South Australia Cooper Basin Joint Venture

# Environmental Impact Report:

# Production and Processing Operations

Santos

**February 2003**

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| Santos Ltd | ENVIRONMENTAL IMPACT REPORT: PRODUCTION AND PROCESSING OPERATIONS<br>South Australia Cooper Basin Joint Venture<br>February 2003<br>First Edition (February 2003) |
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# Glossary

| | |
|---|---|
| Crude Oil | Untreated oil from an oil production well. |
| Gathering System | Network of hydrocarbon pipelines that relay raw gas, condensate and crude oil to satellite and Moomba processing plants. |
| Inerts | A non-reactive and non-toxic gas. |
| Lunette | Crescent-shaped sand dune |
| Raw Gas | Untreated gas from a gas production well. |
| Sales Gas | Gas, mainly methane that has been treated so that it meets predetermined specifications. |
| Satellite | Remote operating plant where raw gas or crude oil are processed prior to relay to the Moomba plant. |
| Trunkline | Hydrocarbon pipelines that connect satellite facilities to the Moomba plant. |

# List of Abbreviations

| | |
|---|---|
| APPEA | Australian Petroleum Production & Exploration Association |
| bbls | Barrels |
| Bcf | Billion cubic feet |
| BTEX | Benzene, Toluene, Ethylbenzene & Xylene |
| CCCC | Cooper Creek Catchment Committee |
| $CO_2$ | Carbon dioxide |
| CSP | Crude Stabilisation Plant |
| DEH | Department for Environment and Heritage |
| DOSAA | Department of State Aboriginal Affairs |
| Ecos | Ecos Consulting (Aust) Pty Ltd |
| EIP | Environmental Improvement Plan |
| EIR | Environmental Impact Report |
| EPA | Environment Protection Agency |
| EPBC Act | Environment Protection and Biodiversity Conservation (*Act 1999*) |
| ESD | Emergency Shutdown Systems |
| ETP | Ethane Treatment Plant |
| GAB | Great artesian basin |
| GABCC | Great Artesian Basin Consultative Council |
| GTA | Gas Turbine Driven Turbo-Alternator |
| HiLo | Safety Shut down valve for flowlines |
| $H_2S$ | Hydrogen Sulphide |
| IMS | Incident Management System |
| ILUA | Indigenous Land Use Agreement |
| kg | Kilogram |
| km | Kilometre |
| $km^2$ | Square kilometres |
| kph | Kilometres per hour |
| kV | Kilo volt |
| kW | Kilo watt |
| KPI | Key performance indicator |
| L | Litre |
| LDB | Lower Daralingie Bed |
| LPG | Liquid Petroleum Gas |
| LRP | Liquids Recovery Plant |
| LTU | Land Treatment Unit |
| m | Metre |
| $m^3$ | Metre cubed |
| $m^3$/hr | Cubic metres per hour |

# List of Abbreviations cont.

| | |
|---|---|
| mg/L | Milligrams per litre |
| mm | Millimetre |
| Mscmd | Millions standard cubic meters per day |
| MW | Mega watt |
| MWe | Mega watt equivalent |
| NASAA | National Association Sustainable Agriculture Australia |
| NCR | Non-conformance Report |
| NPI | National Pollution Inventory |
| NPW | National Parks and Wildlife |
| NPWS | National Parks and Wildlife Service |
| OBE | Organic Beef Export |
| °C | Degrees Celsius |
| PAH | Polycyclic aromatic hydrocarbons |
| PEL | Petroleum Exploration Licence |
| PFW | Produced Formation Water |
| PIRSA | Primary Industries and Resources South Australia |
| PJ | Peta-joules |
| PPL | Petroleum Production Licence |
| ppm | Parts per million |
| PSV | Pressure Safety Valves |
| RFDS | Royal Flying Doctor Service |
| RGCP | Raw Gas Conditioning Plant |
| ROW | Right-of-way |
| SACBJV | South Australian Cooper Basin Joint Venture |
| SEO | Statement of Environmental Objectives |
| STA | Steam Turbine Driven Turbo-Alternator |
| TPH | Total Petroleum Hydrocarbons |
| UPS | Uninterrupted Power Supply |

# 1 Introduction

This chapter provides an overview of the Environmental Impact Report (EIR) for the South Australia Cooper Basin Joint Venture (SACBJV) petroleum production and processing operations (referred to throughout as operation/s).

This document fulfils the requirements of an EIR for the SACBJV's current operations and has been prepared in accordance with current legislative requirements, in particular, with Section 97 of the South Australian *Petroleum Act 2000* and Regulation 10 of the *Petroleum Regulations 2000*. Additionally, the Act and Regulations require the development and implementation of a Statement of Environmental Objectives (SEO). A draft SEO has been prepared in conjunction with this document (Santos 2003).

This EIR is comprised of 10 chapters and a number of technical appendices. These are briefly outlined in Table 1-1.

Table 1-1: Environmental Impact Report Outline

| Chapter | Title | Content |
|---|---|---|
| Chapter 1 | Introduction | ▪ Introduces the purpose and format of this document. |
| Chapter 2 | Background | ▪ Provides background history, includes resource and operations information and identifies the location of SACBJV Cooper Basin operations. |
| Chapter 3 | Legislative Framework | ▪ Provides a brief description of the assessment process. |
| Chapter 4 | SACBJV Production and Processing Operations | ▪ Describes SACBJV production and processing operations in detail. |
| Chapter 5 | Existing Environment | ▪ Describes the existing physical, biological and social environment in the Cooper Basin. |
| Chapter 6 | Consultation | ▪ Documents consultation process and strategies to date. |
| Chapter 7 | Environmental Hazards and Consequences | ▪ Identifies hazards, potential consequences and risk minimisation strategies. |
| Chapter 8 | Environmental Risk Assessment and Management Strategies | ▪ Outlines the risk assessment process its application. And includes mitigation, monitoring and training strategies to manage environmental impacts. |
| Chapter 9 | Summary | ▪ Provides a brief overview of SACBJV environmental performance. |
| Chapter 10 | References and Further Reading | ▪ Lists reference material utilized in the preparation of this document. |

| Chapter | Title | Content |
|---|---|---|
| Appendix A | PIRSA Oil in Water Content Requirements | ▪ Provides PIRSA recommended standards for produced formation water disposal. |
| Appendix B | Threatened flora and fauna species in the Cooper Basin | ▪ Lists *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) threatened flora and fauna in the Cooper Basin. |
| Appendix C | Common Species Names and Scientific Equivalents | ▪ Provides scientific names for common species names used in the EIR. |
| Appendix D | Cooper Creek Flood Classes and Extent of Inundation | ▪ Contains maps of the extent of inundation of the Cooper Creek floodplain for each of nine flood classes. |
| Appendix E | Overview of Stakeholder Consultation Process | ▪ Provides a summary of the consultation process, including a list of key stakeholders. |
| Appendix F | Stakeholder Comments and Responses | ▪ Contains a summary of stakeholder comments and associated responses, and where appropriate a reference to where changes were made or an explanation of why no changes were made. |
| Appendix G | Summary of National Pollution Inventory (NPI) Submissions | ▪ Contains summary of NPI submissions for the 1999 to 2000 reporting period. |
| Appendix H | Risk Assessment and Management Summaries | ▪ Contains risk assessment and management summaries for hazards identified in Chapter 8. |
| Appendix I | Santos Environmental Policy | ▪ Contains a copy of the Santos Environmental Policy. |

# 2 Background

This chapter introduces SACBJV participants, provides a context for site location and outlines operations covered by this EIR. SACBJV environmental management systems, including environmental objectives, key issues and policy framework are also discussed.

## 2.1 Santos Australia Cooper Basin Joint Venture

SACBJV was founded in 1954 by a group of Adelaide businesspeople who believed that South Australia and the Northern Territory had oil and gas potential. This was eight years before any commercial quantities of hydrocarbons were found in Australia. The search proved to be a long and expensive one, but it was ultimately rewarded with the discovery of one of Australia's major petroleum provinces.

Since its first discoveries in the 1960s, and after the investment of billions of dollars, SACBJV has grown to become one of Australia's major energy providers. Currently, the SACBJV meets over one-third of the demand for domestic gas in Australia, as well as producing significant quantities of crude oil and petroleum liquids.

The South Australia Business Unit (SABU) operates the Moomba processing plant and associated facilities on behalf of the 11 companies that comprise the Cooper Basin Joint Venture:

- Santos Limited
- Alliance Petroleum Australia Pty Ltd[1]
- Bridge Oil Developments Pty Ltd[1]
- Reef Oil Pty Ltd[1]
- Santos (BOL) Pty Ltd[1]
- Vamgas Pty Ltd[1]
- Basin Oil NL
- Boral Energy Resources Limited
- Delhi Petroleum Pty Ltd
- Gulf (Aust) Resources NL.

In excess of 440 gas wells and 120 oil wells and associated infrastructure are operated in the Cooper Basin, which supply gas and liquid hydrocarbons to the SACBJV owned and operated processing plant at Moomba (Figure 2-1).

[1] A wholly owned Santos Ltd subsidiary.

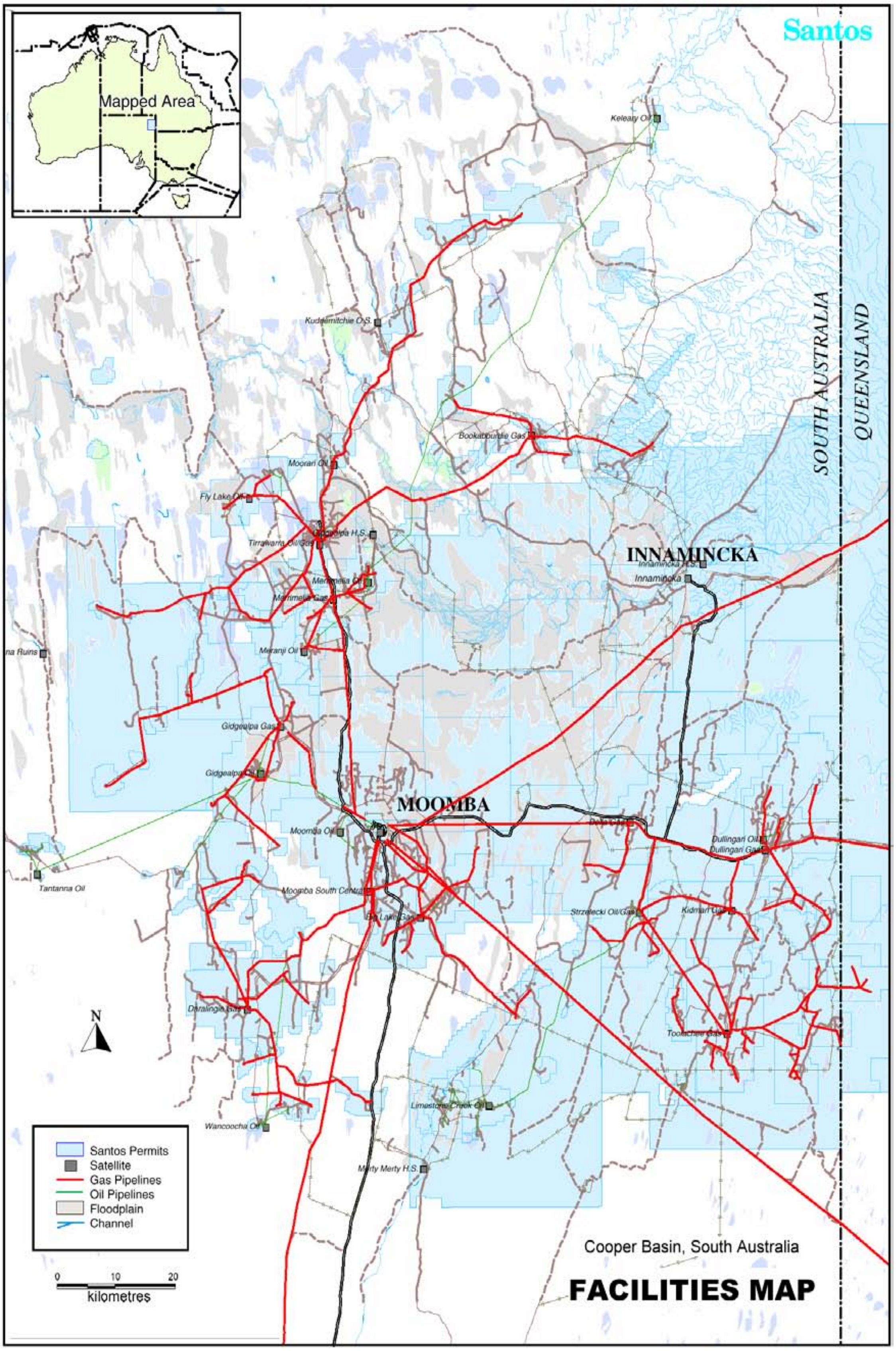



Figure 2-1: SACBJV Production and Processing Facilities in the Cooper Basin

## 2.2 Location

The Moomba operation is located in the Strzelecki Desert, approximately 800km north of Adelaide. The purpose-built plant and facilities are used for the gathering and processing of natural gas and oil found in the South Australian sector of the Cooper and Eromanga basins, and some Queensland gas via the Ballera pipeline.

Gas is distributed via underground pipelines to South Australia, New South Wales and the Australian Capital Territory. The Moomba fields also produce crude oil and gas liquids (condensate and liquefied petroleum gases). The liquids flow as a mixture to Port Bonython, 659km away on the Spencer Gulf, near Whyalla, where they are separated into various products for sale to domestic and international markets.

Santos, as operator of the Moomba facility, provides services and facilities for personnel involved in the operation and maintenance of the processing plant and field gathering facilities, as well as for those involved in exploration, drilling and essential support activities.

## 2.3 Petroleum Resource Rationale

Natural gas produced by SACBJV in the Cooper Basin has been used to produce or power the production of a variety of goods, packaging, industrial processes and fuels across a range of sectors.

Total gas reserves in the SACBJV acreage in South Australia are estimated at 2466 PJ. In 2000, Cooper Basin operations produced:

- 177,500 tonnes of LPG
- 1,440,100bbls of condensate
- 1,800,400bbls of crude oil
- 100PJ of sales gas and ethane (Santos 2000a).

Gas is considered a 'cleaner' hydrocarbon fuel source and is an important transitional fuel as society moves from a high carbon fuel source(s) (ie. coal) towards more sustainable energy production and consumption. SACBJV is continuing oil and gas exploration in the area to help meet increasing demand for gas and oil in South Australia and interstate.

## 2.4 Optimisation

In 1999, the SACBJV initiated an internal review of its key Moomba utilities, raw water supply, demineralised water production, electric power generation and compressed 'instrument' air to identify opportunities to improve performance and optimise operations. The study reviewed utility operating and maintenance performance, utility-specific problems, and established the effective capacity of plant and equipment.

An independent third party was engaged to review and make recommendations to ensure long term utility reliability. Consultants continued to review utility systems throughout 2000 to determine the additional capacity required for the supply of current and future utilities requirements.

## 2.5 Strategy and Policies

The Santos Environmental Health and Safety Management System (EHSMS) provides the framework within which all aspects of the Company's environmental responsibilities in Australia are managed. The key elements of EHSMS are described in The Santos Australian Environmental Management System and Corporate Requirements. This document also specifies the minimum environmental requirements for the Company's Business Unit Environmental Management Systems.

The SABU Management System aims to minimise business risk in its varied forms including commercial, quality, safety, financial, and environmental. It also provides a framework to ensure that the process or activity is performed to requirements and continuous improvement is achieved. The SABU Management System ensures that SAEMS requirements are fulfilled. It provides detailed information on the implementation of each component of the environmental management system and assigns personnel responsibilities. SABU personnel have intranet access to the Management System and copies are available from SABU Environmental Services or Site Managers (for example, the Moomba Area Manager).

The SAEMS and the environmental component of the SABU Management System incorporate key elements of national and international environmental management standards. Principles of ecologically sustainable development provide a foundation for the systems. International Standards Organisation ISO 14001 Standard has been used as a guide in the ongoing development of SACBJV environmental management systems.

SACBJV environmental management systems will continue to evolve in response to executive management reviews, changing technology, industry practices, regulatory requirements, research and monitoring, and community expectations.

## 2.6 Environmental Objectives

SACBJV procedures are designed to achieve the following principle objectives:

- Continuously improve the safety of employees, contractors, the public and other third parties.
- Conserve soil resources by minimising disturbance and avoiding contamination.
- Avoid the introduction or spread of pest plants and animals and implement control measures as necessary.
- Reduce disturbance to drainage patterns and avoid contamination of surface waters and shallow groundwater resources.
- Avoid disturbance to sites of known cultural and heritage significance.
- Minimise loss of aquifer pressures and avoid aquifer contamination.
- Conserve natural environment habitats by minimising disturbance to native vegetation and reducing risks to native fauna.
- Minimise air pollution and greenhouse gas emissions.
- Maintain and enhance partnerships with the Cooper Basin community.
- Avoid or minimise disturbance to pastoral infrastructure and landholders.
- Optimise waste reduction and recovery.
- Remediate and rehabilitate operational areas to agreed standards.

# 3 Legislative Framework

This chapter briefly describes the legislative framework that currently applies to petroleum licensing in South Australia.

This EIR has been compiled in accordance with the *Petroleum Act 2000*, *Petroleum Regulations 2000* and in consultation with PIRSA.

