide to the Common Plants of the Cooper Basin – South Australia and Queensland* (Whiltshire and Schmidt, 2003) (the Field Guide). This predominantly includes tree and larger shrub species that are long lived and / or do not regenerate readily from seed or rootstock.
- Vegetation that is restricted in distribution and / or is locally important (e.g. for habitat or for land stability)
- Vegetation communities identified as conservation priorities in the South Australian Arid Lands Biodiversity Strategy (DEH 2009).

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
			▪ Litter	▪ Construction wastes are managed in accordance with relevant Santos standards, which includes the use of secure storage and transport of wastes. ▪ Application of the waste hierarchy system (avoid, reduce, reuse, recycle, treat, and dispose). ▪ Procurement processes and contracts manage contractor's activities. ▪ Contractors are required to comply with Santos standards and procedures, which are incorporated into requirements of the procurement/tender process. ▪ Construction activities are undertaken in accordance with Santos standards and procedures. ▪ Monitor pest plants when present, within the construction area for outbreaks and where necessary implement control measures. **Sensitive Environments** ▪ Where the EPBC Act is potentially triggered as a result of pipeline operations (and failure of controls), Santos will comply with legal requirements as they arise. ▪ Pipeline activities are not undertaken within one kilometre of the Coongie Lakes National Park. ▪ All new and / or re-disturbances are subject to an environmental assessment in accordance with relevant Santos standards. **Soil** ▪ Unauthorised off-road or off-lease driving or creation of shortcuts is unacceptable. ▪ Sensitive gibber terrain is protected through appropriate construction and maintenance practices. ▪ Construction activities are not carried out on salt lakes as a preference. ▪ Off road/lease disturbance and first disturbances are undertaken in accordance with Santos standards. ▪ Management of sensitive areas (e.g. sloped areas or gibber) is detailed in scope of works, approval documents and company procedures. **Water** ▪ Pipeline routes are located and constructed to minimise impact to water flows (e.g. channel contours are maintained on floodplains and at creek crossings). ▪ Where required, detailed hydrological assessment is undertaken for structures such as above ground pipelines to ensure no significant impacts on surface water flows or aquatic fauna (e.g. fish passage must be maintained). ▪ Sensitive land systems (e.g. wetlands) are avoided where possible. Where activities are undertaken in or near these areas, appropriate review, assessment and mitigation measures are in place to ensure that surface water flows are maintained and impacts to surface water and shallow groundwater resources is avoided. ▪ Monitoring of erosion and drainage patterns post-construction and corrective actions implemented where required. **Reinstatement (at Construction) and Restoration (at Decommissioning)** ▪ Reinstate construction areas as soon as possible. ▪ Rip areas of compacted soil (except on gibber plains and tableland environments). ▪ Respread topsoil and stockpiled vegetation seed stock to facilitate revegetation. ▪ Restore natural contours to minimise impacts to natural drainage patterns. ▪ Pig pipelines to remove residual hydrocarbons and sludge. ▪ Assess the site for any contamination and remediate and validate where required. **Landholders** ▪ Dust suppression measures carried out where required to minimise safety hazards associated with poor visibility. ▪ Landholders are consulted as required where activities may affect pastoral operations and notified prior to survey, construction and undertaking of operations (pursuant to Regulations). ▪ Induction of employee and contractor personnel with respect to pastoral landholders including issues such as use of gates, fencing and infrastructure. ▪ Systems are in place for logging landholder complaints to ensure that issues are addressed as appropriate. ▪ Minimise the time that areas are open by undertaking progressive clearing and reinstatement of vegetation.				

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Pipeline construction and decommissioning	Disturbance to cultural heritage sites	Earthworks	▪ Disturbance or damage to cultural heritage sites	**Systems** ▪ Observation of procedures and guidelines for the identification, management and protection of cultural heritage sites. ▪ Consultation with stakeholders (i.e. native title groups, government agencies, landholders etc.) in relation to the possible existence of cultural heritage sites. ▪ Appropriate cultural heritage training is provided for the level of access required (e.g. additional training for first disturbance or authorised off-road/off-lease activities). ▪ Potential cultural heritage sites are avoided during scouting. ▪ Inspections and checks of cultural heritage clearances areas. ▪ Processes are in place to meet requirements of legislation and agreements with native title claimant groups with respect to protection and reporting of discovery of unknown heritage sites during pipeline construction and decommissioning activities. ▪ Use of Cultural Heritage Assessment Request (CHAR) process.	**S** **F** **C&R** **C**	**III**	**d**	**3**
Pipeline construction and decommissioning	Impacts to native vegetation and fauna	Movement of construction materials (earthworks)	▪ Introduction and / or spread of pest plants	**Systems** ▪ Consultation with landholders in relation to the possible existence of pest plants. ▪ Induction of employee and contractor personnel with respect to existence and spread of pest plants. ▪ Ensure that imported material is from an area considered to be pest plant/disease free. ▪ Implementation of Cooper Basin Pest Plants and Animals Management Plan. **Response** ▪ Monitor pest plants when present, within the construction area for outbreaks and where necessary implement control measures.	**E**	**II**	**c**	**2**
Pipeline construction, operation and decommissioning	Impacts to native vegetation and fauna, erosion and siltation of watercourses	Movement of heavy machinery and vehicles	▪ Dust generation ▪ Soil compaction ▪ Erosion ▪ Damage to native vegetation ▪ Injury or death of native fauna ▪ Introduction and / or spread of pest plants ▪ Damage to third party infrastructure ▪ Disruption to land use (e.g. grazing and recreation) ▪ Increased public access to remote areas	**Design** ▪ Rip areas of compacted soils (except on gibber and tableland environments) where required. ▪ Consultation with landholders in relation to proposed routes. ▪ Minimise the creation of new access tracks. ▪ Undertake a Safety Management Study during the design process to address location and non-location specific threats and develop adequate controls to mitigate environmental and public / third party safety risk. **Systems** ▪ Driving on designated areas only (i.e. lease and access tracks). ▪ Unauthorised off-road or off-lease driving or creation of shortcuts is unacceptable. ▪ Signage and road closures where appropriate. ▪ Where areas of sensitive vegetation are identified they will be flagged and signposted to indicate restricted access applies. ▪ Communication of heavy vehicle movement and other potential hazards to safety associated with pipeline operations to potentially affected parties prior to commencement of operations. ▪ Dust suppression as required. ▪ Adherence to applicable road safety and transport legislation. ▪ Induction of employees and contractor personnel with respect to road use and driver behaviour, conservation and tourism. ▪ Implementation of a traffic management plan where required. ▪ Internal approvals system.	**S** **E** **F** **C&R** **C**	**III**	**c**	**2**
Pipeline construction and decommissioning	Disturbance to cultural heritage sites	Movement of heavy machinery and vehicles	▪ Disturbance or damage to cultural heritage sites	**Systems** ▪ Observation of procedures and guidelines for the identification, management and protection of cultural heritage sites. ▪ Consultation with stakeholders (i.e. native title groups, government agencies, landholders etc.) in relation to the possible existence of cultural heritage sites.	**S** **E** **F** **C&R** **C**	**III**	**b**	**2**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
				▪ Appropriate cultural heritage training is provided for the level of access required (e.g. additional training for first disturbance or authorised off-road / off-lease activities). ▪ Potential cultural heritage sites are managed in liaison with relevant stakeholders. This may include avoiding a site during scouting activities. ▪ Processes are in place to meet requirements of legislation and agreements with native title claimant groups with respect to protection and reporting of discovery of unknown heritage sites during pipeline construction and decommissioning activities. ▪ Signage to indicate public versus private roads and access tracks to discourage third party access to infrastructure, and / or cultural heritage sites. ▪ Audits of cultural heritage clearances areas.				
Pipeline construction, operation and decommissioning	Impacts to public safety and collision with livestock or native fauna resulting in injury or loss	Movement of heavy machinery and vehicles	▪ Collision with livestock or native fauna resulting in injury or loss ▪ Potential impacts to public safety	**Design** ▪ Pipeline operations are undertaken at locations where public access is restricted. ▪ Undertake a Safety Management Study during the design process to address location and non-location specific threats and develop adequate controls to mitigate environmental and public/third party safety risk. **Systems** ▪ Active promotion of appropriate road use behaviours. ▪ Induction of employees and contractor personnel with respect to road use and driver behaviour. ▪ Use of In Vehicle Monitoring System (IVMS) to track speed, route and harsh braking for entire workforce, including contractors and / or other appropriate journey management systems. ▪ Setting of appropriate speed limits for Santos personnel and contractors. ▪ Driver awareness training mandatory for company and contractor personnel. ▪ Policy of driving with vehicle lights on. ▪ Minimising night-time driving to the greatest extent possible. ▪ Signage throughout the Cooper Basin to warn of possible hazards on the roads. ▪ Driving on designated areas only (i.e. access tracks and designated lease areas). ▪ Procurement and contract management includes Environmental and Workplace Health and Safety Management Plan pre-qualification. ▪ Implementation of a construction management plan for contractors. **Response** ▪ Reporting systems in place for recording injuries and accidents.	**S** **E** **C&R** **C**	**I**	**c**	**1**
Pipeline construction, operation and decommissioning	Contamination of soil and / or shallow groundwater resources, erosion and impacts to native vegetation	Flooding of surrounding floodplain/watercourses	▪ Contamination of soil, surface water and / or shallow groundwater resources ▪ Soil erosion and siltation of watercourses ▪ Loss of vegetation and topsoil (either stockpiled or in situ)	**Design** ▪ Erosion control measures in place, where appropriate. ▪ Nodal compressors are typically located in dry environments. **Systems** ▪ Monitoring of Cooper Basin weather patterns. ▪ Works programs in floodplain areas scheduled to take into account seasonal conditions and rainfall/flood likelihood. ▪ Construction activity not undertaken during flood warning period. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ Control strategies for fuel, oil and chemical storage and handling. **Response** ▪ Fencing of affected areas if threat is posed to livestock or native fauna.	**E** **F**	**III**	**a**	**1**
Pipeline construction, operation and decommissioning	Contamination of soil and / or shallow groundwater resources and potential impacts to public safety.	Loss of containment of gas, sludge or oil	▪ Contamination of soil, surface water and / or shallow groundwater resources ▪ Impacts to native vegetation ▪ Potential impact to third party groundwater users	**Design** ▪ Fit for purpose equipment. ▪ Installation of emergency isolation valves where required.	**E** **F** **C&R** **C**	**III**	**c**	**2**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
			▪ Impacts or injury to, or loss of, livestock and native fauna ▪ Impacts to stakeholder business reputation ▪ Localised reduction in air quality with greenhouse gas emissions ▪ Explosion with purging and venting of hydrocarbon gases ▪ Potential impacts to public safety ▪ Fire or explosion	▪ All new Santos pipelines are designed, tested and constructed in general accordance with AS 2885 requirements to have sufficient strength, ductility and toughness to withstand design loads to which it may be subjected during construction, testing and operation. **Systems** ▪ Undertake a Safety Management Study during the design process to address location and non-location specific threats and develop adequate controls to mitigate environmental and public / third party safety risk. ▪ Safety, testing, maintenance and inspection procedures are implemented according to the IMP. ▪ Prestart-up checklist prior to commissioning and decommissioning activities. ▪ Pipeline construction integrity verification e.g. hydrotest (records maintained). ▪ Supported above ground pipelines are inspected to minimise the potential for contact with surface soils as a result of sand / sand drift or failure of pipe supports. ▪ Adherence to Santos standards and implementation of management systems to monitor infrastructure. ▪ Santos safety checks, inspections and risk assessments. ▪ QA / QC checks prior to hydrocarbon introduction into pipe. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with pipeline construction and operation. ▪ Personnel are trained to supervise and instruct individuals entering lease to conduct work. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct work on a lease. ▪ Hazardous area management criteria are followed. ▪ Monitoring of weather conditions. ▪ Restricted access to site. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ Pipeline HC removal (via pigging) prior to decommissioning. ▪ Regularly educate staff on emergency response procedures. **Response** ▪ Appropriate emergency response plans are in place. ▪ Annual review and exercise of response equipment and procedures to ensure preparedness. ▪ Emergency spill response equipment on site. ▪ Spill response and clean up. ▪ Fencing of impacted areas if threat is posed to native fauna or livestock. ▪ Areas assessed for contamination and remediated where required on decommissioning.				

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Pipeline construction, operation and decommissioning	Contamination of soil and / or shallow groundwater resources	Loss of containment of chemicals, fuel or hydrotest water	▪ Contamination of soil, waterways and / or shallow groundwater resources ▪ Exposure of contaminants by native fauna and livestock ▪ Impacts to native vegetation or fauna habitats ▪ Impacts to third party groundwater users ▪ Impacts to stakeholder business reputation	**Systems** ▪ Undertake a Safety Management Study during the design process to address location and non-location specific threats and develop adequate controls to mitigate environmental and public / third party safety risk. ▪ Fuel, oil and chemical storage and handling in accordance with the Safety Data Sheet (SDS), SMS, EPA Bunding Guidelines and AS 1940. ▪ Regularly educate staff of product, review and monitor chemical and fuel storage, including signage / labelling, proper packing and tie downs. ▪ Regularly educate staff on emergency response procedures. ▪ Use of biocides and corrosion inhibitor chemicals are kept to a minimum and where practicable biocides which degrade rapidly when exposed to UV are used. ▪ Management of water containing biocide, other chemicals or hydrocarbons, may either be into existing lined and fenced evaporation ponds, or to satellite facility pond systems. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. **Fauna** ▪ Livestock and native fauna access to fuel, chemicals and fluid storage areas is managed by the relevant Santos standards. ▪ Specific controls include: - ecological assessment of new proposed lease sites to evaluate sensitivity, including habitat assessment - storage of fuels and chemicals in designated areas - scheduled (and / or upon request) removal of waste from operational sites - spill response and clean up - pond construction to include steep sided edges to prohibit vegetation growth and / or creation of beaches which could attract birdlife - erection of fencing around infrastructure to limit access by livestock and native fauna, where required - regular and ongoing inspections by site operators to ensure integrity of site controls, such as fencing. **Response** ▪ Implementation of appropriate emergency/spill response procedures. ▪ Annual review and exercise of response equipment and procedures to ensure preparedness. ▪ Spill response and clean up. ▪ Fencing of impacted areas if threat is posed to native fauna or livestock.	**E** **F** **C&R** **C**	**II**	**c**	**2**
Pipeline construction, operation and decommissioning	Contamination of soil and / or shallow groundwater resources and potential impacts to public safety	Ignition of fire along ROW during construction	▪ Potential impacts to public safety ▪ Damage to third party infrastructure ▪ Localised reduction in air quality with generation of greenhouse gas emissions	**Systems** ▪ Operation under fire permit requirements. ▪ Personnel are trained to supervise and instruct individuals entering area to conduct work. ▪ Safe work permits and hot work permits must be obtained to ensure only individuals with proper clearance can conduct works. ▪ Management plans and procedures for construction and decommissioning activities include fire management and firewatchers, as required. ▪ Safety, testing, maintenance and inspection procedures are implemented. **Response** ▪ Emergency response procedures contain a bushfire scenario. ▪ Implementation of appropriate emergency response procedures ▪ Spill response and clean up.	**S** **E** **F** **C&R** **Cs**	**II**	**b**	**1**

7.5 Direct Air Capture

Direct Air Capture activities introduce the following potential risks:

- Contamination to soil or waterways during the disposal of the carbon dioxide capturing material; and
- Personnel exposure to concentrated CO_2 leading to potential asphyxiation.

The key steps to minimising the risks associated with Direct Air Capture include:

- Unit shut down systems being part of the direct air capture unit's design
- Implementing an exclusion zone around the unit when in operation. This exclusion zone will be based on dispersion modelling
- Ensuring personal CO_2 gas detectors are used by any personnel entering the unit's exclusion zone
- Any handling of the carbon capture material will be handled by qualified people, and
- Disposal of the material will be organised with the relevant disposal groups.

The hazards, potential consequences, management strategies and level of residual risk associated with Direct Air Capture are summarised in Table 7.4.

Table 7-4: Direct Air Capture Risk Assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	**Risk Issue**	**Cause**	**Impact**	**Controls**	**S, E, C&R, F, W, C**	**Consequence**	**Likelihood**	**Residual Risk**
Direct Air Capture – waste disposal	Contamination to soil or waterways during disposal	Introduction of foreign contaminant to environment during waste disposal	▪ Damage to local ecosystems	**Design** ▪ CO_2 Capture material waste disposal organised with waste disposal groups ▪ Amine based disposal systems well established ▪ Post trial, CSIRO will collect and handle the Capture material	**E** **C&R** **C**	**II**	**b**	**1**
Direct Air Capture – Personnel exposure to CO_2	CO_2 leak from facilities during operation impacting personnel; Existing personal gas detectors at site do not monitor CO_2 Operations staff are not familiar with high pressure CO_2 handling	Leak in pipe or equipment during operation of the system.	▪ Asphyxiation risk of any personnel in the area from high concentration CO_2 gas	**Systems** ▪ Safety shutdown systems included in the design ▪ Routine use of gas detection by personnel in plant area. Existing personal gas detectors will detect oxygen deficiency **Design** ▪ Personal CO_2 detectors will be introduced as part of the CCS project ▪ CSIRO will provide personal CO_2 detectors for staff during the trial ▪ Exclusion zones established around the unit while in operation based on dispersion modelling.	**S** **C&R** **W** **C**	**IV**	**b**	**2**

7.6 Satellite Facilities

7.6.1 Construction

Construction of new satellite facilities and associated supporting infrastructure (e.g. solar arrays or powerlines) introduces hazards such as:

- site preparatory earthworks
- movement of heavy vehicles and equipment
- vegetation clearance
- loss of containment of oil and gas during plant commissioning
- venting during plant commissioning
- storage and use of fuel and chemicals
- generation of waste.

Land disturbance impacts associated with facility construction are managed in accordance with relevant Santos standards. Tools such as the ESP tool are used in the planning phase, along with site inspections where required to progress internal assessments and approval for construction (as described in Section 7.4.1). Approval conditions are in accordance with the relevant Santos standards, the SEO and other relevant regulatory requirements and must be accepted by the relevant project proponent prior to any on-ground works being undertaken. Facilities are located to avoid sensitive land systems or areas of higher ecological value where practicable (e.g. areas of significant habitat).

Earthworks and movement of light and heavy vehicles and earthworks

Movement of light and heavy vehicles (for example trucks, scrapers and bulldozers) during construction activities is controlled to minimise the potential for impacts to vegetation, soils and / or public safety. Impacts include vehicles inadvertently damaging native vegetation, introducing pest plant or animal species, generating dust and / or compacting soil (other than that which is required for construction) and traffic.

Earthworks can result in impacts similar to the movement of light or heavy vehicles as well as potentially disturbing cultural heritage sites, altering surface water flows and exposing soils to wind and water erosion.

The type and severity of potential impacts associated with earthworks is dependent on the land system in which the activities are being carried out. Dunefields are generally more resilient and less likely to suffer long-term impacts. The sensitive nature of wetland areas means that a higher level of control on activities and operations is employed to minimise disturbance and manage impacts, and facilities are typically sited to avoid wetlands or areas subject to flooding. Salt lakes are avoided as they are susceptible to scarring and hence difficult to rehabilitate. The steeper slopes and escarpments of tableland land systems are avoided for the construction of facilities due to their instability and the potential for erosion when disturbed.

Potential impacts of specific earthwork activities in different Cooper Basin land systems are discussed further in Section 7.11.1.

Earthworks have the potential to introduce pest plants or animal species into the region from movement of vehicles and construction equipment. As discussed in Section 5.3, the region has relatively few pest plants. Buffel grass is prevalent in some areas (e.g. Moomba compound) and is managed in accordance with Santos' Buffel Grass Control Plan which has been developed in consultation with DEM and meets the Biosecurity SA requirements for Pest and Plant Management.

Vegetation clearance

Hazards associated with vegetation clearance are loss of native vegetation and fauna habitat, siltation of natural drainage lines and watercourses, destabilisation of creek beds, introduction of pest plants or animal species and damage to sites of cultural heritage. Vegetation clearance may also impede the movement of native fauna, particularly small mammals or reptiles across cleared areas. However, this is considered unlikely in most land systems in the Cooper Basin due to the presence of naturally bare or unsheltered locations (Moss and Low 1996).

Construction activities in heavily wooded areas, such as Coolibah woodland, are avoided or minimised as far as practicable and vegetation clearance is kept to a minimum.

Venting and loss of containment during plant commissioning

During plant commissioning, there is potential for loss of containment of oil and gas, possibly resulting in localised contamination soil, waterways and / or shallow groundwater resources. Venting activities have the potential to have localised air quality impacts and may pose a hazard to native fauna and public safety. Commissioning is undertaken in accordance with specific plans developed for the commissioning activities. Controls outlined in Section 7 and in Table 7-5 under satellite facility operations are implemented to minimise the potential for impacts during commissioning.

Chemical and fuel storage

Chemical and fuel storage areas and refuelling of construction equipment present a risk for loss of containment. The primary consequence of any loss of containment is localised contamination of soil and impacts to native vegetation. Additional discussion on site contamination because of fuel and chemical releases associated with PPO activities is presented in Section 7.11.6.

Generation of waste

Waste generated during facility construction activities includes minor volumes of general and / or putrescible waste associated with work crews, construction and demolition waste, waste oils, oily rags and chemicals and hydrotest water.

If wastes are not managed, contamination of soil, waterways and / or shallow groundwater resources could occur. Litter is an aesthetic issue and can be a hazard to fauna.

Wastes generated as part of site works programs are managed in accordance with relevant Santos standards and applicable regulatory requirements. In general, waste will be segregated and stored securely on site for collection and transport to the Moomba WMF for recycling or disposal. Further discussion of waste management is provided in Section 7.11.2.

Flooding or fire

Flooding, particularly along the Cooper and Strzelecki Creeks and associated floodplain areas, may result in the inundation of construction sites, and their associated fuel and chemical storage areas. Flooding may result in soil erosion, loss of stockpiled topsoil and contamination of soil and watercourses with fuel, oils or chemicals that are used during the construction process, leading to impacts to native fauna and native vegetation.

Facilities are typically located to avoid areas subject to flooding. Project planning, emergency response and flood watch procedures are management strategies employed to minimise the potential for environmental impacts associated with flooding events. During periods of high rainfall, monitoring of upstream weather conditions is undertaken to pre-empt downstream flooding, and where possible, provide early advice for demobilisation.

The potential consequences of fire resulting from pipeline construction and / or maintenance activities include loss of native vegetation and native fauna habitat, impacts to livestock and the production of particulate air emissions.

The hazards, potential consequences, management strategies and level of residual risk associated with construction of satellite facilities are summarised in Table 7-5.

7.6.2 Operation

Environmental impacts associated with the operation of oil and gas satellites and associated supporting infrastructure include:

- release of emissions to air, land and water from
    - flaring and venting
    - fuel use and other minor losses (fugitives)
- loss of habitat (flora and fauna)
- impacts to third party groundwater users
- impacts to livestock and native fauna
- impacts to stakeholder business reputation.

To minimise the potential impacts to public and third-party safety and the environment, Santos employs an assessment and management system that is designed to identify hazards and develop controls that minimise risk to as low as reasonably practicable (ALARP).

The primary hazard associated with plant operation is the loss of containment (of oil, gas or PFW) through:

- corrosion of piping and / or vessels (external or internal)
- heavy vehicle traffic (i.e. collision with an above ground piping)
- natural events which stress the piping and damage foundations (e.g. flooding)
- overpressure
- metallurgical, material or construction faults
- ageing infrastructure.

With the exception of construction, maintaining plant integrity is the primary control for minimising the potential for failure. The risk of piping and / or vessel failure during operations is generally subject to the following threats:

- Internal:
    - acid gas (CO_2 / H_2S) corrosion
    - microbiologically influenced corrosion (MIC)
    - erosion
- External:
    - Soil / atmospheric corrosion
    - impact damage
    - mechanical joint failure.
    - high cycle fatigue.

To minimise the potential for failure and optimise plant longevity, Santos uses an Integrity Management Program (IMP). The IMP provides a systematic approach to plant operation and maintenance activities in conjunction with the application of appropriate standards to minimise risk to public and third-party safety, and the environment.

Generic IMP for all satellites include high level risks that are consistent across the board. Satellite specific IMPs are developed for major production satellites (e.g. Big Lake and Tirrawarra). IMPs are periodically reviewed and updated as required. The intent of the IMP is to:

- identify relevant threats to the satellite / plant whilst operational
- determine the mitigation, monitoring and inspection activities and associated frequencies

- support program planning to achieve the required life of each plant component
- evaluate the condition of protection barriers (i.e. corrosion rates, coatings, pressure / temperature limits), to forecast the operational life of each plant component.

The monitoring, mitigation and inspection activities undertaken to maintain integrity and minimise the risk of failure include, but are not limited to:

- Monitoring:
  - stream composition temperature and pressure monitoring
  - water sampling and analysis
  - chemical injector checks
- Mitigation:
  - corrosion inhibitor injection
  - batch chemical treatment
- Inspection:
  - thickness testing programs
  - visual inspection and non-destructive testing
  - operational surveillance.

Santos collates the results from the monitoring, mitigation and inspection activities and uploads the information to the API / RBI database to manage inspection strategies. The API / RBI database is also a repository for plant data including, but not limited to:

- design data
- risk profile
- inspection and repair history.

The information stored in the API/RBI database is used to support the major production facility IMPs. The database forms part of a greater Asset Integrity Management System (AIMS), the intent of which is to capture asset data and track plant assets throughout their operational life.

In addition to this and in accordance with Regulation 30 of the *Petroleum and Geothermal Energy Regulations 2013* a Fitness for Purpose (FFP) report has been developed and is reviewed/updated every five years. Refer to Section 7.9.1 for further detail on the FFP.

Emissions

Emissions include greenhouse gas emissions to air (including carbon dioxide, methane and nitrous oxide) (see Section 7.9) as reported annually under *the National Greenhouse and Energy Reporting (NGER) Act*, and other pollutants emitted to air, land and water as reported annually to the National Pollutant Inventory (NPI).

Information reported to the NPI is publicly available on the NPI website (www.npi.gov.au).

Santos continues to consider all reasonable and practicable measures to minimise greenhouse gas emissions from the operation of its satellite facilities, and in doing so, pursue strategies that address the issue of climate change in accordance with Santos' Climate Change Policy. This includes CCS and DAC technologies to remove CO_2 from the air to offset emissions.

During storage, handling and use of process chemicals, cleaning chemicals or fuels, there is the potential for loss of containment to land and water. Chemicals and fuels are stored and handled in compliance with industry and Australian standards.

Loss of containment of oil or gas may also occur as a result of pipeline or equipment failures or accidental overflow of storage tanks and vessels. Loss of containment potentially results in localised impact to soil and shallow groundwater resources at the satellite. Exposed oil or gas may also be an ignition source. Loss of containment of CO_2 could potentially result in concentration of CO_2 in low lying structures or topographic lows which could impact people, stock or fauna in those areas.

Regular monitoring of emergency shutdown valves, fire protection and detection, and control systems is undertaken to ensure that protection levels are adequate.

The location of satellite facilities is assessed during planning and addresses the hazard of potential flood events. Flooding of surrounding floodplain / watercourses which might cause damage to infrastructure could potentially lead to the loss of containment of oil, gas, fuel and / or chemicals.

The hazards, potential consequences, management strategies and level of residual risk associated with operation of satellite facilities are summarised in Table 7-5.

7.6.3 Decommissioning

The potential impacts associated with decommissioning of satellite facilities and site restoration includes:

- contamination of soil, waterways and / or shallow groundwater resources
- impacts associated with earthworks and the use of heavy machinery, such as:
  - impacts to native fauna, vegetation and drainage patterns
  - soil compaction and erosion
  - injury or loss of native fauna or livestock potential damage to third party infrastructure or business reputation
  - potential damage to cultural heritage sites
  - impacts to public safety.

The key steps to minimising the risks associated with decommissioning and restoration of sites include:

- detailed planning and applicable approvals obtained
- disable, clean and remove above ground infrastructure and disposal in accordance with internal and regulatory requirements
- assess, remediate and validate the site for potential contamination, as required (i.e. in accordance with the SEO)
- restore the site, as close as practicable, to pre-existing contours (or as otherwise agreed with the regulator and / or stakeholders)
- relieve soil compaction (e.g. by ripping), where appropriate.

The hazards, potential consequences, management strategies and level of residual risk associated with decommissioning of satellite facilities and associated supporting infrastructure are summarised in Table 7-5.

Table 7-5: Satellite facilities risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Satellite Facilities - construction	Impacts to native vegetation and fauna, erosion and siltation of watercourses	Vegetation clearing	▪ Loss of native vegetation and fauna habitat ▪ Damage to native vegetation ▪ Siltation of watercourses ▪ Erosion ▪ Short to medium term loss of visual amenity ▪ Introduction and / or spread of pest plants	**Design** ▪ Avoid important or 'priority' native vegetation6 where possible. ▪ Use existing disturbed areas where practicable. ▪ Minimise vegetation disturbance, and plan construction to avoid vegetated areas. **Systems** ▪ Relevant internal and external approvals in place before work undertaken. ▪ Prior to greenfield disturbance, or subsequent re-disturbance, a Santos Environmental Adviser and / or ecologist undertakes an environmental assessment in accordance with the relevant Santos standards, the SEO and recommendations based on field inspections, which includes a site inspection for potential sensitive receptors. ▪ Implementation of the ESP tool to assess proposed locations for rare, vulnerable and endangered flora and fauna species before the commencement of construction and implement appropriate avoidance or mitigation measures. ▪ Stockpile and clear vegetation and respread in any areas of temporary disturbance following construction works to facilitate revegetation. ▪ Where possible trim vegetation rather than clear. ▪ Off-road or off-lease driving or creation of shortcuts is prohibited. ▪ No domestic pets allowed at camps or worksites. ▪ Feeding of native fauna (e.g. dingoes) is prohibited. ▪ Compliance with SEB offset obligations.	**E F C&R C**	**II**	**c**	**2**
Satellite Facilities - construction	Impacts to soil, natural drainage lines, vegetation, native fauna and livestock, stakeholder infrastructure	Earthworks	▪ Dust generation ▪ Soil compaction ▪ Erosion (accelerated) ▪ Disturbance to natural drainage patterns ▪ Siltation of watercourses ▪ Damage to native vegetation ▪ Injury or death of native fauna in construction zone ▪ Loss of visual amenity ▪ Introduction and / or spread of pest plants ▪ Disturbance to stakeholder infrastructure and activities ▪ Disturbance to livestock ▪ Impacts to native vegetation and fauna as a result of contamination of soil, shallow groundwater resources and / or watercourses from fuel storage	**General** ▪ Relevant internal and external approvals in place before work undertaken. ▪ Consider alternate locations and construction methods during planning and scouting phase to minimise environmental impacts. ▪ Locate facilities to avoid areas subject to inundation as far as possible. ▪ Use existing disturbed areas where practicable. **Soil** ▪ Off-road or off-lease driving or creation of shortcuts is prohibited. ▪ Sensitive gibber terrain is protected through appropriate site selection and construction practices which include - selecting locations that avoid sloping land is preferable (to minimise the requirements for large cut and fill or importation of borrow material to level the site) - constructing erosion control measures where appropriate (i.e. diversion banks or berms) - rolling of gibber terrain, is preferable, where possible - avoiding environmentally sensitive and restricted areas, such as important native vegetation and fauna habitat, where possible. ▪ Construction activities are not carried out on salt lakes. ▪ First disturbances (such as location scouting) are undertaken in accordance with Santos standards. ▪ Management of sensitive areas (e.g. sloped areas or gibber) is detailed in scope of works, approval documents and company procedures. ▪ Erosion is controlled by appropriate placement, batter slopes and construction of water flow diversion banks. **Vegetation**	**S E F C&R C**	**II**	**c**	**2**

[6] In the Cooper Basin, important vegetation typically includes:

- Plants of Priority 1 or 2 species as defined in the *Field Guide to the Common Plants of the Cooper Basin – South Australia and Queensland* (Whiltshire and Schmidt, 2003) (the Field Guide). This predominantly includes tree and larger shrub species that are long lived and / or do not regenerate readily from seed or rootstock.
- Vegetation that is restricted in distribution and / or is locally important (e.g. for habitat or for land stability)
- Vegetation communities identified as conservation priorities in the South Australian Arid Lands Biodiversity Strategy (DEH 2009).

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
				▪ Construction activities in heavily wooded areas, such as Coolibah woodland, is minimised as far as practicable. ▪ Where pest plants are identified, contaminated material will not be moved to another location. ▪ Monitoring and pest plant control measures are implemented where required. ▪ Vegetation clearance is minimised as far as practicable. **Water** ▪ Facilities are located and constructed to maintain pre-existing water flows (e.g. channel contours are maintained on floodplains and at creek crossings). ▪ Water flow around facility is maintained (flow diverted if required). ▪ Sensitive land systems (e.g. wetlands) are avoided wherever possible. Where activities are undertaken in or near these areas, appropriate review, assessment and mitigation measures are in place to ensure that surface water flows are maintained and contamination of surface water and groundwater resources is avoided. ▪ Monitoring of erosion and drainage patterns post-construction and corrective actions implemented where required. **Reinstatement** ▪ Reinstate construction areas as soon as practicable. ▪ Rip areas of compacted soil (except on gibber plains and tableland environments). ▪ Respread topsoil and stockpiled vegetation. ▪ Total or partial restoration of borrow pits as soon as practicable. ▪ Restore natural contours to minimise impacts to natural drainage patterns. **Stakeholders** ▪ Dust suppression measures carried out where required to minimise safety hazards associated with poor visibility. ▪ Landholders are consulted as required where activities may affect pastoral operations and notified prior to survey, construction and undertaking of operations (pursuant to Regulations). ▪ Induction of employee and contractor personnel with respect to pastoral landholder requirements such as use of gates and infrastructure. ▪ Systems are in place for logging stakeholder complaints to ensure that issues are addressed as appropriate.				
Satellite Facilities - construction	Disturbance to cultural heritage sites	Earthworks	▪ Disturbance or damage to cultural heritage sites	**Systems** ▪ Observation of procedures and guidelines for the identification, management and protection of cultural heritage sites. ▪ Consultation with stakeholders (i.e. native title groups, government agencies, landholders etc.) in relation to the possible existence of heritage sites. ▪ Appropriate cultural heritage training is provided for the level of access required (e.g. additional training for first disturbance (scouting) or authorised off-road/off-lease activities). ▪ Known potential cultural heritage sites are avoided during scouting. ▪ Engage cultural heritage monitors ahead of or during first disturbance activities. ▪ Known cultural heritage sites are recorded. ▪ Audits of cultural heritage clearances areas. **Response** ▪ Discovery of new cultural heritage sites managed in accordance with the SMS.	**S** **F** **C&R** **C**	**III**	**d**	**3**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Satellite Facilities - construction	Impacts to vegetation and native fauna, erosion and siltation of watercourses	Movement of heavy machinery and vehicles	▪ Dust and noise generation ▪ Soil compaction; erosion ▪ Contamination of soil, shallow groundwater resources and / or watercourses ▪ Damage to native vegetation ▪ Injury or death of native fauna ▪ Introduction and / or spread of pest plants ▪ Damage to third party infrastructure ▪ Disruption to land use (e.g. grazing and recreation)	▪ Systems. ▪ Driving on designated areas only (i.e. lease and access tracks). ▪ Unauthorised off-road or off-lease driving or creation of shortcuts is avoided. ▪ Rip areas of compacted soils (except on gibber and tableland environments). ▪ Signage and road closures where appropriate. ▪ Inductions. ▪ Landholder consultation.	**E**	**III**	**c**	**2**
Satellite Facilities - construction	Disturbance to cultural heritage sites	Movement of heavy machinery and vehicles along proposed routes	▪ Disturbance or damage to cultural heritage sites	***See section on cultural heritage sites above*** Additional procedures and guidelines include: ▪ Signage to indicate public versus private roads and access tracks to discourage third party access to infrastructure.	**E**	**II**	**c**	**2**
Satellite Facilities - construction	Contamination of soil and / or shallow groundwater resources and potential impacts to public safety	Ignition of fire	▪ Disturbance or damage to cultural heritage sites ▪ Injury to or loss of livestock or native fauna ▪ Disruption to land use (e.g. grazing and recreation) ▪ Impacts to groundwater users ▪ Impacts to public safety ▪ Impacts to native vegetation ▪ Impacts to stakeholder business reputation ▪ Generation of greenhouse gas emissions, localised reduction in air quality	**Systems** ▪ Operation under fire permit requirements. ▪ No smoking or safe smoking areas away from equipment or activity. ▪ Personnel are trained to supervise and instruct individuals entering area to conduct work. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct works. ▪ Petrol vehicles to be excluded from sites. **Response** ▪ Emergency response procedures contain a bushfire scenario. ▪ Safety, testing, maintenance and inspection procedures are implemented.	**S** **E** **F** **C&R** **C**	**III**	**a**	**1**
Satellite Facilities - construction	Contamination or disturbance of soil, shallow groundwater resources and / or watercourses and damage to third party infrastructure	Flooding of surrounding floodplain/watercourses	▪ Damage to infrastructure ▪ Access to contaminants by stock and wildlife ▪ Contamination of soil, shallow groundwater resources and / or watercourses ▪ Impacts to groundwater users ▪ Soil erosion and siltation of watercourses ▪ Loss of vegetation and topsoil (either stockpiled or in situ)	**Design** ▪ Locate facilities to avoid areas subject to inundation as far as possible. ▪ Measures undertaken to reduce potential impacts of flooding where appropriate (e.g. installation of bunds, removal of contents prior to arrival of flood event). ▪ Fully containerised tanks used for on-site storage. **Systems** ▪ Fuel, oil and chemical storage and handling in accordance with the Safety Data Sheet (SDS), SMS, EPA Bunding Guidelines and AS 1940. ▪ Work programs in floodplain areas scheduled to take into account seasonal conditions and rainfall/flood likelihood. ▪ Continuous monitoring of upstream conditions.	**S** **E** **F**	**III**	**a**	**1**

Identification				Control Strategy	Assessment			
Activity	Risk Issue	Cause	Impact	Controls	Risk: S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Satellite Facilities – operation and decommissioning	Contamination of soil; release of atmospheric emissions	Loss of containment and ignition	▪ Generation of greenhouse gas emissions, localised reduction in air quality, potential for fire / explosion ▪ Localised reduction in air quality ▪ Impacts to public safety and third party assets, including livestock ▪ Impacts to stakeholder business reputation ▪ Contamination of soil, shallow groundwater resources and / or surface water ▪ Impacts to native vegetation and fauna habitat ▪ Impacts to third party groundwater users	**Design** ▪ Fit for purpose equipment. ▪ Consideration of proximity to surrounding infrastructure and implementation of a flare exclusion zone. ▪ Plant and equipment designed and constructed in accordance with SMS and Engineering Standards and relevant Australian/International standards (e.g. AS 1210). **Systems** ▪ Preferential use of diesel vehicles. ▪ Process safety and integrity management systems featured in the FFP. ▪ Minimising volume of flammable / combustible substances through all phases of works. ▪ Consideration of weather conditions i.e. wind direction. ▪ Safety, testing, maintenance and inspection procedures are implemented. ▪ Personnel are trained to supervise and instruct individuals entering site to conduct work. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with satellite facilities. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct work at operational facilities. ▪ Hazardous area management criteria are followed. ▪ HAZOP reviews. ▪ Ignition sources are controlled via permit to work. ▪ Restricted access to site. ▪ Red alert days (additional checks and balances). **Response** ▪ Appropriate emergency response plans in place. ▪ Emergency response training for emergency response personnel. ▪ Emergency spill response equipment on site. ▪ Spill response and clean up.	**S** **E** **F** **C&R**	**IV**	**b**	2
Satellite Facilities – operation and decommissioning	Contamination of soil, shallow groundwater resources and / or surface water, soil disturbance and damage to infrastructure	Flooding of surrounding floodplain/watercourses	▪ Contamination of soil, surface water and / or shallow groundwater resources ▪ Damage to infrastructure (e.g. evaporation ponds, chemical/fuel storage) ▪ Exposure of contaminants to native vegetation, native fauna and habitats, and livestock ▪ Impacts to third party groundwater resources users ▪ Soil erosion and siltation of watercourses ▪ Impacts to stakeholder business reputation	**Design** ▪ Work programs in floodplain areas scheduled to take into account seasonal conditions and rainfall/flood likelihood. ▪ Measures undertaken to reduce potential impacts of flooding where appropriate (e.g. installation of bunds, removal of contents prior to arrival of flood event via vacuum truck). ▪ Fully containerised tanks used for on-site storage. ▪ Planning of the installation of new satellite facilities addresses flood risk. **Systems** ▪ Fuel, oil and chemical storage and handling in accordance with the Safety Data Sheet (SDS), SMS, EPA Bunding Guidelines and AS 1940. ▪ Regularly educate staff of product, review and monitor chemical and fuel storage, including signage / labelling, proper packing and tie downs. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ Manage upstream facilities / assets to mitigate potential hazards at the satellite. ▪ Implementation of flood response management plan. **Response** ▪ Appropriate emergency response plans in place. ▪ Emergency spill response equipment on site. ▪ Spill response and clean up. ▪ Fencing of contaminated areas if threat is posed to native fauna or livestock.	**S** **E** **F**	**II**	**c**	2

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Satellite facilities – operation and decommissioning	Contamination of soil, shallow groundwater resources and / or surface water	Loss of containment of chemicals or fuels during transport / handling, storage and use	▪ Contamination of soil, surface water and / or shallow groundwater resources ▪ Localised contamination of soil ▪ Injury to or loss of native fauna or livestock through exposure ▪ Potential impacts to third party groundwater users ▪ Impacts to stakeholder business reputation	**Systems** ▪ Fuel, oil and chemical storage and handling in accordance with the Safety Data Sheet (SDS), SMS, EPA Bunding Guidelines and AS 1940. ▪ Regularly educate staff of product, review and monitor chemical and fuel transportation, including signage / labelling, proper packing and tie downs. ▪ Driver training and use of In Vehicle Monitoring System (IVMS) to track speed, route and harsh braking. ▪ Use of Safety Data Sheets (SDS). ▪ Licensed operators and site induction process. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ Logged incidents are reviewed and areas for improvement are identified for inclusion in future improvement plans. ▪ Regular monitoring of control systems (including emergency shutdown valves) to ensure that protection levels are adequate. **Response** ▪ Appropriate emergency response plans in place. ▪ Emergency spill response equipment on site. ▪ Spill response and clean up. ▪ Fencing of affected areas if threat is posed to livestock or native fauna.	**S** **E** **F** **C&R**	**II**	**d**	**2**
Satellite facilities - operation	Greenhouse gas emissions, fire hazard	Fugitive emissions to atmosphere	▪ Generation of significant greenhouse gas emissions ▪ Reduction in localised air quality ▪ Fire hazard ▪ Potential impacts to public safety	**Systems** ▪ Restricted access to satellites and signage to inform public and third parties. ▪ Implementation of a preventative maintenance strategy to minimise fugitive releases. ▪ Consideration of reasonable and practicable measures to minimise greenhouse gas emissions in accordance with Santos' Climate Change Policy. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ Gas detection is undertaken within operational areas in accordance with SMS. ▪ Equipment operated and maintained in line with manufacturer specifications.	**S** **E**	**II**	**d**	**2**
Satellite facilities – operation	Greenhouse gas emissions, fire hazard	Venting of carbon dioxide, hydrogen sulphide and carbon monoxide	▪ Generation of significant greenhouse gas emissions ▪ Reduction in localised air quality ▪ Impacts to native fauna (birds) ▪ Potential impacts to public safety	**Design** ▪ Remote location of satellite facilities. **Systems** ▪ Restricted access to satellites and signage to inform public and third parties. ▪ Landowners notified of proposed operations and consultation process initiated to ensure appropriate procedures in place to mitigate impacts. ▪ Gas detection is undertaken within operational areas. ▪ Equipment designed, installed, operated and maintained to Australian standards, in line with manufacturer specifications. ▪ Minimise frequency and duration of venting. ▪ Emissions reported annually in accordance with the National Pollution Inventory.	**S** **E**	**I**	**b**	**1**

Identification				Control Strategy	Assessment			
Activity	Risk Issue	Cause	Impact	Controls	Risk			
					S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Satellite facilities - operation	Greenhouse gas emissions; fire/explosion (snuffed flare)	Flaring of propane, butane, methane and ethane	▪ Generation of significant greenhouse gas emissions ▪ Reduction in localised air quality ▪ Fire / explosion hazard	**Design** ▪ Remote location of satellite facilities. ▪ Fit for purpose equipment. ▪ Consideration of proximity to surrounding infrastructure and implementation of a flare exclusion zone. ▪ Use of separators and vertical flare stack to eliminate unburnt gases. **Systems** ▪ Restricted access to satellites and signage to inform public and third parties. ▪ Preventative maintenance mitigating amount of unnecessary flaring due to valve performance. ▪ Gas detection is undertaken within operational areas. ▪ Operator routine inspection and corrective maintenance. ▪ Flaring and venting activities are actively managed and minimised. ▪ Continual review and improvement of operations. ▪ Competent site personnel and contractors on site at all times. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with satellite facilities.	**S** **E**	**I**	**b**	**1**
Satellite facilities – operation and decommissioning	Contamination of soil, surface water and / or shallow groundwater resources	Loss of containment of gas or oil (pipeline rupture or leaks from satellite equipment)	▪ Uncontrolled release of fluids (liquid or gas) to surface ▪ Contamination of soil, surface water and / or shallow groundwater resources ▪ Impacts to livestock and native fauna ▪ Potential impacts to third party groundwater users ▪ Potential impacts to public safety ▪ Injury to or loss of livestock and native fauna ▪ Impacts to native vegetation, native fauna habitat ▪ Impacts to stakeholder business reputation ▪ Generation of greenhouse gas emissions, localised reduction in air quality, potential for fire/explosion	**Design** ▪ Fit for purpose equipment. ▪ Inline monitoring alarms, fusible loop system (in the event of a fire). ▪ Auto shutdown system. ▪ Plant and equipment designed and constructed in accordance with SMS and Engineering Standards, and relevant Australian/International standards (e.g. AS 1210). **Systems** ▪ Identification of critical barriers and monitoring / maintenance using performance standards. ▪ Safety, testing, maintenance and inspection procedures are implemented. ▪ Personnel are trained to supervise and instruct individuals entering site to conduct work. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with satellite facilities. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct work on a lease. ▪ Hazardous area management criteria are followed. ▪ Restricted access to site. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ Approvals planned to minimise hazardous situations, with controls in place to address risks. **Response** ▪ Implementation of emergency / spill response procedures. ▪ Emergency response training for emergency response personnel. ▪ Emergency spill response equipment on site. ▪ Regular review and exercise of response equipment and procedures. ▪ Spill response and clean up. ▪ Fencing of contaminated areas if threat is posed to livestock or native fauna.	**S** **E** **F**	**III**	**c**	**2**
Satellite Facility - operation and decommissioning	Contamination of soil, surface water and / or shallow groundwater resources	Management of hydrotest water or water used for flushing pipelines / equipment, pigging or cleaning	▪ Contamination of soil, surface water and / or shallow groundwater resources ▪ Impacts to native vegetation or fauna habitat	**Systems** ▪ Use of biocides and corrosion inhibitor chemicals are kept to a minimum and where practicable biocides which degrade rapidly when exposed to UV are used. ▪ Management of water which contains biocide, other chemicals or hydrocarbons may be into existing lined and fenced evaporation ponds, or to satellite facility pond systems sited to prevent the contamination of surface or near surface waters. ▪ Preferential use of satellite pond water, where possible. ▪ Hydrotest water volumes typically limited to 500 L.	**E** **F**	**I**	**c**	**1**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Satellite Facilities - decommissioning	Impacts to soil, natural drainage lines, native vegetation and fauna, and third party assets (livestock and infrastructure)	Earthworks, including grading, stockpiling, backfilling, and reinstating	▪ Injury to or loss of livestock and native fauna ▪ Loss of visual amenity ▪ Impacts to native vegetation and fauna habitat ▪ Introduction and / or spread of pest plants ▪ Disturbance to natural drainage patterns ▪ Soil erosion and siltation of watercourses ▪ Inversion of soil profile ▪ Dust generation ▪ Soil compaction ▪ Impeded native fauna movement through construction/decommissioning zone ▪ Damage/disturbance to landholder/stakeholder infrastructure and activities and business reputation.	**Design** ▪ Minimise impact by restricting earthworks to the minimum area necessary (typically occur on existing, disturbed infrastructure sites). ▪ Minimise vegetation disturbance, and plan works to avoid sensitive vegetation and significant or “priority” vegetation. **Systems** ▪ Assets decommissioning to be in accordance with SMS, which defines minimum mandatory requirements for the planning and management of asset decommissioning. ▪ Cooper Basin Pest Plants and Animals Management Plan. ▪ Management of sensitive areas (e.g. sloped areas or gibber) is detailed in scope of works, approval documents and company procedures. ▪ Reinstate construction areas as soon as possible. ▪ Rip areas of compacted soil (except on gibber plains and tableland environments). ▪ Respread topsoil and stockpiled vegetation seed stock to facilitate revegetation. ▪ Restore natural contours to minimise impacts to natural drainage patterns. ▪ Regular removal of waste from site. ▪ Liaison with landowners regarding notification and management of works and site issues including livestock management. ▪ Minimise the time trench lines and excavations remain open, with a corresponding increase in the frequency of native fauna exit structures. ▪ Observation of procedures for location of services and infrastructure. ▪ Obtain excavation permits where required. ▪ Off road / lease disturbance and first disturbances are undertaken in accordance with Santos standards. Unauthorised off-road or off-lease driving or creation of shortcuts is unacceptable. ▪ Dust suppression measures carried out where required to minimise safety hazards associated with poor visibility. ▪ Induction of employee and contractor personnel with respect to pastoral landholders including issues such as use of gates, fencing and infrastructure. ▪ Systems are in place for logging landholder complaints to ensure that issues are addressed as appropriate. ▪ Encourage minimised time that areas are open with progressing clearing and reinstatement of vegetation.	**S** **E** **F** **C**	**II**	**c**	**2**
Satellite Facilities - decommissioning	Disturbance to cultural heritage sites	Earthworks	▪ Disturbance or damage to cultural heritage sites	**Systems** ▪ Observation of procedures and guidelines for the identification, management and protection of cultural heritage sites. ▪ Satellite facility sites have generally undergone cultural heritage assessment and clearance prior to construction. ▪ Consultation with stakeholders (i.e. native title groups, government agencies, landholders etc.) in relation to the possible existence of cultural heritage sites. ▪ Appropriate cultural heritage training is provided for the level of access required (e.g. additional training for first disturbance or authorised off-road/off-lease activities). ▪ Potential cultural heritage sites are avoided during scouting. ▪ Inspections and checks of cultural heritage clearances areas. ▪ Processes are in place to meet requirements of legislation and agreements with native title claimant groups with respect to protection and reporting of discovery of unknown cultural heritage sites during satellite facility decommissioning activities.	**S** **E** **F** **C&R** **C**	**III**	**c**	**2**
Satellite Facilities - decommissioning	Impacts to native vegetation and fauna	Movement of construction materials (earthworks)	▪ Introduction and / or spread of pest plants	**Systems** ▪ Consultation with landholders in relation to the possible existence of pest plants. ▪ Induction of employee and contractor personnel with respect to existence and spread of pest plants. ▪ Ensure that imported material is from an area considered to be pest plant / disease free. **Response** ▪ Monitor pest plants when present, within the construction area for outbreaks and where necessary implement control measures.	**E**	**II**	**c**	**2**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Satellite Facilities - decommissioning	Impacts to native vegetation and fauna, erosion and siltation of watercourses	Movement of heavy machinery and vehicles	▪ Dust generation ▪ Soil compaction ▪ Erosion ▪ Damage to native vegetation ▪ Injury or loss of native fauna ▪ Impact to stakeholder business reputation ▪ Disturbance to cultural heritage sites ▪ Introduction and / or spread of pest plants ▪ Damage to third party infrastructure ▪ Disruption to land use (e.g. grazing and recreation) ▪ Increased public access to remote areas	**Systems** ▪ Driving on designated areas only (i.e. lease and access tracks). ▪ Unauthorised off-road or off-lease driving or creation of shortcuts is unacceptable. ▪ Rip areas of compacted soils (except on gibber and tableland environments) where required. ▪ Signage and road closures where appropriate. ▪ Consultation with landholders. ▪ Minimise creation of new access tracks. ▪ Communication of heavy vehicle movement and other potential hazards to potentially affected parties prior to commencement of activities. ▪ Dust suppression, as required. ▪ Adherence to applicable road safety and transport legislation. ▪ Induction of employees and contractor personnel with respect to road use and driver behaviour. ▪ Implementation of a traffic management plan where required. ▪ Internal approvals system.	**S** **E** **F** **C&R** **C**	**III**	**c**	**2**
Satellite facilities - decommissioning	Disturbance to cultural heritage sites	Movement of heavy machinery and vehicles	▪ Disturbance or damage to cultural heritage sites	**Systems** ▪ Observation of procedures and guidelines for the identification, management and protection of cultural heritage sites. ▪ Consultation with stakeholders (i.e. native title groups, government agencies, landholders etc.) in relation to the possible existence of cultural heritage sites. ▪ Appropriate cultural heritage training is provided for the level of access required (e.g. additional training for first disturbance or authorised off-road/off-lease activities). ▪ Potential cultural heritage sites are managed in liaison with relevant stakeholders. ▪ Signage to indicate public versus private roads and access tracks to discourage third party access to infrastructure, and hence impacts to cultural heritage sites. ▪ Processes are in place to meet requirements of legislation and agreements with native title claimant groups with respect to protection and reporting of discovery of unknown heritage sites during pipeline construction and decommissioning activities. ▪ Audits of cultural heritage clearances areas.	**S** **E** **F** **C&R** **C**	**III**	**b**	**2**
Satellite facilities - decommissioning	Impacts to public safety, native fauna or livestock	Movement of heavy machinery and vehicles	▪ Collision with native fauna or livestock resulting in injury or loss ▪ Potential impacts to public safety	**Systems** ▪ Active promotion of appropriate road use behaviours. ▪ Induction of employees and contractor personnel with respect to road use and driver behaviour. ▪ Use of In Vehicle Monitoring System (IVMS) to track speed, route and harsh braking of the entire workforce, including contractors. ▪ Setting of appropriate speed limits for oil and gas industry personnel. ▪ Driver awareness training for all company and contractor personnel. ▪ Policy of driving with vehicle lights on. ▪ Signage throughout the Cooper Basin to warn of possible hazards on the roads. ▪ Driving on designated areas only (i.e. access tracks and designated lease areas). ▪ Procurement and contract management includes Environmental and Workplace Health and Safety Management Plan pre-qualification. ▪ Implementation of a decommissioning management plan for contractors. ▪ Reporting systems in place for recording injuries and accidents.	**SP** **E** **F** **C&R** **C**	**V**	**b**	**3**

7.7 Produced Formation Water Facilities

The potential impacts associated with management of PFW include:

- impacts to soil, waterways and / or shallow groundwater resources due to loss of containment from separation tanks, interceptor ponds or evaporation ponds (e.g. vertical and / or lateral seepage and salinisation)
- groundwater mounding beneath evaporation ponds
- impacts to vegetation and / or vegetation root zones and native fauna habitat
- impacts to native fauna and livestock through exposure
- livestock congregation around PFW sites impacting on native flora
- impacts to third party groundwater users
- impacts to pastoral and / or other business reputation.

In accordance with Santos standards, the location of new satellite facilities (which receive PFW from production and processing operations) and PFW pond systems is subject to detailed planning and includes consideration of matters such as flood risk and proximity to floodplains and waterways and other sensitive receptors.

The controls and procedures employed to manage the potential risks associated with PFW management, the associated storage of fuel or chemicals and generation of other liquid and / or solid wastes are outlined in:

- Section 4.5– Produced Formation Water and Associated Facilities
- Section 7.4.1 - Pipeline Construction – Storage and handling of fuel and chemicals
- Section 7.4.1. – Pipeline Construction – Generation of waste
- Section 8 – Management of Environmental Risks.

PFW facilities are designed and constructed in accordance with the relevant standards of the day (e.g. EPA Wastewater Lagoon Construction Guidelines) and may include use of synthetic and / or clay liners.

As per standard day-to-day operations, routine inspection of hose lines, connections, high pressure equipment and trip systems are undertaken to identify operational faults and ensure design limits are not compromised during operation. Where required, emergency shutdown systems are installed to prevent uncontrolled releases.

Ongoing operation of PFW ponds is subject to standard Santos procedures including inspections which are scheduled and completed as part of Operator Surveillance tasks. The outcomes of these inspections are used to inform maintenance requirements which are prioritised on a risk-basis. Where a potential risk to sensitive receptors and / or containment risk is identified, additional investigative works include, but are not limited to:

- seepage monitoring (visual or physical i.e. soil sampling)
- pond water quality monitoring
- pond level/capacity monitoring

The outcomes of the investigation works are used to develop preventative or mitigated controls. These controls may include, but not be limited to:

- targeted water quality monitoring
- shallow groundwater monitoring
- pond wall / erosion repairs
- reinstatement of rundown / balance lines

- pond retrofitting/upgrade
- pond replacement.

7.7.1 PFW reuse

Potential impacts associated with PFW reuse are considered on a case-by-case basis. Refer to Section 4.5.3 for more detail on internal approval and conditions for potential reuse options.

The hazards, impacts and level of residual risk associated with PFW are summarised in Table 7-6.