## 3.1 Petroleum Act and Regulations 2000

The legislation governing onshore petroleum exploration and production in South Australia has recently been reviewed via an extensive process of industry and public stakeholder consultation that commenced in 1996 (Malavazos 2001). The review process led to the proclamation of the *Petroleum Act 2000* and *Petroleum Regulations 2000* on the 25 September 2000 (PIRSA 2001). The key objectives of the new legislation are:

- to protect the natural, cultural, heritage and social aspects of the environment from risks associated with activities governed by the Act;
- to provide for constructive consultation with stakeholders, including effective reporting of industry performance to other stakeholders; and
- to provide security of title for petroleum, geothermal energy, and other resources governed by the Act and pipeline licences.

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.

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 the 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 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
- utilization of a natural reservoir to store petroleum or another 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.

As a requirement of Part 12 of the Act, a regulated activity can only be conducted if an approved 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 on the basis of information provided in an EIR. The EIR is provided by the licensee and contains an assessment of the potential impacts of an activity on the environment.

PIRSA have published generic SEOs for the following regulated activities:

- Pipeline Preliminary Survey Activities in South Australia, 2001
- Drilling and Well Operations in the Cooper / Eromanga Basin – South Australia, 2000
- Seismic Operations in the Cooper and Eromanga Basins South Australia, 1998.

## 3.2 SACBJV Legislative Requirements

As a requirement of the recently enacted *Petroleum Act 2000* and *Petroleum Regulations 2000*, the SACBJV is required to submit an EIR and draft SEO for the South Australian Cooper and Eromanga Basin production and processing operations. The SACBJV has prepared this EIR in accordance with Section 97 and Regulation 10 of the Act and Regulations respectively. This document relates only to SACBJV operations in the South Australian Cooper and Eromanga basins (Petroleum Production Licences 6 to 167 inclusive, excluding 21 and 62).

Operations that are specifically covered by this EIR include:

- plant and satellite construction, operation, maintenance and abandonment
- formation water disposal operations
- pipeline, trunkline and flowline construction, operation and abandonment
- road construction, maintenance and restoration
- oil spill management and spill site restoration
- land treatment unit operations
- waste management operations.

The following section outlines specific requirements of the EIR as outlined within the Act and Regulations.

## 3.3 Environmental Impact Report

In accordance with Section 97 of the *Petroleum Act 2000*, the SACBJV 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 inherent in the regulated activities to the health and safety of the public
- contain sufficient information to make possible an informed assessment of the likely impact of the activities on the environment.

As per Regulation 10 of the *Petroleum Regulations 2000,* 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 site 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:
    - information on the following:
        - 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)
    - information on the estimated frequency of these events
    - 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 following:
        - 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
    - an explanation of the basis on which these consequences have been predicted;
    - a list of all owners of the relevant land
    - information on any consultation that has occurred with the owner of the relevant land, any Aboriginal groups or representatives, any agency or instrumentality of the Crown, or any other interested person or parties, including specific details about relevant issues that have been raised and any response to those issues, but not including confidential information.

## 3.4 Assessment and Approval

Once the EIR and draft SEO are submitted an assessment is made by PIRSA to determine whether the activities are to be classified as 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 an SEO may be approved after internal government approval.
- 'Medium Impact' activities, the EIR and proposed SEO are subject to a public consultation process, with comment sought for a period of at least 30 business days.
- 'High Impact' activities are required to undergo an environmental impact assessment under the provisions of the *Development Act 1993*.

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 EIR and SEO) must be entered on an environmental register. This public register is available on the PIRSA internet so that community access is readily available (McDonough 1999).

# 4 SACBJV Production & Processing Operations

SACBJV is the designated operator for all activities conducted pursuant to the South Australian *Petroleum Act 2000* within the 160 Petroleum Production Licences (PPLs 6 to 167 inclusive but excluding PPLs 21 and 62 within the South Australian sector of the Cooper Basin). The Petroleum Group within PIRSA has offered a further 31 PPLs in the South Australian Cooper Basin for which SACBJV is the designated operator. Two PPL applications lodged with PIRSA are still to be offered.

This chapter provides a technical description of the SACBJV production and processing operations that are covered by this EIR and the accompanying SEO (Santos 2003). The EIR and SEO do not apply to Cooper Basin activities relating to:

- well site and access track construction
- drilling
- well completion
- pre-well head production
- down hole abandonment
- restoration of well sites and access tracks
- seismic operations.

These activities are covered by two separate SEO's:

- Statement of Environmental Objectives for Seismic Operations in the Cooper and Eromanga Basins, South Australia (PIRSA 1998)
- Statement of Environmental Objectives for Drilling and Well Operations in the Cooper/Eromanga Basin, South Australia (PIRSA 2000).

In addition to the activities listed above the EIR and SEO for production and processing operations does not cover sales gas pipelines or the liquids stream to Port Bonython.

Currently, the gas gathering system provides raw gas from approximately 440 gas wells through to 12 gas satellite facilities. Similarly, the oil gathering systems provide crude oil from approximately 120 oil wells through to 12 oil satellite facilities. There are also 13 nodal compressors, which increase the pressure of the gas/oil at the well head and maintain flow rates to the satellite stations. The outputs from the gas and oil satellites are directed to the Moomba processing plant 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 owned and operated by other companies and do not form part of this EIR or SEO documentation.

## 4.1 Grouping of Facilities

The operations considered in this EIR include the aboveground facilities and pipelines that extend from the gas and oil wells through to the output from the Moomba processing plant.

To assess environmental impact of the SACBJV operation, the facilities have been grouped and considered as follows:

- gathering systems
- satellite facilities (gas and oil)
- produced formation water facilities
- Moomba plant – process facilities
- Moomba plant - utilities
- support infrastructure.

The following activities associated with SACBJV operations are included in other SEOs and are therefore not discussed in this EIR:

- exploration activities
- drilling activities
- sub-surface well/reservoir infrastructure.

## 4.2 Gathering Systems

Gathering systems are networks of pipelines (ie. flowlines and trunklines) that direct gas and oil from the production wells to satellite facilities and on to the Moomba processing plant. Smaller remote oil wells do not use pipeline transfer, but rather oil is transferred to tank farms and then to trucks for road transport to processing facilities.

A gathering system may consist of several pipeline networks 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.

There are approximately 1440km of gas and oil flowlines located in the Cooper Basin. Flowlines are low-pressure pipelines that transport oil or gas from wells to satellites. Flowlines are usually constructed of steel and range in diameter from 70mm to 150mm.

The main gathering lines that direct gas and oil from the satellites into the Moomba processing plant are known as gas or oil trunklines. There are approximately 888km of oil and gas trunklines in the Cooper Basin. These pipelines are constructed of steel and have an average diameter of 100mm - 762mm. Oil trunklines are designed to carry between 470m$^3$ and 1730m$^3$ of oil per day. Gas trunklines typically carry between 0.9Mscmd to 5.7Mscmd of gas per day. A summary of the pipeline gathering systems is provided in Table 4-1 and Table 4-2.

Raw gas and crude oil enter a satellite through one or more headers, which can also be individually operated or isolated. Such individual control adds to the integrity and flexibility of production in case of individual operational difficulties with wells, pipelines, networks or satellites.

## Table 4-1: Pipeline Gathering System - Oil Trunklines

| Trunk Line | Length (km) | Outside Diameter (mm) | Design Flow ($m^3$/d) | Above/Below Ground |
|---|---|---|---|---|
| Tantanna | 41.3 | 150 | 1272 | Above |
| Mutteroo (Mutteroo to Gidgealpa 14.9km)* | 14.9 | 100 | 477 | Above |
| Cuttapirrie (gas and condensate) | 49 | 250 | 240 (actual) | Above |
| Bookabourdie | 42.5 | 300 | 135 (actual) | Above |
| Spencer | 5.5 | 100 | 477 | Above |
| Gidgealpa | 20.6 | 150 | 960 | Below |
| Keleary | 94.5 | 100 | 920 | Above |
| Merrimelia | 7.4 | 150 | 634 | Below |
| Tirrawarra | 49.2 | 250 | unavailable | Below |
| Meranji | 17.0 | 100 | 576 | Below |
| Moomba Oil (Moomba to Gidgealpa 3.6km)* | 5.6 | 114 | 1430 | Above |
| Wancoocha (Wancoocha to Moomba South 52.0km)* | 58.0 | 100 | 1430 | Below |
| Moomba South | 1.9 | 100 | 1430 | Above |
| Alwyn/Jena/Ulandi | 5.0 | 100 | 1430 | Above |
| Limestone Creek | 44.7 | 100 | 23.3 | Above |
| Strzelecki | 12.7 | 150 | 1730 | Below |
| Dullingari (satellite to tie-in) | 20.6 | 150 | 806 | Below |
| Dullingari (tie-in to Moomba) | 48.2 | 200 | | Below |
| **Total Length (km)** | | | | **538.6** |

*Sections of pipeline that have been decommissioned (shut-in)

## Table 4-2: Pipeline Gathering System - Gas Trunklines

| Trunk Line | Length (km) | Outside Diameter (mm) | Typical Daily Flowrate (Mscmd) |
|---|---|---|---|
| Della - Moomba | 43.5 | 762 | 5.7 |
| Tirrawarra - Moomba | 49.1 | 510 | 3.8 |
| Big Lake (new BL satellite to old BL satellite) | 9.8 | 500 | unavailable |
| Big Lake (old satellite to Moomba) | 10.3 | 350 | 2.7 |
| Daralingie - Moomba | 43.6 | 510 | 1.7 |
| Gidgealpa - Moomba | 25.5 | 406 | 0.9 |
| MBA Reinjection (sales gas) | 11.0 | 356 | unavailable |
| Tirra - Moomba (old ethane) | 50.1 | 219 | unavailable |
| Moomba North (comprises of Moomba NW, Moomba central and Moomba NE) | each 7 - 15 | 219 | 2.3 |
| Ballera (south-west Qld) | 180.5 | 400 | 4.5 |
| **Total Length (km)** | | | **423.6** |

### 4.2.1 Pipeline Construction and Operation

Pipelines are constructed to transport crude oil, condensate and gas from well heads to satellite stations (for example Tirrawarra and Strzelecki) and the Moomba processing plant. Pipeline construction and operation activities are described in the following sections.

Pipelines are typically constructed of steel and range in size from 70mm to 762mm in diameter. There is just over 888km of trunklines and approximately 1440km of flowlines in the Cooper Basin region.

All pipeline design and construction is undertaken in accordance with the following industry accepted Australian codes and standards:

- AS 2885.2-1997 Pipelines - Gas and Liquid Petroleum - Design and Construction (Standards Australia 1997)
- AS 1978-1987 Pipelines - Gas and liquid Petroleum - Field Pressure Testing (Standards Australia 1987).

The purpose of the AS 2885 series of Standards is to ensure the protection of the general public, pipeline operating personnel and the environment, and to ensure safe operation of pipelines that carry petroleum fluids at high pressures.

The AS 2885 series of Standards achieve their purpose by defining important principles for design, construction and operation of petroleum pipelines. The principles are expressed in practical rules and guidelines for use by competent persons and organisations. The five fundamental principles on which the AS 2885 series of Standards are based are as follows:

a) A pipeline shall be designed and constructed to have sufficient strength and ductility to withstand all identifiable forces to which it may be subjected during construction testing and operation.
b) Before a pipeline is placed into operation it shall be inspected and tested to prove its integrity.
c) Important matters relating to safety, engineering design, materials, testing and inspection shall be reviewed and approved to a responsible entity, referred to as the operating authority. The responsible entity shall, in each case, be defined.
d) Operations and maintenance shall provide for continued monitoring and safe operation of the pipeline.
e) Where changes occur in or to a pipeline, which alter the design assumptions or affect the original integrity, appropriate steps shall be taken to assess the changes to ensure continued safe operation of the pipeline.

The following Santos design specifications are also applied during pipeline construction:

- 1500-120-S002 Excavation and Backfilling Specification (Santos 1996)
- 1500-50-G007 Pipeline Gathering Systems Design Code (Santos 1999a)
- 1500-120-S020 Buried Field Pipeline System Specification (Santos 1999b)
- 1500-120-S027 Aboveground Pipeline Systems Specifications (Santos 1999c).

All oil pipelines are designed, constructed, operated and maintained in accordance with the SABU procedure 3.4.1 Oil Pipeline Management System (Santos 1999d).

Adherence to design standards minimises the risk of pipeline failure, which may have serious environmental implications in sensitive locations, such as on floodplains (see sections 9.1 and 9.2). Design standards with particular reference to pipeline integrity and loss of oil/condensate to the environment are as follows.

- The pipeline shall be constructed with steel pipe of an appropriate diameter and wall thickness for the operating pressure requirements. Appropriate mitigation measures must be used as described in the risk assessment report, such as the installation of heavier wall thickness pipe where it is buried under rivers, creeks and roadways.
- On floodplains and under creeks, it may be necessary to use concrete weighting to counter the buoyancy of the pipeline when the soil is saturated with water.
- Buried pipe shall be coated with a high integrity external coating and shall be protected by cathodic protection devices to achieve electrical potentials with the aim of reducing the potential for corrosion associated with any defects that may develop in the coating. For buried sections of predominantly aboveground pipelines, the protective coating must include adequate provision of protective coating to ensure that uncoated pipe is not subject to burial and possible corrosion by sand movement.
- Pipelines shall be equipped with two overpressure protection devices to prevent line rupture;
  - a high pressure shut down valve to isolate the well from the pipeline
  - a pressure safety valve (PSV) designed to relieve the pressure above design operating pressure of the pipeline.
- Liquid pipelines may be equipped with thermal PSVs and check valves to prevent line rupture as a result of temperature induced expansion.
- PSVs and flowline bleed points shall be provided with sumps or drums of sufficient capacity (for example, 200 litres) to contain discharged fluids. Alternatively, a buried one cubic metre sump with fence is a more preferable method of containing discharged fluids.
- Launching and receiving facilities for pipe cleaning devices, referred to as pigs, shall be constructed with a concrete splash pad with sump to contain minor spills during removal/insertion of pigs and a nine cubic metre sump for draining the receiver/launcher prior to opening.
- Aboveground pipelines must be supported to maintain them clear of corrosive soils in accordance with guidelines in 1500-120-S027.

<u>Route Selection, Survey and Site Preparation</u>

Surveys are undertaken and a preferred route alignment is selected according to evaluation criteria, such as constructability, environmental sensitivity, safety and cost. The centreline is established and engineering aspects of construction finalised. For buried pipelines, the right-of-way (ROW) is cleared, with topsoil and vegetation stockpiled separately.

The ROW may be cleared, but not graded, during construction of aboveground flowlines. Aboveground flowlines require a narrower easement and so result in reduced disturbance to vegetation and topsoil.

Pipeline Construction

Construction of a buried pipeline involves trenching along the alignment to a depth of approximately one metre after the ROW is cleared. Trenching to a depth of at least two metres may be necessary in locations where lines pass through sand dunes, areas subject to inundation, wash out areas or under roads.

A wheel trencher or an excavator is used to dig the trench in which the pipe is laid. Distances of between 200m and 2100m can be excavated per day depending on terrain, equipment and weather conditions. Two to four kilometre sections of the trench are kept open and trench breaks are installed to facilitate fauna movement across and out of the open trench.

Steel pipe is transported to the pipeline easement in sections and laid end-to-end adjacent to the trench on raised skids (typically wooden blocks with sandbags placed on top) to protect the pipe coating from damage. This process is known as 'pipe stringing'. In the case of aboveground flowlines, sections of pipe are laid out on raised skids adjacent to the eventual pipeline supports.

Pipes are typically welded in one-kilometre lengths and several stages of welding are applied to ensure join welds are completed to the full thickness of the pipe. Each weld is radiographed to test for compliance to specifications. Welding of pipelines is undertaken in accordance with Australian Standard 2885.2 – 1995.

Sideboom tractors are used to lower the welded pipeline sections 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.

Sideboom tractors are also used to lower welded pipeline sections onto pipe supports for aboveground pipelines. Aboveground flowlines are installed so that they are positioned approximately 100mm above the ground surface. Aboveground pipelines are buried when they cross roads, floodplains, rivers and channels.

Pipeline Testing

The integrity of pipelines is verified using hydrostatic testing conducted in accordance with the SAA Code for Field Pressure Testing of Pipelines (Australian Standard 1978 - 1987).

During hydrostatic testing, the pipeline is capped with test manifolds, filled with water and pressurised up to 125% of operating pressure for a minimum of two hours. A 24-hour leak test then follows.

The use of biocides and chemicals with hydrostatic test water may be required under some circumstances to prevent internal corrosion of the pipeline. Hydrostatic test water may be sourced from existing SACBJV water bores or from creeks or waterholes with sufficient water flows. Produced formation water may also be utilized as a water source provided that it is adequately treated with biocide to remove potential for bacterial contamination of the pipeline.

Disposal of hydrostatic test water, which contains biocide and other chemicals, may be into existing lined and fenced evaporation ponds, or to specifically constructed pits sited to prevent the contamination of surface or near surface waters.

Site Restoration

The easement is re-instated and restored as soon as possible after pipe laying and backfill. This involves removal of all construction generated refuse, re-contouring of the site, re-establishment of natural drainage lines, bank restoration (if necessary), topsoil respreading and respreading of any cleared vegetation.

### 4.2.2 Gas Systems

Raw gas, from each gas well, is directed into a gathering line via a combination of well bore pipes and an aboveground well head, known as a 'Christmas tree' because of its distinctive shape. Immediately downstream of most well heads is a HiLo safety shutdown valve and a well head production metering skid. SACBJV is currently reviewing the installation of HiLo safety shutdown valves at all well heads.

A gas well head production skid may include any or all of the following equipment:

- auto controlled choke
- pressure safety valve (PSV)
- a meter run and flow recording device
- corrosion inhibitor injection facilities
- telemetry transmission for relay of well head pressure, flow, temperature and choke position to remote control and monitoring locations.