Table 7-6: Produced formation water risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
PFW storage and management	Contamination of soil, and / or shallow groundwater, salinisation	Presence of PFW Ponds	▪ Impacts to third party groundwater users ▪ Contamination of soil, waterways and / or shallow groundwater resources ▪ Injury to or loss of livestock and native fauna (exposure or entrapment) ▪ Impacts to stakeholder business reputation ▪ Damage to native vegetation and fauna habitat ▪ Salinisation ▪ Groundwater mounding beneath evaporation ponds ▪ Increased grazing/predator pressure	**Design** ▪ PFW pond systems design, which includes detailed planning and consideration of flood risks, proximity to floodplains, waterways and other sensitive receptors. ▪ Design and construction of new ponds in accordance with applicable internal and regulatory standards (e.g., EPA Wastewater lagoon guidelines). **Systems** ▪ PFW plant and pond system maintenance and inspection schedules. ▪ Where required, emergency shutdown systems are installed. ▪ Pest management. ▪ Water quality monitoring as required. **Response** ▪ Pond skimming and hydrocarbon recovery. ▪ Seepage monitoring (visual or physical i.e. soil sampling). ▪ Pond water quality monitoring. ▪ Pond level/capacity monitoring. ▪ Targeted water quality monitoring. ▪ Shallow groundwater monitoring. ▪ Pond wall/erosion repairs. ▪ Reinstatement of rundown / balance lines. ▪ Pond retrofitting / upgrade. ▪ Pond replacement. **Other** ▪ See Fuel and Chemical Storage and Handling (Table 7-15). ▪ See Waste Management (Table 7-11)	**E** **F** **C&R** **C**	**II**	**d**	**2**
PFW storage and management	Contamination of soil, and / or shallow groundwater, salinisation	Loss of containment of produced water formation from pond systems	▪ Impacts to third party groundwater users ▪ Contamination of soil, waterways and / or shallow groundwater resources ▪ Injury to or loss of livestock and native fauna (exposure) ▪ Impacts to stakeholder business reputation ▪ Damage to native vegetation and fauna habitat ▪ Salinisation ▪ Groundwater mounding beneath evaporation ponds	**Design** ▪ PFW pond systems design, which includes detailed planning and consideration of flood risks, proximity to floodplains, waterways and other sensitive receptors. ▪ Design and construction of new ponds in accordance with applicable internal and regulatory standards (e.g., EPA Wastewater lagoon guidelines). **Systems** ▪ PFW plant and pond system maintenance and inspection schedules. ▪ Where required, emergency shutdown systems are installed. ▪ Water quality monitoring as required. **Response** ▪ Pond skimming and hydrocarbon recovery. ▪ Seepage monitoring (visual or physical i.e. soil sampling). ▪ Pond water quality monitoring. ▪ Pond level / capacity monitoring. ▪ Targeted water quality monitoring. ▪ Shallow groundwater monitoring. ▪ Pond wall / erosion repairs. ▪ Reinstatement of rundown / balance lines. ▪ Pond retrofitting / upgrade. ▪ Pond replacement. **Other** ▪ See Fuel and Chemical Storage and Handling (Table 7-15). ▪ See Waste Management (Table 7-11)	**E** **F** **C&R** **C**	**III**	**d**	**3**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
PFW storage and management	Contamination of soil, waterways and / or shallow groundwater resources	Flooding of surrounding floodplain / watercourses	▪ Damage to infrastructure (e.g. evaporation ponds) ▪ Exposure of livestock and native fauna to contaminants ▪ Soil erosion and siltation of watercourses ▪ Loss of vegetation and topsoil (either stockpiled or in situ)	**Design** ▪ PFW pond systems design, which includes detailed planning and consideration of flood risks, proximity to floodplains, waterways and other sensitive receptors. ▪ Measures undertaken to reduce potential impacts of flooding where appropriate (e.g. installation of bunds, removal of contents prior to arrival of flood event, maintain a minimum freeboard in ponds). **Systems** ▪ PFW plant and pond system maintenance and inspection schedules. ▪ Monitoring and communicating Cooper Basin Flood Reports, when available.	**E** **F**	**III**	**c**	**2**
PFW reuse	Contamination of soil or watercourses	Regular application of PFW to ground	▪ Salinisation or impact to soils ▪ Exposure of livestock and native fauna to contaminants ▪ Potential impacts to topsoil, native vegetation and fauna habitat	**Systems** ▪ Relevant external approvals obtained where required. ▪ Liaise with landowners where required. ▪ Reuse is managed in accordance with relevant water quality criteria (e.g. ANZECC (2000) / ANZG (2018)) and risk assessment outcomes. ▪ Risk to sensitive receptors is minimised by implementation of Santos standards and internal approvals processes.	**E** **F**	**II**	**b**	**2**

7.8 Enhanced Hydrocarbon Recovery

The main hazards associated with fluid injection schemes include surface spills of any chemicals used to treat fluids prior to injection and loss of containment from high pressure pipelines.

Other hazards associated with fluid injection schemes include:

- injection of non-compatible waters into a formation, which may lead to a reduction in the reservoir quality and / or impacts to third party groundwater users
- injection of fluids containing biocides and / or tracers
- injection of fluid into unintended formations or aquifers due to loss of subsurface well integrity or out-of-zone fracture growth
- loss of containment (with failure of high-pressure lines) of reinjection fluid and / or any chemicals used to treat water.

Injecting fluid into a zone where fluids are incompatible may lead to a reduction in the reservoir or aquifer water quality. Therefore, quality and compatibility testing is undertaken on the injection fluid prior to activities being undertaken to ensure that the water quality of the receiving aquifer / reservoir is not adversely affected. Scale inhibitor and a biocide may be used to condition injection fluids and minimise the potential for bacterial growth. The amount of biocide or inhibitor added to the injection fluid is minimal in comparison to the volume of water present in the reservoir and therefore the risk of adversely impacting reservoir water quality is negligible. Water quality testing is undertaken periodically to ensure consistency of injection fluid quality.

Injection wells are routinely tested for leaks from packers, tubulars and / or casing strings, as per Santos' standard operating procedures.

In waterflood schemes, injection pressures may be above or below formation fracture pressures, depending on the reservoir characteristics and scheme design. Injecting at pressures above the formation fracture pressure will initiate small fractures in the formation, which will increase the formation injectivity and allow for increased fluid injection rates.

Reinjection activities are only undertaken in reservoirs where the risk of fluid loss to adjacent formations (i.e. overlying and / or underlying aquitards) is considered low. Containment of injected fluids within the storage reservoir is also a key consideration for carbon storage. This is covered in the carbon storage EIR (Santos 2021b).

Tracers (if used) are added to the fluid injection well under controlled conditions by specialist contractors in a sealed/closed system. Tracers are used to track injection fluids and provide confidence that a system is operating in accordance with design specifications. The type of tracer used will be dependent on the injection scheme and target formation.

Failure of high-pressure lines may result in a release of fluids containing contaminants or a release of gas (including CO_2) where it could impact environmental or human health receptors. Injection fluid is typically transferred through HDPE, steel or composite lines that are rated and tested to meet project requirements. Water and gas injection skids have high-low shutdowns and are monitored by telemetry.

Reinjection programs are subject to detailed technical assessment which includes modelling and require regulatory approval prior to commencement.

7.8.1 Radioactivity

The potential for radioactivity resulting from Naturally Occurring Radioactive Materials (NORM) that are brought to the surface during production activities. Based on previous experience with Cooper Basin petroleum operations, levels of radioactivity associated with NORMs in produced fluids are not expected to be significant and are expected to be well below any levels of concern. Where present, NORMs usually present a potential issue when they are concentrated (e.g. by the formation of mineral scales or sludges over time in tanks, piping and facilities).

Appropriate protocols (e.g. risk assessment, monitoring where required) will be implemented where radioactive tracers are used to confirm that radiation levels are well below any levels of concern. Santos maintains a NORMS Exposure Controls document under the Santos Management System that details safe systems of work for when there is a potential NORMs risk. This document applies across all Santos operations.

Other radioactive material are managed under the Santos SMS Radioactive Materials and Explosives Technical Standard. This maps out controls around the use of radioactive sources and tools. This SMS document includes the requirement for radioactive source tool supplying companies to be licenced and have procedures in place for the safe handling of radioactive sources and equipment.
All radioactive materials will be handled in accordance with relevant legislation and guidelines (e.g. Radiation Protection and Control Act 2021).

The hazards, potential consequences, management strategies and level of residual risk associated with water / gas reinjection are summarised in Table 7-7.

Table 7-7: Enhanced hydrocarbon recovery risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
EHR scheme – sub-surface operations	Degradation of reservoir or aquifer quality	Injection of non-compatible water	▪ Contamination or souring of reservoir or aquifer	**Design** ▪ Demonstrated fluid compatibility in the design phase. ▪ Injection fluid treatment design. ▪ Reinjection activities are only undertaken in reservoirs where the risk of fluid loss to adjacent formations is considered low. ▪ Reinjection programs are subject to detailed technical assessment which includes modelling. **Systems** ▪ Applicable approvals are obtained prior to operations. ▪ Operational program for water quality testing on injection water. ▪ Establishment and measurement of chemical dosage metering.	**E** **F** **C&R** **C**	**III**	**a**	1
EHR scheme – sub-surface operations	Injection of water / gas into non-target reservoirs / aquifers	Loss of well integrity	▪ Impact to environmental or human health receptors ▪ Inability of third party groundwater users to undertake their respective activities ▪ Cross-flow between aquifer formations resulting in degradation of reservoir / aquifer quality ▪ Breach / release of waters at surface resulting in erosion, impacts to soil and / or surface water quality, loss of fauna habitat and impacts to native vegetation	**Design** ▪ Well design in accordance with the Drilling, Completions and Well Operations (DCWO) SEO, such as: - Aquifers isolated behind casing string(s) cemented in place - Casing string and cement slurry designed by qualified and competent engineers and confirmed by senior engineers or external consultants where necessary - Appropriately designed casing and wellhead installed on new wells drilled and retained for use. **Systems** ▪ Well drilling, completions, operations, integrity management and decommissioning in accordance with the requirements of the DCWO SEO, including: - Effective barriers exist to maintain well control and prevent crossflow between separate aquifer systems or hydrocarbon reservoirs outside of the target reservoirs - Operational reports verify that barriers have been set and / or remedial cement work carried out in accordance with the work program as submitted to and / or agreed by DEM - Cased hole cement bond logs to confirm quality of cement job in the casing strings - Well integrity management system and checks to confirm well integrity over well life - Where integrity monitoring identifies potential issues, a risk assessment to evaluate safety and environmental impacts is undertaken to develop prevention and mitigation controls where appropriate. ▪ Regular production operator checks throughout well life. ▪ Reporting and records of loss of well integrity events and corrective actions are in accordance with the requirements of the DCWO SEO. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with EHR schemes. ▪ Real time pressure monitoring on injection wells and pressure relief valve on the high-pressure EHR pump/compression system. ▪ In the event of an environmental incident resulting from a loss of well integrity, SMS requirements will be implemented as outlined in the DCWO SEO.	**S** **E** **F** **C&R** **C**	**III**	**b**	2
EHR scheme – sub-surface operations	Injection of water into non-target reservoirs / aquifers	Fracture propagation out of target zone	▪ Impacts to environmental or human health receptors ▪ Inability of third party groundwater users to undertake their respective activities ▪ Cross-flow between aquifer formations resulting in degradation of reservoir / aquifer quality	**Design** ▪ Reservoir modelling for injection scheme design. ▪ Completion design for injection wells. ▪ Fit for purpose equipment. **Systems** ▪ Integrity of the well bore and packer are routinely tested. ▪ Cement bond logs run to test for poor cement bonds where appropriate. ▪ Real time pressure monitoring on injection wells and over pressure protection. ▪ Injection operating guidelines. ▪ Ongoing monitoring of reservoir response to injection. ▪ Well integrity management system, testing, maintenance and inspection procedures are implemented. ▪ Ensure individuals in areas of responsibility are trained to handle events.	**C** **E** **F** **C&R** **C**	**III**	**b**	2

Identification				Control Strategy	Assessment			
					Risk			
Activity	**Risk Issue**	**Cause**	**Impact**	**Controls**	**S, E, C&R, F, W, C**	**Consequence**	**Likelihood**	**Residual Risk**
EHR scheme – surface operations	Impact to soil and / or shallow groundwater resources	Loss of containment of reinjection water (PFW, water containing chemicals, including biocide inhibitor)	▪ Livestock and native fauna access to contaminants ▪ Impacts to native vegetation ▪ Impacts to stakeholder business reputation ▪ Erosion, scouring, loss of fauna habitat, siltation into waterways ▪ Soil and shallow groundwater resource contamination	**Design** ▪ Quality control of pond construction (if constructed) including above ground earthen bunds to prevent surface water ingress. ▪ Ponds (if constructed) designed with liners, as required. ▪ Equipment designed and operated in accordance with relevant standards and guidelines. ▪ Injection fluid is transferred in lines that are rated and tested to meet project requirements. ▪ Injection surface infrastructure equipped with shut downs and injection monitoring. **Systems** ▪ Makeup water stored in designated tanks or ponds. ▪ Maintain minimum pond freeboard. ▪ Regular inspection and maintenance of pond walls. ▪ Transfer lines tested and maintained to design conditions. ▪ Pipeline monitored for leaks (pressure gauges and visual inspection) as per Santos standards. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. **Response** ▪ Spill response and clean up. **Other** ▪ See Pipelines (Table 7-3).	**E** **C&R** **C**	**II**	**a**	**1**
EHR scheme – surface operations	Impacts to land and water systems and public safety	Loss of containment (release of fluids from high pressure pumps and flowlines)	▪ Erosion, scouring, sedimentation, surface water contamination, loss of fauna habitat, impacts to native vegetation ▪ Localised soil and / or shallow groundwater resource contamination and / or salinisation ▪ Anoxic (CO_2 rich) atmospheres adversely impacting native vegetation, livestock and native fauna or people ▪ Impacts to stakeholder business reputation ▪ Potential impacts to public safety ▪ Generation of greenhouse gas emissions, localised reduction in air quality	▪ Plant and equipment designed and constructed in accordance with SMS and Engineering Standards, and relevant Australian/International standards (e.g. AS 2885). ▪ Injection surface infrastructure (pumps, flowlines, filtration, chemical dosing facilities) equipped with automatic overpressure shut downs and telemetry monitoring. ▪ Transfer lines tested and maintained to design standards. ▪ Pipeline monitored for leaks (pressure gauges and visual inspection) as per Santos standards. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ Spill response and clean up. ▪ See Pipelines (Table 7-3).	**S** **E** **F** **C&R**	**III**	**b**	**2**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
EHR scheme – surface operations	Contamination of soil and / or shallow groundwater resources	Loss of containment – storage of chemicals (tracers, corrosion inhibitor, emulsion breaker)	▪ Contamination of soil, surface water and / or shallow groundwater resources resulting in impacts to native vegetation or fauna habitat ▪ Injury to or loss of native fauna or livestock through exposure ▪ Impacts to third party groundwater users ▪ Impacts to public safety (exposure to contaminants) ▪ Impacts to stakeholder business reputation	**Design** ▪ Fit for purpose equipment. **Systems** ▪ Safety procedures implemented by specialists hired to conduct work. ▪ Chemical substances are stored in accordance with Santos standards and relevant Australian standards. ▪ Safety, testing, maintenance and inspection procedures are implemented. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with EHR schemes. ▪ SDS available for all chemicals used. ▪ Tracers (if used) are added to the fluid injection well under controlled conditions by specialist contractors in a sealed / closed system and in accordance with the Radiation Protection and Control regulations 2022 ▪ Other radioactive tools/ sources are all managed in accordance with regulatory requirements, and in accordance with the Santos Management System. **Response** ▪ Appropriate emergency response plans in place. ▪ Emergency spill response equipment on site. ▪ Spill response and clean up. **Other** ▪ See Satellite Facilities (Table 7-5)	**S** **E** **F** **C&R**	**II**	**b**	**2**

7.9 Moomba Plant – Process Facilities

Hazards that are common to facilities and processes include:

- release of emissions to air, land and water from flaring, venting, fuel use and other minor losses (fugitives)
- loss of containment of fuel, chemicals, oil and other potentially hazardous materials
- fire or explosion from ignition of HC gas
- generation of general and industrial wastes.

In addition to emissions and loss of containment, risk to public safety and disruption to natural gas supply to the South Australian market are also potential hazards. Public safety risk is minimal due to the level of security, restricted access, and remote location of the Moomba Gas Plant. Historically, the Moomba Plant has been the primary supplier of natural gas to the South Australian market. However, South Australia's reliance on Moomba has decreased in recent years.

The most likely cause of a disruption to gas supply is explosion or fire, the controls for which include:

- construction, operation and maintenance of fit for purpose equipment
- infrastructure integrity management
- safety testing, maintenance and inspection
- hazardous area management

Refer to Section 7.9.2 for more detail on explosion / fire risk management.

7.9.1 Fitness for purpose

Moomba Plant undergoes a Fitness for Purpose assessment.

In accordance with Regulation 30 of the *Petroleum and Geothermal Energy Regulations 2013*, a Fitness for Purpose (FFP) report has been developed and is reviewed and / or updated every five years.

The intent of the FFP is to demonstrate how Santos manages risk associated with the operations in the Cooper Basin including:

- public health and safety
- environmental risk
- security of supply of natural gas.

The most recent FFP report was completed in 2018 and is validated in conjunction with DEM through site visits. This validation process verifies implementation or undertaking of:

- third party reviews
- equipment upgrades/replacement based on risk assessments
- risk reduction mechanisms
- equipment upgrades to improve the reliability of Moomba Plant utility systems
- management system and program improvements
- ongoing development and improvement of the SMS
- action close-out associated with the Moomba Plant Whole of Plant Risk Assessments (WOPRA)
- Formal Safety Assessment (FSA) on Moomba Plant to identify and characterise significant process hazards (refer to Section 7.9.2 Process safety)
- actions associated with recommendations of the FSA.

The report concluded that the facilities and systems operated by Santos are fit for purpose.

7.9.2 Process safety

Process safety management aims to contain oil, gas and other processed substances, and prevent unplanned or uncontrolled releases leading to major accident events[7] (MAEs) and major incidents[8] (MIs) which could result in fatalities and serious injury, significant property damage or environmental harm. The process safety framework manages process safety barriers to reduce operating risks So Far As Is Reasonably Practicable (SFAIRP).

Effective management of process safety requires:

- identification and understanding of the hazards and scenarios and apply appropriate controls to prevent process safety incidents
- management and governance of the controls for effective implementation, performance assurance, deviation management and escalation of non-complying controls.

The key concept of Santos' approach to process safety management is the presence of multiple barriers. The purpose of these barriers is to prevent or to mitigate the consequence of loss of containment incidents. Each barrier serves to either prevent an initiating event from developing into a loss of primary containment incident (LOCI) or mitigates the consequence of a LOCI once it has occurred. Barriers may be managed in barrier groups for efficiency. Each barrier group is underpinned by a standard in the SMS, including:

- design integrity
- secondary containment
- integrity management
- procedures
- permit to work and isolations
- basic process control system
- instrumented protective system
- pressure relief and inventory management
- ignition control
- fire detection and protection
- emergency response.

Barriers assessed as safety critical are managed through process safety key performance indicators (KPIs). These are a combination of lead and lag indicators used to measure barrier strength, e.g. safety critical compliance.

If the regulator considers that there is a potential for a major incident to occur at a facility it will be designated as a major hazard facility (MHF). This is based on the quantity and combination of Schedule 15 chemicals present, the type of activity at the facility that involves Schedule 15 chemicals or land use activities. The operator of a determined MHF is required to prepare a safety case to apply for a MHF licence, as stipulated in the WHS Regulations. The safety case summarises safety information such as major incidents that could occur, the safety assessment, and the facility's emergency plan. The safety case demonstrates that the control measures will eliminate or minimise the risk of a major incident

[7] A Major Accident Event (MAE) is defined in the SMS as *'an event connected with a facility, including a natural event, having the potential to cause multiple fatalities of persons at or near the facility (or as defined within the relevant legislation pertaining to a facility.)'*

[8] A Major Incident is defined in the SMS as '*an event involving or potentially involving flammable or toxic chemicals that expose a person to a serious risk to health and safety, including the loss of containment, fire or explosion (facility (or as defined within the relevant legislation pertaining to a facility.)'*

occurring and minimise the magnitude and severity of a major incident, so far as is reasonably practicable.

Santos has completed the safety case for the Moomba Gas Plant and received a MHF licence.

7.9.3 Emissions

Emissions (e.g. flaring, venting and fugitive emissions) include greenhouse gas emissions to air (carbon dioxide, methane and nitrous oxide) as reported annually under the NGER Act, and other pollutants emitted to air, land and water as reported annually to the NPI.

Information reported to the NPI is publicly available on the NPI website (www.npi.gov.au).

7.9.4 Inlet separation

The main hazard associated with the inlet separation is the disposal of process wastes. Process wastes include:

- oil sludge, typically managed at the sludge treatment plant
- sour water (east flow), typically managed via the Moomba interceptor pond system
- PFW, typically directed to the Moomba interceptor pond system.

Approximately 60 – 70% of oil sludge generated annually at Moomba is recovered in the process, while the remainder is taken off site for disposal at an EPA licensed facility.

Approximately 1500 m^3/day of sour water is transferred to an engineered waste lagoon referred to as 'Lake Brooks'. Data from 2013 showed that sour water had a high salinity and elevated levels of aluminium and boron that can affect native fauna and native vegetation.

Approximately 300 m^3/day of PFW (total from all processes) is currently treated at the Moomba pond system.

The possible consequence of waste handling and management at each of the above sites may potentially result in contamination to soil and / or shallow groundwater resources (oil sludge, sour water and PFW), acidification (sour water) and / or salinisation (sour water and PFW) of soil or groundwater.

In addition to possible soil and groundwater contamination, the Moomba Pond system poses a hazard to native fauna (i.e. birds), as there is the potential for birds to ingest contaminants and / or become oiled.

The storage and handling of chemicals, fuels and other hazardous materials is managed in accordance with Santos Standards (see Section 7.4.1).

Wastes generated by Moomba Plant activities are managed in accordance with Santos' Waste Management Plan, see Section 4.9.2.

7.9.5 Raw Gas Conditioning Plant

The hazards associated with the RGCP include the emission of CO_2 and H_2S.

Typical composition of air emissions from the CO_2 removal process includes:

- carbon dioxide
- water vapour
- hydrogen sulphide
- methane
- vanadium
- potassium carbonate.

Moomba Plant wastewater is managed at the plant evaporation ponds or the interceptor pond system. The discharge of wastewater from the CO_2 removal process has the potential to generate soil and / or shallow groundwater resource contamination and / or salinisation, and for the exposure of livestock to contaminants and native fauna.

See Section 4.9.2, which describes waste and wastewater management.

7.9.6 Liquids recovery

Oil sludge and oily water management are environmental hazards associated with liquids recovery. Inappropriate management of sludge and oily water discharging from the LRP could potentially lead to impacts to soil and / or shallow groundwater resources.

Oily water goes to the Moomba interceptor pond system. Oil sludge, which is collected from tank bottoms, sumps and interceptor ponds, is managed at the sludge treatment plant.

7.9.7 Liquids processing

Hazards associated with liquids processing at the tank farm are potential loss of containment which may result in impacts to soil and / or shallow groundwater resources, see Section 7.9.7. Impacts to soil and / or shallow groundwater resources may result in impacts to native fauna or impacts to third party groundwater users.

Hazards associated with liquids processing in the Crude Stabilisation Plant are potential loss of containment, which may result in impacts to soil and / or shallow groundwater resources, flaring of gases and chemical management. Impacts to soil and / or shallow groundwater resources may result in impacts to native fauna or impacts to third party groundwater users. Flaring may result in impacts to local air quality and contribute to greenhouse gas emissions for Moomba Plant (see Section 7.9.9).

7.9.8 Tank farm and truck load-in

Fugitive emissions generated from stored crude oil storage tanks has the potential to impact local air quality and contribute to greenhouse gas emissions for Moomba Plant.

The loss of crude oil and condensate during the transfer from road tankers to the floating roof storage tanks could result in contamination to soil and / or shallow groundwater resources.

Loss of containment of diesel from storage tanks or during handling and refuelling activities may lead to impacts to soil.

7.9.9 Flare systems

Flaring contributes to emissions of CO_2 and dark smoke impacting air quality. Air emissions are managed in accordance with the EPA licence.

A flare system is provided for both plant venting and emergency relief. Low pressure gas is directed to the flare, which is continuously alight. During any process anomalies, gas can be sent directly to the flare. Also, during any emergency, gas in the plant can be directed to the flare.

7.9.10 Gas compression facility - Moomba North

Hazards at Moomba North are the same as Moomba Plant and managed similarly.

The hazards, potential consequences, management strategies and level of residual risk associated with Moomba Plant are summarised in Table 7-8.

Table 7-8: Moomba Gas Plant – process facilities and utilities risk assessment

<table>
<tr><th colspan="4">Identification</th><th>Control Strategy</th><th colspan="4">Assessment</th></tr>
<tr><th rowspan="2">Activity</th><th rowspan="2">Risk Issue</th><th rowspan="2">Cause</th><th rowspan="2">Impact</th><th rowspan="2">Controls</th><th colspan="4">Risk</th></tr>
<tr><th>S, E, C&R, F, W, C</th><th>Consequence</th><th>Likelihood</th><th>Residual Risk</th></tr>
<tr><td>Gas and liquid processing – oil sludge management (inlet separation and LRP and Moomba North)</td><td>Contamination of soil and / or shallow groundwater resources</td><td>Loss of containment of oily sludge during collection, transfer/transport and treatment (on-site)</td><td>Impacts to native vegetation from contamination of soil and / or shallow groundwater resources
Exposure of native fauna to contaminants</td><td>Design
Pits are lined in accordance with applicable standards of the day.
Sludge Treatment Plant is a purpose built and fully contained facility.
Moomba interceptor and pond system is fenced – pest animal access and sand drift control.
Moomba Gas Plant (MGP) has restricted access.
Greater Moomba Area (Moomba facilities) is fenced.
Systems
Reliability and Maintenance Management System (RAMMS) framework.
Asset Integrity Management System (AIMS).
SMS standards.
Manual skimming of interceptor ponds.
Regular operator checks.
Sludge cake removed and treated off-site.
Engage licensed waste transport contractors.
Adherence to EPA guidelines (WTC) processes.
Minimum freeboard maintained in storage ponds.
Continued competency assessment, education and training of individuals responsible for activities associated with operation of Moomba Plant.
Maintenance of a contaminated sites register and implementation of corrective actions.
Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation.
Safe work permits must be obtained to ensure only individuals with proper clearance can conduct work.
Response
Implementation of emergency response procedures.
Appropriate emergency response plans in place.
Emergency spill response equipment maintained and tested on site.
Spill response and clean up.</td><td>S
E
C&R
C</td><td>III</td><td>c</td><td>2</td></tr>
</table>

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Gas processing – oil/oily water, sour water west flow (including Moomba North, LRP, PFW, RGCP/Benfield Trains) management	Contamination of soil and / or shallow groundwater resources	Loss of containment of oil / oily water or sour water (west flow)	▪ Contamination of soil and / or shallow groundwater resources ▪ Exposure of native fauna and habitat, native vegetation and waterways to contaminants ▪ Impacts to third party groundwater users	**Design** ▪ Fit for purpose equipment. ▪ Plant and equipment design and operations risk management. ▪ Ponds are lined in accordance with applicable standards. ▪ Sludge Treatment Plant is a purpose built and fully contained facility. ▪ Moomba Gas Plant (MGP) has restricted access. ▪ Greater Moomba Area (Moomba facilities) is fenced. **Systems** ▪ Interceptor ponds skimmed. ▪ Regular operator checks, inspection and maintenance. ▪ Minimum freeboard maintained in storage ponds. ▪ Integrity management plans implemented for below and above ground pipelines. ▪ Monitoring (and response to) upstream and downstream activities, and response, that might cause overflow. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with operation of Moomba Plant. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct work. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. **Response** ▪ Level alarms in sumps provide real time monitoring to inform incident response. ▪ Implementation of spill response procedures, which include immediate reporting of spills/leaks. ▪ Spill response and clean up. ▪ Emergency spill response equipment maintained and tested on site. ▪ Wastewater Management Plan.	**S** **E** **C&R** **C**	**II**	**c**	**2**
Gas processing – CO_2 trains, Moomba North	Unauthorised gas emissions	Greenhouse (and other) gas emissions, fire from loss of containment.	▪ Disruption to gas supply ▪ Generation of greenhouse gas emissions ▪ Localised reduction in air quality ▪ Impacts to public safety	**Design** ▪ Fit for purpose equipment. ▪ Plant and equipment designed and constructed in accordance with SMS and Engineering Standards, and relevant Australian/International standards (e.g. AS 1210). ▪ Remote location of Moomba Plant. **Systems** ▪ Reliability and Maintenance Management System (RAMMS) framework. ▪ Asset Integrity Management System (AIMS). ▪ SMS standards. ▪ Authorised emissions. ▪ Dispersion monitoring and modelling. ▪ Routinely undertake stack monitoring. **Response** ▪ Appropriate corrective actions undertaken.	**E** **C&R** **C**	**II**	**b**	**1**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Liquids processing – tank farm and truck load-in	Contamination of soils and / or shallow groundwater resources	Loss of containment associated with storage of oil and tank farm and road tankers	▪ Contamination of soil and / or shallow groundwater resources ▪ Exposure of native fauna and habitat and native vegetation to contaminants ▪ Impacts to public safety if off-site movement of contaminants occurs	**Design** ▪ Fit for purpose equipment. ▪ Plant and equipment designed and constructed in accordance with SMS and Engineering Standards, and relevant Australian/International standards (e.g. AS 1210). ▪ Hardstand areas. ▪ Cathodic protection. ▪ Instrumentation, high-level alarms and controls incorporated into tank design. ▪ Floating roof storage tanks individually bunded in accordance with relevant guidelines e.g. EPA Bunding Guidelines. ▪ Fencing minimises entry of livestock and native fauna and public. ▪ Truck load-in area designed with sumps and pumps. **Systems** ▪ Reliability and Maintenance Management System (RAMMS) framework. ▪ Asset Integrity Management System (AIMS). ▪ Identification and management of critical barriers through the relevant risk assessment / management process. ▪ SMS standards. ▪ Operator checks and monitoring. ▪ Internal and external inspections of tanks as per applicable standards and industry guidelines. ▪ Procurement processes and contracts manage contractor's activities (truck drivers / trucks). ▪ Continued competency assessment, education and training of individuals responsible for activities associated with operation of Moomba Plant. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct work. **Response** ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ Emergency response procedures are implemented in accordance with Regulation 31. ▪ Implementation of spill response procedures, which include immediate reporting of spills/leaks. ▪ Spill response and clean up. ▪ Emergency spill response equipment maintained and tested on site.	**S** **E** **F** **C&R** **C**	**II**	**c**	**2**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Liquids processing – Crude Stabilisation Plant	Contamination of soils and / or shallow groundwater resources	Loss of containment associated with operation of the CSP	▪ Contamination of soil and / or shallow groundwater resources	**Design** ▪ Fit for purpose equipment. ▪ Plant and equipment designed and constructed in accordance with SMS and Engineering, and relevant Australian/International standards (e.g. AS 1210). ▪ Concrete pad and closed drainage system. **Systems** ▪ Reliability and Maintenance Management System (RAMMS) framework. ▪ Asset Integrity Management System (AIMS). ▪ SMS standards. ▪ Operator checks and monitoring. ▪ Internal and external inspections of vessels as per applicable standards and industry guidelines. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with operation of Moomba Plant. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct work. **Response** ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ Emergency response procedures are implemented in accordance with Regulation 31. ▪ Implementation of spill response procedures, which include immediate reporting of spills / leaks. ▪ Spill response and clean up. ▪ Emergency spill response equipment maintained and tested on site.	**S** **E** **F** **C&R** **C**	**II**	**c**	**2**
Liquids processing – tank farm and truck load-in	Greenhouse (and other) gas emissions	Failure of floating roof; fugitive venting of gases	▪ Greenhouse gas emissions ▪ Localised reduction in air quality	**Design** ▪ Fit for purpose equipment. ▪ Plant and equipment designed and constructed in accordance with SMS and Engineering Standards and relevant Australian/International standards (e.g. AS 1940). ▪ Minimisation of vapour space between the material stored and the roof of the floating storage tanks to limit product loss. ▪ Remote location of Moomba Plant. ▪ Santos continues to consider all reasonable and practicable measures to minimise greenhouse gas emissions from the operation of Moomba Plant, and in doing so, pursue strategies that address the issue of climate change, in accordance with Santos' Climate Change Policy. **Systems** ▪ Reliability and Maintenance Management System (RAMMS) framework. ▪ Inspections. ▪ Upstream controls – Total Vapour Pressure (TVP) operating window. ▪ Installation of alarms in storage tanks to assist operators in identifying faults or failures of the floating roof. **Response** ▪ Emergency shutdown. ▪ Emergency response plan.	**S** **E** **F** **C&R** **C**	**I**	**d**	**2**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Liquids processing – trunklines/ pipelines	Soil and / or shallow groundwater resource contamination	Loss of containment (pipeline / trunkline)	▪ Contamination of soil and / or shallow groundwater resources ▪ Exposure of native fauna and habitat and native vegetation to contaminants ▪ Exposure of livestock to contaminants ▪ Impacts to public safety	**Design** ▪ Fit for purpose equipment. ▪ Plant and equipment designed and constructed in accordance with SMS and Engineering Standards and relevant Australian/International standards (e.g. AS 2885). ▪ Fencing. **Systems** ▪ Reliability and Maintenance Management System (RAMMS) framework. ▪ Asset Integrity Management System (AIMS). ▪ SMS standards. ▪ Inspection and testing undertaken. ▪ Specific testing for microbes to enable management of potential Microbiologically Influenced Corrosion (MIC). ▪ Integrity management plan. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with operation of Moomba Plant. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct work. **Response** ▪ Emergency response procedures are implemented in accordance with Regulation 31. ▪ Loss of containment is reported and investigated. ▪ Implementation of spill response procedures, which include immediate reporting of spills/leaks. ▪ Emergency spill response equipment maintained and tested on site. **Other** ▪ See Pipelines (Table 7-3).	**S** **E** **F** **C&R** **C**	**III**	**D**	**2**
Moomba Gas Plant - Gas/oil supply (transfer to market)	Contamination of soil and / or shallow groundwater resources Greenhouse (and other) gas emissions, fire	Loss of containment (pipeline or equipment failure)	▪ Disruption to gas supply ▪ Disruption of Port Bonython feed ▪ Generation of greenhouse gas emissions ▪ Localised reduction in air quality ▪ Contamination of soil, shallow groundwater resources and / or watercourses ▪ Impacts to public safety ▪ Exposure of native fauna and habitat and native vegetation to contaminants ▪ Exposure of livestock to contaminants	**Design** ▪ Fit for purpose equipment. ▪ Restricted access to site. **Systems** ▪ Identification and management of critical barriers through the relevant risk assessment/management process. ▪ Reliability and Maintenance Management System (RAMMS) framework. ▪ Asset Integrity Management System (AIMS). ▪ SMS standards. ▪ Safety, testing, maintenance and inspection procedures are implemented. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with operation of Moomba Plant. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct work. ▪ Hazardous area management criteria are followed. **Response** ▪ Emergency response procedures contain a bushfire scenario. ▪ Emergency response plans implemented, including drills. ▪ Emergency spill response equipment maintained and tested on site. ▪ Implementation of spill response procedures, which include immediate reporting of spills / leaks. ▪ Spill response and clean up. ▪ Gas storage and plant bypass for gas supply contingency.	**S** **E** **F** **C&R** **C**	**III**	**b**	**2**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Moomba Gas Plant - Flare Systems	Greenhouse (and other) gas emissions, fire hazard and impacts to public safety	Operation of flares	▪ Loss of visual amenity ▪ Localised reduction in air quality	**Design** ▪ Fit for purpose equipment. ▪ Plant and equipment design. ▪ Remote location of Moomba Plant. ▪ Restricted access to site. **Systems** ▪ Fuel, flare and vent (FFV) monitoring and measuring – optimising flame quality, minimising use of gas. ▪ Reliability and Maintenance Management System (RAMMS) framework. ▪ Asset Integrity Management System (AIMS). ▪ SMS standards. ▪ Authorised emissions. ▪ Dispersion monitoring and modelling. ▪ Where possible, liquids are diverted to the Flare Gas Recovery Compressor and recovered as fuel gas, in preference to being flared. **Response** ▪ Appropriate corrective actions undertaken.	**S** **E** **F** **C&R** **C**	**II**	**b**	**1**
Moomba Gas Plant Utilities – waste and wastewater (sour water east flow) management	Soil and / or shallow groundwater resources contamination	Loss of containment and inappropriate management of waste streams and wastewaters (sour water east flow)	▪ Contamination of soil and / or shallow groundwater resources ▪ Exposure of native fauna and habitat and native vegetation to contaminants ▪ Exposure of livestock (and potential impact to stakeholder business reputation) contaminants ▪ Impacts to public safety if off-site movement of contaminants occurs ▪ Salinisation	**Design** ▪ Pond systems for management of sour water east flow. ▪ Studies are undertaken to investigate wastewater management options for Moomba Plant to identify modifications that could be implemented based on operational requirements and constraints. **Systems** ▪ Implementation of Waste Management Plan. ▪ Licenced landfill operated in accordance with licence conditions and Landfill Environmental Management Plan (LEMP). ▪ Segregation and applicable storage of waste and wastewater streams. ▪ Licenced contractors and waste trucks contracted; and applicable WTCs completed in accordance with regulations, as required. ▪ Implementation of Wastewater Management Plan. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation Response. **Response** ▪ Loss of containment is reported and investigated. ▪ Emergency response procedures are implemented. ▪ Emergency spill response equipment maintained and tested on site. ▪ Spill response and clean up. **Other** ▪ See Waste Management (Table 7-11)	**S** **E** **F** **C&R** **C**	**I**	**a**	**1**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Moomba Gas Plant Processing Facilities and Utilities - chemical and fuel storage	Contamination of soils and / or shallow groundwater resources	Loss of containment of chemicals and fuel	▪ Contamination of soil and / or shallow groundwater resources within Moomba Plant	**Design** ▪ Plant and equipment design. ▪ Bunding according to relevant standards such as EPA Bunding Guidelines. ▪ Hardstand, sealed areas. ▪ Fenced plant and restricted access. **Systems** ▪ Storage of chemicals, fuels and oils in accordance with the Safety Data Sheet (SDS), SMS, EPA Bunding Guidelines and AS 1940. ▪ Chemical management practices. ▪ Appropriate labelling of chemicals. ▪ Licensed delivery service. ▪ Controlled waste management, WTC and licensed contractors. ▪ Tank inspections and maintenance as per Australian Standards e.g. AS 1940. ▪ Regularly educate staff of product, review and monitor chemical and fuel transportation, including signage / labelling, proper packing and tie downs. ▪ SDSs on site and available. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with operation of Moomba Plant. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct work. **Response** ▪ Emergency response procedures are implemented. ▪ Spill response and clean up. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. **Other** ▪ See fuel and chemical storage and handling (Table 7-15: Fuel and chemical storage and handling risk assessment).	**S** **E** **F** **C&R** **C**	**I**	**b**	**1**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Moomba Gas Plant Processing Facilities and Utilities- emergency situation, disaster, natural event	Public safety, impacts to third party assets, air emissions, impacts to wildlife / wildlife habitat and contamination of soil and / or shallow groundwater resources	Explosion or fire Flood event	▪ Disruption to gas supply ▪ Generation of greenhouse gas emissions ▪ Localised reduction in air quality ▪ Fire and explosion hazard ▪ Impacts to public safety and third-party assets (and stakeholder business reputation) ▪ Impacts to native fauna and habitat and native vegetation ▪ Contamination to soil and / or shallow groundwater resources	**Design** ▪ Fit for purpose equipment. ▪ Fire safety equipment and systems. ▪ Restricted access to Moomba Plant and Moomba facilities. **Systems** ▪ No public access to Moomba Plant compound due to security and fencing. ▪ Safety Case assessment and review undertaken every 5 years validating risk management systems, and identification and management of critical barriers through the relevant risk assessment / management process. ▪ Safety, testing, maintenance and inspection procedures are implemented. ▪ Continued competency assessment, education and training of individuals responsible for activities associated with operation of Moomba Plant. ▪ Safe Work Permit system implemented to ensure only individuals with proper clearance can conduct work on inside Moomba Plant. ▪ Consideration of weather conditions i.e. wind direction for safe work. ▪ Hazardous area management criteria are continuously reviewed according to relevant Australian Standards and legislative requirements. ▪ Reliability and Maintenance Management System (RAMMS) framework. ▪ Asset Integrity Management System (AIMS). ▪ SMS standards. **Response** ▪ Emergency response procedures are implemented in accordance with Regulation 31. ▪ Emergency response procedures contain a bushfire scenario. ▪ Emergency spill response equipment maintained and tested. ▪ Spill response and clean up.	**S** **E** **F** **C&R** **C**	**V**	**a**	**3**

7.10 Moomba Gas Plant - Utilities

Hazards associated with the operation and maintenance of utilities located within the confines of Moomba Plant are considered in Section 7.9 and include:

- storage and handling of fuel and chemicals
- generation of general and operational waste
- emission of greenhouse and other gases to atmosphere.

Supporting infrastructure and facilities to Moomba Plant are considered in separate risk assessments. See Section 7.11.

7.11 Supporting Infrastructure and Facilities

7.11.1 Road construction and maintenance

Environmental hazards associated with road construction and maintenance includes movement of heavy vehicles, earthworks, vegetation clearance, chemical and fuel storage and waste disposal. Potential consequences resulting from road construction include:

- erosion
- disturbance or damage to cultural heritage sites
- compaction of soils
- disturbance to surface water drainage patterns
- impacts to native fauna and flora
- introduction of pest plants or animal species
- soil contamination
- impacts to public safety
- damage to third party infrastructure
- generation of noise and dust
- loss of visual amenity.

The hazards, potential consequences, controls, management strategies and level of residual risk associated with road and access track construction are summarised in Table 7-10.

Movement of light and heavy vehicles and earthworks

Movement of light and heavy vehicles (for example trucks, scrapers and bulldozers) during road construction is controlled to minimise the potential for impacts to vegetation, soils and / or public safety. Impacts include vehicles inadvertently damaging native vegetation, introducing pest plant or animal species, generating dust and / or compacting soil (other than that which is required for construction) and traffic.

Earthworks can result in impacts similar to the movement of light or heavy vehicles as well as potentially disturbing cultural heritage sites, altering surface water flows and exposing soils to wind and water erosion.

The type and severity of potential impacts associated with earthworks is dependent on the land system in which the activities are being carried out (see Section 4.9.1). Dunefields are generally more resilient and less likely to suffer long-term impacts, as supported by a study of seismic lines traversing dunefields in the Cooper Basin (SEA 1999), which concluded that natural rates of erosion on dunes were not accelerated as a result of disturbance to the soil surface.

The sensitive nature of wetland areas means that a higher level of control on activities and operations is employed to minimise disturbance and manage impacts, such as impeding surface water flows and fish passage.

Salt lakes are avoided as they are susceptible to scarring and hence difficult to rehabilitate.

The steeper slopes and escarpments of tableland land systems are avoided for the construction of roads due to their instability and the potential for erosion when disturbed. Potential impacts of specific earthwork activities in different Cooper Basin land systems are summarised in Table 7-9.

Earthworks have the potential to introduce pest plants or animal species into the region from movement of vehicles and construction equipment. As discussed in Section 5.3, the region has relatively few pest plants. Buffel grass is prevalent in Moomba compound and is managed in accordance with the Cooper Basin Pest Plants and Animals Management Plan which has been developed to meet Biosecurity SA requirements for Pest Plant Management.

Table 7-9: Impacts associated with road construction and maintenance in Cooper Basin land systems

Land systems	Activity/Hazard		
	Grading (road and access track construction and maintenance)	**Excavation/Digging (e.g. borrow pits)**	**Soil Stockpiling (for respread during restoration)**
Wetlands and floodplains	▪ Vegetation clearance ▪ Introduction of pest plants or animal species ▪ Soil erosion (wind and water) ▪ Soil compaction ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites (generally low density of sites in floodplains) Note: Higher level of controls employed where required in sensitive areas.	▪ Vegetation clearance ▪ Introduction of pest plants or animal species ▪ Soil erosion (wind and water) ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites (generally low density of sites in floodplains) Note: Higher level of controls employed where required in sensitive areas.	▪ Disturbance of natural drainage systems (e.g. siltation) ▪ Soil erosion (wind and water) ▪ Introduction of pest plants or animal species Note: Higher level of controls employed where required in sensitive areas.
Gibber plains and tablelands	Grading is generally not undertaken on gibber plains and tablelands.	▪ Vegetation clearance ▪ Introduction of pest plants or animal species ▪ Soil erosion (particularly susceptible to water erosion e.g. severe gullying) ▪ Disturbance of natural drainage systems (e.g. siltation) ▪ Inversion of the soil profile ▪ Disturbance to cultural heritage sites Note: Construction avoided on steeper slopes and escarpments	▪ Soil erosion (wind and water) ▪ Disturbance of natural drainage systems ▪ Inversion of the soil profile ▪ Introduction of pest plants or animal species Note: Construction avoided on steeper slopes and escarpments

Land systems	Activity/Hazard		
	Grading (road and access track construction and maintenance)	**Excavation/Digging (e.g. borrow pits)**	**Soil Stockpiling (for respread during restoration)**
Dunefields	▪ Vegetation clearance ▪ Introduction of pest plants or animal species ▪ Soil erosion (wind and water erosion) ▪ Disturbance to cultural heritage sites (dunefields near waterholes are typically of high Aboriginal cultural significance)	▪ Vegetation clearance ▪ Introduction of pest plants or animal species ▪ Soil erosion (wind and water erosion) ▪ Disturbance to cultural heritage sites (dunefields near waterholes are typically of high Aboriginal cultural significance) ▪ Inversion of the soil profile	▪ Soil erosion (wind erosion) ▪ Inversion of the soil profile ▪ Introduction of pest plants or animal species
Salt lakes	N / A (No construction on salt lakes)	N / A (No construction on salt lakes)	N / A (No construction on salt lakes)

Vegetation clearance

Hazards associated with vegetation clearance are loss of native vegetation and fauna habitat, siltation of natural drainage lines and watercourses, destabilisation of creek beds, introduction of pest plants or animal species and damage to sites of cultural heritage. Vegetation clearance may also impede the movement of native fauna, particularly small mammals or reptiles across cleared areas. However, this is considered unlikely in most land systems in the Cooper Basin due to the presence of naturally bare or unsheltered locations (Moss and Low 1996).

Road construction in heavily wooded areas, such as Coolibah woodland, is minimised as far as practicable and vegetation clearance is kept to a minimum.

Chemical and fuel storage

Chemical and fuel storage areas and refuelling of construction equipment present a risk for loss of containment. The primary consequence of any loss of containment is localised contamination of soil and impacts to native vegetation. Additional discussion on site contamination from fuel and chemical releases associated with PPO activities is presented in Section 7.11.6.

Borrow pits

Borrow pits in some locations may provide an alternative water source for livestock and native fauna which can result in the redistribution of livestock and native fauna to areas that may not have otherwise been available for grazing. Additional watering points also attract scavenging fauna which may impact livestock and native fauna.

The location of new borrow pits considers the following:

- minimise impacts to the environment (e.g. native vegetation and landforms)
- locate pits in areas where surface run-off into the pits is minimised to reduce water retention
- avoid cultural heritage sites
- stakeholder engagement to minimise impact to third party operations

- minimise visual impacts from construction activities by using native vegetation and landforms for screening
- maintain applicable clearance distances between borrow pits and infrastructure (e.g. facilities, fences, homesteads, roads and airstrips) to minimise risk associated with livestock, safety, erosion, and visual impacts.

Poorly sited or constructed borrow pits may result in soil erosion or reduced visual amenity. Erosion is controlled by appropriate placement, batter slopes and construction of water flow diversion banks. Livestock and native fauna may become trapped in waterlogged or muddy borrow pits.

Flooding

Flooding, particularly along the Cooper and Strzelecki Creeks and associated floodplain areas, may result in the inundation of road construction sites, and their associated fuel and chemical storage areas. Flooding may result in soil erosion, loss of stockpiled topsoil and contamination of soil and watercourses with fuel, oils or chemicals that are used during the construction process, leading to impacts to native fauna and native vegetation.

Movement of construction materials

Borrow material is often used during road construction and maintenance. This material is generally not moved over large distances however, there is the potential for pest plant or animal species to be moved along with the construction material.

Public Access Routes

There is an array of public access routes (PAR) that are used by tourists in the region. These are not maintained or generally used by Santos particularly by heavy vehicles.

If Santos utilise these roads to access a well site or for drill rig access it will be in consultation with relevant department of DEW.

Table 7-10: Road construction and maintenance risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Road construction and maintenance	Impacts to native vegetation and fauna, erosion and siltation of watercourses	Vegetation clearing	▪ Impeded native fauna movement through construction zone ▪ Loss of native vegetation and fauna habitat ▪ Damage to native vegetation ▪ Siltation of watercourses ▪ Erosion ▪ Short to medium term loss of visual amenity ▪ Introduction and / or spread of pest plants	**Design** ▪ Avoid important or 'priority' native vegetation[9] where possible. ▪ Use existing routes/disturbed areas where practicable. ▪ Minimise vegetation disturbance, and plan construction to avoid vegetated areas. ▪ Roads are designed and constructed to minimise impacts to native fauna. **Systems** ▪ Relevant internal and external approvals in place before work undertaken. ▪ Implementation of the ESP tool to assess proposed road routes and borrow pit sites for rare, vulnerable and endangered flora and fauna species before the commencement of construction and implement appropriate avoidance or mitigation measures. ▪ Stockpile and clear vegetation and respread following construction works to facilitate revegetation. ▪ Where possible trim vegetation rather than clear. ▪ Off-road or off-lease driving or creation of shortcuts is prohibited. ▪ No domestic pets allowed at camps or worksites. ▪ Feeding of native fauna (e.g. dingoes) is prohibited. ▪ Compliance with SEB offset obligations.	**E** **F** **C&R** **C**	**II**	**c**	**2**
Road construction and maintenance	Impacts to soil, natural drainage lines, vegetation, native fauna and livestock, stakeholder infrastructure	Earthworks	▪ Inversion of soil profile ▪ Dust generation ▪ Soil compaction ▪ Erosion (accelerated) ▪ Disturbance to natural drainage patterns ▪ Siltation of watercourses ▪ Damage to native vegetation ▪ Impeded native fauna movement through construction zone ▪ Injury or death of native fauna in construction zone ▪ Loss of visual amenity ▪ Introduction and / or spread of pest plants ▪ Disturbance to stakeholder infrastructure and activities ▪ Disturbance to livestock ▪ Impacts to native vegetation and fauna from contamination of soil, shallow groundwater resources and / or watercourses from fuel storage	**General** ▪ Relevant internal and external approvals in place before work undertaken. ▪ Consider alternate routes, locations and construction methods during planning and scouting phase to minimise environmental impacts. ▪ Use existing routes / disturbed areas where practicable. **Soil** ▪ Off-road or off-lease driving or creation of shortcuts is prohibited. ▪ Sensitive gibber terrain is protected through appropriate construction and maintenance practices which include - selecting routes that avoid sloping land is preferable (to minimise the requirements for large cut and fill or importation of borrow material to level the site) - constructing erosion control measures where appropriate (i.e. diversion banks or berms) - rolling of gibber terrain is preferable, where possible - avoiding environmentally sensitive and restricted areas, such as important native vegetation and fauna habitat, where possible. ▪ Construction activities are not carried out on salt lakes. ▪ First disturbances (such as location scouting) are undertaken in accordance with Santos standards. ▪ Management of sensitive areas (e.g. sloped areas or gibber) is detailed in scope of works, approval documents and company procedures. ▪ Erosion is controlled by appropriate placement, batter slopes and construction of water flow diversion banks. **Borrow Pits** The location of new borrow pits considers: ▪ minimisation of impacts to the environment (e.g. native vegetation and landforms) ▪ minimising water retention ▪ avoidance of cultural heritage sites ▪ stakeholder engagement to minimise impact to third party operations	**S** **E** **F** **C&R** **C**	**II**	**c**	**2**

[9] In the Cooper Basin, important vegetation typically includes:

- Plants of Priority 1 or 2 species as defined in the *Field Guide to the Common Plants of the Cooper Basin – South Australia and Queensland* (Whltshire and Schmidt, 2003) (the Field Guide). This predominantly includes tree and larger shrub species that are long lived and / or do not regenerate readily from seed or rootstock.
- Vegetation that is restricted in distribution and / or is locally important (e.g. for habitat or for land stability)
- Vegetation communities identified as conservation priorities in the South Australian Arid Lands Biodiversity Strategy (DEH 2009).

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
				▪ minimisation of visual impacts from construction activities by using native vegetation and landforms for screening ▪ maintenance of applicable clearance distances between borrow pits and infrastructure (e.g. facilities, fences, homesteads, roads and airstrips) to minimise risk associated with livestock, safety, erosion, and visual impacts. **Vegetation** ▪ Road construction in heavily wooded areas, such as Coolibah woodland, is minimised as far as practicable. ▪ Where pest plants are identified, contaminated material will not be moved to another location. ▪ Monitoring and pest plant control measures are implemented where required. ▪ Vegetation clearance is minimised as far as practicable. **Water** ▪ Roads are located and constructed to maintain pre-existing water flows (e.g. channel contours are maintained on floodplains and at creek crossings). ▪ Roads constructed at (or not significantly above) the natural surface as a minimum standard. ▪ Culverts and floodways are installed where required to maintain water flows, drainage and surface runoff. ▪ Where required, detailed hydrological assessment is undertaken for structures such as roads in floodplains or creek crossings to ensure no significant impacts on surface water flows or aquatic fauna (e.g. fish passage must be maintained). ▪ Sensitive land systems (e.g. wetlands) are avoided wherever possible. Where activities are undertaken in or near these areas, appropriate review, assessment and mitigation measures are in place to ensure that surface water flows are maintained, and contamination of surface water and groundwater resources is avoided. ▪ Monitoring of erosion and drainage patterns post-construction and corrective actions implemented where required. **Reinstatement** ▪ Reinstate construction areas as soon as practicable. ▪ Rip areas of compacted soil (except on gibber plains and tableland environments). ▪ Respread topsoil and stockpiled vegetation. ▪ Total or partial restoration of borrow pits as soon as practicable. ▪ Restore natural contours to minimise impacts to natural drainage patterns. **Stakeholders** ▪ Dust suppression measures carried out where required to minimise safety hazards associated with poor visibility. ▪ Landholders are consulted as required where activities may affect pastoral operations and notified prior to survey, construction and undertaking of operations (pursuant to Regulations). ▪ Induction of employee and contractor personnel with respect to pastoral landholder requirements such as use of gates and infrastructure. ▪ Systems are in place for logging stakeholder complaints to ensure that issues are addressed as appropriate.				
Road construction and maintenance	Disturbance to cultural heritage sites	Earthworks	▪ Disturbance or damage to cultural heritage sites	**Systems** ▪ Observation of procedures and guidelines for the identification, management and protection of cultural heritage sites. ▪ Consultation with stakeholders (i.e. native title groups, government agencies, landholders etc.) in relation to the possible existence of heritage sites. ▪ Appropriate cultural heritage training is provided for the level of access required (e.g. additional training for first disturbance (scouting) or authorised off-road/off-lease activities). ▪ Known potential cultural heritage sites are avoided during scouting. ▪ Engage cultural heritage monitors ahead of or during first disturbance activities. ▪ Known cultural heritage sites are recorded. ▪ Audits of cultural heritage clearances areas **Response** ▪ Discovery of new cultural heritage sites managed in accordance with the SMS.	**S** **F** **C&R** **C**	**III**	**d**	**3**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Road construction and maintenance	Disturbance to cultural heritage sites	Construction of borrow pits	▪ Disturbance or damage to cultural heritage sites ▪ Creation of new borrow pits	***See section on cultural heritage sites above***	**C&R** **C**	**III**	**d**	**3**
Road construction and maintenance	Impacts to vegetation and native fauna, erosion and siltation of watercourses	Movement of heavy machinery and vehicles	▪ Dust and noise generation ▪ Soil compaction; erosion ▪ Contamination of soil, shallow groundwater resources and / or watercourses ▪ Damage to native vegetation ▪ Injury or death of native fauna ▪ Introduction and / or spread of pest plants ▪ Damage to third party infrastructure ▪ Disruption to land use (e.g. grazing and recreation) ▪ Increased public access to remote areas	**Systems** ▪ Driving on designated areas only (i.e. lease and access tracks). ▪ Unauthorised off-road or off-lease driving or creation of shortcuts is avoided. ▪ Rip areas of compacted soils (except on gibber and tableland environments). ▪ Signage and road closures where appropriate. ▪ Inductions. ▪ Landholder consultation.	**E**	**III**	**c**	**2**
Road construction and maintenance	Disturbance to cultural heritage sites	Movement of heavy machinery and vehicles along proposed routes	▪ Disturbance or damage to cultural heritage sites	***See section on cultural heritage sites above*** Additional procedures and guidelines include: ▪ Signage to indicate public versus private roads and access tracks to discourage third party access to infrastructure.	**E**	**II**	**c**	**2**
Road construction and maintenance	Impacts to public safety and collision with livestock or native fauna resulting in injury or loss	Movement of heavy machinery and vehicles along proposed routes	▪ Collision with livestock or native fauna resulting in injury or loss ▪ Potential impacts to public safety	**Systems** ▪ Active promotion of appropriate road use behaviours. ▪ Induction of employees and contractor personnel with respect to road use and driver behaviour. ▪ Setting of appropriate speed limits for Santos personnel and contractors. ▪ Use of In Vehicle Monitoring System (IVMS) to track speed, route and harsh braking and / or other appropriate journey management. ▪ Driver awareness training for company and contractor personnel. ▪ Policy of driving with vehicle lights on. ▪ Signage throughout the Cooper Basin to warn of possible hazards on the roads. ▪ Driving on designated areas only (i.e. access tracks and designated lease areas) – unauthorised off-road driving is prohibited. ▪ Necessary measures (e.g. signage/fencing) taken to prevent the public accessing restored areas. **Response** ▪ Reporting systems in place for recording injuries and accidents.	**S** **E** **F** **C&R** **C**	**V**	**b**	**3**
Road construction and maintenance	Contamination of soil and / or shallow groundwater resources and potential impacts to public safety	Ignition of fire along road corridor	▪ Disturbance or damage to cultural heritage sites ▪ Injury to or loss of livestock or native fauna ▪ Disruption to land use (e.g. grazing and recreation) ▪ Impacts to groundwater users ▪ Impacts to public safety ▪ Impacts to native vegetation ▪ Impacts to stakeholder business reputation ▪ Generation of greenhouse gas emissions, localised reduction in air quality	**Systems** ▪ Operation under fire permit requirements. ▪ No smoking or safe smoking areas away from equipment or activity. ▪ Personnel are trained to supervise and instruct individuals entering area to conduct work. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct works. ▪ Petrol vehicles to be excluded from sites. **Response** ▪ Emergency response procedures contain a bushfire scenario. ▪ Safety, testing, maintenance and inspection procedures are implemented.	**S** **E** **F** **C&R** **C**	**III**	**a**	**1**
Road construction and maintenance	Contamination or disturbance of soil, shallow groundwater resources and / or watercourses	Flooding of surrounding floodplain/watercourses	▪ Damage to infrastructure ▪ Access to contaminants by stock and wildlife	**Design** ▪ Measures undertaken to reduce potential impacts of flooding where appropriate (e.g. installation of bunds, removal of contents prior to arrival of flood event).	**S** **E** **F**	**III**	**a**	**1**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
	and damage to third party infrastructure		▪ Contamination of soil, shallow groundwater resources and / or watercourses ▪ Impacts to groundwater users ▪ Soil erosion and siltation of watercourses ▪ Loss of vegetation and topsoil (either stockpiled or in situ)	▪ Fully containerised tanks used for on-site storage. **Systems** ▪ Fuel, oil and chemical storage and handling in accordance with the Safety Data Sheet (SDS), SMS, EPA Bunding Guidelines and AS 1940. ▪ Work programs in floodplain areas scheduled to take into account seasonal conditions and rainfall / flood likelihood. ▪ Continuous monitoring of upstream managed water.				

7.11.2 Waste management

Numerous types of waste and streams of wastewater are generated by production and processing activities. A consistent approach to managing waste streams across Santos' Cooper Basin operation is adopted. The hazards, potential consequences, management strategies and level of residual risk associated with waste management are summarised in Table 7-11.

The primary environmental hazard associated with the management of wastes and wastewater is the loss of containment which could result in:

- contamination of soil, shallow groundwater resources and / or waterways
- exposure of native fauna or livestock to contaminants
- impacts to third party surface water and / or groundwater users
- impacts to stakeholder business reputation introduction of pest plants or animal species
- fire
- impacts to visual amenity.

Potential impacts are dependent on the characteristics of the waste or wastewater. Santos operates the Moomba WMF and WWTP under an EPA licence and in accordance with conditions set within it. WWTPs are operated in accordance with relevant regulatory requirements.

Facilities are designed and operated with consideration to potential environmental impacts.

Management plans, which aim to minimise risks, are continuously reviewed and implemented for the following activities:

- management of waste and wastewater steams
- landfill operation
- individual landfarms (Moomba).