Well heads are discussed in greater detail in Section 4.3.2 of the Drilling and Well Operations EIR.

Nodal Compressors

As wells deplete and reservoir pressure drops, the flowrate from the wells also falls. To maintain flowrates at a reasonable level, gas pressure is boosted by large gas compressors known as nodal compressors. Corrosion inhibitor is injected at the nodal compressors to maintain pipe integrity.

## 4.3 Satellite Facilities

There are two types of satellite facilities

- gas satellites
- oil satellites.

Satellite stations are fenced facilities that are normally staffed during the day and locked at night with operations monitored from the Moomba Control Centre. There are 24 satellite stations. There are also a number of oil facilities, which are equivalent to small satellites. Nodal compressors, gas and oil satellites and oil facilities are listed in Table 4-3.

**Table 4-3: Cooper Basin Satellites and Nodal Compressors**

| Nodal Compressors | Gas Satellites | Oil Satellites | Oil Facilities |
|---|---|---|---|
| Amyema | Big Lake | Dullingari | Moomba Oil Facility |
| Aroona | Bookabourdie | Fly Lake | Moomba #104 Oil Facility |
| Brumby | Daralingie | Gidgealpa | Spencer Oil Facility |
| Lepena | Della | Keleary | |
| Mawson-Karunda | Dullingari | Limestone Creek | |
| Moomba North | Kidman Gas | Meranji | |
| Moomba South East | Gidgealpa | Merrimelia | |
| Munkarie | Merrimelia | Narcoonowie | |
| Strzelecki #15 | Moorari | Strzelecki | |
| Toolachee North | Strzelecki | Tantanna / Lake Hope | |
| Toolachee North West | Tirrawarra | Tirrawarra | |
| Toolachee South | Toolachee | Wancoocha (mothballed) | |
| Toolache West | | | |

### 4.3.1 Gas Satellites

Raw gas is delivered to satellites via pipeline networks as outlined in Section 4.2. Gas satellites (Table 4-3) deliver pressure-boosted raw gas from fields to the Moomba processing plant.

A typical gas satellite incorporates:

- gathering and manifold system from the gas wells
- an inlet header system for raw gas
- gas, liquid hydrocarbon (condensate) and water separation facilities
- gas compression and cooling systems
- condensate handling facilities
- telemetry and communications system
- emergency shutdown and control systems
- utility facilities, including fuel gas system, fire detection, instrument air, evaporative coolers, emergency power generation and wash-down water
- wastewater treatment facilities, including interceptor pits and evaporation ponds
- a flare system and vent facilities
- pipeline connection to a trunkline
- perimeter fencing.

<u>Processes</u>

A gas satellite provides its own fuel gas system. Electrical power is either provided from Moomba or generated on site at the satellite.

Raw gas enters a gas satellite where it is separated into the three component phases - gas, hydrocarbon liquid (condensate) and water (produced formation water) - inside inlet separator vessels.

Once separated, the natural gas component undergoes compression and is cooled in after-coolers. Any remaining condensed hydrocarbon liquid (condensate) in the gas is recovered in separators and reinjected into the discharge header. The two-phase (ie. gas and condensate) hydrocarbon mixture is sent to the Moomba Plant via a trunkline.

Produced formation water passes via a drain system into an interceptor pond where any entrained hydrocarbons are recovered by manual skimming or vacuum truck (Section 4.7.2; Figure 4-1). The separated water is processed to achieve an oil in water content of:

- less than 30mg/L if the water is being disposed of via closed (bunded) evaporation ponds or
- less than 10mg/L if the water is directed to free-form (unbunded) evaporation ponds or infiltration basins.

The above oil in water content criteria are based on recommended standards that have been provided by PIRSA (correspondence dated 15 September 1989 Ref No. SR 28/1/3 TA:CH) for formation water ponds in the South Australian Cooper Basin under the conditions of approval for these facilities (Appendix A). It is assumed that the 30mg/L requirement is based on the current standard used for the disposal of formation water from offshore rigs directly to the marine environment. The oil in water standards are currently being reviewed in accord with the SACBJV produced formation water disposal water quality research project as outlined in the Santos Action Plan (Section 8.2.8). The project aims to quantify and assess the suitability of current disposal management criteria for PFW and to determine potential areas for improvement.

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 situation, gas in the plant can be directed to the flare.

Gas satellite waste management is detailed in Section 4.7.2.

### 4.3.2 Oil Satellites

A typical oil satellite consists of:

- gathering and manifold system from the 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)
- telemetry and communications system
- emergency shutdown and control systems
- wastewater treatment facilities, including interceptor pits and evaporation ponds
- quality testing facilities
- chemical injection system for corrosion prevention and emulsion breaking
- flare system
- pipeline connection to an oil trunkline
- perimeter fencing.

Processes

Electrical power for a satellite and nearby oil fields is provided by electrical generation equipment at the satellite.

Oil satellite facilities receive fluids from oil producing wells, separate the gas and water from the oil, and then transfer the processed oil to the Moomba processing plant via an oil trunkline. At some satellite stations, processed oil is stored in tanks and transported by truck to the Moomba plant.

Produced formation water passes via a drain system into an interceptor pond where any entrained hydrocarbons are recovered by manual skimming or vacuum truck (Section 4.7.2; Figure 4-1). The separated water is processed to achieve an oil in water content of:

- less than 30mg/L if the water is being disposed of via closed (bunded) evaporation ponds
- less than 10mg/L if the water is directed to free-form (unbunded) evaporation ponds or infiltration basins.

As discussed in Section 4.3.1, the above oil in water content criteria are based on recommended standards that have been provided by PIRSA. These standards are currently being reviewed in accord with the SACBJV produced formation water disposal water quality research project as outlined in the Santos Action Plan (Section 8.2.8).

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, the gas can be sent directly to the flare. Also, during any emergency situation, the gas in the plant can be directed to the flare.

Oil satellite waste management is detailed in Section 4.7.2.

## 4.4 Produced Formation Water

When oil and gas is pumped to the surface, it is accompanied by varying quantities of water. Once the petroleum products have been removed, the remaining water is disposed of. This water is known as produced formation water (PFW) and is produced at satellites and the Moomba plant.

Typically PFW is disposed of to evaporation ponds. However, trials and studies on alternate uses such as using PFW for waterflood (injection) to enhance hydrocarbon recovery are being conducted in the Cooper Basin. A more detailed discussion on waterflood is provided in the Drilling and Well Production EIR (SA Cooper Basin Operators 2003).

Once PFW is separated from oil and gas, it undergoes primary treatment and is then transferred to a lined interceptor pit. From this point, there are two options for treatment and disposal of the water, either disposal to evaporation ponds or injection/infiltration to near surface aquifers.

A summary of PFW disposal facilities and their sizes is provided in Table 4-4.

### Table 4-4: SACBJV Produced Formation Water Treatment Facilities

| Facility Name | Area ($m^2$) | Facility Name | Area ($m^2$) |
|---|---|---|---|
| Amyema/Brumby Nodal Compressor | 24,956 | Merrimelia Oil Satellite | 735,100 |
| Aroona Nodal Compressor | 16,650 | Moomba Oil Facility | 132, 172 |
| Big Lake 36 Oil Satellite | 111,450 | Moomba-Plant Lake Brooks | 324,900 |
| Big Lake Gas Satellite | 16,900 | Moomba-Plant Northern Evaporation Pond | 19,648 |
| Bookabourdie Satellite | 26, 334 | Moomba South Central Satellite | 12,225 |
| Daralingie Gas Satellite | 14,096 | Moomba South East Nodal Compressor | 5,156 |
| Della Gas Satellite | 162, 494 | Moomba South Oil | 31,112 |
| Dullingari Gas Satellite | 21,600 | Munkarie Compressor | 36,517 |
| Dullingari Oil Satellite | 234,800 | Murta South Nodal Compressor | 12,345 |
| Gidgealpa Gas Satellite | 62,738 | Narcoonowie Oil Facility | 176,400 |
| Gidgealpa Oil Satellite | 546,320 | Spencer Oil Facility | 122,600 |
| Keleary Satellite | 83,950 | Strzelecki 15 Nodal Compressor | 10,750 |
| Kidman Gas Satellite | 128,025 | Strzelecki Oil Satellite | 536,886 |
| Lepena Nodal Compressor | 60,372 | Tantanna Oil Satellite | 722,218 |
| Limestone Creek Oil Satellite | 144,161 | Tirrawarra Gas Satellite | 89,154 |
| Mawson/Kurunda Nodal Compressor | 692 | Toolachee East Compressor | 14,040 |
| Meranji Oil Satellite | 665,345 | Toolachee North Nodal Compressor | 20,546 |
| Merrimelia Gas Satellite | 15,039 | Toolachee South Nodal Compressor | 36,671 |
| **Total Area of all PFW Facilities** | | | 5,053,362 |

The stages of PFW treatment are illustrated in Figure 4-1 and discussed in the following sections.

Primary Treatment

This can be either physical (gravity) or chemical treatment (emulsion breakers). Chemical treatment is the initial PFW separation stage and aims to maximise hydrocarbon recovery prior to disposal. Primary treatment takes place in vessels and tanks (the separation plant) located in the vicinity of the PFW disposal facility. Water is discharged from the base of the tanks to a lined interceptor pit in the disposal system.

Interceptor Pits

An interceptor pit is the first pond in any system and is lined with an impervious membrane and fenced to prevent stock access. The interceptor pit is used as a buffer to ensure that any hydrocarbons carried over from primary separation do not enter the unlined ponds. Hydrocarbons entering the system can be manually skimmed or vacuumed from the surface of the interceptor pit.

Water exits the interceptor pit by an underflow pipe to prevent hydrocarbons on the surface from moving further into the system. Any water leaving an interceptor pit should have a concentration of not more than 30mg/L of hydrocarbon (Section 4.3.1).

Evaporation Systems

The most common means of PFW disposal is the use of a pond system to evaporate water. There are many variables in design of evaporation systems - for example they can either be opened, closed, bunded or free form.

An open evaporation system is one in which livestock and wildlife have access to the water for drinking purposes, whilst a closed evaporation system is fenced to prevent stock and wildlife access. Whether a system is open or closed depends upon water quality considerations and consultation with pastoral lessees.

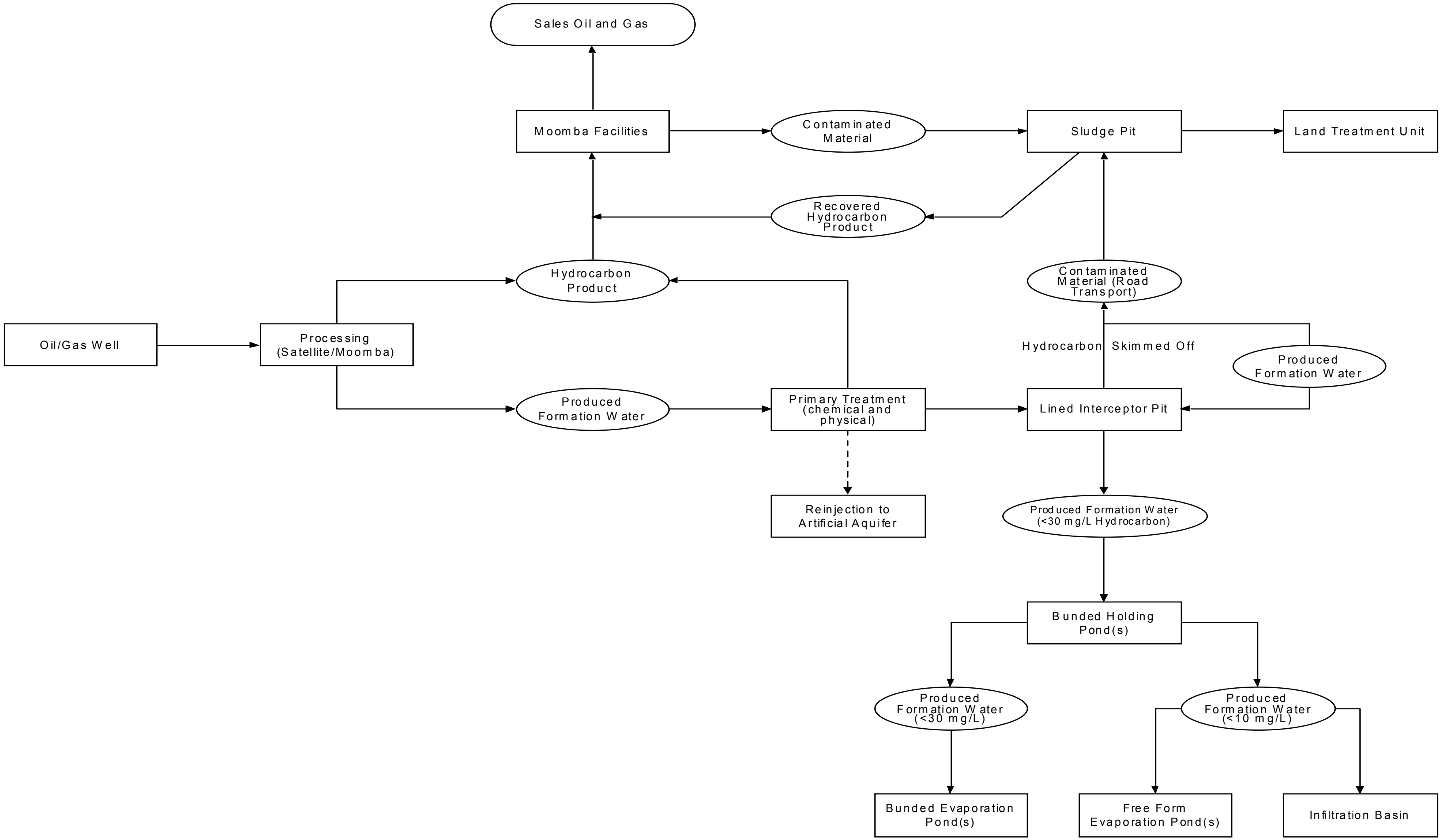
Bunded evaporation systems consist of a series of specially constructed shallow ponds to which PFW is discharged, whilst free form water disposal utilizes natural landscape features to form the final evaporation pond in the system as described above.

Free form evaporation systems require at least two specially constructed and bunded ponds following primary separation and the disposal to lined interceptor pond prior to discharge to the free form evaporation pond. This acts as a safety mechanism in the event of an oil release to the system. Free form evaporation systems most commonly utilize a dune corridor, with bunds constructed at an appropriate distance apart to form the evaporation pond.

Secondary Use of PFW

As PFW is a potentially contaminated process by-product, its use for secondary purposes (such as road construction, dust stabilisation or livestock watering) is strictly regulated.

The secondary use of PFW as ballast water for oil field tankers is acceptable provided that the ballast, when not required, is discharged to an approved PFW disposal facility. Additionally, PFW may occasionally be used as a drilling water source, depending upon water quality requirements. Ballast water is discharged directly to interceptor ponds to enable any free residual oil to separate from the water and be recovered via surface skimming. Only ballast water is discharged from oil field tankers to interceptor pits and under no circumstances is oil, condensate or fluid with greater than 30mg/L hydrocarbon content discharged from oil field tankers to interceptor pits.




## Figure 4-1: Produced Formation Water Treatment Process

## 4.5 Moomba Plant – Process Facilities

The Moomba plant is located in the Strzelecki Desert in central Australia, approximately 800km north of Adelaide. The plant receives raw gas, hydrocarbon condensate and crude oil from gas and oil fields in the Cooper Basin. An illustration of the Moomba process facilities is provided in Figure 4-5.

Gas trunklines feed raw gas into the Moomba plant from gas and oil satellites. The trunklines provide gas from satellite plants and also transport sales gas and ethane that has been recovered from selective underground reinjection storage formations. Liquid hydrocarbon condensate also enters the Moomba plant through the gas trunklines as a two-phase flow mixture with raw gas. Crude oil is delivered to the Moomba facilities through oil trunklines or by road tanker.

Designated Moomba gas wells are used to store excess sales gas from the Moomba Plant during periods of low customer demand. This excess sales gas and/or ethane is reinjected into an underground storage area, the Lower Daralingie Bed (LDB) formation, located at Moomba South (10km south of Moomba).This reservoir has the capacity to hold a total of 80Bcf of product (48% sales gas, 14% ethane and 38% raw gas).

Similarly, an atmospheric storage area contains two floating roof crude oil tanks within individual bunds with the capacity to store 47,700m$^3$ (300,000bbl) and 15,900m$^3$ (100,000bbl) of crude oil. A Pressure Storage Area contains a propane refrigerant bullet, which is sited within an individual earthen bund, and three natural gas liquids vessels that are in a common bund.

Sales gas leaves the Moomba site by pipeline to supply customers in Adelaide, Canberra, Sydney and other regional centres. Ethane leaves the site by pipeline to supply Qenos in Sydney. A single pipeline transfers crude oil and natural gas liquids to the liquids processing plant at Port Bonython.

Production volumes for sales gas, ethane, crude oil, condensate and LPG from 1995 to 2000 are presented in Figure 4-2 to Figure 4-4.

Fuel gas or processed natural gas produced at the site is used to provide energy for the Moomba plant utilities including:

- steam generation
- electric power generation
- fired process facilities
- driving process turbines and compressors.