Periodic monitoring of waste and wastewater management facilities provides a review of compliance against licence and regulatory requirements, and the effectiveness of controls and management strategies implemented.

Monitoring of WMFs is undertaken in accordance with the relevant regulations and licences, management plans and Santos standards.

Table 7-11: Waste management risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Waste management	Contamination of soil and / or shallow groundwater resources or waterways, exposure, fire	Storage and transport of general waste	▪ Scavenging by native and pest species. ▪ Localised contamination of soil and / or shallow groundwater resources ▪ Injury or loss of livestock and native fauna ▪ Impact to stakeholder business reputation ▪ Litter ▪ Reduced visual amenity ▪ Damage to native vegetation and fauna habitats ▪ Fire (landfill, composting facility)	**Design** ▪ Designed and engineered facilities in accordance with EPA requirements. **Systems** ▪ Application of the waste hierarchy system (avoid, reduce, reuse, recycle, treat, and dispose). ▪ Waste management is undertaken in accordance with applicable regulatory requirements and licences. ▪ Compliance with EPA licence conditions and requirements of the *Environment Protection Act 1993* and relevant regulations. ▪ Periodic auditing of WMFs for compliance against licence and regulatory requirements. ▪ Waste streams are segregated on site where appropriate to maximise opportunities for waste recovery, reuse and recycling. ▪ Covered bins are provided for the collection and storage of wastes. Rubbish loads are covered during transport to a licensed waste facility. ▪ Waste Management Plan. ▪ Landfill Environmental Management Plan. ▪ Landfarm Management Plans. ▪ Inspections, monitoring and maintenance of facilities.	**S** **E** **F** **C&R** **C**	**I**	**c**	**1**
Wastewater management	Contamination of soil and / or shallow groundwater resources, exposure	Sewage treatment and effluent management	▪ Localised contamination of soil and / or shallow groundwater resources or waterways ▪ Injury or loss of native fauna or livestock ▪ Impacts to impacts to stakeholder business reputation ▪ Introduction and / or increase in pest plant species ▪ Scavenging by native and pest species. ▪ Reduced visual amenity ▪ Damage to native vegetation and fauna habitats	**Design** ▪ Fit for purpose plant and equipment. ▪ Use of permanent septic systems with long term camps where possible. ▪ Secondary treated sewage wastewater is disposed of onto land well away from any place from which it is reasonably likely to enter any waters, and to minimise spray drift and ponding. ▪ Fencing installed where required around irrigation areas. **Systems** ▪ Wastewater Management Plan. ▪ Periodic auditing of WMFs for compliance against licence and regulatory requirements. ▪ Department of Health and Wellbeing approved transportable aerated wastewater treatment plants for temporary purposes, such as camps. ▪ Wastewater (sewage and grey water) disposal where possible in accordance with the South Australian *Public Health (Wastewater) Regulations 2013* and / or in consultation with the Department for Health and Wellbeing and/ or in accordance with licenses / permits, if any. ▪ Appropriate controls for management of sewage effluent (developed in consultation with Department for Health and Wellbeing) implemented for situations where excursions outside effluent quality guidelines may occur (e.g. startup or system upset). ▪ Inspections, monitoring and maintenance of facilities.	**S** **E** **F** **C&R** **C**	**I**	**b**	**1**
Waste management	Contamination of soil and / or shallow groundwater resources or waterways	Management of contaminated soil	▪ Localised contamination of soil and / or shallow groundwater resources or waterways ▪ Exposure of native fauna or livestock to contaminants	**Design** ▪ Suitably designed and engineered facility in accordance with EPA guidelines. **Systems** ▪ Compliance with EPA licence conditions and regulatory requirements. ▪ Development and implementation of Landfarm Management Plan, which documents operational controls, management practices and Santos standards.	**SP** **E** **F** **C&R** **C**	**II**	**c**	**2**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Waste management	Contamination of soil and / or shallow groundwater resources or waterways, exposure	Management of hazardous materials (chemicals, asbestos)	▪ Localised contamination of soil and / or shallow groundwater resources ▪ Exposure of wildlife and livestock to harmful chemicals ▪ Impacts to impacts to stakeholder business reputation ▪ Injury or loss of native fauna or livestock ▪ Impacts to native vegetation and fauna habitats ▪ Potential impacts to public safety	**Design** ▪ Designed and engineered containment facilities. **Systems** ▪ Application of the waste hierarchy system (avoid, reduce, reuse, recycle, treat, and dispose). ▪ Compliance to requirements of EPA licence conditions and requirements of the *Environment Protection Act 1993* and relevant regulations. ▪ Waste streams are segregated on site where appropriate to maximise opportunities for waste recovery, reuse and recycling. ▪ Waste Management Plan. ▪ Landfill Environmental Management Plan. ▪ Disposal of asbestos containing material in accordance with the *Work Health and Safety Act 2012* and the *Work Health and Safety Regulations 2012*. ▪ Inspection and maintenance of facilities. ▪ Transportation of chemicals, fuels and oils in accordance with the Safety Data Sheet (SDS), SMS, and relevant guidelines such as the ADG Code. ▪ Regularly educate staff of product, review and monitor chemical and fuel transportation, including signage/labelling, proper packing and tie downs. ▪ WTC documentation, use of licenced contractors. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ SDSs available. **Response** ▪ Appropriate emergency response plans in place. ▪ Emergency spill response equipment on site. ▪ Spill response and clean up. ▪ Fencing of affected areas if threat is posed to livestock or native fauna.	**SP** **E** **F** **C&R** **C**	**III**	**b**	**2**

7.11.3 Water supply

Water for production and processing operations, such as steam generation, process requirements, domestic purposes and firewater, is sourced from artesian bores at Gidgealpa approved under the DEW water licence 162791. Raw water is processed through the Reverse Osmosis (RO) plant to achieve required water quality standards. Potable water at satellite facilities is trucked from Moomba as required and stored on site in tanks. The potential consequence of groundwater extraction is the depletion of artesian and sub-artesian water supplies in the region.

PFW may be used for construction purposes, hydrotest water, truck ballast or for bioremediation. The potential consequence of reuse of PFW is contamination of soil, surface water and / or shallow groundwater, if suitability assessment and reuse management is not undertaken. Where satellite pond water of suitable quality is not available, groundwater will be used. Extraction of groundwater is undertaken within the framework of the *Landscape South Australia Act 2019* and in accordance with water well construction permits and licence conditions.

The Cooper Creek is an alternative source of water when conventional forms, such as PFW or bore water, are limited. Extraction of water from the Cooper Creek is subject to strict internal approval flow and volumetric criteria. The volume of water extracted from the Cooper Creek for operational use is reported to DEM through annually. The potential consequences of extracting water from Cooper Creek include impacting third party users, livestock, native fauna and native fauna habitat at or downstream of extraction point/s.

Santos implements water saving initiatives and is committed to continuously identifying opportunities to improve water usage.

To minimise the amount of seepage from water storage areas, turkey's nests may be constructed using synthetic liners.

The water source for operations and / or projects is considered as part of the initiation phase and in some cases satellite water (e.g. Gidgealpa Oil Satellite) will be piped from the closest suitable water source to the operation site. Where distances exceed approximately 20 km, water will be trucked to the activity area.

If there is no suitable satellite pond water and / or existing bore water available for operational activities, a new groundwater extraction bore may be required. The installation and construction of new groundwater extraction bores will be undertaken in accordance with the *Far North Prescribed Wells Area Water Allocation Plan* (FNPWA WAP) and the Landscape South Australia Act by a licensed water bore driller. Prior to drilling works, a search of government registered bores within a 5 km radius of the proposed location will be undertaken. Where registered bores are identified within this area, consultation with the water bore owner will be undertaken to ensure that the potential impacts associated with drawdown are managed appropriately.

Where proposed groundwater bores are in an area adjacent to, and / or in the vicinity of, a surface water system that is dependent on base flow, an impact assessment will be undertaken. Where the results of an assessment indicate that the risk of impacting surface water systems is not acceptable the proposed bore will be moved to an alternative location.

Santos' groundwater consumption for project operations is not considered a risk. Implementation of control systems such as preferentially using oil and gas satellite pond water and compliance with relevant licence conditions ensures that the risk to other groundwater users is negligible.

The hazards, potential consequences, management strategies and level of residual risk associated with aquifer use are summarised in Table 7-12.

Table 7-12: Water supply risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Groundwater use	Localised salinisation of soil	Spills or leaks associated with the storage and / or transportation of water for operational use	▪ Localised salinisation or contamination of soil ▪ Resource depletion	**Design** ▪ Fit for purpose equipment. ▪ Turkey's nests are designed and constructed to minimise loss of water to seepage. ▪ Appropriate water source used based on operational requirements and minimisation of pumping distances. **Systems** ▪ Selection criteria for contracting company and personnel. ▪ Testing, maintenance and inspection procedures are implemented. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation.	**E C&R C**	**I**	**c**	**1**
Groundwater use	Aquifer / formation depressurisation	Extraction of water from the artesian and sub-artesian reservoirs	▪ Depletion of GAB and sub-artesian water supplies ▪ Impacts to groundwater users	**Systems** ▪ Use PFW as a water source where feasible. ▪ Minimise use of groundwater. ▪ Compliance with water licence and allocations. ▪ Utilisation of existing Santos groundwater bores where applicable. ▪ Installation of any new water bores is undertaken in accordance with all government regulations and licensing conditions. ▪ Installation of any new water bores in accordance with the Far North Prescribed Wells Area Water Allocation Plan (FNPWA WAP) and will include consultation as required. ▪ Installation of any new water bores will include an impact assessment of adjacent surface water systems (that are dependent on base flow).	**E C&R C**	**II**	**b**	**1**
PFW reuse	Contamination of soil and / or shallow groundwater resources and / or waterways, localised salinisation of soils	Application of PFW to ground	▪ Salinisation ▪ Localised contamination of soils	**Systems** ▪ Suitability assessment of PFW quality prior to reuse to minimise impact to sensitive areas. ▪ Approval for reuse gained through internal Santos processes. ▪ Reuse projects are typically short-term.	**E C**	**II**	**b**	**1**
Water extraction	Modification of natural flows, consumption of natural resource	Extraction of water from Cooper Creek	▪ Loss of visual amenity ▪ Damage to native vegetation ▪ Introduction and / or spread of pest plants ▪ Disturbance to natural drainage patterns ▪ Disturbance or damage to cultural heritage sites ▪ Disruption to land use (e.g. grazing and recreation) ▪ Localised contamination of soil and / or watercourses	**Systems** ▪ Approval for extraction is gained through internal Santos processes. Application will include estimated total volume of water required. ▪ A request to extract water from Cooper Creek must demonstrate that PFW and / or groundwater of an acceptable quality cannot be sourced within an economically viable haulage distance (maximum 2 hour return journey). ▪ Approved extraction occurs where potential risks to existing users downstream of Cullyamurra have been assessed and impacts mitigated. ▪ Any approved extraction occurs where water flow at Cullyamurra is >= 2.15m (>= 0.1m flow at Innamincka Causeway) and rising. ▪ Water should not be extracted from permanent water refuges (e.g. Cullyamurra). Maps of approved surface water extraction points at Innamincka, Kudrieke and Mitchie Crossings are included in Appendix D. Extraction only occurs at these points, and does not involve permanent pumping stations. ▪ Cumulative extraction is capped at 15 ML per year. Extraction volumes recorded in monitoring database and included in annual DEM reporting.	**S E C&R C**	**I**	**a**	**1**

7.11.4 Steam supply

Gas-fired boilers are used to produce steam required for energy transfer around Moomba Plant and electricity generation for the Moomba Facility. As steam is produced, combusted gas products and boiler blowdowns are generated. Combusted gas products go to atmosphere, similar to flaring. Boiler blowdown is captured and managed through the 'sour water west flow' system.

Wastes and wash down water are generated during maintenance activities which could potentially impact soil and / or surface water. To minimise the risk of impact to soil and / or shallow groundwater associated with maintenance activities controls are implemented to ensure that chemicals are handled in accordance with applicable Australian Standards and regulations.

Reliability of steam supply is managed by maintaining adequate steam reserve, and by issuing weekly steam shedding plans. Available steam reserve has been increased through increased steam efficiency in the CO_2 trains. Boiler upgrades have also improved the reliability of steam supply to minimise potential risk to security of gas supply.

Combusted gases will add to the site's overall greenhouse gas emissions and may pose a risk to wildlife (birds) and local air quality.

The hazards, potential consequences, management strategies and level of residual risk associated with steam production are summarised in Table 7-13: Steam supply risk assessment.

Table 7-13: Steam supply risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Steam Supply	Greenhouse (and other) gas emissions	Combustion of gas	▪ Generation of greenhouse gas emissions ▪ Reduction in local air quality ▪ Impacts to native fauna - birds ▪ Impacts to visual amenity ▪ Fire	**Design** ▪ Fit for purpose equipment. ▪ Remote location of Moomba Plant. ▪ Plant and equipment designed and constructed in accordance with SMS and Engineering Standards, and relevant Australian/International standards (e.g. AS 1210). **Systems** ▪ Reliability and Maintenance Management System (RAMMS) framework. ▪ Asset Integrity Management System (AIMS). ▪ SMS standards. ▪ Equipment and plant maintenance (preventative and corrective).	**E** **C&R**	**I**	**b**	**1**
Steam Supply – waste/ wastewater management	Contamination of soil and / or shallow groundwater resources	Inappropriate management of waste/wastewater	▪ Localised contamination of soil ▪ Litter ▪ Contamination of stormwater	**Design** ▪ Fit for purpose equipment. ▪ Boiler blowdown water is managed via a system of interceptor and evaporation ponds. **Systems** ▪ Application of the waste hierarchy system (avoid, reduce, reuse, recycle, treat, and dispose). ▪ Storage and handling of chemicals, fuels and oils in accordance with the Safety Data Sheet (SDS), SMS, EPA Bunding Guidelines and AS 1940. ▪ Compliance to applicable licence and regulatory requirements. ▪ Waste streams are segregated on site where appropriate to maximise opportunities for waste recovery, reuse and recycling. ▪ Covered bins are provided for the collection and storage of wastes. Rubbish loads are covered during transport to a licensed waste facility. ▪ Wastewater Management Plan. **Other** ▪ See Waste Management (Table 7-11).	**S** **E** **F** **C&R** **C**	**I**	**a**	**1**

7.11.5 Power generation and network

Gas turbine driven alternators will release combusted gases as emissions to atmosphere and blowdown wastewater to site wastewater drain systems, as electricity is generated. Steam turbine driven alternators will generate condensate which is managed via a drain system.

The emergency diesel generator requires the storage of diesel on-site. Potential impacts of power generation include reduced air quality, contamination of soil, waterways and / or shallow groundwater resources. Diesel stored on-site is in accordance with applicable Australian Standards and industry guidelines, such as AS 1940.

Power supply is managed by automatic and procedural shedding processes to ensure continued supply of power to critical operations and minimise risk to gas supply. This includes removing power to auxiliary sections of the Moomba compound, or ceasing power supply to outlying satellites.

Risk of losing power supply is minimised by spreading the load across the Gas Turbine Alternators (GTAs) and Steam Turbine Alternators (STAs) to minimise the impact if one piece of equipment fails. There is a degree of automatic balancing of steam and power.

The risk of interrupted gas supply in reduced by an emergency power supply line which provides sufficient power to keep critical equipment on and provides the power requirements for a black start of a GTA.

The hazards, potential consequences, management strategies and level of residual risk associated with power generation are summarised in Table 7-14.

Table 7-14: Power generation risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Power generation	Greenhouse (and other) gas emissions	Combustion of gas	▪ Generation of greenhouse gas emissions ▪ Reduction in local air quality ▪ Impacts to native fauna - birds ▪ Impacts to visual amenity ▪ Fire	**Design** ▪ Fit for purpose equipment. ▪ Plant and equipment design. ▪ Remote location of Moomba Plant. **Systems** ▪ Reliability and Maintenance Management System (RAMMS) framework. ▪ Asset Integrity Management System (AIMS). ▪ SMS standards. ▪ Equipment and plant maintenance (preventative and corrective).	**E** **C&R**	**I**	**b**	**1**
Power generation – diesel storage	Contamination of soil and / or shallow groundwater resources	Loss of containment	▪ Localised contamination of soil and / or groundwater resources ▪ Contamination of stormwater	**Systems** ▪ Storage of chemicals, fuels and oils in accordance with the Safety Data Sheet (SDS), SMS, EPA Bunding Guidelines and AS 1940. ▪ Chemical management practices. ▪ Appropriate labelling. ▪ Licensed delivery service. ▪ Inspections and maintenance. ▪ Regularly educate staff of product, review and monitor chemical and fuel transportation, including signage / labelling, proper packing and tie downs. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. **Response** ▪ Appropriate emergency response plans in place. ▪ Emergency spill response equipment on site. ▪ Loss of containment is reported and investigated. ▪ Establishment and implementation of spill response procedures which include reporting, investigation/assessment and corrective action processes. ▪ Spill response and clean up.	**S** **E** **F** **C&R** **C**	**I**	**b**	**1**
Power generation – waste (and wastewater) management	Contamination of soil and / or shallow groundwater resources	Inappropriate management of waste/wastewater	▪ Localised contamination of soil ▪ Litter ▪ Contamination of stormwater	**Systems** ▪ Application of the waste hierarchy system (avoid, reduce, reuse, recycle, treat, and dispose). ▪ Compliance to applicable licence and regulatory requirements. ▪ Waste streams are segregated on site where appropriate to maximise opportunities for waste recovery, reuse and recycling. ▪ Covered bins are provided for the collection and storage of wastes. Rubbish loads are covered during transport to a licensed waste facility. **Other** ▪ See Waste Management (Table 7-11: Waste management risk assessment ▪	**S** **E** **F** **C&R** **C**	**I**	**a**	**1**

7.11.6 Fuel and chemical storage and handling

The main risks associated with the handling and storage of fuel and chemicals are:

- loss of containment which could result in contamination of soil, groundwater resources and / or waterways
- loss of volatiles to the atmosphere
- potential impacts to public safety
- fire and explosion.

To minimise the risk of impact, the storage and handling of fuel and chemicals is undertaken in accordance with the Safety Data Sheet (SDS), SMS, EPA Bunding Guidelines, and AS 1940.

The hazards, potential consequences, management strategies and level of residual risk associated with fuel and chemical handling and storage are summarised in Table 7-15.

Table 7-15: Fuel and chemical storage and handling risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Fuel and chemical storage and handling	Localised contamination of soils and / or shallow groundwater resources and / or waterways, public safety	Loss of containment – on- or off-site	▪ Localised contamination of soil ▪ Contamination of water resources (surface and shallow groundwater resources) ▪ Potential impacts to public safety ▪ Injury to or loss of livestock and native fauna ▪ Impacts to impacts to stakeholder business reputation ▪ Damage to native vegetation ▪ Fire or explosion	**Systems** ▪ Transportation, storage and handling of chemicals, fuels and oils in accordance with the Safety Data Sheet (SDS), SMS, and relevant standards and guidelines such as the EPA Bunding Guidelines and AS 1940. ▪ Regularly educate staff of product, review and monitor chemical and fuel transportation, including signage / labelling, proper packing and tie downs. ▪ Cover dry chemicals during transportation. ▪ Chemical and fuel storage procedures, including signage, are reviewed and monitored in audit process in accordance with relevant Santos standard. ▪ Removal of fuel or chemicals from site where inundation or flooding is a risk. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. **Response** ▪ Appropriate emergency / spill response procedures for loss of containment. ▪ Spill response and clean up. ▪ Fencing of affected areas if threat is posed to livestock or native fauna. ▪ Emergency response procedures are carried out in accordance with Regulation 31.	**E** **F** **C&R** **C**	**II**	**c**	**2**

7.11.7 Moomba Airport

Native fauna strike (including birds) is a major risk to aircraft and public safety due to potential damage to aircraft. Potential consequences of aircraft crashes or incidents include impacts to public safety, contamination of soils and / or waterways and injury or impacts to livestock or native fauna.

Grasses and other vegetation are therefore managed to minimise the attraction of native fauna to the area, particularly birds.

Fuel releases are generally associated with handling (e.g. refuelling of aircraft or transfers to onsite fuel storage from road tankers). Potential consequences of releases may include contamination of soils and / or waterways, injury or impacts to livestock or native fauna and damage to native vegetation.

To minimise the risk of release to grade, fuel is stored and handled in bulk tanks on site in accordance with the SDS, SMS, and relevant aviation and Australian standards and guidelines, such as the EPA Bunding Guidelines and AS 1940.

The hazards, potential consequences, management strategies and level of residual risk associated with operation of the Moomba airport are summarised in Table 7-16.

Table 7-16: Moomba airport risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Moomba Airport - fuel handling and storage	Localised contamination of soils, shallow groundwater resources and waterways	Loss of containment	▪ Localised contamination of soil ▪ Localised contamination of soil and / or waterways (off-airport accidents) ▪ Injury to or loss of livestock and / or native fauna ▪ Damage to native vegetation	**Systems** ▪ Handling, transport and storage of fuel (bulk aviation fuel) is in accordance with the SDS, SMS, and applicable Australian Standards and industry guidelines (including aviation safety standards, EPA Bunding Guidelines and AS 1940). ▪ Regularly educate staff of product, review and monitor fuel transportation, including signage / labelling. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. **Response** ▪ Emergency / spill response plans are in place. ▪ Spill kits are available on site and on fuel tankers. ▪ Spill response and clean up.	**E** **F** **C**	**II**	**b**	**1**
Moomba Airport - accident	Plane accident	Site conditions causing an accident	▪ Impacts to public safety ▪ Injury to or loss of livestock and / or native fauna ▪ Localised contamination of soil and / or waterways ▪ Fire	**Design** ▪ Foreign object debris (FOD) fencing. **Systems** ▪ Airline provider has applicable licenses, registrations and safe track record. ▪ Airport is operated in accordance with Civil Aviation Safety Authority (CASA) standards. ▪ Jet A-1 fuel supply and storage meets industry standards. ▪ Restricted access to the airport and aerodrome. ▪ Management of vegetation and surface water ponding adjacent to the airport to minimise attraction of wildlife (e.g. Black Kites). ▪ Covered bins are provided for the collection and storage of wastes to minimise attraction of wildlife. **Response** ▪ Emergency response plans are in place for aircraft incidents. ▪ Implementation of emergency/spill response procedures.	**S** **E** **F** **C&R** **C**	**V**	**a**	**3**

7.11.8 Fire training ground

The potential consequences of a release of fire-fighting chemicals include:

- contamination of soils, waterways and / or shallow groundwater resources
- impacts to stakeholder business reputation
- injury or impacts to livestock or native fauna.

Fire-fighting chemicals used on site no longer contain Per- and Polyfluoroalkyl substances (PFAS).

To minimise the potential for environmental impact, chemicals are stored on site in designated areas in liquid and / or dry form as per the Safety Data Sheet (SDS), SMS, and relevant standards and guidelines such as EPA Bunding Guidelines and AS 1940.

Fire and explosion are also possible hazards associated with fire training operations. A fire or explosion can pose a danger to the public, can potentially produce significant amounts of atmospheric emissions and lead to contamination of soil and / or waterways.

The hazards, potential consequences, management strategies and level of residual risk associated with operation of the fire training ground are summarised in Table 7-17: Fire training ground risk assessment.

Table 7-17: Fire training ground risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Fire training ground – fuel and chemical storage	Contamination of soils, shallow groundwater resources and waterways	Loss of containment of fuel and / or chemical	▪ Localised contamination of soil ▪ Contamination of water resources (surface and shallow groundwater resources) ▪ Impacts to impacts to stakeholder business reputation ▪ Injury to or loss of livestock and / or native fauna	**Design** ▪ Runoff from the site is directed to a lined interceptor pit. ▪ Fire training ground is located in a fenced compound. **Systems** ▪ Handling and storage of chemicals, fuels and oils in accordance with the Safety Data Sheet (SDS), SMS, and relevant standards and guidelines such as EPA Bunding Guidelines and AS 1940. ▪ Regularly educate staff of product, review and monitor chemical and fuel transportation, including signage/labelling, proper packing and tie downs. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. ▪ Spill kits available on site. **Response** ▪ Spill response and clean up. **Other** ▪ See Fuel and Chemical Storage and Handling (Table 7-15: Fuel and chemical storage and handling risk assessment).	**E** **C&R** **C**	**III**	**b**	2
Fire training ground - Waste (and wastewater) management	Contamination of soil and / or shallow groundwater resources, exposure, fire	Loss of containment or inappropriate management of waste and wastewaters	▪ Scavenging by native and pest species. ▪ Localised contamination of soil and / or shallow groundwater resources ▪ Litter ▪ Reduced visual amenity ▪ Fire	**Systems** ▪ Application of the waste hierarchy system (avoid, reduce, reuse, recycle, treatment, disposal). ▪ Covered bins and prompt collection of waste. ▪ Wastes generated as part of site / aircraft maintenance/repairs are managed in accordance with WMP and regulatory requirements. ▪ Inspection and maintenance of facilities. **Other** ▪ See Waste Management (Table 7-11: Waste management risk assessment ▪)	**S** **E** **F** **C&R** **C**	**I**	**b**	1
Fire training ground	Contamination of soil and / or shallow groundwater resources, public safety	Explosion or uncontrolled fire	▪ Contamination of soil and / or waterways ▪ Potential impacts to public safety ▪ Generation of greenhouse gas emissions ▪ Localised reduction in air quality	**Systems** ▪ No smoking or safe smoking areas away from equipment or activity. ▪ Personnel are trained to supervise and instruct individuals entering area to conduct work. ▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct works. ▪ Safety, testing, maintenance and inspection procedures are implemented. **Response** ▪ Spill response and clean up. ▪ Implementation of appropriate emergency/spill response procedures for explosion or fire.	**S** **E** **F** **C**	**IV**	**a**	2

7.11.9 Camps, offices and contractor facilities

The generation of general waste and sewage (and grey water) are the main hazards associated with camps, offices and contractor facilities. There is minor use of chemicals at domestic volumes. Loss of containment could lead to contamination of soil and / or stormwater. Cultural heritage sites which are known or may be present adjacent to camp facilities could potentially be impacted by camp residents.

The hazards, potential consequences, management strategies and level of residual risk associated with operation of camps, offices and contractor facilities are summarised in Table 7-18: Camps, offices and contractor facilities risk assessment.

Table 7-18: Camps, offices and contractor facilities risk assessment

Identification				Control Strategy	Assessment			
					Risk			
Activity	**Risk Issue**	**Cause**	**Impact**	**Controls**	**S, E, C&R, F, W, C**	**Consequence**	**Likelihood**	**Residual Risk**
Camps, offices and contractor facilities – fuel and chemical handling and storage	Contamination of soils	Loss of containment, inappropriate management	▪ Localised contamination of soil ▪ Contamination of stormwater	**Systems** ▪ Fuels and chemicals stored are generally in small quantities. ▪ Fuel and chemical storage in accordance with the Safety Data Sheet (SDS), SMS, and relevant Australian standards and industry guidelines such as EPA Bunding Guidelines and AS 1940. ▪ Procurement processes to embed specific conditions in contracts, which includes a LTO. **Response** ▪ Appropriate emergency/spill response procedures for spills or leaks to soil and water. ▪ Loss of containment is managed via the Incident Management System (IMS) and implementation of corrective actions is based on incident investigation. **Other** ▪ See Fuel and Chemical Storage and Handling (Table 7-15: Fuel and chemical storage and handling risk assessment).	**S** **E** **C**	**I**	**c**	**1**
Camps, offices and contractor facilities - waste	Contamination of soil and / or shallow groundwater resources or waterways, exposure	Loss of containment, inappropriate management	▪ Scavenging by native and pest species. ▪ Localised contamination of soil ▪ Reduced visual amenity	**Design** ▪ Sewage (and grey water) is treated by septic or by the Moomba WWTP. **Systems** ▪ Application of the waste hierarchy system (avoid, reduce, reuse, recycle, treat, and dispose). ▪ Procurement processes to embed specific conditions in contracts, which includes a LTO. ▪ Compliance to applicable licence, Santos and regulatory requirements. ▪ Waste streams are segregated on site where appropriate to maximise opportunities for waste recovery, reuse and recycling. ▪ Covered bins are provided for the collection and storage of wastes. ▪ Waste is removed regularly. ▪ Waste Management Plan and Wastewater Management Plan. **Other** ▪ See Waste Management (Table 7-11: Waste management risk assessment ▪)	**S** **E** **C**	**I**	**b**	**1**
Camps, offices and contractor facilities - vehicle movements	Impacts to native fauna	Vehicle collision on camps and within the confines of offices or contractor facilities	▪ Injury or loss of native fauna	**Systems** ▪ Active promotion of appropriate road use behaviours. ▪ Induction of employees and contractor personnel with respect to road use and driver behaviour. ▪ Setting of appropriate speed limits for oil and gas industry personnel. ▪ Use of In Vehicle Monitoring System (IVMS) to track speed, route and harsh braking. ▪ Driver awareness training mandatory for all company and contractor personnel. ▪ Policy of driving with vehicle lights on. ▪ Signage erected to warn of possible hazards on the roads. ▪ Driving on designated areas only (i.e. access tracks and designated lease areas). ▪ Reporting systems in place for recording injuries and accidents. ▪ Procurement processes to embed specific conditions in contracts, which includes a LTO.	**E**	**1**	**c**	**1**

Identification				Control Strategy	Assessment			
					Risk			
Activity	Risk Issue	Cause	Impact	Controls	S, E, C&R, F, W, C	Consequence	Likelihood	Residual Risk
Camps offices and contractor facilities - personnel	Disturbance to cultural heritage sites	Personnel impacting cultural heritage sites adjacent to the camp or contractor facilities	▪ Disturbance or damage to cultural heritage sites	**Systems** ▪ Observation of procedures and guidelines for the identification, management and protection of cultural heritage sites. ▪ Consultation with stakeholders (i.e. native title groups, government agencies, landholders etc.) in relation to the possible existence of heritage sites. ▪ Appropriate cultural heritage training is provided for the level of access required. ▪ Known potential cultural heritage sites are avoided during scouting. ▪ Engage cultural heritage monitors ahead of or during first disturbance activities. ▪ Known cultural heritage sites are recorded. ▪ Audits of cultural heritage clearances areas. ▪ Where required, identified cultural heritage sites are signposted and / or exclusion zones implemented.	**S** **F** **C&R** **C**	**III**	**d**	**3**

8 Management of Environmental Risks

The Santos Management System (SMS) sets out the requirements for business at Santos across key activities and functions, including Environment, Health and Safety (EHS) requirements. The SMS is readily available to employees and contractors via the Santos intranet 'Discover'.

The SMS Framework provides structured, comprehensive and efficient EHS practices for Santos' activities and operations and in general accordance with both AS/NZS ISO 45001 Occupational Health and Safety Management Systems – Requirements with Guidance for Use and AS/NZS ISO 14001 Environmental Management Systems – Requirements with Guidance for Use.

The Framework of the SMS is multi-layered and comprises policies, code of conduct, management standards, processes and procedures (refer Figure 8-1). The upper layer of the framework comprises the overarching SMS policies which outline Santos' objectives and the behaviours expected of anyone who works for or with Santos and demonstrates the commitment Santos has made to continual improvement in respect of EHS performance. These policies include an Environment, Health and Safety Policy which applies to all Santos operations within Australia. The policies are available on the Santos website (www.santos.com).

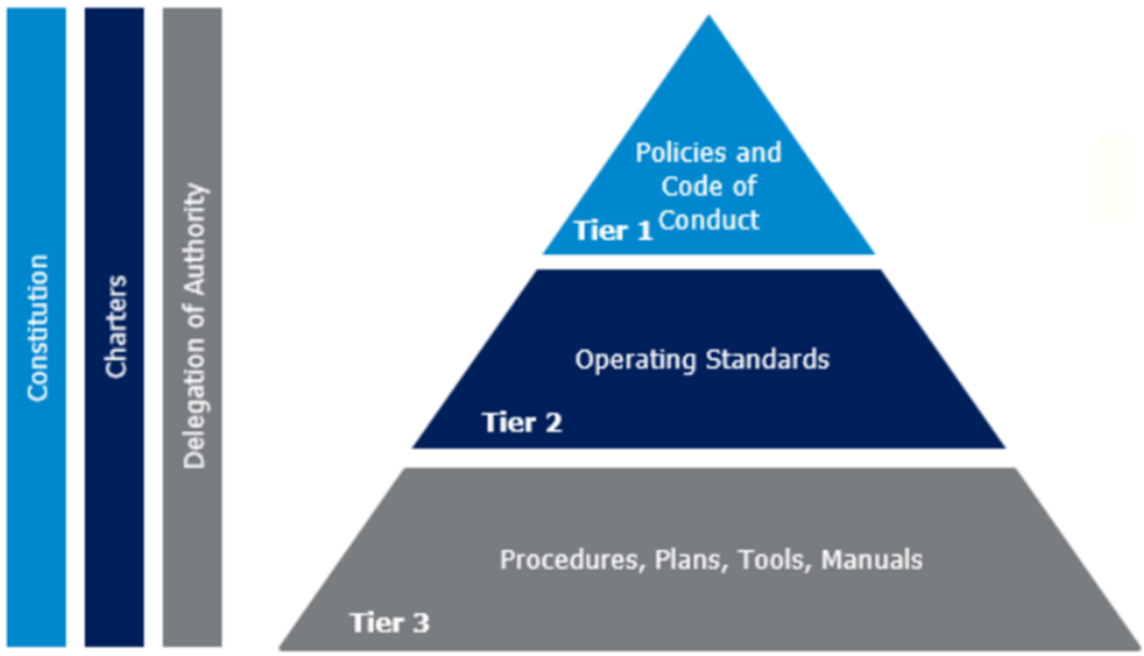


Figure 8-1: Santos Management System Framework

Figure 8-2: Santos Operations Excellence Wheel

8.1 Operating Standards

Operating Standards developed as part of the SMS set out the minimum and mandatory requirements in relation to key business purposes, operational matters and assurance activities. The requirements necessary to ensure that environmental, health and safety risk is effectively managed are included in relevant management standards. These Standards include, but are not limited to:

- Communications
- Commercial
- Joint Venture
- Development
- Decommissioning
- Finance (multiple)
- Data Information Management
- Government and Stakeholders
- Emergency and Crisis
- Incident Reporting and Investigation
- Logistics
- Risk Management

- Assurance
- Compliance
- Production Planning and Allocation
- Integrity Reliability Surveillance
- People (multiple)
- Contracting and Procurement

8.2 Other Applicable Standards

Santos' activities are undertaken in general accordance with relevant requirements of the following applicable Australian and international standards where practicable:

- AS/NZS ISO 31000 Risk Management
- AS/NZS ISO 45001 Occupational Health and Safety Management Systems – Requirements with Guidance for Use
- AS/NZS ISO 14001 Environmental Management Systems – Requirements with Guidance for Use
- AS 2885.0 Pipelines – Gas and Liquid petroleum – General requirements
- AS/NZS 2885.1 Pipelines – Gas and Liquid Petroleum – Design and Construction
- AS/NZS 2885.2 Pipelines – Gas and Liquid Petroleum – Welding
- AS 2885.3 Pipelines – Gas and Liquid Petroleum – Operation and Maintenance
- AS 2885.5 Pipelines – Gas and Liquid Petroleum – Field Pressure Testing
- AS/NZS 2885.6 Pipelines – Gas and Liquid Petroleum – Pipeline safety management
- AS 1940 The storage and handling of flammable and combustible liquids
- AS/NZS 3788 Pressure equipment – In-service inspection
- AS 1210 Pressure vessels

8.3 Job Safety Analysis and Permit to Work

Job Hazard Analysis (JHA) is a practical risk assessment tool used by workers to identify and document hazards associated with a job/task and what will be done to control the risks associated with the hazards.

Santos and its contractors perform a JHA before conducting a job/task if:

- the job/task is not a routine low-risk job/task
- there is not a documented risk assessment for the job/task that:
  - identifies reasonably foreseeable EHS hazards
  - details required control measures including who is responsible for each control measure
  - includes a process to ensure that the information in the documented risk assessment is clearly communicated and understood by all those undertaking the job/task
  - there are other material risks that may present when the work is conducted (e.g. other work being conducted in close proximity (simultaneous operations), that would not be covered in an existing documented risk assessment for the job/task.

Santos and its contractors use the multi-purpose industry accepted Permit to Work (PTW) system. PTW is an international leading practice, risk-based, work authorisation process that is used throughout the Australian Onshore Oil and Gas Industry. The PTW System applies to production and processing operations.

The PTW system is used in conjunction with applicable regulatory requirements, good industry practice and project specific documentation, and forms part of the Santos and Contractor Environmental Health and Safety Management Systems.

8.4 Training

Prior to the commencing work in field operations, field personnel are required to undertake an EHS induction specific to the work site, to ensure they understand their role in protecting their safety, and safety of others, and regarding protecting the environment. Level three inductions are required to be undertaken by all personnel who enter satellites and / or nodal compressor stations.

Induction records are maintained.

Appropriately trained personnel will be on site during operations, with lease access restricted to only necessary personnel during pressure pumping activities.

Contractors' training matrix is available upon request.

8.5 Emergency Preparedness

Santos uses an Emergency Response Plan to provide company and Contractor personnel with guidance for responding to an emergency at or near an activity. The Emergency Response Plan is for all Santos workers and sites within the Cooper Basin and central Australia.

The plan supports Santos' 'defensive approach' to emergencies of 'get away and ESD (emergency shut down)' and provides the following:

- basic principles for an emergency response
- emergency checklists
- the interface with other Santos emergency and incident plans.

Santos and contractor personnel are required to undertake emergency response drills to practice and prepare for potential incidents on site.

8.6 Incident Response and Management

Incidents are managed in accordance with the Santos Incident Reporting, Investigating and Learning Procedure. Refer to Figure 8-3 for the reporting, investigating and learning process flow.

EHS incidents are recorded in the Santos EHS Toolbox Incident Management System (IMS) which is a platform for reporting and management of incidents and incident investigations. Events with an actual or potential consequence of ≥IV are classified as a High Potential Event (HPE) and will trigger a HPE investigation. All other incidents will be investigated using 5 Whys or a Technical Investigation.

The main focus of investigating incidents is to:

- reduce overall risk and harm
- prevent recurrence of events that can cause serious harm.

The system also provides a mechanism for recording Reportable Incidents, as defined under the Act and associated regulations.

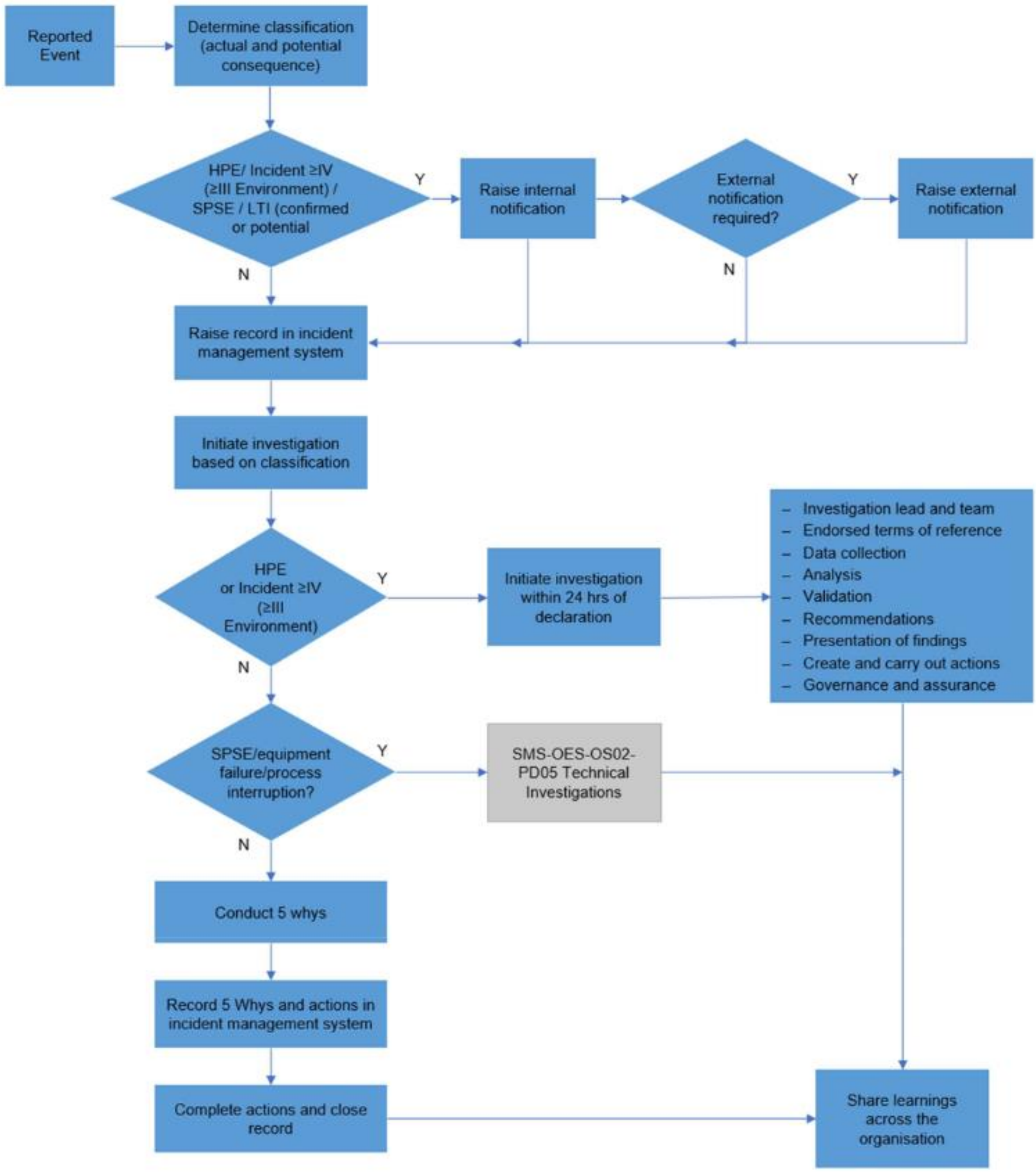


Figure 8-3: Incident reporting, investigation and learning process (SMS)

8.7 Environmental Monitoring and Audits

The SMS is subject to an internal audit program to review implementation and effectiveness of the management system against the requirements of the standards.

Ongoing monitoring and auditing of production and processing operations is undertaken to evaluate the extent to which environmental risks are being managed, minimised and where reasonably practicable, eliminated.

Opportunities for improvement identified as part of the audit process inform a management strategy to address potential hazards where appropriate.

8.8 Management of Historical Land and Groundwater Impact

Santos has prepared a management framework to allow the systematic assessment of soil and groundwater conditions associated with known discrete loss of containment events or historical impacts, attributable to petroleum hydrocarbon and produced fluid management and storage practises. Developed in accordance with the *National Environment Protection (Assessment of Site Contamination) Measure 1999*, amended 2013 (NEPC, 2013) the framework involves a phased approach leveraging regional and site-specific data to facilitate quantification of risks and uncertainties.
To support the framework, a conceptual exposure model was developed to identify potentially complete exposure pathways by which human and ecological receptors may be exposed to potential contaminants of concern in soil and groundwater. In addition to the conceptual exposure model, site-specific Tier 2 risk-based screening levels have been developed as part of the framework and have been independently peer reviewed and approved by an environmental specialist appointed by DEM.
Whilst the risk assessment approach has been developed to evaluate human health, ecological and other stakeholder concerns associated with soil and groundwater conditions, the assessment and management of known and potential historical impacts require a range of other issues to be considered as part of the iterative process.
The framework outlines the evaluation process whereby human health, ecological risks, impact to groundwater and nuisance are systematically evaluated. The framework includes a decision matrix which reflects the step-wise / iterative nature of the assessment activities with the early focus on activities to address operational concerns, containing the release or potential for migration, and management of potential risks to human health and the ecological receptors from soil impacts.
The management framework has been developed in consultation with DEM.

In addition to the management framework outlined above, Santos is currently investigating contaminants of potential concern (COPCs) identified in groundwater in the Moomba region attributed to the historical use of firefighting foams and other chemicals within the Moomba Plant facilities. This is being undertaken in consultation with DEM and SA EPA. An assessment plan and Sampling and Quality Analysis Plan (SAQP) has been developed in consideration of relevant standards and guidelines. Following endorsement of the SAQP by DEM, the soil and groundwater investigation was initiated at the Moomba site. A Detailed Site Investigation report, in line with the assessment plan and ASC NEPM, will document the nature and extent of COPCs in soils and groundwater arising from these historical activities. If required, a site-specific risk assessment will be completed consistent with the ASC NEPM and management framework discussed above.

8.9 Reporting

External reporting requirements (e.g. Serious or Reportable incidents, annual reports) are carried out in accordance with the *Petroleum and Geothermal Energy Act 2000*, and the SEO.

Santos implements internal and external reporting procedures to ensure that environmental issues and / or incidents are appropriately responded to. Internal reporting covers:

- number, severity and close out status of incidents
- monthly summaries of incidents
- progress against key performance indicators
- audit schedule and findings
- works in progress
- site and task force meetings
- external meetings and / or liaison with key stakeholders (e.g. DEM).

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Appendix A

Threatened Flora and Fauna Species in the Cooper Basin

Table A1 Listed plant species recorded or predicted in the Cooper Basin[1]

Species	Common Name	Conservation Status[2]	
		Cth	SA
*Acacia carneorum**	Needle Wattle	V	V
Acacia confluens	Arkaroola Wattle		V
Acacia georginae	Georgina Gidgee		R
Acacia loderi	Nealie		R
*Acacia peuce**	Waddy, Waddi, Waddy-wood, Birdsville Wattle	V	
Acacia pickardii	Pickard's Wattle	V	R
Acacia tenuissima	Slender Wattle		R
Atriplex eichleri	Eichler's Saltbush		R
Atriplex kochiana	Koch's Saltbush		V
Bergia occultipetala			V
Bulbostylis turbinata			R
Calandrinia stagnensis			R
Callitriche sonderi	Matted Water Starwort		R
Codonocarpus pyramidalis	Slender Bell-fruit, Camel Poison	V	E
Cyperus bifax	Downs Flat-sedge		R
Cyperus concinnus			R
Cyperus dactylotes			V
Cyperus nervulosus			R
Elacholoma prostrata	Small Monkey-flower		R
Eleocharis papillosa	Dwarf Desert Spike-rush	V	R
Eleocharis plana	Flat Spike-rush		R
Eragrostis lacunaria	Purple Love-grass		R
Eremophila polyclada	Twiggy Emubush		R
Eremophila subfloccosa ssp. glandulosa	Green-flower Emubush		R
Eriocaulon carsonii ssp. carsonii	Salt Pipewort, Button Grass	E	E
Eryngium vesiculosum	Prostrate Blue Devil		R
Frankenia cupularis			R
Frankenia plicata		E	V
Frankenia subteres			R
Gilesia biniflora	Western Tar-vine		R
Gratwickia monochaeta			R
Gymnoschoenus sphaerocephalus	Button Grass		E
Iotasperma sessilifolium			R
Neurachne lanigera	Woolly Mulga-grass		R

Species	Common Name	Conservation Status[2]	
		Cth	SA
Nymphoides crenata	Wavy Marshwort		R
Ophioglossum polyphyllum	Large Adder's-tongue		R
Orobanche cernua var. australiana	Australian Broomrape		R
Osteocarpum acropterum var. deminutum	Wingless Bonefruit		R
Osteocarpum pentapterum	Five-wing Bonefruit		E
Phlegmatospermum eremaeum	Spreading Cress		R
Pimelea penicillaris	Sandhill Riceflower		R
Podolepis muelleri	Button Podolepis		V
*Pterostylis xerophila**	Desert Greenhood	V	V
Roepera humillima	Small-fruit Twinleaf		R
Sclerolaena blackiana	Black's Bindyi		R
*Sclerolaena walkeri**		V	
Senecio gypsicola	Gypsum Groundsel		R
Senecio laceratus	Cut-leaf Groundsel		R
Stylidium desertorum			V
Swainsona behriana	Behr's Swainson-pea		V
Swainsona fuscoviridis	Dark Green Swainson-pea		R
Swainsona leeana	Lee's Swainson-pea		R
Swainsona microcalyx	Wild Violet		R
Swainsona oligophylla			R
Synostemon ramosissimus			R
Tecticornia cupuliformis			V
Utricularia violacea	Violet Bladderwort		R
Wurmbea deserticola	Desert Nancy		R

[1]Search area is 26°S-30°S, 138°E-141°E. Database records and species ratings were current at the time of searching (May 2022) (see NatureMaps 2022, DAWE 2022b).

[2]Conservation status under the SA *National Parks and Wildlife Act 1972* and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: R – Rare, V – Vulnerable, E – Endangered, EX – Extinct

* Indicates the species has been predicted to occur by the protected matters search tool (DAWE 2022b) but has not been recorded in the BDBSA (NatureMaps 2022).

Table A2 Listed fauna species recorded or predicted in the Cooper Basin[1]

Species	Common Name	Conservation Status[2]	
		Cth	SA
Birds			
Actitis hypoleucos	Common Sandpiper		R
*Amytornis barbatus barbatus**	Bulloo Grey Grasswren, Grey Grasswren (Bulloo)	E	
Amytornis barbatus diamantina			R
*Amytornis merrotsyi merrotsyi**	Short-tailed Grasswren (Flinders Ranges)	V	V
Amytornis modestus	Thick-billed Grasswren	V	
Amytornis modestus cowarie	Thick-billed Grasswren (NE)	sp	
Amytornis modestus raglessi	Thick-billed Grasswren (northern FR)	sp	
Anhinga novaehollandiae novaehollandiae	Australasian Darter		R
Anseranas semipalmata	Magpie Goose		E
Antigone rubicunda	Brolga		V
Aphelocephala pectoralis	Chestnut-breasted Whiteface		R
Aprosmictus erythropterus erythropterus	Red-winged Parrot		R
Ardea intermedia plumifera	Plumed Egret		R
Ardeotis australis	Australian Bustard		V
Arenaria interpres interpres	Ruddy Turnstone		R
Biziura lobata menziesi	Musk Duck		R
Bubulcus ibis coromandus	Eastern Cattle Egret		R
Burhinus grallarius	Bush Stonecurlew		R
Calidris ferruginea	Curlew Sandpiper	CE	E
Calidris melanotos	Pectoral Sandpiper		R
Calidris subminuta	Long-toed Stint		R
Charadrius mongolus mongolus	Lesser Sand Plover		R
Chlamydera maculata	Spotted Bowerbird		E
Cladorhynchus leucocephalus	Banded Stilt		V
Conopophila whitei	Grey Honeyeater		R
Dromaius novaehollandiae	Emu		ssp[3]
Egretta garzetta nigripes	Little Egret		R
Elanus scriptus	Letter-winged Kite		V
Emblema pictum	Painted Finch		R
Epthianura crocea crocea	Yellow Chat		E
Falco hypoleucos	Grey Falcon	V	R
Falco peregrinus macropus	Peregrine Falcon		R
Falco subniger	Black Falcon		R
Gallinago hardwickii	Latham's Snipe		R
Geophaps plumifera leucogaster	Spinifex Pigeon		R

Species	Common Name	Conservation Status[2]	
		Cth	SA
Grantiella picta	Painted Honeyeater	V	R
Haliaeetus leucogaster	White-bellied Sea Eagle		E
Hamirostra melanosternon	Black-breasted Buzzard		R
Hieraaetus morphnoides	Little Eagle		V
*Limosa lapponica baueri**	Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit	V	R
Limosa limosa melanuroides	Black-tailed Godwit		R
Lophochroa leadbeateri	Major Mitchell's Cockatoo		R
Lophoictinia isura	Square-tailed Kite		E
Melanodryas cucullata	Hooded Robin		ssp[3]
Melithreptus gularis laetior	Golden-backed Honeyeater		R
Microeca fascinans	Jacky Winter		ssp[3]
Myiagra inquieta	Restless Flycatcher		R
Neophema chrysostoma	Blue-winged Parrot		V
Neophema elegans elegans	Elegant Parrot		R
Ninox connivens connivens	Barking Owl		R
Northiella haematogaster (NC)	Bluebonnet (Eastern and Naretha)		ssp[3]
Oriolus sagittatus sagittatus	Olive-backed Oriole		ssp[3]
Oxyura australis	Blue-billed Duck		R
*Pedionomus torquatus**	Plains-wanderer	CE	E
Pezoporus occidentalis	Night Parrot	E	E
Phaps histrionica	Flock Bronzewing		R
Plegadis falcinellus	Glossy Ibis		R
Pluvialis fulva	Pacific Golden Plover		R
Podiceps cristatus australis	Great Crested Grebe		R
Rostratula australis	Australian Painted Snipe	E	V
Spatula rhynchotis	Australasian Shoveler		R
Stictonetta naevosa	Freckled Duck		V
Thinornis cucullatus cucullatus	Hooded Plover	V	V
Tringa glareola	Wood Sandpiper		R
Tyto longimembris longimembris	Eastern Grass Owl		R
Tyto novaehollandiae novaehollandiae	Australian Masked Owl		E
Zapornia tabuensis	Spotless Crake		R
Fish			
Mogurnda clivicola	Flinders Ranges Mogurnda, Flinders Ranges Purple-spotted Gudgeon	V	CE
Mammals			
Dasyuroides byrnei	Kowari	V	E

Species	Common Name	Conservation Status[2]	
		Cth	SA
Leporillus conditor	Greater Stick-nest Rat	V	V
Macrotis lagotis	Greater Bilby (Bilby)	V	V
Mormopterus eleryi	Bristle-faced Free-tailed Bat		V
Notomys cervinus	Fawn Hopping-mouse		V
Notomys fuscus	Dusky Hopping-mouse	V	V
Petrogale xanthopus xanthopus	Yellow-footed Rock-wallaby	V	V
Pseudomys australis	Plains mouse, Palyoora	V	V
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat		R
Tachyglossus aculeatus	Short-beaked Echidna	ssp	ssp[3]
Trichosurus vulpecula	Common Brushtail Possum		R
Reptiles			
Aspidites ramsayi	Woma		R
Austroblepharus kinghorni	Blacksoil Skink		R
Ctenotus astarte	Ashy Downs Ctenotus		R
Ctenotus joanae	Blacksoil Ctenotus		R
Emydura macquarii	Macquarie Tortoise		V
Morelia spilota	Carpet Python		R
Pseudonaja guttata	Speckled Brown Snake		R
Frogs			
Cyclorana cultripes	Knife-footed Frog		R

[1]Search area is 26°S-30°S, 138°E-141°E. Database records and species ratings were current at the time of searching (May 2022) (see NatureMaps 2022, DAWE 2022b).

[2]Conservation status under the SA *National Parks and Wildlife Act 1972* and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: R – Rare, V – Vulnerable, E – Endangered, EX – Extinct

[3]Subspecies is listed under the *National Parks and Wildlife Act 1972*, however subspecies information is not contained in BDBSA records.

* Indicates the species has been predicted to occur by the protected matters search tool (DAWE 2022) but has not been recorded in the BDBSA (NatureMaps 2022).

Appendix B

Moomba Plant – Schematic Diagram

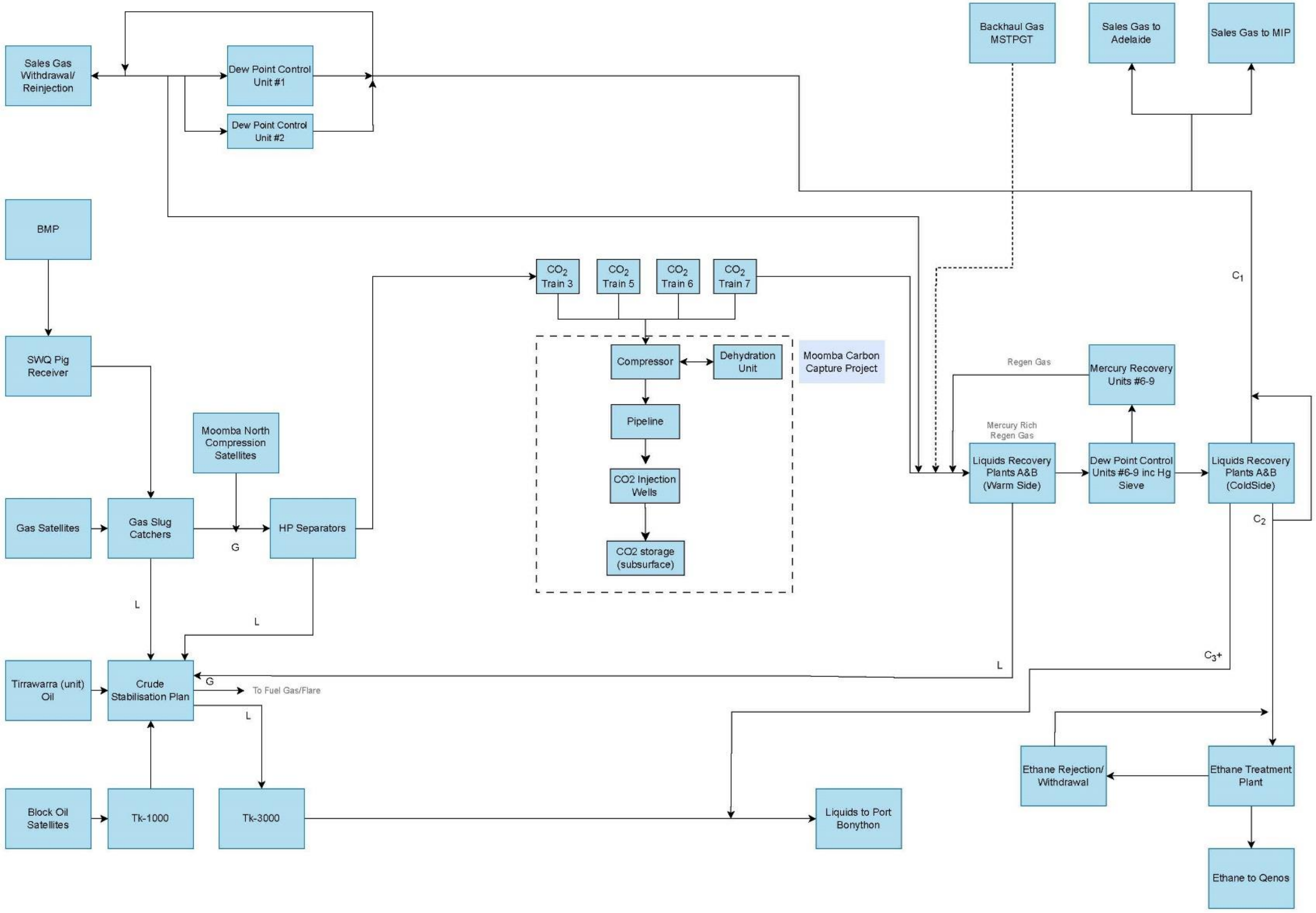

Figure B1: Schematic of gas and oil processing at Moomba

Appendix C

Stakeholder Consultation

Email submission for Stakeholder consultation:

The Santos South Australian Cooper Basin Statement of Environmental Objectives: Production and Processing Operations (SEO) and Environmental Impact Report (EIR), have undergone a 5 yearly review to meet the requirements of Regulation 14 of the *Petroleum and Geothermal Energy Regulations 2013*.

As part of this review process, Santos are required to engage in public consultation to finalise review of our Draft Production and Processing SEO and EIR.