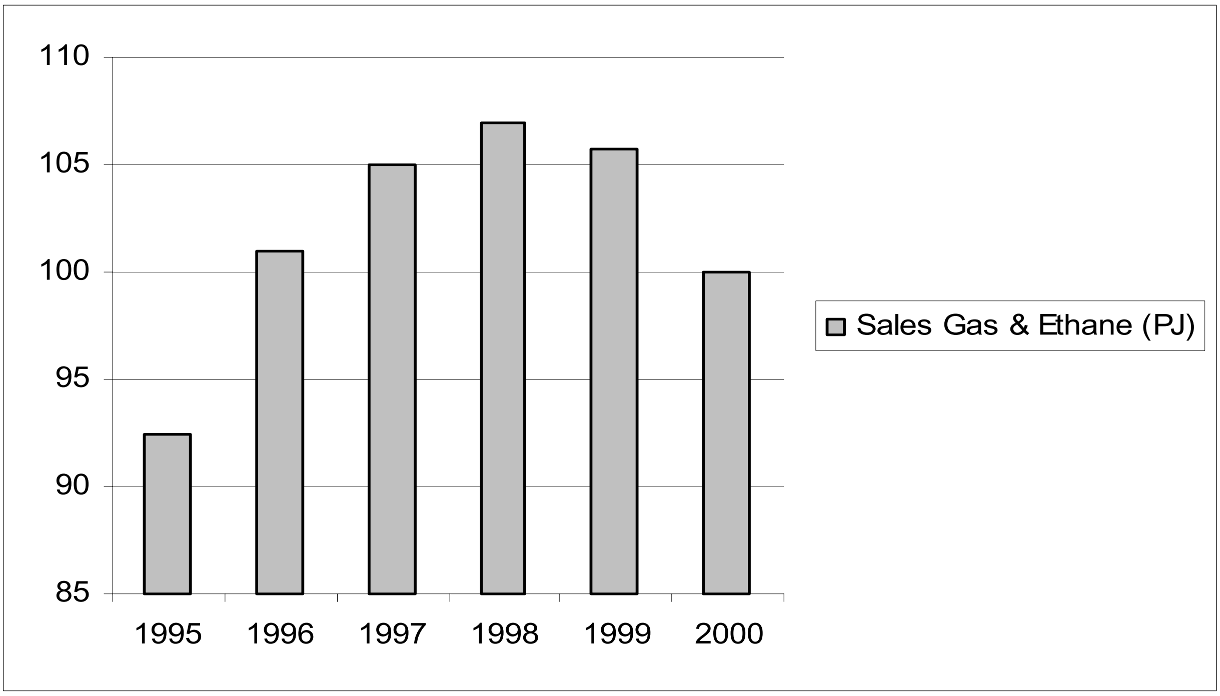



Figure 4-2: Cooper Basin Sales Gas and Ethane Production 1995 - 2000

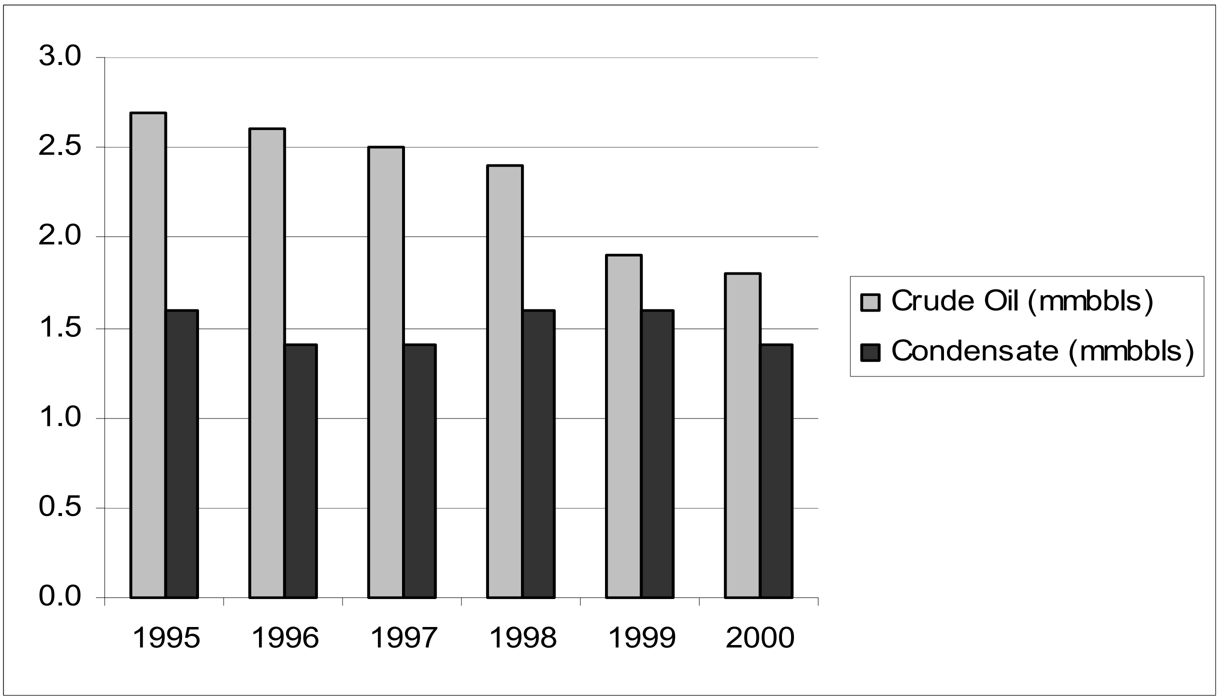



Figure 4-3: Cooper Basin Crude Oil and Condensate Production 1995 - 2000

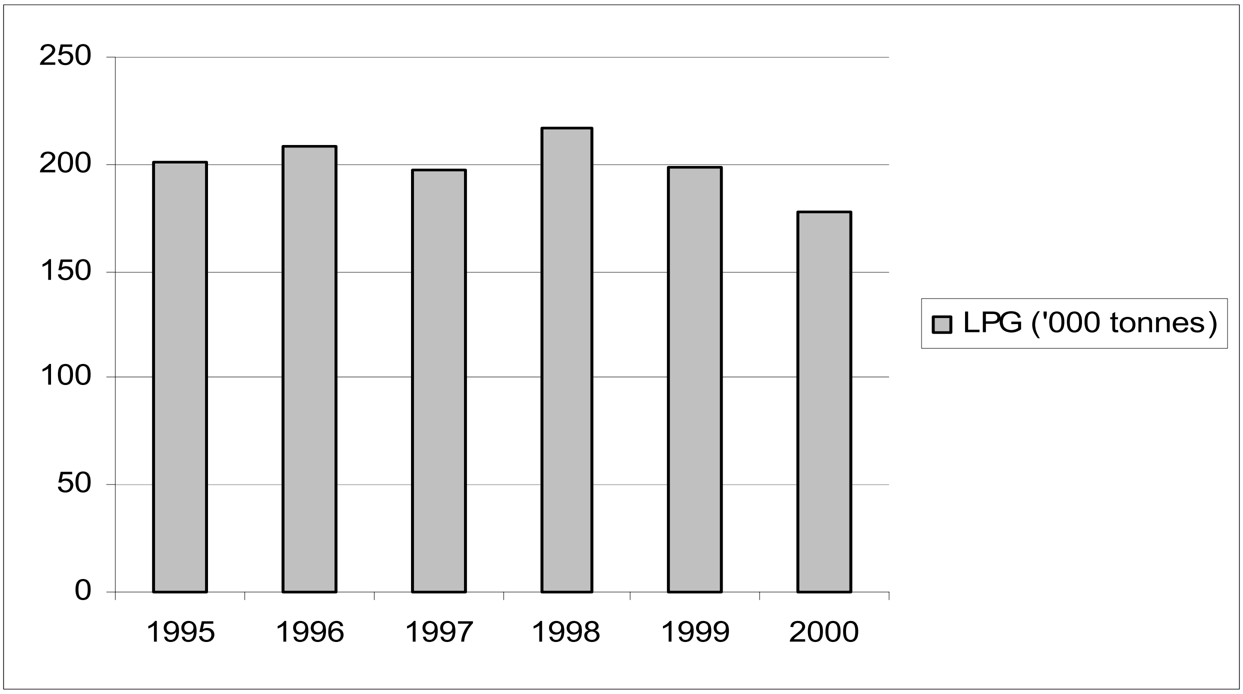



**Figure 4-4: Cooper Basin LPG Production 1995 - 2000**

### 4.5.1 Gas Processing

The processing of gas at the Moomba plant involves several stages which are detailed below and include:

- inlet Separation
- raw gas conditioning
- liquids recovery

Incoming raw gas streams enter the inlet separation section of the Moomba plant, which provides three-phase separation of gas, hydrocarbon-condensate and water.

The inlet separation facilities include:

- raw gas inlet header
- slugcatchers
- condensate/water coalescer
- high pressure (HP) separators and low pressure (LP) separators.

The separated gas is transferred from the HP and LP separators to the raw gas conditioning plant (RGCP) for inert gas removal. Meanwhile, condensate is further processed in the crude stabilisation plant and separated water is sent to the oily water system for treatment.

The RGCP consists of a series of vessels and associated equipment in which hot potassium carbonate is used to remove inert gas (ie. carbon dioxide ($CO_2$) and hydrogen sulphide ($H_2S$)). Inerts are removed to achieve gas specification for use by industry and domestic households and to prevent the formation of dry ice in the cold sections of the liquids recovery plant (LRP).

Of the total gas volume entering the RGCP, approximately 17% of it is removed as $CO_2$ and 0.002% is removed as $H_2S$.

To remove the inerts, the natural gas stream passes up through a vessel known as an absorber, in which hot potassium carbonate solution flows over metal packing. The carbonate solution absorbs some of the inert gas to become a bicarbonate solution. The gas passes out of the top of the absorber and a bicarbonate rich solution passes from the bottom of the absorber to the regenerator where, following pressure reduction and heating, the entrained gas is driven off.

The combined gas leaving the RGCP, called sweet-gas, contains 0.5% to 3.0% $CO_2$ and less than 1ppm $H_2S$ after dehydration. This gas is fed to the liquids recovery plant (LRP).

The purpose of the LRP is to recover a maximum volume of liquid hydrocarbons from the Moomba plant gas feed. This is accomplished by cryogenic distillation, which separates ethane and heavier hydrocarbons from sales gas. The LRP is equipped with dehydration facilities to reduce the moisture content of the feed gas to a level such that ice will not form in the cryogenic sections of the LRP. This is accomplished by a process of cooling and molecular sieve dehydration. The separated wastewater is sent to the oily water system for treatment.

Ethane gas from the LRP is fed to the ethane treatment plant (ETP) which produces ethane of suitable quality for petrochemical feedstock sales. The ethane can also be directed to sales gas or re-injected back into the ground for future processing.

Subsequent distillation of the liquid stream separates ethane gas from propane and butane. Ethane recovered from the LRP is fed into the ethane treatment plant (ETP). The ETP utilizes an amine $CO_2$ removal process with single stage regeneration and a molecular sieve dehydration process. The high purity ethane produced is then transferred, via the ethane pipeline, to Qenos in Sydney for use as petrochemical feedstock.

The separated propane and butane are mixed with stabilised crude prior to pumping the two-phase fluid via pipeline to the Port Bonython fractionation plant for processing.

Due to the high priority of maintaining continuous sales gas flow, the plant can be switched to a much simplified flow scheme should the cryogenic plant be temporarily unavailable. In this operating mode, less liquid hydrocarbons are produced by condensation with the aim of decreasing the hydrocarbon dew point of the gas product to acceptable values. This operating mode is referred to as dewpoint control mode (DPCM).

### 4.5.2 Liquid Processing (Crude Stabilisation Plant)

Liquid hydrocarbons at the Moomba plant are either recovered from raw gas processing or pumped or trucked to Moomba from oil satellites. Crude oil is classified either as block oil (i.e. stabilised enough to store in tankage) or unit oil (requiring immediate processing to remove volatile fractions).

The stored block oil can be directed to the crude stabilisation plant (CSP) or the distillate plant for processing.

The CSP removes water from the crude oil feedstocks and water from the liquid hydrocarbons (condensate) recovered from the raw gas inlet feed. The CSP comprises a distillation column with the overhead fractions recombined with the bulk of the separated gas for gas processing.

The 'reduced' or 'stabilised' crude from the CSP is stored in tankage prior to pumping with mixed liquefied petroleum gases (LPG) from the LRP, via fluid pipelines, to the Port Bonython fractionation plant.

The tank farm and truck unloading facilities at Moomba consist of oil tanks for receiving piped and trucked block oil, plus the storage and shipping of stabilised crude from the CSP. Block oil may then be pumped to the CSP and distillate plant.

The distillate plant at Moomba consists of two skid-mounted 'Val-Verde' units that produce commercial grade distillate. The commercial grade distillate is pumped to bulk storage at the Moomba site for distribution to end-users.

## 4.6 Moomba Plant – Utilities

The Moomba plant is self-sufficient in the production of:

- water
- compressed air
- steam
- electric power.

### 4.6.1 Water

Water is essential to operations in the Cooper Basin. Water is required for:

- steam generation
- process requirements
- domestic purposes.

These uses require water of various qualities. Domestic water requires water suitable for human consumption, whereas steam generation and some process facilities require water of higher purity.

Raw water is provided by an aboveground pipeline from artesian bores at Gidgealpa, 27km north-west of the Moomba plant. Currently 3800 tonnes of water is transported per day from Gidgealpa. This quantity is expected to increase to 4080t/day following a system upgrade, which is expected to be complete in approximately six months. The water is purified, according to its end use, by various systems including:

- reverse osmosis
- flash evaporation.

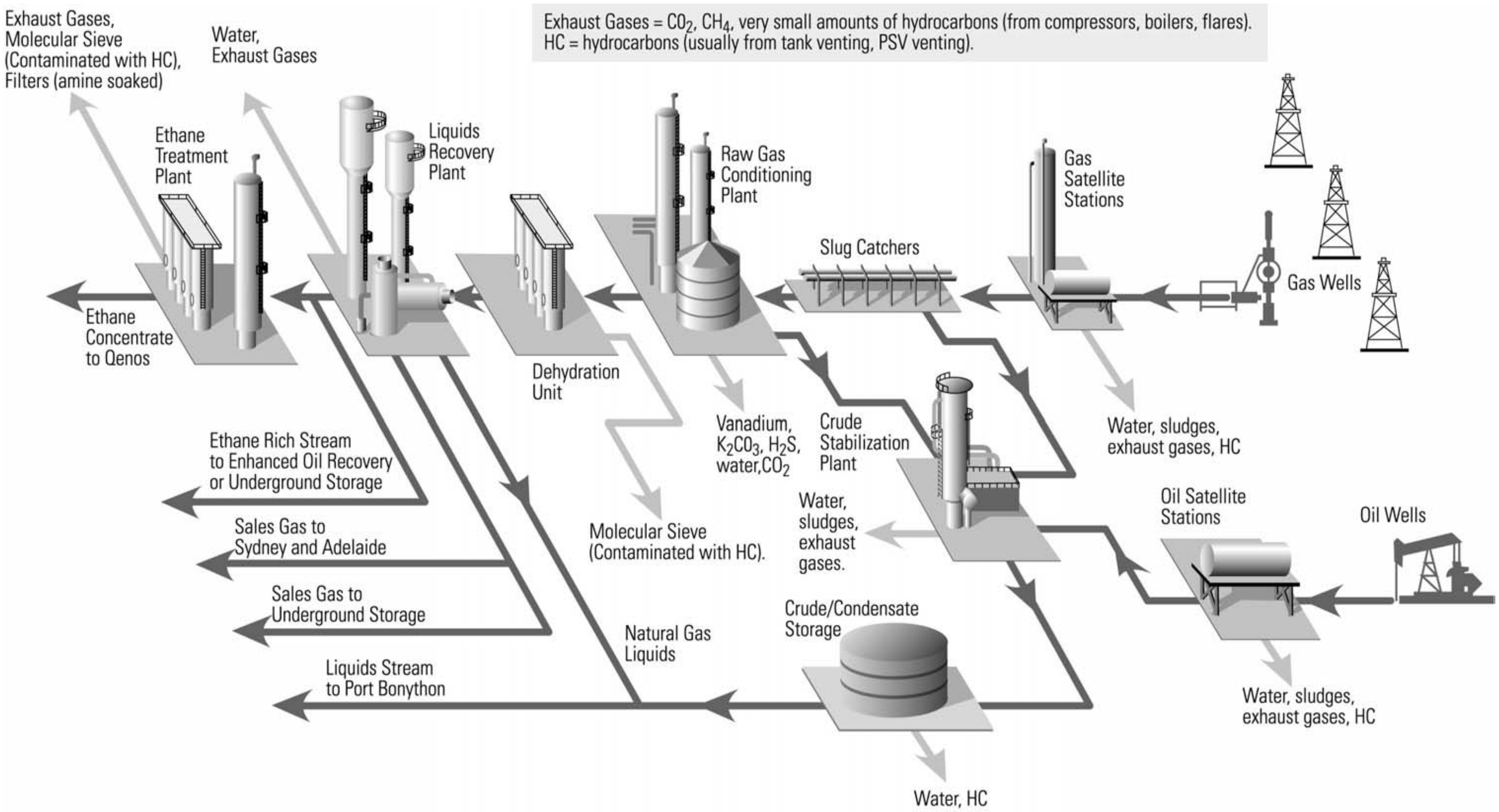



Figure 4-5: Moomba Processing Plant: Waste Streams and Product

### 4.6.2 Compressed Air

Compressed air is primarily required as 'instrument' air to drive pneumatic actuators on control valves. Pneumatic actuators are control devices that translate control signals into a mechanical action which then opens or closes a valve.

The instrument air system consists of electrically driven air compressors and a portable diesel powered compressor (for emergency back-up), air dryers and various air receivers. The system can deliver approximately 2100$m^3$/hr of instrument air.

### 4.6.3 Steam

The Moomba facility has seven boilers producing high-pressure super-heated steam. The steam is used for process heating and to drive process steam turbines.

Steam is used as a medium for transferring energy around the Moomba plant with high efficiency. The high-pressure steam generated in the boilers is let-down to a low pressure steam system as it is used in the plant process.

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

### 4.6.4 Electricity

Moomba has four steam turbine driven turbo-alternators (STAs) and two gas turbine driven turbo-alternators (GTAs). There is also a 400kW diesel driven emergency alternator.

The electrical generation capacity for Moomba is rated at 22.7MWe and its power distribution system comprises a 3.3kV grid (5MW) and an 11 kV system (17.7MW).

Electrical power is generated for all activities at the Moomba processing plant and associated facilities (camp, amenities, contractor facilities etc.) and for two nearby satellite plants.

## 4.7 General Infrastructure

### 4.7.1 Road Construction and Maintenance

There are approximately 3532km of SACBJV constructed and maintained roads throughout the Cooper Basin. These roads include 1176km of main roads and 2,356km of minor roads and access tracks (Table 4-5).

Roads cover approximately 0.016% of the combined licence areas (PELs and PPLs) in the South Australian Cooper Basin (approximately 1,345,412 hectares of land).

## Table 4-5: Cooper Basin Road Classes

| Road Class | Description | Total Length (km) |
|---|---|---|
| A | Moomba roads and roads connecting Moomba to satellites. Class A roads are operable within three days of 100mm of rain. | 244 |
| B | Satellite access roads and field spine roads. Class B roads are operable within three days of 100mm of rain. | 155 |
| C | Satellite access roads and field spine roads with low usage and field access roads to well heads. No wet weather access. | 777 |
| D & E | Class D roads comprise field access tracks with no wet weather access. Class E roads comprise access tracks to rigs, borrow pits, water bores, etc. No wet weather access. | 2356 |
| **Total Length (km)** | | **3532** |

Once surveys are complete and a preferred road alignment is selected, a road is constructed according to the land system(s) it will pass through. In most cases, the easement is cleared and graded but under some circumstances the easement may be rolled (for example in gibber plains or where the terrain is naturally flat and susceptible to erosion when disturbed). Table 4-6 provides information on the road construction methods applied to land systems in the Cooper Basin. Figure 5-1 shows location of main roads in relation to the various land systems in the Cooper Basin.

## Table 4-6: 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 | | | | | | • |
| Utilize naturally cleared areas | • | • | • | • | • | |
| Avoid steep slopes | | | • | • | • | |
| Weave road between trees and large shrubs | • | • | • | • | • | |
| Clear and grade easement | • | • | | | • | |
| Roll easement | | | • | • | | |
| Cap road surface with clay or similar borrow material | • | • | | • | • | |
| Culverts or similar devices installed on drainage line crossing | • | • | | • | • | |

Road construction styles are assessed according to the amount of anticipated use as well as the environmental sensitivity of the area. Erosion controls are implemented during and after construction and particular attention is given to flood and water flow areas.

Following construction, rehabilitation is undertaken to ensure that surrounding surface drainage is restored and erosion control structures are installed in areas prone to erosion.

Borrow Pits

Supplies of suitable construction material, such as gravel and soil, are usually extracted from sites referred to as borrow pits. Borrow pits are excavated to provide:

- soft earth for trench backfilling
- rubble and earth for upgrading or constructing roads and maintenance of satellite facilities
- rubble and earth for the construction of aboveground pipeline infrastructure.

There are currently four Extractive Mineral Leases (EML) that are maintained by SACBJV for ongoing extraction of material at Della, Toolache, Merrimelia and Strzelecki. Borrow pits vary considerably in dimension depending upon the quality and quantity of material contained in them. However, the average size of borrow pits is estimated to be approximately 3000 m².

Site selection, environmental management and restoration of borrow pits is undertaken in accordance with SACBJV Environmental Procedures for Borrow Pit Management (Santos 1997a). Existing borrow pits are used in preference to new ones where appropriate. If large amounts of material are required, a series of smaller borrow pits is used in preference to a single large pit. SACBJV has an ongoing program of determining locations of borrow pits and recording locations on a GPS database.

### 4.7.2 Waste Management

SACBJV recognise that waste management is an important issue which is incorporated into construction, operation and abandonment phases of development. SACBJV strives to prevent pollution by reducing the use of energy, water, material resources, and recycling waste where possible. To achieve these goals, the SACBJV continually assess product usage and production processes to achieve sustainable production by reducing waste emissions at the source.

There are three residential camps associated with the South Australian Cooper Basin operations. Waste management at these facilities is associated with domestic waste and general living amenities.

The SACBJV is responsible for the management of all wastes it generates and for its disposal in an approved manner. Waste from operations is generated from two main streams - operation waste and domestic waste (Table 4-7 and Table 4-8).

**Table 4-7: Typical Waste Streams - Operation Waste**

| Waste Type | Disposal | Annual Amount |
|---|---|---|
| Gaseous waste | ▪ Flared to atmosphere - mainly propane, butane, methane, some ethane<br>▪ Vented – $CO_2$, $H_2S$, CO | ▪ Moomba plant flare – 20,416 tonnes<br>▪ Field flares – 10,182 tonnes<br>▪ Vented – not available |
| Produced formation water | ▪ Interceptor pits and then to evaporation ponds/ infiltration basins | ▪ 8,300,000$m^3$ |
| Oily sludge | ▪ Sludge pit and then to:<br>▪ Land treatment unit (LTU), then landfill; or<br>▪ Recovered to process | ▪ To sludge pit: 2900$m^3$<br>▪ To LTU: 1200$m^3$<br>▪ Recovered to process: 2100$m^3$<br>▪ Evaporated: 100$m^3$ |

| Waste Type | Disposal | Annual Amount |
|---|---|---|
| Tank bottom sludges | ▪ Sludge pit and then to LTU or recovered to process. Alternative treatment options currently being reviewed | ▪ LTU: 300m$^3$<br>▪ Process: 200m$^3$ |
| Pig-receiver/ Slugcatcher scale | ▪ Rust scale and sludge to sludge pit and then to LTU | ▪ Not measured. Varies greatly |
| Contaminated soil | ▪ Stockpiled at landfarm for use in LTUs | ▪ Stockpile: 4000m$^3$ |
| Desalination brines | ▪ Sour water pit and then to Lake Brooks | ▪ Not currently measured |
| Stormwater run-off (plant) | ▪ Sour water pit and then to Lake Brooks.<br>▪ From oil areas to the northern interceptor pit, then to evaporation pond | ▪ Not currently measured. Varies greatly depending on rainfall |
| Hydrotest water | ▪ Recycled for each hydrotest section | ▪ Not currently measured |
| Laboratory effluent | ▪ Benfields ($K_2C0_3$,Vn) Di-ethyl amine, crude, solvents: - >95% returned to plant process; <5% used in reactions, then disposed to grey water system (sewage plant)<br>▪ Listed wastes – to chemical waste depot other than above | ▪ Volumes not currently measured. Likely to be in 10's of litres a year to sewage plant where it is diluted |
| Used chemical drums | ▪ Moomba Waste Depot and recycled where possible | ▪ Recycled: 800<br>▪ Landfill: 7200 – 9600 |
| Molecular sieves | ▪ Moomba Chemical Waste Depot | ▪ Variable. 100m$^3$ – 400m$^3$ |
| Chemical waste | ▪ Moomba Chemical Waste Depot | ▪ Carbon: 3m$^3$<br>▪ Charcoal: 3 tonnes<br>▪ HCL Acid: 100L |
| Scrap metal | ▪ Recycled where possible or added to landfill at Moomba Waste Depot | ▪ Recycled: 28 tonnes<br>▪ Landfill: not currently measured |
| Timber pallets (skids) | ▪ Recycled | ▪ 2000 pallets |
| Vehicle tyres | ▪ Moomba Waste Depot:<br>▪ Shredded and added to landfill | ▪ 2400 – 3600 tyres |
| Asbestos | ▪ Asbestos waste depot | ▪ 45m$^3$ – 90m$^3$ |

## Table 4-8: Typical Waste Streams - Domestic Waste

| Domestic Waste | Disposal | Annual Amount |
|---|---|---|
| Storm water run-off (camp) | ▪ Run-off to vegetation | ▪ Not currently measured |
| Sewage | ▪ Treated at Moomba sewage treatment plant and disposed of in Lake Brooks | ▪ Not currently measured |
| Grey water | ▪ Recycled to irrigation or discharged to Lake Brooks | ▪ Not currently measured |
| Food waste, paper and plastic | ▪ Moomba Waste Depot (landfill) | ▪ 1460 tonnes |
| Glass and cans | ▪ Moomba Waste Depot (landfill) | ▪ 19 tonnes |
| Workshop waste (rags, filters) | ▪ Moomba Waste Depot (landfill) | ▪ 730 tonnes |

### 4.7.3 Moomba Airport

An airstrip and associated airport facilities have been constructed at Moomba. The airport mainly services` flights to and from Adelaide and Ballera (a processing plant in Queensland). In addition to these flights, a helicopter is on permanent stand-by. The helicopter is utilized to enable relatively rapid access to difficult areas and provides emergency services, particularly when roads are closed due to wet weather.

The airport facilities are located in a fenced compound. Grasses and other vegetative growth is restricted to prevent the attraction of fauna to the area, particularly birds (for example, corellas), which can cause a safety hazard.

Aviation fuel is stored in drums on site in accordance with aviation safety standards.

### 4.7.4 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. Run-off from the site is directed to an interceptor pit before entering the northern evaporation pond.

# 5 Existing Environment

The Cooper Basin covers a total area of 130,000km$^2$ of which approximately 50,000 km2 lies within north-east South Australia (refer to Figure 5-1). Cooper Basin Operators' licence areas in the South Australian region of the Cooper Basin can generally be described as arid with a uniform climate. They contain a wide diversity of land systems that are defined by geological, geomorphological and hydrological influences.

This chapter provides an outline for the operations area of regional climatic conditions, biophysical environments and social environments, including indigenous heritage and land use.

It should be noted that the collection and documentation of flora and fauna in north-east South Australia has been patchy and sparse. Consequently, status and habitat requirements for some species within the area is poorly understood (SEA 2000). Appendix B lists flora and fauna species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that are likely to occur in the Cooper Basin region, and Appendix C lists the common species names and scientific equivalents.

## 5.1 Climate

The climate in the Cooper Basin is generally characterised by hot dry summers and mild dry winters. In summer, average daily maximum temperatures exceed 34°C and the average minimum is 22°C (Marree Soil Conservation Board 1997). Average daily temperatures in winter range from 7°C to 20°C (Marree Soil Conservation Board 1997). Both seasonal and diurnal temperature ranges vary considerably, with the Bureau of Meteorology recording a maximum temperature of 49.1°C and minimum temperature of -1.4°C.

Rainfall variability in the Cooper Basin is amongst the highest in Australia, while average annual totals are amongst the lowest. Mean annual rainfall is approximately 150mm, with no distinct seasonal pattern (Laut et al. 1977). North-west monsoons weakly affect the northern region in summer and moist tropical air occasionally penetrates further south producing intense but relatively short-lived thunderstorms (Marree Soil Conservation Board 1997).

Average seasonal evaporation rates are in the order of 550mm in summer and 150mm in winter. Average annual evaporation is extremely high at around 3,800mm (Marree Soil Conservation Board 1997).

The most common wind direction throughout the year is from the south-east. However, wind direction is more southerly in the south of the basin and more easterly in the north. Light winds (<20kph) are most common from May to July, while the greatest frequencies of strong winds (41-61kph) occur from September to January.

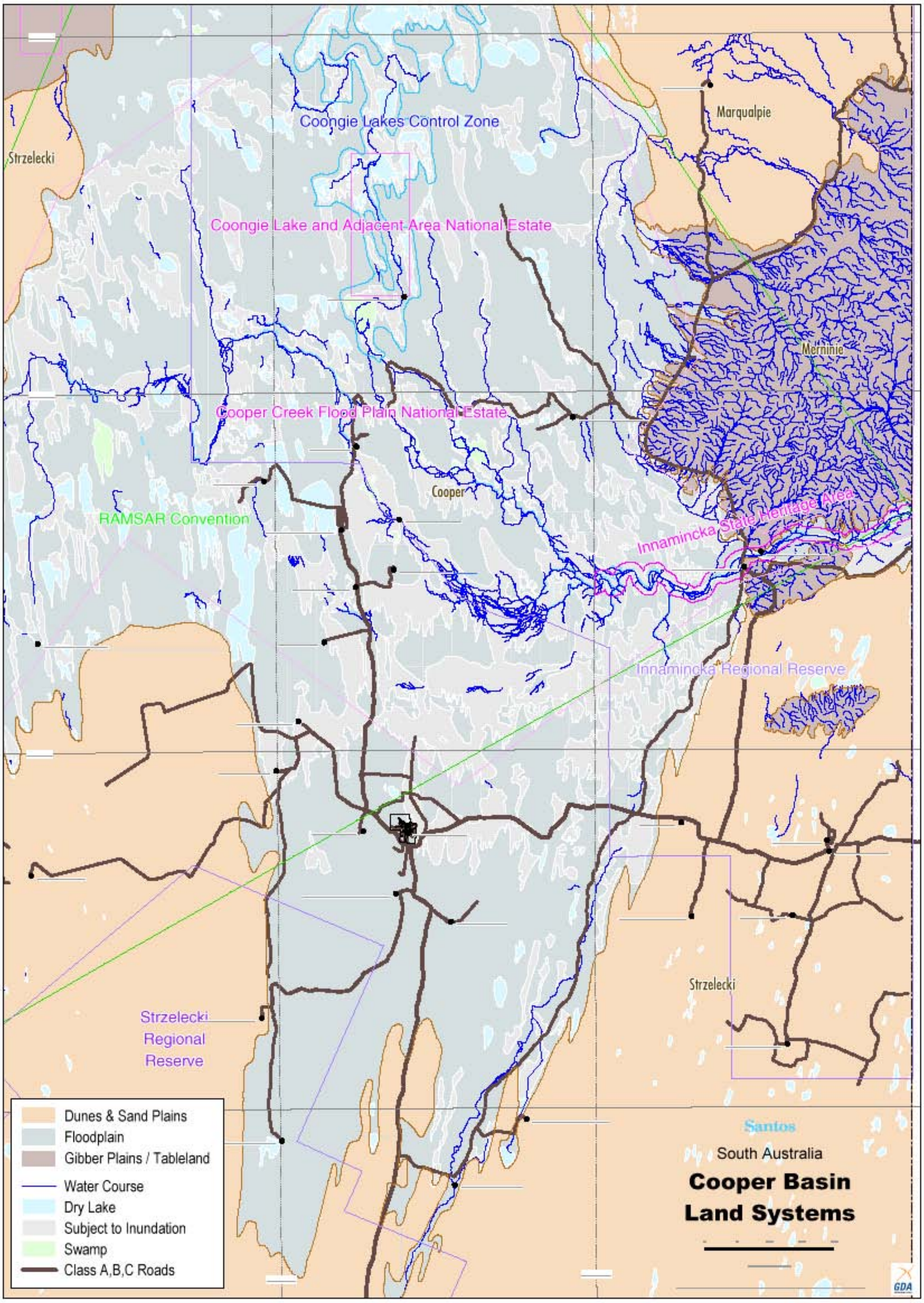



Figure 5-1: Cooper Basin Land Systems

## 5.2 Biophysical Environment

The six major land systems contained within the Cooper Basin licence areas are:

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

The sensitivity of each system to disturbance depends upon its basic characteristics: geology, landform, soils, hydrology, flora and fauna. Each land system has been discussed with respect to these characteristics.

### 5.2.1 Dunefields

The dunefields of the Tirari and Strzelecki deserts dominate the Cooper Basin Operators' licence areas. These dunefields mainly occur in the far north-west, south-west and south-east regions of the Cooper Basin licence areas (refer 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). The process of dune development and migration 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 claypans (Twidale and Wopfner 1990, Santos 1997b). Dunes range in height from 5m to 35m and trend approximately north-east (Twidale and Wopfner 1990). Sand cover rarely exceeds 30m and a stony base is usually 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. In sandy desert areas, the potential for wind erosion to effect 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 fairly 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 1997b).

In those parts of the basin where 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

The dunefields are extremely arid and lack any permanent surface water. 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 1997b). 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 dunefields.

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 1997b). 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's 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 primarily in sand dunes along Strzelecki Creek in the vicinity of Lake Blanche (Morton et al. 1995). 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).