Please see attached for your review and comment:

- Explanatory report
- Draft Environmental Impact Report (EIR) and
- Draft Statement of Environmental Objective (SEO)

Can you please provide any comments or questions within two weeks **(05/05/2023)** to cooper.environment@santos.com , cc amelia.badri@santos.com

Further to this, can you please acknowledge and send read receipt of this email to cooper.environment@santos.com , cc amelia.badri@santos.com

Stakeholder Groups:

Landholders

- Gidgealpa Station
- Merty Merty Station
- Mungeranie Station
- Clifton Hills Station
- Cordillio Downs Station
- Bollards Lagoon Station
- Innamincka Station
- Innamincka Station and Strezelecki Regional Reserve
- Lindon White Catch

Traditional Owners

- Yandruwandha / Yawarrawarrka
- Dieri

Other Government Bodies

- Innamincka Progress Group
- Conservation Council SA
- Nature Foundation SA
- Wilderness Society
- Department for the Premier and Cabinet - Aboriginal Affairs and Reconciliation
- Department for Health & Wellbeing
- SafeWork SA
- Department for Infrastructure & Transport
- PIRSA DEW Pastoral Unit (note Pastoral Act managed by DEW now)
- SAAL Landscape Board
- Department for Environment and Water
- Environment Protection Authority
- Outback Communities Authority
- Great Artesian Basin Coordinating Committee

Third parties

- Beach Energy Limited
- Delhi Petroleum P/L
- Beach Energy (Operations) Ltd
- Great Artesian Oil & Gas P/L
- Impress (Cooper Basin) P/L
- Ambassador Exploration Pty Ltd
- Red Sky Energy
- ReNu Energy
- Clean Energy Australasia
- Vintage Energy
- Alligator Energy
- Epic Energy
- APA

Table C1: Stakeholder consultation comments and Santos responses for Santos consultation on revised EIR, May 2023

Agency / stakeholder	EIR reference	Agency / Stakeholder Comment	Santos Comment
South Australian Arid Lands Landscape Board (LSA)			
(LSA C1)	Pg 13	While the EIR identifies the Water Affecting Activities (WAA) Control Policy (WAACP) as a legislative requirement, it would be beneficial to say that the WAACP considers all water resources, including surface waters. This is to reinforce and distinguish from the WAP which primarily focuses on groundwater and associated ecosystems. e.g. "*This Act and the regional Water Affecting Activities Control Policy considers all water resources, including surface waters and set out a number of water affecting activities that must not be undertaken without a permit.*"	Noted, text added.
(LSA C2)	Whole document	A number of Water Affecting Activities have been identified in this EIR. E.g. Tables 4-5, 7-3, 7-9. For all work involving water resources, advice for permit requirements should be discussed with the SA Arid Lands Landscape Board and be administered in accordance with the Board's Water Affecting Activities Control Policy.	Noted. This is undertaken where activities may require a Water Affecting Activities permit.
(LSA C3)	Tables 7-2 Page 95, 7-9, Page 149	How are sensitive areas defined? All water resources should be considered as sensitive. Where possible all pipeline work, road construction and maintenance activities should avoid water resources.	Sensitive areas are identified using the Santos Environmental Sensitivity Profile Model (see Section 5.1) and the processes outlined in Section 5.1.1. Given the nature of the Cooper Basin (e.g. vast areas that are infrequently and unpredictably flooded by the Cooper Creek) inclusion of a generic statement around avoiding all water resources may not be feasible. To address this, the EIR and SEO outline measures to avoid or minimise impacts to water resources.
(LSA C4)	In general	We note that activities on salt lakes are avoided (e.g. Tables 4-5, 7-2 and 7-9). We also recognise that there is effort to minimise impact to drainage channels/lines/systems.	Noted.

Agency / stakeholder	EIR reference	Agency / Stakeholder Comment	Santos Comment
(LSA C5)	4.2.7	Mentions removal of above ground infrastructure but why not below ground as well?	As noted in this section, buried pipelines are generally cleaned and left in situ. This is a standard practice across the pipeline industry as it significantly reduces disturbance and environmental impacts associated with digging up decommissioned infrastructure.
(LSA C6)	4.9.11	Would it be possible to provide a map of what tracks, pipelines and satellite stations they intend decommissioning, along with a timeline? There appears to be a lot of disused pipelines up to and within Innamincka RR	Information on planned decommissioning is provided to DEM on an annual basis.
(LSA C7)	5.3.1	Re Dusky Hopping Mouse; the last comprehensive surveys appear to have been done for the pipeline in 2011/12. We feel this is due a follow-up with more formal/routine monitoring of this species going forward.	The Dusky Hopping-mouse is widespread in dunefields across the Cooper Basin. Pre-construction assessments are undertaken for activities including pipelines and none have identified potential for significant impact on (or the need for ongoing monitoring of) Dusky Hopping-mouse. While monitoring of this species may provide interesting data on general abundance and population trends, any data collected is unlikely to have any direct relevance to Santos activities regulated under the PGE Act or achievement of SEO objectives.
Department for Health & Wellbeing (SA) – DHW			
(DHW C1)	Page 46, paragraph 1	With the **EIR**, on page 46 under the first paragraph of 'Wastewater Management' I would just like to point out that the description of the wastewater management system for the Moomba Camp, and associated buildings is not entirely correct. Currently it is a very simple system which is good. The 'aerated' pond (the original system installed back in the 80s!) and settling system is used. Treated wastewater is either evaporated or goes out to Lake Brooks. Just to clarify, there is no treatment via MBBR and currently no re-use or irrigation back into the camp. The 'Southern Contactors Yards' currently use an Aerated Wastewater Treatment System where treated effluent is irrigated to surface.	Noted, Text amended. *Note page 44*

Agency / stakeholder	EIR reference	Agency / Stakeholder Comment	Santos Comment
(DHW C2)	Page 46, paragraph 3	Also on page 46, paragraph 3, just to also clarify this. Dullingari and Tirrawarra both use similar systems to treat and dispose of wastewater. It is a combined septic tank and single pond system known as a small 'STED' (Septic Tank Effluent Drainage) system. The document is correct in saying that even smaller camps like Limestone Creek use a Septic Tank and Sub-surface disposal method.	Noted, Text amended. *Note page 44*
Department of Environment and Water (DEW)			
DEW (C1), P3	Sect 1.1	*"The South Australian Cooper Basin currently…"* *"The Cooper Basin asset is strategically…"* Although mentioned in the first sentence of the second paragraph, the Eromanga's importance with respect to containing the reservoir rocks from which the majority of conventional oil and some gas is produced from the Cooper-Eromanga Oil and Gas Field appears lost. Only the Cooper Basin is mentioned with respect to current importance and current source of petroleum hydrocarbon production in this section. Whilst it may be argued to be the source rock for much of the petroleum hydrocarbons found, this nuance is not the subject of the introduction. Further, much of the Produced Formation Water (PFW) comes from the Eromanga Basin, which is a key environmental management issue.	Section 2.1 has been amended to clarify, as follows: 'the Cooper Basin (which encompasses both the Cooper and Eromanga geological basins) houses…'
DEW (C2), P3	4.2.1	*Pigging can typically only be used for larger diameter pipelines.* Although typical diameter pipelines are described later, the minimum diameter for pigging mentioned here would aid understanding.	Noted, Text updated
DEW (C3), P3	Table 4.2	What is the PFW processing capacity of each facility?	For the PFW processing capacity, further detail can be provided. The calculation is based on average daily or annual evaporation rate across the assets.
DEW (C4), P3	Figure 4.2	Has "polished water" been defined yet? Please define if not.	Section 4.5.1 updated with definition of Polished water.

Agency / stakeholder	EIR reference	Agency / Stakeholder Comment	Santos Comment
DEW (C5), P1	Sect 4.6 Sect 4.7	*“Waterflood activities are currently undertaken in the Merrimelia and Charo fields and have demonstrated improved secondary oil recovery. Previously waterflood activities were carried out in the Dullingari, Gidgealpa and Jena fields.”* *“Santos undertook miscible EOR in the Tirrawarra field from 1984 to 1996, during which time raw gas and ethane were used as the injection fluid.”* *“From 2023, Moomba Gas Plant will also supply CO2 for storage at several sites in the South Australian Cooper Basin.”* Are volumes of water and gas used during waterflooding reported to DEM? Are these volumes published?	Response or action required by Santos (DEW C5): Water use volumes are tracked internally. These are not reported to DEM. We do however provide DEM with annual water use reports for authorised water licenced activities.
DEW (C6), P1	4.7, 7.9.4 and elsewhere	*“Lake Brooks”* “Lake Brooks” appears to be a colloquial name for the Moomba wastewater treatment facility, however the reference to “Lake Brooks” is confusing if one is not familiar with this name. Further, the link between Lake Brooks and the treatment facility is not made until later in the document. DEW strongly recommend referring to the facility by its official name lest it be confused with an actual lake	‘Lake Brooks’ has been removed or replaced by ‘Moomba plant evaporation ponds where relevant.
DEW (C7), P1	4.9.3	*“There are several Santos owned groundwater bores in Santos tenures in the Cooper Basin that are used regularly by landholders to support their industry.”* Are these volumes metered? How is this water accounted? Under whose water licence do these totals go against?	Response or action required by Santos (DEW C7): Landowners access the water under their own approval structure. These are not accounted for under Santos’ water use licences .
DEW (C8), P3	4.9.7	*“▪ groundwater monitoring infrastructure”* The described infrastructure, is it being used to monitor contamination, groundwater drawdown or both? How are data reported and to whom?	As noted in Section 4.9.7, monitoring equipment is installed to support authorised activities covered by the EIR. Groundwater monitoring infrastructure may be installed for a range of purposes, including development of the ESP model (see Section 5.1), monitoring of produced formation water disposal (see Section 7.7) or monitoring / management of

Agency / stakeholder	EIR reference	Agency / Stakeholder Comment	Santos Comment
			loss of containment events. Data reporting is dependent on the nature of the monitoring.
DEW (C9), P3	5.3.4	Note that salt lakes, particularly Lake Blanche (and the unmentioned Lake Callabonna), may contain springs.	Noted. GAB springs at the southern margins of the Cooper Basin are referred to in Section 5.4.3. Lake Callabonna is not mentioned as it lies well outside the Cooper Basin and the coverage of the EIR.
DEW (C10), P3	Figure 5.4	The figure is of poor resolution and is hard (if not impossible in places) to read. Please replace.	Image updated
DEW (C11), P3	5.4.2 "Unconventional Resources"	*"Most of the oil pools in the Eromanga Basin are located over and adjacent to the margins of the Permian-Triassic Cooper Basin (Heath et al. 1989). Stratigraphically, the Eromanga fields are characterised by vertically stacked pools, with the largest accumulation of oil usually located just below the deepest, most competent seal. Heath et al. (1989) considers that much of the oil and gas in the Eromanga Basin was actually sourced from the underlying Cooper rocks."* This discussion appears to be concerned with conventional oil plays. Indeed this whole section appears to discuss oil and gas plays in general, rather than specifically "unconventional" plays.	This discussion on unconventional resources has been removed from the EIR as it is not relevant to production and processing operations. Its main purpose is to support discussion of fracture stimulation. This is covered in the Drilling, Completion and Well Operations EIR (where this text is retained).
DEW (C12), P3	5.4.3	*The Namur and Hutton sandstones (Algebuckina Sandstone equivalents) are thought to be among the primary sources of groundwater to GAB springs (Priestley et al. 2020).* Note that Keppel et al (2020) published a paper discussing the source of spring water specific to the region south of the Cooper Basin and found hydrochemical evidence for multiple aquifer sources. This includes springs found on Lake Blanche. This has pertinence because it is not necessarily just the Eromanga (GAB) aquifers mentioned in the highlighted quote that require consideration with respect to spring protection. https://www.royalsocietyqld.org/wp-content/uploads/Proceedings%20126%20v2/05_Keppel_et_al_Web.pdf	Noted. The existing text does not preclude other aquifer sources for springs. However, a sentence has been added 'Hydrochemical evidence has suggested multiple aquifer sources for some of these springs (Keppel et al. 2020).'

Agency / stakeholder	EIR reference	Agency / Stakeholder Comment	Santos Comment
		https://www.waterconnect.sa.gov.au/Content/Publications/DEW/LEBSA_Hydro ecological_Characterisation_of_Lake_Blanche_springs.pdf	
DEW (C13), P1	Table 7.10 pg 153	A control under "Water" should include that groundwater is only obtained from appropriately constructed and licenced water wells.	Noted, however this is not relevant under 'Water' in this table as it relates to impact of earthworks.
DEW (C14), P3	7.11.3	*"The installation and construction of new groundwater extraction bores will be undertaken in accordance with the Far North Prescribed Wells Area Water Allocation Plan (FNPWA WAP) and DEW by a licensed water bore driller."* DEW? Technically I believe it is the *Landscapes SA Act (2019),* of which the FNPWA WAP is a regulatory instrument. DEW are charged with administering the *Landscapes SA Act (2019)*.	Text edited to replace DEW with Landscape SA Act.
DEW (C15), P1	7.11.3	*"The installation and construction of new groundwater extraction bores will be undertaken in accordance with the Far North Prescribed Wells Area Water Allocation Plan (FNPWA WAP) and DEW by a licensed water bore driller."* Discussion concerning how water supply wells are decommissioned once they are no longer required appears missing from this document.	Water supply wells are not regularly decommissioned, however this would be undertaken in accordance with requirements of the FNPWA WAP and Landscape SA Act. Note: Decommissioning of water supply wells is outside the scope of the PGE Act and the SEO.
DEW (C16), P3	Table 7.12	*"Compliance with water licence and allocations where applicable."* When are they not applicable?	Removed 'where applicable'
SA Environment Protection Authority (EPA)			
EPA (C1)	Section 3.2	Replace Radiation Protection and Control Act 1982 with Radiation Protection and Control Act 2021	Noted and amended
EPA (C2)	Section 4.5	Table 4-3: Compounds commonly found in produced formation water This table should be reviewed for accuracy, with regard to species labelled as 'Organic'. Calcium Carbonate is an inorganic compound, and 4-Bromoflurobenzene and 1,2- Dichloroethane-D4 appear to be laboratory compounds used in TRH/TPH testing.	Noted and amended
EPA (C3)	Section 4.9.2	Table 4-6: Typical waste streams – operational waste from production and processing operations	Noted and amended

Agency / stakeholder	EIR reference	Agency / Stakeholder Comment	Santos Comment
		Gaseous Waste (reported to the EPA via NPI): Include CCS/EHR as management methods. Include NGER in reporting comment. Produced formation water: Include Waterflood (EHR) as a management method.	
EPA (C4)	Section 4.9.6	Table 4-8 Table could include Oilfield production and processing chemicals (Corrosion Inhibitors, Biocides, Scale Inhibitors, Antifoams, Foamers, Pour Point Depressants/inhibitors, Wax Dispersants/Dissolvers/Inhibitors, Asphaltene Inhibitors, EHR polymers and drag reducers)	Noted and amended
EPA (C5)	Appendix B	Figure B1: Schematic of gas and oil processing at Moomba Update schematic to include the CCS process. Adjust page orientation to capture entire graphic.	CCS is outside of the scope of the SEO and EIR. Addressed separately in the Carbon Capture and Storage SEO: https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/PGER003222021.pdf and Carbon Capture and Storage EIR: https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/PGER003212021.pdf
EPA (C6)	Section 7	As a general comment, chemical vendor and/or production chemistry (in-house or 3rd-party) support is a critical aspect of oil and gas production/processing risk management, and therefore environmental risk management. Something to this effect could be incorporated into the relevant control statements throughout section 7, although this may be considered as covered already under SMS controls?	Currently managed under Santos SMS for chemical selection and management.
EPA (C7)	Section 7.8	The Radiation Protection and Control Act 1982 was updated in 2021, with the Radiation Protection and Control Regulations 2022 released in February 2022. Recommend referencing these as part of the control strategy for the management of Tracers and/or any other radioactive sources.	Table 7.7 updated to reflect EPA recommendation.

Agency / stakeholder	EIR reference	Agency / Stakeholder Comment	Santos Comment
Aboriginal Affairs and Reconciliation (AAR)			
AAR (C1)	5.5.1 Aboriginal Cultural Heritage (Table 5.5)	*Site Types – Scarred Trees (Rare)* Consider changing to culturally modified trees as mature trees can be naturally scarred. And where referenced throughout the document.	Changed to 'culturally modified trees'.
AAR (C2)	6.4 EIR and SEO Review 2023 (Tables 6.1 and 6.2)	As per Agency comments in this document Review will be under AGD - AAR in 2023	Noted.
	9 References	AAR notes that there has been no update to Aboriginal heritage references since the 1990s in this document. No reference to AAR factsheets or heritage agreements in this list.	Added current fact sheet *Managing Aboriginal Heritage in South Australia*.
	Appendix C Stakeholder Consultation	Will this appendix include comment from native title parties or Aboriginal heritage organisations?	Any comments received from native title parties or Aboriginal heritage organisations will be included.
Landowner –(LAN)			
LAN (C1)	Water use	Note no change to the water licence for formation water – still at 60ML/day. Acknowledging that it is a problematic area, it would be preferable to see some improvements on how PFW is managed.	Acknowledged
LAN (C2)	Pond design	Is consideration given to PFW pond design to take in the huge variations in rainfall events. General EPA guidelines/regulations may not be written to take these factors into account.	Yes, Pond design takes into consideration location of desired pond, size, environmental considerations such as rainfall and watercourse systems in the area (as applicable). These impact the final design and location of the ponds.
LAN (C3)	Soil and groundwater monitoring	Is regular testing undertaken of soils, ground water etc nearby to these ponds or where the PFW is used (eg on roads) to monitor changes or build up of contaminants over time?	Routine monitoring is undertaken in the Cooper Basin with assessments of soil, ground water and PFW quality in ponds monitored as required.

Agency / stakeholder	EIR reference	Agency / Stakeholder Comment	Santos Comment
LAN (C4)	Road construction	Suggest that the use of existing road networks are utilised instead of constructing new roads or to minimise construction therefore reducing the clearance of veg, visual impacts and the cumulative effects of increasing infrastructure in the Basin	Yes, existing road networks are utilised when possible. Any new roads are assessed prior to construction for location, design and any potential impact. With the aim to minimise/reduce any impacts associated with the proposals.
LAN (C5)	Accreditation	Page 80. OBE Organic is not a certifying body. Examples of certifying bodies are NASAA, ACO and AusQual.	Noted and amended;
LAN (C6)	Environmental risk assessment	The cumulative impacts from activities in the Basin needs to be included in the Environmental Risk Assessment	Acknowledged – • Section 7.2 of the EIR notes that the potential for cumulative impacts is considered in the risk assessments undertaken for Santos production and processing activities using tools such as the Operational Risk Matrix and the Environmental Sensitivity Profile Model. • An acknowledgement of the potential for cumulative impacts and that this potential is recognised and considered during risk assessment, planning, design, construction and operational management, monitoring and auditing of production and processing activities. • Santos considers that the existing objectives, assessment criteria and guide to how the objectives can be achieved that are currently in the SEO, adequately address potential cumulative impacts for a range of production and processing activities.

Table C2: Stakeholder consultation comments and Santos responses for Santos consultation on revised SEO, May 2023

Agency / stakeholder	SEO reference	Agency / Stakeholder Comment	Santos Comment
South Australian Arid Lands Landscape Board (LSA)			
(LSA C8)	Objective 2	Currently states: *"No new water affecting activities as defined under the Landscape South Australia Act 2019) undertaken unless applicable permits have been obtained".* Could update wording to reflect the policy and agencies involved, i.e. both SAAL Landscape Board and DEW depending on the permit required. e.g. "…outlined in accordance with the Water Affecting Activities Control Policy (effective from 15 March 2021) from the SA Arid Lands Landscape Board." Also, refer to the Control Policy for the complete list of Water Affecting Activities as current objectives listed in the "Guide to…" do not provide an exhaustive list of WAAs that are considered.	Noted. The assessment criteria is worded to ensure that it remains relevant for the duration of the SEO if agencies or policies change.
(LSA C9)	Objective 2	Sensitive land systems (e.g. wetlands). Would like to see all water resources, recognising the diversity across the region, classified as sensitive. If updated we would recognise that there is aim to avoid water systems where possible.	Refer to EIR comment LSA C3 above regarding use of the ESP model and sensitivity and commitments regarding avoidance of water resources.
Department of Environment and Water (DEW)			
DEW (C1), P3	1.1 &1.2	*"The South Australian Cooper Basin currently…"* *"The Cooper Basin asset is strategically…"* *"Santos currently has an interest in over 180 Petroleum Production Licences (PPLs) in the South Australian Cooper Basin surrounding the Moomba processing facility."* *"…the South Australian portion of the Cooper Basin (Santos 2022)."* Although mentioned in the first sentence of the second paragraph, the Eromanga's importance with respect to containing the reservoir rocks from	Section 1.1 has been amended to clarify, as follows: 'the Cooper Basin (which encompasses both the Cooper and Eromanga geological basins) houses…'

Agency / stakeholder	SEO reference	Agency / Stakeholder Comment	Santos Comment
		which the majority of conventional oil and some gas is produced from the Cooper-Eromanga Oil and Gas Field appears lost. Only the Cooper Basin is mentioned with respect to current importance and current source of petroleum hydrocarbon production. Whilst it may be argued to be the source rock for much of the petroleum hydrocarbons found, this nuance is not the subject of the introduction. Further, much of the Produced Formation Water (PFW) comes from the Eromanga Basin, which is a key environmental management issue.	
DEW (C2), P1	Table 1 Section 4	*Surface Water and Groundwater Quality and Use* *No impact on groundwater dependent ecosystems as a result of groundwater extraction or contamination*.* Impacts associated with drawdown to be considered also. Pressure loss resulting from drawdown may impact third party users of groundwater if not properly monitored. Control measures relating to government regulations and licencing conditions will also pertain to drawdown impacts.	Noted. Impacts to third party users are covered by the assessment criteria: *No reduction in the capacity of third-party surface water or groundwater users to undertake their respective activities, as a result of regulated activities.*
DEW (C3), P3	Table 1 Section 4	*Proposed groundwater bores proximal to surface water systems or ecosystems that are baseflow dependent are excluded where risk is apparent.* Relatedly, one can specify that planning of new groundwater bores will adhere to principals spelled out in the FNWAP, that will is in-line with the statement above.	Added 'Planning of new groundwater bores considers the principles of the Far North Prescribed Wells Area Water Allocation Plan.'
DEW (C4), P3	Table 1 Section 7	*"…shortfall with the Gas Criteria for…"* Gas should be GAS	Amended.
SA Environment Protection Authority EPA			
EPA (C1)	Section 2.1	Stipulate which legislation	Noted – amended
EPA (C2)	Section 2.2 Table 1	Objective 2/Loss of Containment/* No phase-separated hydrocarbons visible on water surface in freeform or final-stage evaporation pond	Noted – amended

Agency / stakeholder	SEO reference	Agency / Stakeholder Comment	Santos Comment
		The lack of phase-separated hydrocarbons is not an adequate assessment criteria for water quality. Certain hydrocarbons have finite water solubility and may appear as a single phase, as can hydrocarbon-water emulsions. The objective is the lack of hydrocarbons within the free-form or final-stage evaporation pond, which is managed through mechanical, operational and chemical control programs.	
EPA (C3)	Table A3	Goal – Minimise hydrocarbon discharge into the environment. The absence of phase-separated hydrocarbon in water does not necessarily meet the objective of minimising hydrocarbon discharge to the environment. Suggest expanding the GAS criteria definitions to include the presence of emulsions as an apparent single phase that trigger the appropriate corrective action.	Acknowledged and considered for future revisions of GAS scoring criteria.
EPA (C4)	3.3 Reporting to the EPA	Adding “as soon as reasonably practicable” will provide greater awareness of section 83(1) requirements.	Noted and amended
Aboriginal Affairs and Reconciliation (AAR)			
AAR (C1)	2.1 Environmental Objectives	*Objective 5. Avoid damage, disturbance or interference to sites, objects or remains of Aboriginal and/or non-Aboriginal heritage.* Recommend specifically referencing the *Aboriginal Heritage Act 1988* (SA) (Act).	The Act is specifically referenced in the assessment criteria.
AAR (C2)	Table 1: Cooper Basin PPO Environmental Objectives and Assessment Criteria: 5. Avoid damage disturbance or interference to sites, objects and remains of Aboriginal and/or non-Aboriginal heritage	*Systems are in place to avoid harm to identified sites of cultural and heritage significance including ongoing consultation with relevant Aboriginal heritage organisation, Native Title group or Heritage Department (DPC-AAR and DEW).* Suggest: Systems are in place to avoid harm to identified sites of cultural and heritage significance including ongoing consultation during the life of the project with relevant Aboriginal heritage organisations, including Native Title groups, Recognised Aboriginal Representative Bodies (RARBs), Aboriginal heritage associations, Traditional Owners and heritage agencies (AAR and Heritage SA). Phrases in the SEO/EIR document that refer to a Native Title party should be amended to reflect the broader grouping above	Amended. Amended in the SEO and EIR where relevant. Some phrases refer to existing agreements / protocols with

Agency / stakeholder	SEO reference	Agency / Stakeholder Comment	Santos Comment
			native title parties / groups and continue to be appropriate.
		AAR is no longer within Department of Premier and Cabinet. Remove all references to DPC-AAR in any project document.	Amended to 'AAR'.
		Note s20 of the Act requires the discovery of all Aboriginal heritage to be reported to AAR.	Noted. Covered in the 'Guide to how' column as follows: *Processes are in place to meet the requirements of the Aboriginal Heritage Act and agreements with respect to protection and reporting of discovery of Aboriginal heritage during disturbance, and production and processing operations.*
		The *Aboriginal Heritage (Misc) Amendment Bill 2023* introduced to Parliament on 18 May 2023 includes new reporting provisions under section 20A and 20B.	Noted.
		Reference to working area clearances (WACs). Please note that a WAC is not defined under or referenced by the Act. Amend to make clear that WACs cannot ever authorise impacts to Aboriginal heritage.	Added note in 'Guide to how' column: 'Note that Work Area Clearances are not defined or referenced under the Aboriginal Heritage Act and cannot authorise impacts to Aboriginal heritage.'
		Managing Aboriginal Heritage in South Australia is the current fact sheet.	Noted. Added to references.
AAR (C3)	Table 2: Incident definitions for Santos' Cooper Basin activities	*Serious Incidents 3 a).* *Damage, disturbance or interference to sites of cultural or heritage significance without appropriate permits and approvals* The Act references authorisations rather than permits or approvals.	Noted. The term 'approvals' covers authorisations.