### 5.2.2 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 (refer to 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 which are 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

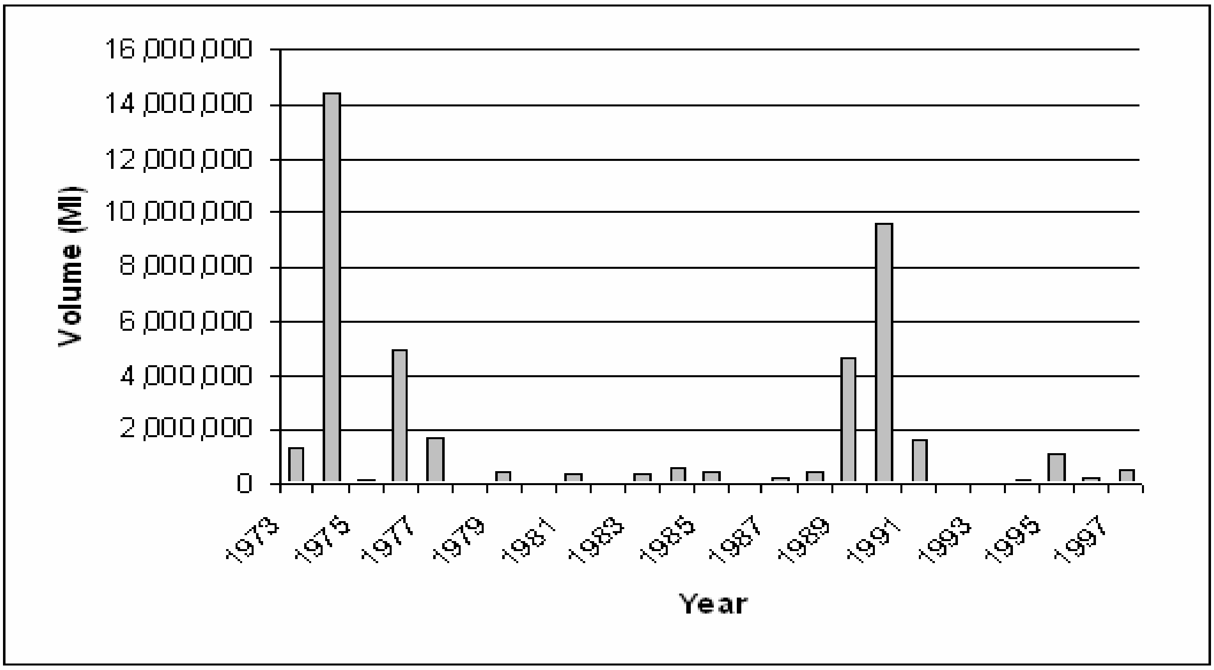
The floodplains of the Cooper Basin are primarily associated with the Cooper Creek drainage system. The Cooper Creek originates in the moister catchments of south-west Queensland and channels water through the basin to Lake Eyre. Cooper Creek still has the hydrologic character of an unregulated arid zone river with an extremely variable flow regime. The Cooper flows every year, although 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 140km upstream from Coongie Lakes).

Puckridge et al. (1999) have developed nine flood classes for the lower Cooper Basin floodplain based on the 25 year Cullyamurra record. Table 5-1 provides expected frequencies and volumes for each of these flood classes. The area inundated by each flood class is presented in Appendix D. 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.

## Figure 5-2: Annual Flow Volumes of Cooper Creek, Cullyamurra Gauge Station, 1973 - 1997




Source: Puckridge *et al.* 1999.

## Table 5-1: Cooper Creek Flood Classes, Volumes and Frequency

| Flood Class | Daily Flow Volume (Ml/day) | Total Volume (Ml) | Frequency | Comment |
|---|---|---|---|---|
| 1 | 600 - 1,200 | 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 | 1,200 - 2,500 | 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 | 2,500 - 5,400 | 130,000 - 220,000 | 1-2 years | Significant part of flows into the main branch as far as Embarka Swamp. |
| 4 | 5,400 - 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. |
| 6 | 40,000 - 100,000 | 1,400,000 - 2,400,000 | 5 years | Results in flows into Wilpinnie Creek. Flow into this area can disrupt gasfield 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. |
| 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.

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 and bean tree fringe 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 may be considered the main cover of tributary streams. Shrubland of lignum, old man saltbush or Queensland bluebush may also extend into the coolibah woodlands, but tends to be characteristic of outer floodplains (Santos 1997b).

Fauna

Within the arid zone, the most vital and important environmental areas are those connected with sites of permanent water. They provide permanent habitat for a variety of 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).

Generally, watercourse habitat supports more mammal species than other habitat types in the basin. Thirty-five species of native mammal have been recorded from 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 Australian endemics (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 the region (Brandle and Hutchinson 1997).

### 5.2.3 Wetlands

Despite its aridity, the Cooper Basin contains an array of wetlands. The Coongie Lakes and 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 to waterfowl (Morton et al. 1995, Blackley et al. 1996).

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 1997b).

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 rainfalls. Flooding is considered to be the most crucial factor in the recharge of many wetlands in the basin area.

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 Puckeridge 1990). Aquatic vertebrates include the water rat and Cooper Creek short-necked tortoise.

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

The Coongie Lakes system supports enormous 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.

### 5.2.4 Salt Lakes

The basin is dotted with numerous salinas, or salt lakes and salt pans, of varying sizes (referred to as dry lakes in Figure 5-1). 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 (for example, rivers and streams). The larger salt lakes in the licence area include Lake Blanche, Lake Hope, Lake Gregory, Lake Etamunbane and Lake Uloowaranie (Santos 1997b).

Geology, Soils and Landform

Salt lakes usually have a low topography and dry surface covered with a gypsum (salt) crust. Lunettes are found along parts of the eastern shores of lakes. Little is known about the physical attributes of many salt lakes.

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 fauna.

Salt lakes are particularly depauperate with regard to 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.

### 5.2.5 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 Cooper Basin include Wadi Wadi or Innamincka Dome, Mount Kingsmill and Kertietia Hill (refer to 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 1997c). 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 (Section 5.2.6).

### 5.2.6 Gibber Plains

Throughout SACBJV 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 1997b). Refer to 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 -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 1997b).

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 an immense range of 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 bushes, may form a tall open shrubland.

Fauna

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

Only a minority of the bird assemblage of the South Australian Cooper Basin is considered to be resident (Brandle and Reid 1997). Gibber areas are an important habitat for a number of bird species including the chestnut-breasted white face, 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. Gile's planigale 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 Geology and Hydrogeology

The Eromanga and Cooper basins are located in central and eastern Australia. The saucer-shaped Eromanga Basin extends over one million square kilometres in Queensland, New South Wales, South Australia, and the south-east of the Northern Territory (refer Figure 5-1).

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 200m–300m (Drexel and Preiss, 1995 Drexel and Preiss, 1995).

Eromanga Basin sediments were deposited during the Jurassic-Cretaceous period, and reach a maximum thickness of between 1200m and 2700m 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). These sediments are gently folded in some areas and contain a succession of aereally extensive sandstone formations that serve as oil reservoirs and regional aquifers.

Beneath the Eromanga basin is the fault-bounded Permian-Triassic Cooper basin, which extends over a much smaller area of about 153,000km$^2$ in north-east South Australia and south-west Queensland (Stanmore 1989). Total Cooper Basin sediment accumulations exceed 1500m in some places and are characterized by fluvial, deltaic, and swamp deposits that include some coal measures (Thornton 1979). These sediments contain petroleum reservoirs (mainly gas) and aquifers. The South Australian end of the Cooper Basin includes several north-east to south-west trending depocenters, 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 in excess of 7000psi 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 a number of 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 Great Artesian Basin (GAB) (Habermehl 1980). From 10 to 5 Ma A(million years before present day) 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, 1986).

Geothermal gradients in the Cooper and Eromanga range from 30DegC/km on the margins to 60DegC/km in the Nappamerri Trough. Here temperatures in the basal Cooper sediments reach approximately 250$^0$C.

The Cooper and Eromanga basins are currently subject to a regionally compressive stress regime. Motion along fault bounded basement blocks result 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.

With respect to hydrogeology, the rock column of the Eromanga and Cooper basins can be broadly subdivided into aquifers and confining beds (aquitards). Aquifers are formations that are able to 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. Confining beds (aquitards) are units that impede the movement of water, and in general have low hydraulic conductivities or permeability. The reservoir pressure of an aquifer can be described as a pressure or a hydraulic head. In general, the hydraulic head drives the flow of water from one part of an aquifer to another, (ie. 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 orthogonal to these contours to show the direction of lateral groundwater flow. Differences in head potential between aquifers occur when a confining layer is present and flow in each aquifer occurs independent of the other.

In this situation, the 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.

If the hydraulic head is the same in two aquifers separated by a confining bed, the mixing of fluids between aquifers will not occur even if the aquitard is breached by a fault or well bore.

The Poolowanna and Birkhead formations, the Murta Member, the Westbourne Formation, and, to a lesser extent, the marine Toolebuc and Wallumbilla formations are aquitards within the Eromanga basin. The Patchawarra Formation, Murteree Formation, Roseneath Shale, Toolachee Formation, and, to a lesser extent, Nappamerri Formation are aquitards within the Cooper Basin. There is little information on the hydraulic properties of these aquitards. However, the hydraulic conductivities of these beds have been estimated by numerical model calibration to be about $10^{-4}$m/day (Audibert 1976). Despite these low hydraulic conductivities, the aquitards have enabled hydraulic communication between aquifers over 'geologic time' such that most are in hydraulic equilibrium and 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 Eyre Basin; the Winton, Macunda, Coorikiana, Murta, Namur, Adori, Birkhead, Hutton, Poolawanna, Cuddapan formations of the Eromanga Basin and the Nappamerri, Toolachee, Daralingie, Epsilon, Patchawarra and Tirrawarra/Merrimellia formations of the Cooper Basin. Hydraulic conductivities measured within aquifers range between 0.1 m/day and 10 (Audibert 1976). Observed porosity values within the sandstone aquifers are about 0.3 (Senior and Habermehl 1980).

Table 5-2 contains a summary of the pressure, permeability and salinity characteristics of these aquifers.

Based on all the geological data available, the aquifers can be grouped into six regionally pervasive hydrogeological cells.

1. The Meteoric Recharge Section (water table or unconfined aquifer)
2. The Eyre, Winton and Macunda formations (uppermost GAB aquifer, non flowing)
3. Coorikiana Sandstone (GAB aquifer, non-flowing)
4. Cadna – Owie Formation and Jurassic sand units (main GAB aquifer)
5. The Cooper Basin (normal pressure)
6. The Cooper Basin (abnormal pressure)

Whilst the data available strongly supports this interpretation, it is recognised that in some areas the data to prove the regional interpretation is unavailable. Where this occurs, the well data can provide an 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 of the Basins are in direct communication. All cells do not necessarily exist in all parts of the basin. Towards the margins of the Cooper Basin and along some intra-basin highs, the GAB and Cooper Basin cells are in connection and the Cooper Basin (abnormal pressure) does not exist. Also, the Coorikana Sandstone is only known from the southern and western Eromanga Basin.

Geochemical correlation between source rocks and petroleum reservoirs has been inconclusive and has led some investigators to question whether Eromanga hydrocarbons were sourced by either Eromanga or Cooper sediments (Heath et al. 1989). 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) used these and other factors to argue that much of the oil and gas in the Eromanga Basin was actually sourced from the underlying Cooper rocks.

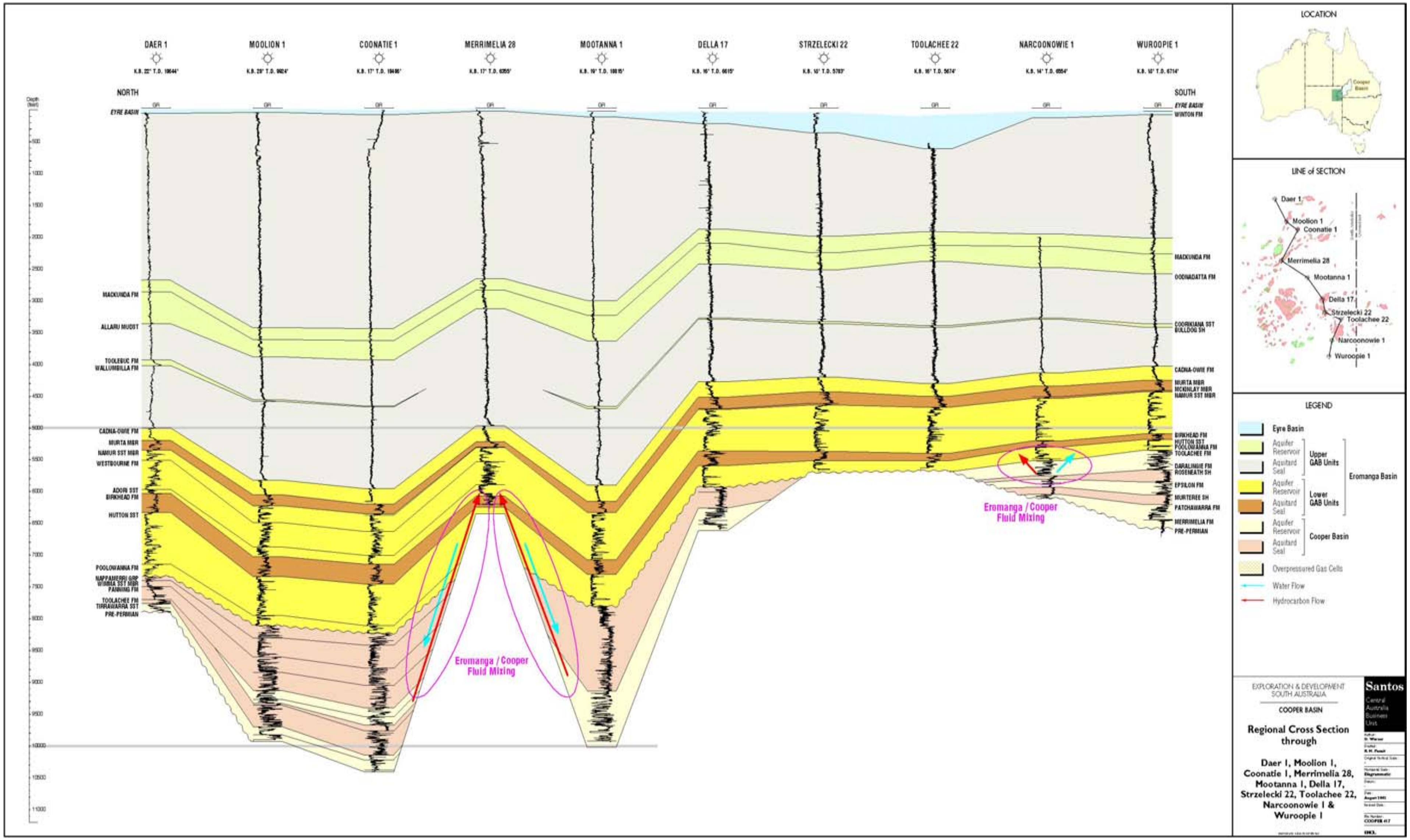
In the Cooper Basin, the location of oil and gas fields is closely related to the distribution of maturity in the source rocks; most gas fields are located in or near the 'hot' Nappamerri Trough, whereas the 'cooler' Patchawarra Trough is home to most of the oil fields in the Cooper reservoir rocks (Kanstler et. al. 1983; Hunt et. al. 1989).

The distribution of hydrocarbons and hydrogeological cells in a well bore can guide the effective management of the impact of drilling and production on the hydrocarbon and water resources of the region.

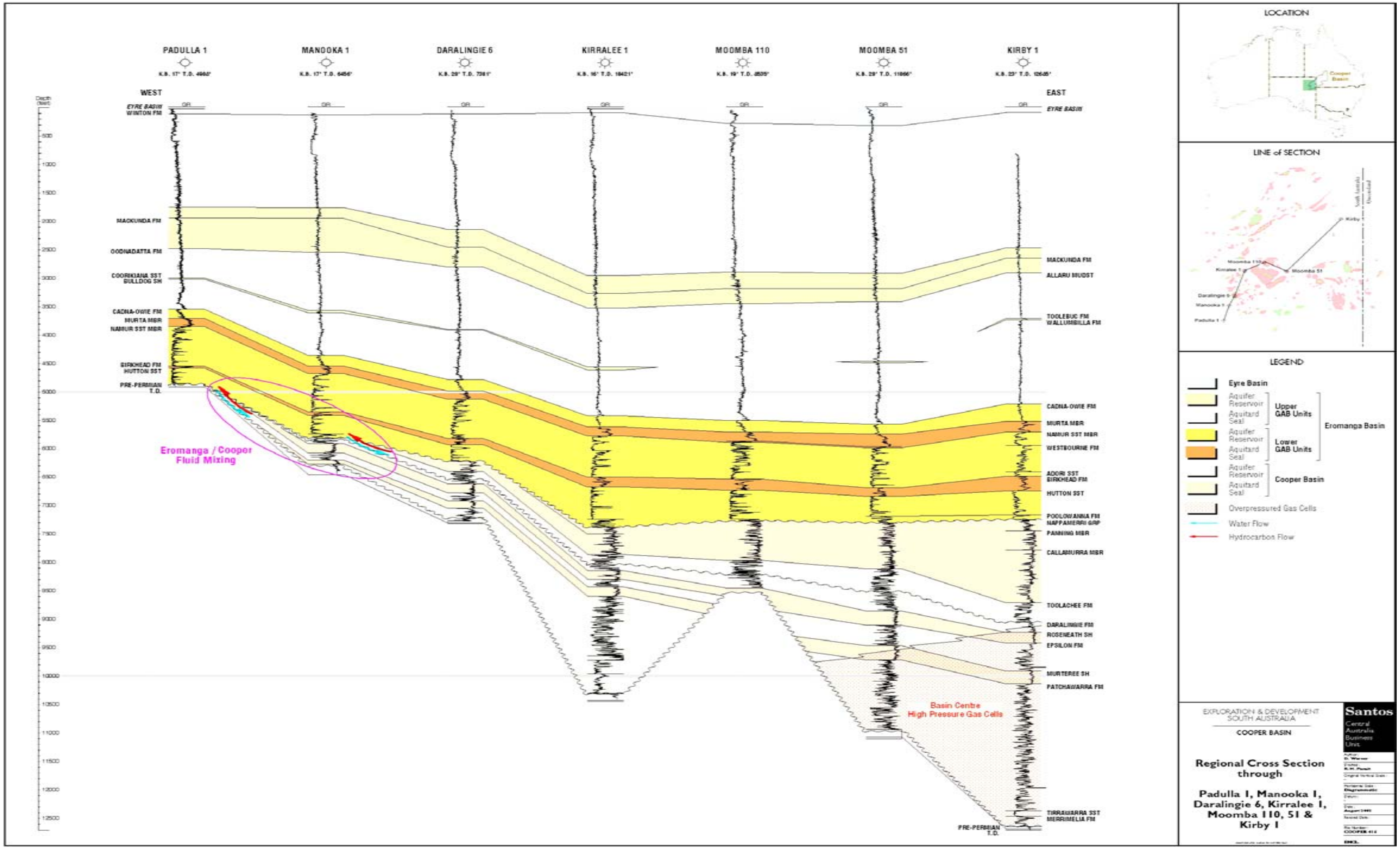
## Table 5-2: Summary of Salinity, Pressure and Permeability Characteristics.

| Reservoir/ Aquifer | Use | Extent | Salinity | Pressure System (6) | Permeability |
|---|---|---|---|---|---|
| **Eyre Formation** | Limited use for petroleum exploration (rig water) | Basin wide | (2)Unclear, probably high(>9000 ppm) | Uppermost aquifer. Unknown, probably less than GAB | High |
| **Winton Formation** | | Basin wide | As above | As above | High |
| **Macunda Formation** | | Basin wide | (2)Unclear, probably high (>9000 ppm) | Uppermost GAB aquifer. Known to be less than GAB (Della 20 evidence) | High |
| **Coorikiana Sandstone** | Potential reservoir | Restricted to more marginal southern and central areas of basin | (2)Unclear, probably high (>9000 ppm) dataset, may be high or low | GAB Aquifer between bulldog shale and Oodnadatta Formation. One data point apparently less than GAB. Unclear if in communication with GAB in Cooper area | Generally low but local areas up to moderate |
| **Murta Formation** (multiple sands) | Known reservoir | Basin wide, but sands may be limited in extent | (3)Limited data (3000-4000 ppm) for Murta sands | Part of main GAB aquifer (Algebuckina Sandstone equivalent). Data pressures variable and source not verifiable, may be problem with mixing McKinlay Member data. | High - up to multiple darcy |
| **Namur Sandstone** (includes McKinlay member of Murta Fm) | Known aquifer and reservoir | Basin wide | (4)300-4000 ppm | Part of main GAB aquifer (Algebuckina Sandstone equivalent). May have local depleted zones | High - up to multiple darcy |
| **Adori Sandstone** | Known aquifer and reservoir | Restricted to northern part of basin | (4)300-4000 ppm | Part of main GAB aquifer (Algebuckina Sandstone equivalent). May have local depleted zones | High - up to multiple darcy |
| **Birkhead Formation** (multiple sands) | Known reservoir | Basin wide | (4)300-4000 ppm | Part of GAB. May have local depleted zones | Highly variable |
| **Hutton Sandstone** | Known aquifer and reservoir | Basin wide | (4)300-4000 ppm | Part of main GAB aquifer (Algebuckina Sandstone equivalent). May have local depleted zones | High - up to multiple darcy |
| **Poolowanna Formation** | Known reservoir | Basin wide? | 3000-4000 ppm in Cooper Basin area, but in excess of 9000 ppm in northern areas | Unclear if part of GAB. May have local depleted zones | High - up to multiple darcy |
| **Cuddapan Formation** (multiple sands) | Known reservoir | Patchawarra Trough only | Unknown | ? | High - up to multiple darcy |
| **Nappamerri Group** (multiple sands) | Known reservoir | Basin wide, but sands of local extent. Degree of interconnection across basin unclear | (5)3000-7000 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) | Known reservoir | Basin wide, but sands of local extent. Complex interconnections across basin | 1500 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) | Known 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) | Known reservoir | As above | Limited dataset, 2000 to10,000 ppm apparently depending on connection with GAB | As above | Highly variable |
| **Patchawarra Formation** (multiple sands) | Known reservoir | As above | 2000 to 18,000 ppm. Low salinities in Weena/Tinga Tingana Trough | As above | Highly variable |
| **Tirrawarra/Merrimelia Formation** | Known reservoir | Basin wide except for south east and around local highs | Limited dataset for Tirrawarra 5000 to 17,000 ppm no data for Merrimelia | As above | Highly variable |
| **Pre Permian Basement** | Known 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 5-3a: Regional Geological Cross-sections of the Cooper Eromanga Basin Area



## Figure 5-4b: Regional Geological Cross-sections of the Cooper Eromanga Basin Area



## 5.4 Aquifer Use

Due to the dry climate of the region overlying the GAB in South Australia, groundwater is a particularly important resource. Land use is generally restricted to low intensity stock grazing (GABCC 1998) and where accessible and of acceptable quality, groundwater is used for both residential and stock watering purposes. Other industries reliant on the groundwater resources in the region include oil and gas exploration and production, copper and uranium mining and other mining, specifically opal mining (for example at Coober Pedy and Andamooka). The quality of the water required for each of these activities is variable and accessibility to water of appropriate quality may restrict land uses in some locations. The socio-economic value of these industries is discussed further in Section 5.4.4.

In the Cooper and Eromanga basins the petroleum industry is responsible for the extraction of significant quantities of water from the GAB and other aquifers as a result of petroleum production. The majority of 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 differing physical properties of oil and water, over time the oil tends to 'float' to the surface and sit above the water. These formations usually exist under pressure so when they are accessed by drilling a bore hole the oil will flow to the surface. Over time, water will take the place of the produced hydrocarbons and rise up the bore hole 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 and is separated from the oil stream at satellite stations and disposed of to surface evaporation ponds.

Due to the depth of the artesian aquifers in the centre of the basin, the majority of pastoral water use from these aquifers in South Australia occurs along the southern and western margins of the basin where the majority of bores intersect artesian aquifers at less than 600m (GABCC 1998). On the western margin, these bores coincide approximately with the Oodnadatta track. There are also a number of 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 various industries will vary depending on specific needs. Salinity is used as a guide for the suitability of water for stock. It can be expressed as Total Dissolved Solids (TDS), a measure of the weight of dissolved salts in water. Groundwater quality in the shallow (water table) aquifers in the Moomba region is not generally suitable for stock watering purposes due to a high salt content. The ANZECC Water Quality Guidelines (ANZECC 2000) indicate that water of up to 5000mg/L TDS is acceptable for stock watering, with levels of TDS higher than this likely to result 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 greater than this value. Likewise, the salinity of water in the uppermost GAB aquifer (Eyre, Winton and Macunda formations) is also generally too saline for use. However, the salinity of the main flowing GAB aquifer is much less than these aquifers, being often in the range 600mg/l - 2000mg/L in the eastern part of South Australia, which is acceptable for stock watering purposes.

## 5.5 Social Environment

The Cooper Basin area has broad indigenous cultural and European historical significance. There are a range of current land use types throughout the area including conservation, tourism, oil and gas production and pastoral activities. While the regional population has decreased with time, tourist numbers remain consistent. The region are 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 1998a).

The traditional Aboriginal landowners of the Cooper Basin currently have little direct involvement with, or connection to, the land in the region (pers. comm. A. Lance 2001). Most members of Aboriginal groups from the Cooper Basin region of north-east South Australia now live in Port Augusta in South Australia or Tippaburra in north-west New South Wales. The North East Lands Council is the Aboriginal organisation with responsibility for cultural heritage matters in the Cooper Basin region.

Aboriginal sites can still be identified throughout the region and include features of spiritual importance and archaeological sites: for example middens, artefact scatters, rock engravings, arrangement sites, burial sites and quarries (Blackley et al. 1996). These are summarised in Table 5-3.

**Table 5-3: Land Types and Aboriginal Artefacts**

| Land Types | Artefacts and Sites | Location of Sites |
|---|---|---|
| Sand dunes | Burial sites: common | Often in eroding sand dunes |
| | Shell middens: common | Near sources of permanent water such as Cooper Creek and Coongie Lakes |
| Floodplains | Burial sites | Isolated dunes and sandy rises |
| | Campsites | Isolated dunes and sandy rises |
| | Shell middens | Near lakes and rivers |
| | Rock Art | Near lakes and rivers |
| | Tree scars: rare | Along rivers and creeks |
| | Stone artefact scatters | Near lakes and rivers |
| Gibber plains | Cleared pathways | Near stone arrangements |
| | Stone tool quarries | Mesa caps |
| | Stone arrangements | Gibber country |

Sand dunes often contain the largest and most important archaeological sites within the Cooper Basin region. Any stone found on a sand dune is likely to have been brought there by Aboriginal people. 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. Campsites and burial sites are often 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). Scars made by Aboriginal people can be found on large, old river red gums and box trees along rivers and creeks, and boomerang scars on smaller trees of various types including eucalypts and acacias. Scarred trees are relatively uncommon.

Large numbers of Aboriginal sites are 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 one kilometre strip either side of Cooper Creek, totalling 120km$^2$. It is rich in Aboriginal relics, campsites, quarries and engravings with several unique designs located around Cullyamurra waterhole.

### 5.5.2 Non-Aboriginal Cultural Heritage

Europeans commenced exploration of the region during the 1840s. Pastoral development rapidly followed exploration and by the mid 1880s all available pastoral leases in the region had been taken up.

Rapid pastoral expansion was due in part to the presence of Afghan cameliers who are thought to have advanced the opening up and development of the region by fifty to sixty years. Afghan cameliers 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.

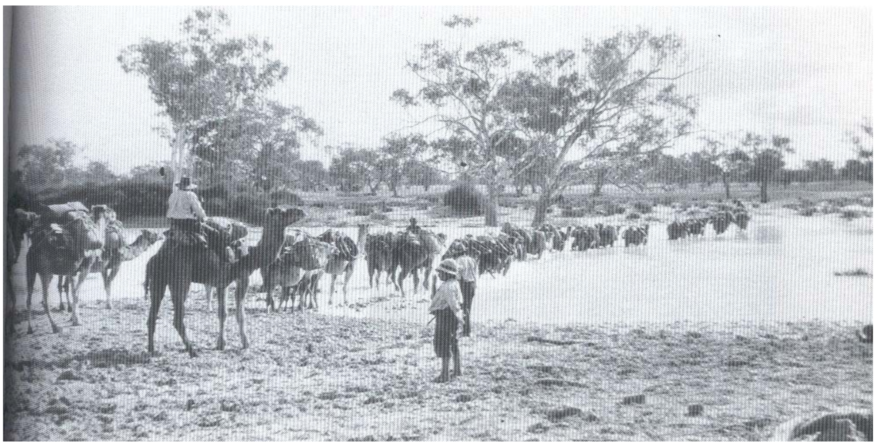


Plate 5-1: Camel Train Carrying Supplies to Cordillo Station at Innamincka c1926 (Tolcher 1986)

There are numerous historical sites scattered throughout the region, many of which are listed on the National Heritage Register. Most sites are associated with exploration and the expansion of pastoralism throughout the north-east deserts.

Historical sites in the far north-east of South Australia listed on the National Heritage Register (2001) as registered or indicative are:

- Blanchewater Homestead on the Strzelecki Track
- Wills Monument and Blazed Tree
- Burke's Memorial
- Grays Tree
- Horse Capstan Pump and Well
- Tinga Tingana Homestead Ruin
- Cordillo Downs Homestead and Woolshed
- Australian Inland Mission Nursing Home (former)
- Cadelga Outstation Ruin.

### 5.5.3 Land use and Tenure

The primary land uses in the basin are pastoralism, oil and gas exploration and production, conservation and tourism (Marree Soil Conservation Board 1997). Sixty percent of the region is used for pastoral production and the majority 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 SACBJV operational area are:

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

The SACBJV operates on four properties that have either obtained a level of certification or are in the process of conversion to NASAA Organic Beef Export. The (OBE) these include Bollards Lagoon, Merty Merty, Mungeranie and Cordillo Downs. The OBE guidelines identify the maximum levels of chemicals (including metals and hydrocarbons) allowable in soil, consistent with allowing organic certification for beef exports.

In addition many landholders in the SACBJV operational region are certified under the Cattle Care Quality Assurance system. Cattle Care is an initiative of the Cattle Council of Australia and places emphasis on minimising the risk of chemical contamination, bruising and hide damage and ensuring that herds are effectively managed and improved. In particular, the contamination of property and livestock by organochlorines and other persistent chemicals must be minimised, and contaminated cattle identified. Prevention of bruising and hide damage puts the onus on landholders to manage the property carefully and reduce the risk of damage from foreign bodies.

Conservation

The region contains some of South Australia's largest conservation reserves dedicated under the *National Parks and Wildlife Act 1972*. The main reserves are Innamincka Regional Reserve and Strzelecki Regional Reserve. Regional Reserves are areas proclaimed for the purposes of conserving wildlife, natural or historical features while allowing responsible use of the areas natural resources. Hence, oil and gas production and processing can occur within Regional Reserve areas. Together, the Innamincka and Strzelecki Regional Reserves account for just over two million hectares of land within the Cooper Basin region (Marree Soil Conservation Board 1997).

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). Coongie Lakes and the adjacent area, and the Cooper Creek floodplain are registered on the National Heritage Register.

Oil and Gas Production

The actual area of land utilized for 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 (Marree Soil Conservation Board 1997). Producing oil and gas fields are spread through pastoral lands, Regional Reserves and the Ramsar wetlands.

SACBJV is the predominate petroleum company in the area, operating a total of 24 gas and oil satellites, the Moomba petroleum processing plant and associated infrastructure (Figure 1-2).

### 5.5.4 Socio-economic

There has been a substantial reduction in numbers of people living and working in the Cooper Basin region over the last 40 years. The present population is small with 250 to 300 residents working in the pastoral industry and a further 600 petroleum industry workers at Moomba (Marree Soil Conservation Board 1997). However, between 40,000 and 50,000 tourists have been estimated to visit the region annually. The Strzelecki Track, Innamincka Regional Reserve and Coongie Lakes wetlands are major tourist attractions in the region.

Infrastructure in the region is minimal. Unsealed roads service the district, with the Strzelecki and Birdsville tracks being the major routes through the region. Moomba and Innamincka are the main population centres (Marree Soil Conservation Board 1997).

The gross value of pastoral production in the region is estimated to be around $37 million per year (Marree Soil Conservation Board 1997). The Cooper Basin operations contribute $50 million in royalties to South Australia each year with total royalties to date amounting to over $650 million (Santos 1998b).

# 6 Consultation

The Cooper Basin is a sparsely populated and remote arid region. The local community broadly includes Innamincka township members, pastoral leaseholders (Table 6-3), the National Parks and Wildlife Service (NPWS), tourists, and petroleum producers and associated contractors.

The Cooper Basin region contains numerous sites of natural and historical interest. In 1987, a portion of the Cooper Basin was incorporated into the Innamincka Regional Reserve. The aim of the reserve is to promote the preservation of natural and historical sites, whilst maintaining an appropriate level of sustainable development.

The SACBJV is a member of the local community and as such recognises the importance of open communication and consultation during production and processing activities and a pro-active contribution to the area as a whole. The SACBJV has operated in the Cooper Basin since the early 1960s and has participated at many levels of the consultative process, from policy making to landowner/occupier liaison. The company has promoted the exchange of information to facilitate good working relations with landowners and stakeholders, and has contributed to regional management and development of the Cooper Basin.

It is a requirement under the *Petroleum Regulations 2000* that information on consultation with relevant landowners, government departments or agencies, Aboriginal groups or representatives, or any other interested person or parties be outlined in an EIR.

Liaison with stakeholders, for information exchange and to promote understanding and reconciliation of competing interests, is inherent in meeting statutory requirements and is considered by the Australian Pipeline Industry Association (APIA Code of Environmental Practice 1996) and PIRSA to be 'good business practice'. Accordingly, the SACBJV has undertaken ongoing consultation with key stakeholders in the Cooper Basin throughout its operation in the region. Stakeholders include regulatory agencies, industry groups and environmental organisations, local tourism and community. An overview of each stakeholder group and issues raised through consultation in the past is provided in the following sections and in tables 6-1, 6-2 and 6-3.