Agency / stakeholder	SEO reference	Agency / Stakeholder Comment	Santos Comment
AAR (C4)	Table 2: Incident definitions for Santos' Cooper Basin activities	*Reportable Incidents 5.* *Any event where an excursion outside a culturally cleared area has occurred or the conditions of cultural heritage clearance have not been complied with* Reference to WACs. Please note that a WAC is not defined under or referenced by the Act. Amend to make clear that WACs cannot ever authorise impacts to Aboriginal heritage under the Act.	Added footnote to reportable incident table.
AAR (C5)	4. List of Abbreviations	AAR is no longer within the Department of Premier and Cabinet (DPC). AAR is an agency within the Attorney General's Department (AGD).	Amended listing to AAR - Aboriginal Affairs and Reconciliation.
Landowner — (LAN)			
LAN (C1)	Environmental objective 4	The Environmental Objective 4 needs to be expanded to capture no disruption of natural flow regimes of surface water by infrastructure.	The additional assessment criteria added under Objective 2, "No unreasonable impacts to third party users such as pastoralists as a result of regulated activities" has been moved to Objective 4, being specific to minimising impacts to third party users
LAN (C2)		An additional objective to include would be 'the management of cumulative impacts to the natural environment through infrastructure and other on ground activities including visual impacts. Perhaps on measure could be the number/km of existing road network utilised instead of constructing new.	Acknowledged, however, outside of scope for Production and Processing SEO.
LAN (C3)		We would also be interested in the documents for seismic, well site, campsite, track construction and decommissioning as well as drilling as these activities can have large environmental impacts.	The scope of the production and processing SEO/EIR includes but is not limited to: ▪ pipeline, trunkline and flowline construction, operation, maintenance and decommissioning ▪ plant and satellite construction, operation, maintenance and decommissioning ▪ produced formation water management ▪ enhanced hydrocarbon recovery

Agency / stakeholder	SEO reference	Agency / Stakeholder Comment	Santos Comment
			▪ road construction, maintenance and restoration ▪ waste management operations ▪ water resource management ▪ Moomba Airport and fire training ground. In addition to the Production and Processing SEO and EIR, Santos for example operate under additional approved SEO's and EIR's, including: • **Geophysical Operations SEO and EIR** which relates to Seismic line and access track preparation, line surveying, Monitoring and auditing of selected locations, line access track and camp site restoration; • **Drilling, completions and Well Intervention** which relates to well site, campsite and access track construction, Drilling, Well completions and workovers, Gas and oil systems on well leases and well and zonal decommissioning; and • **Carbon Storage** which relates to storage of measurable quantities of carbon dioxide (CO2) in subsurface geological formations (defined as 'Carbon Storage') at Santos' Cooper Basin operations in South Australia. You can access copies of the approved SEO's and EIR's referenced above via the DEM website: (https://www.energymining.sa.gov.au/industry/energy-resources/regulation/environmental-register)

Table C3: Stakeholder consultation comments and Santos responses for Santos consultation on revised SEO, October 2024

Comment	Response Priority	Doc ref.	Comment on document (DEW and EPA)	Response or actions required of Santos	Santos response (2024)
EPA – 10th April 2024: *Table 1: Water Quality*					
1	SEO Page 9		The EPA considers produced formation water (PFW) to be waste under the Environment Protection Act (1993) and by association it is also wastewater under the Environment Protection (Water Quality) Policy 2015. Environmental Objective 4 'Avoid adverse impacts to surface water and groundwater quality and minimise impacts to third party users' is too ambiguous and does not sufficiently align with the EP Act (1993) nor the Environment Protection (Water Quality) Policy 2015. It ties the environmental objectives to potential environmental risks, which limits the scope to reactive measures without allowing for preventative measures (i.e. measures that pro-actively assess and manage pollution in accord with EP Act requirements). To be clear, the EPA requires wastewater to be contained within reasonable and practicable limitations. That is a strict compliance requirement, but it is not intended to imply zero pollutant discharge. It is intended to imply that reasonable and practicable systems should be in place to: • Minimise pollutant discharge (i.e. loss of containment) • Detect pollutant discharge to groundwater • Trigger risk assessment/management systems when necessary (i.e. when assessment criteria are exceeded) including proportional control measures to minimise further discharge. The objective should be re-structured to clearly support compliance certainty.	• Environmental Objective: ○ Change objective to 'prevent or minimise groundwater quality impacts and minimise impacts to current and/or possible future third party users'. • Assessment Criteria: ○ Relevant assessment criteria should be updated to include 'PFW monitoring in accordance with relevant monitoring plans demonstrating compliance with appropriate WQ thresholds'. ○ 4th bullet point; Remove all references to contamination. The criteria should read "No impact on groundwater dependent ecosystems as a result of groundwater extraction." • Guide to How Objectives Can Be Achieved: Where a credible risk of impact to groundwater quality as a result of PFW disposal is identified, an appropriate groundwater monitoring plan will be implemented that involves assessment against relevant thresholds that have been informed by baseline.	1) Objective 4 has been updated to "prevent or minimise adverse groundwater quality impacts and minimise impacts to current and/or possible future third party users" 2) Assessment criteria against Objective 4 has been updated to: "PFW monitoring conducted in general accordance with relevant monitoring plans as required, post PFW management review, to demonstrate compliance with appropriate water quality thresholds. 3) 4th bullet point of Objective 4 assessment criteria, has been updated to read "No impact on groundwater dependent ecosystems as a result of groundwater extraction." 4) Guide to how objectives can be achieved has been updated to include the following: "Where a credible risk of impact to groundwater quality as a result of PFW disposal is identified, an appropriate groundwater monitoring plan will be implemented that involves assessment against relevant thresholds."
2	SEO Table 1	Objective 2 *Assessment Criteria/Loss of Containment*	4th bullet point is missing 'hydrocarbons' after the word phase-separated.	• Insert missing word 'hydrocarbons.	SEO objective 2 has been updated to include missing word "hydrocarbons".
3	SEO Table 1	Objective 2 *Assessment Criteria/Waste Management/Guide to How Objectives Can Be Achieved/Waste Management*	The 4th bullet point describes PFW as being managed in accordance with company standards. It is not clear what those standards are.	• Santos to clarify what the company standards are in relation to PFW management and how are these standards set? • Demonstrate why these standards are appropriate.	*SEO updates:* Reference to company standards has been removed from the 4th bullet point. Reference is now only to regulatory standards. Note that each facility may have its own operating procedures, examples could include facility specific operating procedures or manuals, to ensure all infrastructure is operated consistently and correctly and as such too many to list. *EIR updates:* Section 4.5.2 has been updated to include the following description PFW pond systems: PFW monitoring is conducted in general accordance with relevant monitoring plans as required, and after PFW management review is

Comment	Response Priority	Doc ref.	Comment on document (DEW and EPA)	Response or actions required of Santos	Santos response (2024)
					complete to demonstrate compliance with appropriate water quality thresholds.
4			In the 2017 review of the EIR, the EPA stated the driver for PFW monitoring was not clear and that monitoring appears to be reactive, requiring further explanation. The response from Santos (2017 EIR Table D-2: Comment SKM-09) fails to describe threshold limits to which water quality is assessed. The 2024 EIR refers to Total Recoverable Hydrocarbons (TRH) limits of 30 mg/L for engineered evaporation ponds and 10 mg/L for free-form evaporation ponds, however these do not appear in the SEO or linked to the SEO. It is also unclear to the EPA how are these criteria are derived? Is it adequately representing the site specific limit to prevent environmental harm? Further, as detailed in Table 4-3 (EIR), PFW contains contaminants other than TRH, such as heavy metals, which are described as naturally occurring. It is not clear how the other components are managed as part of the water quality assessment.	• Santos is to clarify how other contaminants are managed. Is there baseline data available to set measurement criteria for the naturally occurring metals?	As discussed for Comment 1 (10 April 2024) above, monitoring of produced water management facilities will be undertaken commensurate with the site specific risks associated with the storage/disposal of the PFW. Where a credible risk is identified as a result of PFW disposal, an appropriate pond monitoring plan will be implemented that involves assessment of pond water quality against relevant thresholds.
5	EIR	4.5.2 PFW pond systems	Paragraph 11 describes visual inspection and/or water quality monitoring of ponds is undertaken when required. It is unclear how does Santos determine these requirements. Paragraph 12 declares open evaporation ponds are not fenced and are accessible by native fauna and livestock. It is not clear if native fauna and livestock access triggers water quality testing for open evaporation ponds.	• Santos to clearly state water quality monitoring requirements, including frequency, for all PFW waters, especially those accessible to native fauna and livestock. For clarity, water quality monitoring should be inclusive of laboratory analysis.	Generally, the water quality sampling is focussed on risk and reuse options, ponds identified for monitoring are sampled at a minimum biennial frequency. Santos maintains a rigorous data set of water quality from its various facilities. *EIR update:* Section 4.5.2 PFW pond systems has been updated to include the following statement: Santos commits to undertaking a review of PFW management across the Cooper basin to understand the risk and whether the current monitoring is adequate”
6	EIR	4.5.3 PFW Use	The previous section (4.5.2) states open evaporation ponds can be accessed by native fauna and livestock. Section 4.5.3 does not explicitly acknowledge this as a beneficial reuse option. Noting, Table 4.6 cites livestock watering as a PFW management method.	• Santos is required to specify livestock watering as a beneficial reuse option, and how is this reuse managed.	Section 4.5.3 of the EIR has been updated to refer to “Beneficial Reuse (e.g. livestock watering)” Any water subject to beneficial reuse will be assessed to ensure suitability for the proposed reuse.
EPA – 10th April 2024: Table 2: Radiation					
7	EIR	Radiation sources	Santos have correctly referenced the *Radiation Protection Control Act 2021* (the ‘RPC Act’) in section 3.2. However, other than a reference to the use of radioactive tracers for enhanced hydrocarbon recovery processes, there are no other risks identified with radiation sources in Santos’s operations. The EPA is aware of Santos considering using a nuclear density gauge in the Cooper Basin. Other known sources of radiation in the oil and gas industry include naturally occurring radioactive	• Santos is to add environmental risks associated with the presence of NORMs, radioactive apparatus and any other radiation sources as defined under the RPC Act. Santos should ensure that all necessary EPA licencing requirements are complied with.	EIR updates: Section 7.8 has been updated to include the following information: The potential for radioactivity resulting from Naturally Occurring Radioactive Materials (NORM) that are brought to the surface during production activities. Based on previous experience with Cooper Basin petroleum operations, levels of radioactivity associated with NORMs in produced fluids are

Comment	Response Priority	Doc ref.	Comment on document (DEW and EPA)	Response or actions required of Santos	Santos response (2024)
			material (NORM) that may form as mineral scale or sludge in pipework, tanks and facilities. These could be encountered during pigging operations, tank turn arounds, pipeline maintenance/decommissioning and PFW ponds for example.		not expected to be significant and are expected to be well below any levels of concern. Where present, NORMs usually present a potential issue when they are concentrated (e.g. by the formation of mineral scales or sludges over time in tanks, piping and facilities). Appropriate protocols (e.g. risk assessment, monitoring where required) will be implemented where radioactive tracers are used to confirm that radiation levels are well below any levels of concern. Santos maintains a NORMS Exposure Controls document under the Santos Management System that details safe systems of work for when there is a potential NORMs risk. This document applies across all Santos operations. Other radioactive material are managed under the Santos SMS Radioactive Materials and Explosives Technical Standard. This maps out controls around the use of radioactive sources and tools. This SMS document includes the requirement for radioactive source tool supplying companies to be licenced and have procedures in place for the safe handling of radioactive sources and equipment. All radioactive materials will be handled in accordance with relevant legislation and guidelines (e.g. Radiation Protection and Control Act 2021). In addition to the above Table 7-7 of the EIR has been updated to include the following" Other radioactive tools/ sources are all managed in accordance with regulatory requirements, and in accordance with the Santos Management System"
EPA – 10th April 2024: *Air Quality and Noise*					
8	SEO Table 1	Objective 1 Assessment Criteria	Compliance with relevant air and noise legislation is stated, however it is unclear what relevant air and noise legislations Santos is complying with.	Santos is required to reference the following legislation as minimum. • *Environment Protection (Commercial and Industrial Noise) Policy 2023* • *Environment Protection (Air Quality) Policy 2016*	SEO objective 1 assessment criteria has been updated to include references to the following legislation: • Environment Protection (Commercial and Industrial Noise) Policy 2023 • Environment Protection (Air Quality) Policy 2016
EPA – 10th April 2024: *Site Contamination*					
9	EIR	5.4.4 & 8.8	PFAS contamination should be acknowledged in these sections.	Include PFAS contamination and describe the assessment plan framework being developed to spatially characterise and understand associated risks.	Section 8.8 of the EIR has been updated to include the assessment plan framework being developed to spatially characterise and understand associated risks.
EPA – 10th April 2024: *Waste*					
10	SEO	Objective 2 *Assessment Criteria/Waste*	The 2nd bullet point should also specify the Guidelines for the Environmental Management of Landfill Facilities – Solid Waste	Include reference to EPA Guidelines for the Environmental Management of Landfill Facilities –	SEO objective 2 has been updated to reference compliance with EPA Guidelines for the Environmental Management of

Comment	Response Priority	Doc ref.	Comment on document (DEW and EPA)	Response or actions required of Santos	Santos response (2024)
		Management/Guide to How Objectives Can Be Achieved/Waste Management	Disposal (landfill guidelines) for waste disposed of within the EPA licenced premises.	Solid Waste Disposal (landfill guidelines) applicable	Landfill Facilities – Solid Waste Disposal (landfill guidelines) as applicable.
DEW Response - 10th January 2024					
1	1	Section 4.5 Pg 25	4.5 Produced Formation Water and Associated Facilities Paragraph 2 in Section 4.5 states that the concentrations of heavy metals and other organic and inorganic compounds are present in "*low concentrations.*" It is noted that some heavy metals and organic/inorganic compounds can be harmful to environmental receptors at low concentrations.	Provide typical concentration ranges for the common compounds and elements listed in Table 4-3 to support the statement that concentrations are low and that risks are being appropriately managed.	Due to the nature of Santos operations spanning vast distances and Santos production reservoirs varying across fields and target formations, a typical concentration cannot be provided. There is variability in subsurface environments that will affect groundwater quality as well as natural variability meaning 'typical' concentrations can change across the Cooper Basin. Santos monitors and manages all produced water responsibly and in accordance with regulatory requirements. The PFW management review that will be undertaken will provide typical concentration ranges and will ensure risks are appropriately being managed.
2	1	4.5.3 Pg 31	***Produced Formation Water (PFW)*** The description of PFW management is ambiguous. For example, (our emphasis) "*Internal approval and conditions for activities that reuse PFW **may** be required in accordance with Santos standards" and "PFW monitoring **may** be undertaken to evaluate the quality of water in a pond system" and "monitoring results **may** be compared to applicable water quality criteria to evaluate suitability".* The consistent use of the word "*may*" makes it difficult to understand what will and won't be done with respect to PFW management.	The protocols for use of PFW need to be supported by clear assessment and reporting criteria/commitments that can be used to demonstrate compliance with environmental objectives.	Santos monitors and manages all produced water responsibly and in accordance with regulatory requirements. The PFW management review that will be undertaken will provide typical concentration ranges and will ensure risks are appropriately being managed.
3	1	Pg 31	Under the section "Waterflooding". Text states: "waterflood activities are undertaken in liaison with the regulator and with applicable licences in place". Could this be expanded on to detail what the applicable licences are (e.g. is this referring to discharge and drainage permits)?	Provide additional clarity in relation to what applicable licences entails	Page 32, Waterflood section, has been updated to remove reference to "applicable licences in place". Waterflood activities are undertaken in liaison with the regulator, and where required, supported by applicable licences (e.g. GWL201800).
4	1	4.9.2 Pg 44	Waste management - Wastewater management The text states "*Permanent satellite camps (such as Dullingari, Tirrawarra and Limestone Creek) use a combined septic and single pond system septic systems known as a small 'STED' (septic tank effluent drainage) system with effluent evaporated or released to ground (soakage)."* It could be interpreted from the last line in this sentence that untreated effluent is being released to ground surface.	Please clarify this sentence and amend as required.	The text has been updated to state *"Permanent satellite camps (such as Dullingari, Tirrawarra and Limestone Creek) use a combined septic and single pond system septic systems known as a small 'STED' (septic tank effluent drainage) system with **treated*** effluent evaporated or released to ground (soakage)."
5	1	4.9.3 Pg 45	Water supply	Provide additional information in relation to the Santos owned groundwater bores that are used	Santos propose to remove the statement:

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			The text states that "*There are several Santos owned groundwater bores in Santos tenures in the Cooper Basin that are used regularly by landholders to support their industry*." What is the estimated usage by pastoralists from Santos's wells and how is this accounted for and reported? Can additional details be provided regarding how many and where. What are the purposes of these Santos bores (i.e. are they monitoring bores)?	by landholders (well unit numbers and purpose of these wells). Explain the purpose that the landholder uses the well for. Clarify the estimated usage by pastoralists from Santos's wells and what licence condition exists for the use of this water by pastoralists (including recording and reporting water take).	*"There are several Santos owned groundwater bores in Santos tenures in the Cooper Basin that are used regularly by landholders to support their industry."* Santos currently hold the following ground water licences for South Australia: • GWL 162791; • GWL 180706; and • GWL 201800 Water licence conditions include: • Water allocation on the licence to be only taken from the source described in the licence. • The licensee must prepare annual water use reports and submit these reports to the Department by 30 September of the water-use year. • The licensee must not take water except through the meter • The licensee must not damage or destroy a meter. Santos supports landholders to re-use water where possible and in accordance with regulatory requirements. Santos does not control pastoral activities and details of landholders water rights/ entitlements are not held or managed by Santos.
6	1	Pg 45	Under 4.9.3: "Raw water is provided by artesian bores at Gidgealpa". Is this undertaken in accordance with a water licence (under the LSA Act)? If so, it would be good to stipulate this. This statement is also repeated under 7.11.3 (pg. 150)	Include reference to the relevant licence applicable to this groundwater source.	Section 4.9.3 and Section 7.11.3 have been updated to reference the applicable water extraction licence 162791.
7	1	Pg 45	Document states: "Water extraction from the Cooper Creek is undertaken periodically to supplement available water supplies and meet project water demands. Extraction is undertaken subject to external and internal approval …" The text then outlines what internal authorisation should consider. It would be helpful to specify what external processes entails.	Include what external approval entails for extraction from the Cooper Creek.	Section 4.9.3 has been updated to remove reference to external approval requirements. The Cooper Creek catchment is not a prescribed resource under the Water Allocation Plan for the Far North Prescribed (South Australian Arid Lands Landscape Board). The *Landscape South Australia Act 2019*, states that a site use approval is not required, except where water is used for: a) bore-fed wetlands; or b) watering of stock, where the water is taken from a priority spring (natural well).
8	1	5.1 pg 50	5.1 Environmental Sensitivity Profile Model It is understood that an Environmental Sensitivity Profile (ESP) Model which describes the applicable environmental	Provide the ESP Model in the EIR as an appendix or provide a link so it can be used to set the context for the applicable environmental values.	Appendix E of the SEO has been included to provide further information on the Santos ESP Model.

Comment	Response Priority	Doc ref.	Comment on document (DEW and EPA)	Response or actions required of Santos	Santos response (2024)
			receptors/values in the project area has been developed by Santos. Is the ESP Model publicly available? Given its relevance to defining the existing environment, it would seem appropriate to include it in the EIR.	Specifically, data from the 40 shallow monitoring bores that are referenced should be used to set the context for the groundwater environmental receptors/values.	
9	3	Figure 5-5 and Figure 5-6. Pg 69 and 70	Figure 5-5 and Figure 5-6 were used in the 2003 EIR to illustrate the regional geology. Has any drilling or seismic/geophysical interpretation been done since this time that would warrant updating these geological cross sections?	Consider updating the geological cross sections to include information and data that has been collected since 2003. This would also provide an opportunity to improve the clarity of the existing cross sections and text, some of which is illegible.	Figure 5-5 and Figure 5-6 have been updated to illustrate the regional geology
10	1	5.4.2 Pg 65	5.4.2 Hydrogeology The units of measure for porosity are percent by volume not m/d.	Update the units of measure for porosity.	Section 5.4.2 of the EIR has been updated to reference the following porosity statement: “Porosity values of most Jurassic and Early Cretaceous aquifers range from 10 to 30 percent, diminishing with increasing depth (Senior and Habermehl, 1980).”
11	1	Table 7- 6 Pg 121 and 122	Table 7-6: Produced formation water risk assessment Several impact events have been identified for PFW storage and management. Some of these include: • Contamination of soil, waterways and / or shallow groundwater resources • Salinisation • Groundwater mounding beneath evaporation ponds The management responses for PFW storage and management appear to be solely focused on the risks associated with storing PFW in engineered evaporation ponds. There do not appear to be any specific controls for managing the potential risks associated with discharge of PFW to free-form evaporation ponds which cover a much larger area and are not lined. The only criteria appears to be a Total Recoverable Hydrocarbons (TRH) concentration below 10 mg/L (which is not referenced in Table 7-6 but elsewhere in the EIR). • The risks listed in the dot points above are equally as important for freeform evaporation ponds as they are for engineered evaporation ponds.	Provide specific details on the controls, monitoring and management strategies to address the risks of discharging PFW to free-form evaporation ponds. Controls would be better articulated by separating them into those that apply to (1) engineered evaporation ponds and (2) free-form evaporation ponds. The controls should consider other potential contaminants of concern in PFW other than TRH, such as those listed in Table 4-3. Note undertaking “*water quality testing when required”* is not considered to be an adequate control mechanism to demonstrate compliance with the environmental objectives. The following guidance is provided for establishing effective controls: I. what is to be measured and the form of the measurements that are to be used II. the locations where relevant measurements are to be taken, or how such locations are to be determined III. what is proposed to be taken to constitute the achievement of the relevant outcomes (with consideration being given to any inherent errors of measurement) IV. the frequency of any measurement or monitoring V. any background or control data that is to be used, or how any such data is to be acquired.	As per response provided to item 1 above: 1) Assessment criteria against Objective 4 has been updated to: “PFW monitoring conducted in accordance with relevant monitoring plans as required, post risk assessment, demonstrating compliance with appropriate water quality thresholds’” 2) Guide to how objectives can be achieved has been updated to include the following: - Where a credible risk of impact to groundwater quality as a result of PFW disposal is identified, an appropriate groundwater monitoring plan will be implemented that involves assessment against relevant thresholds that have been informed by baseline.

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12	1	EIR 4.5.2 & 4.9.3	It is noted that landholders are consulted regarding whether evaporation ponds are open or closed (i.e fenced), and that open evaporation ponds enable access for livestock. It is also noted that Santos owned groundwater bores are regularly used by landholders to support their industry. Santos is requested to ensure pastoral lessees are aware that allowing livestock access to evaporation ponds and water from Santos owned bores may result in changed grazing pressures which under certain circumstances is considered clearance under the Native Vegetation Act 1991, and so may require an application and clearance consent from the Native Vegetation Council. Lessees should seek further advice as required.	Santos is requested to ensure pastoral lessees are aware that allowing livestock access to evaporation ponds and water from Santos owned bores may result in changed grazing pressures which under certain circumstances is considered clearance under the Native Vegetation Act 1991, and so may require an application and clearance consent from the Native Vegetation Council. Lessees should seek further advice as required. Additional text, explaining the above requirements should also be included in the EIR.	Santos acknowledge the feedback from DEW/EPA. *EIR update:* Section 4.9.3 of the EIR has been updated to include the following: Where we have written agreements, Santos will provide advice to landholders regarding applicable legislation to them.
13	1		It is also important to note that Santos's use of public access routes (PARs) may impact the PARs condition and usability by pastoralists, tourists, and other users. PARs are intended for occasional use by 4WD cars and movement of stock, and are not built to sustain more intensive use. If Santos is planning to use vehicles other than 4WD cars on PARs (e.g. trucks or other heavy vehicles), then consideration should be given towards how Santos will mitigate and manage their impacts.	Santos to outline whether public access routes (PARs) will be used and the nature of this use (i.e. will this be for vehicles other than 4WD cars (e.g. trucks or other heavy vehicles). If for other vehicles, Santos is requested to outlined how their impacts will be mitigated and managed.	Santos currently adheres to Notice of Entry requirements (NOE) and Notice of activity requirements (NOA) when obtaining approvals for accessing project locations (as required). *EIR update:* Section 7.11.1 of the EIR has been updated to include the following information on public access routes: There is an array of PAR that are used by tourists in the region. These are not maintained or generally used by Santos particularly by heavy vehicles. If Santos utilise these roads to access a well site/rig access it will be in consultation with relevant department e.g. DEW.
Santos					
1	1 - SEO	SEO and EIR - Sect 1: Introduction	n/a	n/a	**Transitional statement:** Santos has updated **Section 1.2 of the SEO** and **Section 1 of the EIR** to reference the following statement based on information from Georgia Matthews (DEM) regarding the transitional position Santos currently are in with regards to Environmental Act and Regulation referencing: This Statement of Environmental Objectives (SEO) / Environmental Impact Report (EIR) was developed prior to the commencement of the Energy Resources Act 2000 (the ER Act) and as such, has been prepared to meet the requirements of section 99 and section 100 of the Petroleum and Geothermal Energy Act 2000 (PGE Act). As this Statement of Environmental Objectives (SEO)/ Environmental Impact Report (EIR) was submitted after the commencement of the ER Act, the document is

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					subject to the transitional provisions under the ER Act and Energy Resources Regulations 2013 (the ER Regulations); that an SEO/EIR that was developed prior to the commencement of the ER Act need only comply with the requirements of the previous Act (PGE Act).
2	1	SEO	n/a	n/a	**Incident reporting:** Section 3 (SEO): Reporting requirements have been updated in Section 3 of the SEO. This change has been made to ensure the correct incident reporting is undertaken in compliance with the Energy Resources Act 2000 (SA) and Energy Resources Regulations (2013).
3	1	EIR – Section 4.9.2	n/a	n/a	**CCS Water:** Table 4.6 in section 4.9.2 has been updated to include the CCS condensed water as a waste stream.
4	1	EIR – Section 8	n/a	n/a	**Statement update:** **The following statement has been updated to reference "in general accordance":** *"*The SMS Framework provides structured, comprehensive and efficient EHS practices for Santos' activities and operations in general accordance with both AS/NZS ISO 45001 …"

Appendix D
Cooper Creek Surface water Extraction Points

Figure D1: Innamincka surface water extraction point

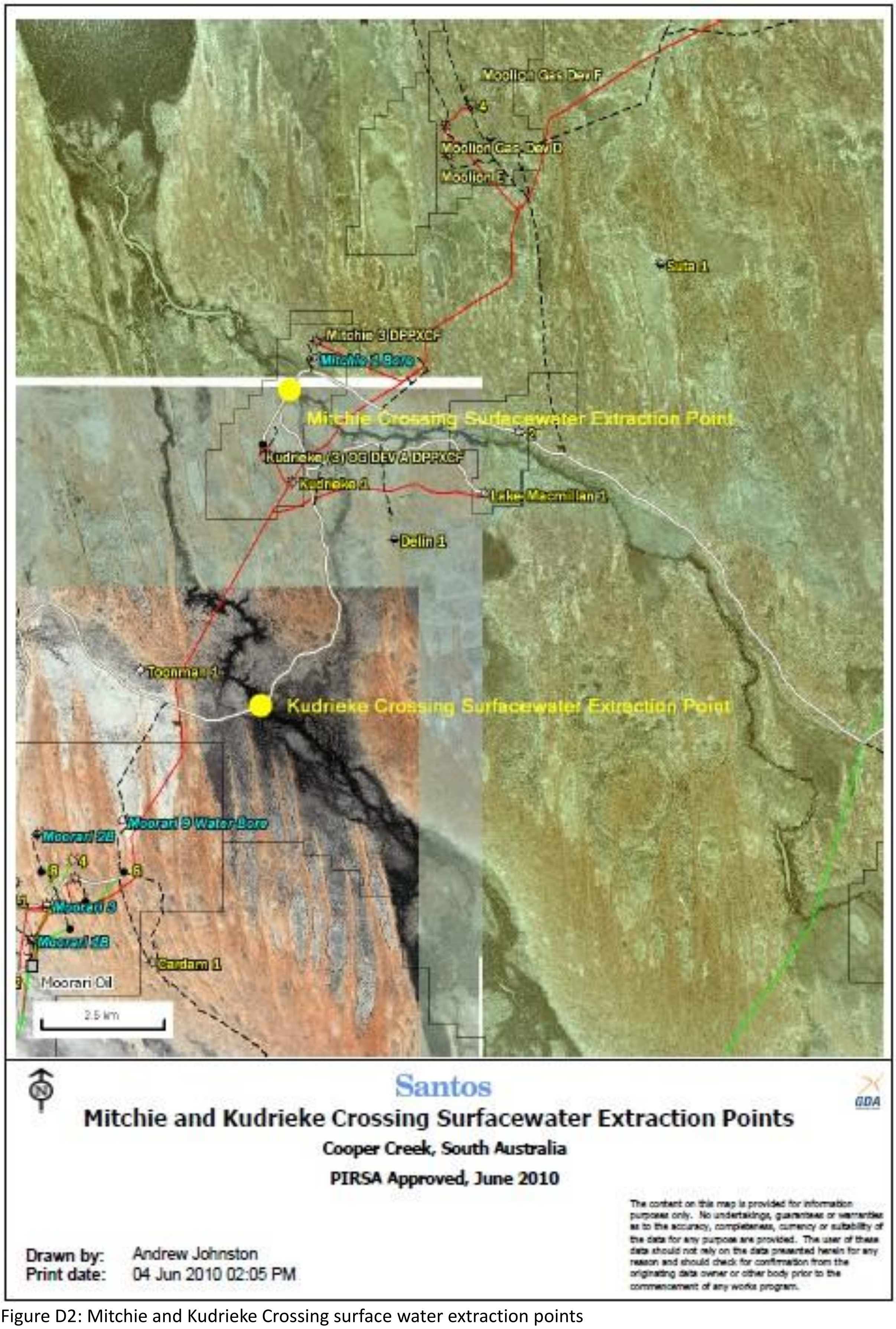

Figure D2: Mitchie and Kudrieke Crossing surface water extraction points

Appendix E: Santos Environmental Sensitivity Profile Model

Environmental Sensitivity Profile Model

Santos has developed an Environmental Sensitivity Profile (ESP) Model to identify and map Cooper Basin environmental values. The ESP was built using analogue and electronic data sets and enables characterisation and profiling of operational areas based on these values. The ESP is a spatial representation of Cooper Basin pathway and receiving environments and provides a platform for risk and impact assessment. The ESP was designed to meet regulatory site conceptualisation standards and requires input of source information (only) to meet the framework criterion of a source, pathway and receptor model.

Analogue and electronic data sets were used to develop the ESP and field surveys were carried out to provide information for the model including, but not limited to:

- analysis of water quality, yield, depth and soil profiles (during installation) from 40 shallow groundwater monitoring bores across the South Australian Cooper Basin (and an additional 41 in south-west Queensland)
- analysis of known shallow landholder and Santos groundwater bore data (using WaterConnect database, where relevant)
- assessment and evaluation of vegetation type, community, wetland status, potential for EPBC-protected fauna and habitat and land systems across 107 analogue sites within the South Australian Cooper Basin and 127 sites in south-west Queensland Cooper Basin
- assessment of aerial photography and government databases to assist in extrapolating field measurements and data for the Cooper Basin.

The ESP Model supports the applicable regulatory objectives by providing a spatial resource which is integrated into existing Santos management systems and is used to inform the following processes:

- planning – identifying appropriate areas for new development, prioritising infrastructure upgrades and prioritising maintenance programs
- implementation – including environmental management plans and incident response
- measurement and evaluation – including monitoring programs
- review and implementation – including targeted auditing programs.

The ESP Model consists of a GIS database of environmental, land use, cultural and physical information which is overlaid by a sensitivity layer. The database includes government data as well as data collected by field investigations initiated by Santos. All Santos personnel have access to the database, which is actively maintained. A field validation program was undertaken to confirm the validity of assumptions used during the development of the model.

Planning and response

The ESP is a tool for informing forward process, planning, incident response and assessment.

In some instances, the information available to make informed and relevant decisions may be limited and in cases such as these additional data may be required. Additional information requirements will be documented using the Santos internal approval process and may include:

- applicable permits
- regulatory advice
- specific management actions required for compliance
- identification of specific activities that are prohibited in the subject area
- additional environmental management activities.

Environmental values

Environmental values in the model are defined by a sensitivity rating scale of one (very low) through to five (very high), which enables the user to understand the sensitivity of the receiving environment. The ranking is used in the disturbance decision making process and to evaluate the level of response in the event of an incident. The sensitivity ratings were developed using existing regulatory conditions, operator experience, historical risk assessments and existing hierarchy ratings in government data layers.

Groundwater sensitivity ratings also include an assessment of the potential beneficial use of the shallow groundwater resources.

Validation process

Field validation of model parameters is undertaken to ensure that the environmental constraints identified in the ESP Model are accurate. The validation process allows for identification of previously unknown sensitive receptors and / or other data gaps. Field validation may include groundwater investigations, ecological assessments and / or cultural heritage surveys. Where the environmental sensitivity is low, a site scout may be adequate to validate the model. The decision to undertake further investigations is based on Santos’ experience with similar incidents and / or existing information, legislative requirements, regulator advice and current expectations.