### Table 6-1: Stakeholder Consultation: Government Agencies

| Department/Agency | Key Issues |
|---|---|
| Environment Australia | ▪ EPBC Act 1999 requirements |
| Environment Protection Authority | ▪ Licensing and reporting requirements<br>▪ Monitoring and reporting of particulate emissions from Moomba plant<br>▪ Water quality monitoring in evaporation ponds<br>▪ Environmental incident reporting (significant environmental incidents)<br>▪ Waste licensing |
| Department of Environment & Heritage | |
| ▪ National Parks and Wildlife Services (NPWS) | ▪ Production and processing activities in designated conservation reserves/areas (eg. Innamincka Regional Reserve, Strzelecki Regional Reserve and Coongie Lakes) |
| ▪ Department of State Aboriginal Affairs (DOSAA) | ▪ Aboriginal Heritage Issues |
| ▪ Heritage SA | ▪ Innamincka State Heritage Area<br>▪ Heritage Sites |
| PIRSA | ▪ Licensing and reporting requirements<br>▪ Action plans and Key Performance Indicators (KPIs)<br>▪ Oil spill remediation<br>▪ Produced formation water monitoring and management<br>▪ Environmental incident reporting (significant environmental incidents) |
| Pastoral Management Board (within PIRSA) | ▪ Stocking rates<br>▪ Access to water<br>▪ Access roads and fences maintenance |
| Department of Water, Land and Biodiversity Conservation | ▪ GAB sustainability<br>▪ Produced formation water |
| Tourism SA | ▪ Third party use of lease areas<br>▪ Maintenance of roads<br>▪ Third party safety |
| Transport SA | ▪ Construction and maintenance of road infrastructure in the Cooper Basin region |
| Planning SA | ▪ Major projects |

### Table 6-2: Stakeholder Consultation: Industry Groups

| Industry Group | Key Issues |
|---|---|
| South Australian Chamber of Mines and Energy (SACOME) | ▪ Petroleum production and development |
| Santos Joint Venture Partners | ▪ Petroleum production and development |
| Petroleum contractors | ▪ Petroleum production and development |
| Petroleum developers | ▪ Petroleum production and development |
| Pipeline operators | ▪ Petroleum production and development |

Table 6-3: Stakeholder Consultation: Community and Environmental Groups

| Community/Environmental Group | Key Issues |
|---|---|
| Representatives of Aboriginal groups | ▪ Identification and preservation of Aboriginal cultural heritage sites |
| Arid Areas Catchment Water Management Board | ▪ Cooper Creek catchment management |
| Australian Conservation Foundation | ▪ Issue by issue (eg. operational activities in designated RAMSAR areas) |
| Conservation Council of South Australia | ▪ Issue by issue (eg. operational activities in designated RAMSAR areas) |
| Cooper Creek Catchment Committee | ▪ Cooper Creek catchment management |
| SA Farmers Federation | ▪ NASAA organic beef certification requirements<br>▪ Water access<br>▪ Pest control |
| Great Artesian Basin Consultative Council | ▪ GAB water extraction |
| Innamincka Progress Association | ▪ Land use issues |
| Lake Eyre Basin Coordinating Group | ▪ Cooper Creek catchment management<br>▪ Multiple landuse strategies for the Cooper Basin |
| Marree Soil Conservation Board | ▪ Issue by issue (eg. pest control, provision of information) |
| Nature Conservation Society | ▪ Issue by issue (eg. operational activities in designated RAMSAR areas) |
| Pastoral leaseholders | ▪ Land access<br>▪ Lease arrangements<br>▪ NASAA organic beef certification requirements<br>▪ Cattle Care Quality Assurance System |
| Wilderness Society | ▪ Flora, fauna and biodiversity issues |

As demonstrated in the above tables, key stakeholders are aware of and understand the relevant issues associated with the SACBJV's production and processing operations in the Cooper Basin. The SACBJV have been operating in the region for over 30 years and has been consulting with relevant stakeholders during that time. This document has been prepared as a result of changes to the Petroleum Act and associated regulations and a specific consultation process has been undertaken to assist in its preparation (refer Section 6.3).

## 6.1 Aboriginal Consultation

The SACBJV recognises the importance of working with traditional landholders and all personnel and contractors working in the field have an important role to play in ensuring that SACBJV fulfils its commitment to protect Aboriginal heritage.

There are currently three Native Title Claims in the South Australian Cooper Basin. Details of each claim are presented in Table 6-4.

Table 6-4: Native Title Claims in the South Australian Cooper Basin

| Title | Location | Approx. Size (km²) | Status | Representative |
|---|---|---|---|---|
| Dieri Mitha | An area in the north-east part of SA including Lake Eyre, parts of the Simpson Desert, the Warburton River and Cooper Creek region and Lake Blanche | 119,445 | Not accepted for registration | Aboriginal Legal Rights Movement Inc. |
| Yandruwandha/ Yawarrawarrka Native Title Claim | North-east corner of SA extending south to Lake Blanche | 40,304 | Accepted for registration | Aboriginal Legal Rights Movement Inc. |
| The Edward Landers Dieri People's Native Title Claim | From Marree in the south to Cameron Corner in the east, to Hodden Corner in the north-east, following the Qld border to Lake Teetatobie, south-west of Gypsum Cliff, west to Lake Eyre, south to Marree | 87,733 | Accepted for registration | Aboriginal Legal Rights Movement Inc. |

All SACBJV personnel are trained in the recognition and management of Aboriginal heritage sites (Santos 1998a). In addition, where appropriate, archaeologists and Aboriginal monitors are utilized to identify and protect Aboriginal sites during new construction works, such as pipeline construction.

The SACBJV aspires to best possible corporate practice and citizenship. As a result the SACBJV is working to enhance its strategies for Aboriginal community relations and consultation by improving consultative processes and developing proactive action plans. The aims are to provide a:

- framework to approach consultation
- positive means of assisting community through employment, training and education opportunities.

Santos, in association with other Cooper Basin operators, is in the process of negotiating Indigenous Land Use Agreements (ILUA) for newly released exploration acreage in the South Australian Cooper Basin. It should be noted that current Santos PPLs are exempt from Native Title and therefore no ILUAs have been entered into.

The SACBJV recognises the importance of processes, such as the ILUA, and strives to improve and develop all aspects of relations with the Aboriginal community.

## 6.2 Government and Community

Interaction with government has occurred at all levels of SACBJV operations throughout the Cooper Basin in order to facilitate better understanding of project issues and meet regulatory and statutory requirements.

There are a number of established working groups in the Cooper Basin region. The SACBJV acknowledges the importance of contributing to the wider community in which it operates and has actively contributed to a number of these groups, including:

- Marree Soil Conservation Board
- Cooper's Creek Catchment Committee (CCCC)
- Arid Areas Catchment Water Management Board
- Lake Eyre Basin Coordinating Group.

The SACBJV have further provided input to community projects including:

- Innamincka Regional Reserve
- Coongie Lakes Control Zone Management Plan
- Coongie RAMSAR boundary review and Management Plan
- Royal Flying Doctor Service (RFDS)
- road maintenance.

The Lake Eyre Catchment Management Framework was initiated in 1995, and consequently the Lake Eyre Basin Coordinating Group was formed. This oversees the CCCC and contains other catchment groups, government observers, selected individuals with required knowledge and an independent chairperson. The aim is to develop regional catchment environmental management strategies based on stakeholder input, cooperation and discussion, and develop a framework for grass roots participation in decision making. The CCCC consists of representatives from community, industry, interest groups and government observers.

The SACBJV provides a mining and petroleum industry representative to the CCCC. This is an important forum for the development of longterm multiple landuse environmental management strategies and communication between all groups within the region.

The SACBJV has consulted with industry groups where those groups have been identified as having an interest in the development of the Cooper Basin and associated operations.

The SACBJV's zone of operations includes landholders and pastoral leases. Issues of land access and lease arrangements have been negotiated at an individual and collective level with pastoral leaseholders and managers.

The Central Australia Business Unit, Santos, has been responsible for stakeholder consultation in South Australia with interested environment groups. To date this has occurred on an issue-by-issue basis.

## 6.3 EIR and SEO Consultation Process

A stakeholder consultation process was a key component of the preparation of this Environmental Impact Report for Production and Processing Operations and its associated Draft Statement of Environmental Objective prior to its submission to PIRSA for review and approval. Consultation workshops were held in both Adelaide and Moomba and an overview of this process, including a list of key stakeholders, is provided in Appendix E. Throughout the consultation process, a number of issues were raised resulting in changes to both the EIR and SEO. These comments and the response to them are summarised in Appendix F.

# 7 Environmental Hazards and Consequences

This chapter identifies and assesses potential environmental hazards and their consequences resulting from SACBJV operations in the Cooper Basin. These have been identified to allow for the assessment of environmental risks and management requirements (Chapter 8).

A hazard is considered to be any source of potential environmental harm, or a situation or event with potential to cause loss (AS/NZS 4360 1999). To identify hazards, the various activities associated with each group of facilities (ie. gathering systems, gas satellite facilities etc.) were considered and the events that could lead to a hazardous situation, and the possible consequences of these events, were identified.

Where possible, environmental hazards and potential consequences have been identified and assessed on the basis of existing information on the magnitude (for example quantity of waste) and/or frequency of activities associated with the SACBJV's operations. However, this information is not available with regard to all activities and associated hazards. Where this is the case, environmental hazards and subsequent consequences have been identified on the basis of petroleum industry experience.

Based on available information the environmental hazards associated with production and processing operations in the Cooper Basin that have potential to result in the most significant environmental consequences are identified as:

- storage and disposal of process wastes (for example, oil sludge)
- accidental spills or leaks associated with pipeline failure or storage of oil, fuels and chemicals
- disposal of domestic and chemical waste and contaminated soil
- emissions vented from satellites and the Moomba processing plant
- earthworks associated with pipeline and road construction.

Key potential environmental consequences associated with the above hazards are:

- contamination of soil, groundwater and/or watercourses
- atmospheric pollution
- soil erosion and disturbance to natural drainage patterns
- disturbance to Aboriginal and non-Aboriginal cultural heritage sites
- loss of native vegetation and habitat
- introduction and/or spread of weeds, pest plants, animals and pathogens
- disturbance or injury to native fauna
- personnel injury or loss of life.

The extent of the consequence is determined by the character of the receiving environment (ie. gibber, dunefield, floodplain etc.) and the size and nature of the hazard (for example, road construction, pipeline rupture, explosion etc.) and effectiveness of the SACBJV's procedures and guidelines in minimising potential impacts. (These procedures and guidelines are discussed in detail in Section 8.2).

Potential environmental hazards and consequences associated with the operations are discussed further in the following sections.

## 7.1 Gathering Systems

### 7.1.1 Pipeline Construction

Environmental hazards associated with pipeline construction include movement of vehicles, earthworks, vegetation clearance, spills associated with chemical and fuel storage and waste disposal. Both flooding (of the Cooper Creek floodplain and associated watercourses) and fire are also considered to be potential environmental hazards associated with pipeline construction.

Horizontal directional drilling and associated fluids are not considered to be hazards as this method of construction is unlikely to be required for pipeline construction activities in the Cooper Basin. A separate approval process applies to directional drilling operations, and hazards associated with this activity need to be assessed at the time of application for approval.

Movement of vehicles (for example, trucks and side boom tractors) is an environmental hazard as there is a possibility that vehicles may inadvertently damage vegetation, generate dust and/or compact soil if not appropriately managed. Earthworks can result in similar consequences, as well as potentially disturbing sites of cultural significance and exposing soils to wind and water erosion.

The type and severity of potential impacts of earthworks is dependent, to a certain extent, on the land system in which the activities are being carried out. Disturbance of soils in some land systems, such as gibber plains and tablelands, can lead to substantial erosion by water while other systems, such as dunefields, are generally more resilient and less likely to suffer any long-term impacts from soil disturbance. Following an examination of 35 seismic lines that traversed dunefields in the Cooper Basin, SEA (1999) concluded that natural rates of erosion on dunes were not accelerated as a result of disturbance to the soil surface.

Wetlands are avoided under most circumstances when planning pipeline routes as they are often of high ecological value and sensitivity. Salt lakes are also avoided as rehabilitation is difficult to undertake and they are therefore likely to be severely scarred by pipeline construction activities.

The potential impacts of specific earthwork activities on different land systems in the Cooper Basin are summarised in Table 7-1.

## Table 7-1: Impacts Associated with Earthworks in Various Cooper Basin Land Systems

| Land System | Activity/Hazard | | | |
|---|---|---|---|---|
| | Grading (15-25m ROW for buried pipelines, 10m for aboveground pipelines) | Trenching and Backfilling (0.75 - 2m depth) | Excavation/Digging (eg. borrow pits) | Soil Stockpiling |
| Wetlands | N/A | N/A | N/A | N/A |
| Floodplains | • Soil erosion (wind and water)<br>• Soil compaction<br>• Disturbance of natural drainage systems (ROW restricted to 8m at creek crossings)<br>• Disturbance to cultural heritage sites (generally low density of sites in floodplains) | • Disturbance of natural drainage systems (ROW restricted to 8m at creek crossings)<br>• Inversion of the soil profile<br>• Disturbance to cultural heritage sites (generally low density of sites in floodplains)<br>• Impeded fauna movement | • Soil erosion (wind and water)<br>• Disturbance of natural drainage systems<br>• Disturbance to cultural heritage sites (generally low density of sites in floodplains) | • Disturbance of natural drainage systems (eg. siltation)<br>• Soil erosion (wind and water) |
| Gibber plains | N/A | • Soil erosion (particularly susceptible to water erosion, eg. severe gullying)<br>• Disturbance of natural drainage systems (eg. siltation)<br>• Inversion of the soil profile<br>• Disturbance to cultural heritage sites<br>• Impeded fauna movement | • Soil erosion (particularly susceptible to water erosion, eg. severe gullying)<br>• Disturbance of natural drainage systems (eg. siltation)<br>• Inversion of the soil profile<br>• Disturbance to cultural heritage sites | • Soil erosion (wind and water)<br>• Disturbance of natural drainage systems<br>• Inversion of the soil profile |
| Tablelands | N/A | • Soil erosion (particularly susceptible to water erosion, eg. severe gullying)<br>• Soil compaction<br>• Disturbance of natural drainage systems (eg. siltation)<br>• Inversion of the soil profile<br>• Disturbance to cultural heritage sites<br>• Impeded fauna movement | N/A | • Soil erosion (wind and water)<br>• Disturbance of natural drainage systems<br>• Inversion of the soil profile |
| Dunefields | • Soil erosion (wind and water erosion)<br>• Disturbance to cultural heritage sites (dunefields near waterholes are typically of high cultural significance) | • Soil erosion (wind and water erosion)<br>• Disturbance to cultural heritage sites (dunefields near waterholes are typically of high cultural significance)<br>• Inversion of the soil profile<br>• Impeded fauna movement | • Soil erosion (wind and water erosion)<br>• Disturbance to cultural heritage sites (dunefields near waterholes are typically of high cultural significance)<br>• Inversion of the soil profile | • Soil erosion (wind erosion)<br>• Inversion of the soil profile |
| Salt lakes | N/A | N/A | N/A | N/A |

N/A - not applicable as the activity is not carried out in this land system.

Other activities along the construction ROW, such as vegetation clearing, can result in loss of vegetation and fauna habitat, siltation of natural drainage lines and watercourses, destabilisation of creek crossings, weed invasion and damage to cultural heritage sites. Vegetation clearance may also impede the movement of fauna within the construction zone. Particular care is taken to ensure that minimal vegetation is cleared in coolibah woodland during ROW preparation. The ROW is limited to 8m in any heavily wooded areas.

A potential source of leaks and/or spills during construction is from chemical and fuel storage areas and refuelling depots associated with construction works. The primary consequence of any leak or spill is localised soil contamination. Discharge of hydrotest water to the ground surface is another potential source of localised soil and groundwater contamination.

The use of biocides and chemicals in hydrostatic test water is required under some circumstances to prevent internal corrosion of the pipeline. Disposal of hydrostatic test water, which contains biocide or other chemicals, may be into existing lined evaporation ponds (ie. produced formation water facilities) or to specifically constructed pits sited to prevent contamination of surface or near surface waters. Test water that is free of additives may be disposed of to land adjacent to the construction zone.

The occurrence of flooding or fire during construction works has a number of potential consequences. For flooding, there is the potential for significant soil erosion in areas that have been subject to earthworks and possibly loss of vegetation. However, this is minimised through planning and procedures which aim to minimise these impacts. In the case of a fire, loss of vegetation and fauna habitat and production of particulate air emissions are possible consequences.

Pipeline construction generates very little waste. Many materials such as pipe off-cuts, rope spacers and timber skids, can be reused or recycled. All remaining waste materials are removed from the work area and disposed at the Moomba Waste Depot.

The impacts associated with construction activities (for example earthworks such as clearing and trenching) are managed by the SACBJV procedures and guidelines. These are discussed in further detail in Section 8.2.

Table 7-2: Summary of Hazards and Potential Consequences Associated with Pipeline Construction

| Hazard | Potential Consequence/s |
|---|---|
| Movement of machinery and vehicles | ▪ Dust generation<br>▪ Soil compaction<br>▪ Soil erosion<br>▪ Damage to native vegetation<br>▪ Injury or death of native fauna<br>▪ Disturbance to cultural heritage sites<br>▪ Introduction and/or spread of weeds<br>▪ Damage to third party infrastructure<br>▪ Disruption to land use (eg. grazing and recreation)<br>▪ Increased public access to remote areas |
| Spills and leaks associated with chemical and fuel storage | ▪ Contamination of soil, groundwater and/or watercourses<br>▪ Access to contaminants by stock and wildlife |
| Earthworks | ▪ Injury or death of fauna in construction zone<br>▪ Loss of visual amenity<br>▪ Damage to native vegetation<br>▪ Introduction and/or spread of weeds<br>▪ Disturbance to natural drainage patterns<br>▪ Damage to third party infrastructure<br>▪ Soil erosion and siltation of watercourses<br>▪ Inversion of soil profile<br>▪ Dust generation<br>▪ Soil compaction<br>▪ Disturbance to cultural heritage sites |
| Ignition of fire along ROW | ▪ Disturbance to cultural heritage sites<br>▪ Loss of vegetation and fauna habitat<br>▪ Release of particulate emissions to the atmosphere<br>▪ Disruption to land use (eg. grazing and recreation) |
| Disposal of hydrotest water | ▪ Contamination of soil and/or watercourse<br>▪ Loss of vegetation and fauna habitat as a result of soil or water contamination |

### 7.1.2 Pipeline Operation

The primary hazard associated with pipeline operation is the loss of oil or natural gas. During 2000, Santos reported 19 oil spill incidents with a cumulative volume of 30m$^3$ of crude oil spilt in the Cooper Basin region. Accidental spills and leaks may result from pipeline failure, which may be caused by:

- heavy vehicle traffic (for example, collision with an aboveground pipeline)
- corrosion of the pipeline (external or internal)
- natural events which stress the pipeline (for example, flood / earthquake)
- overpressure
- metallurgical or construction faults.

A gas or oil leak from the pipeline may result in the release of gas to the atmosphere or contamination of soil or groundwater respectively. The potential exists for oil and condensate to be spilt at any point between an oil well and satellite station. Many of the impacts associated with oil spills and leaks, such as vegetation loss, soil disturbance and drainage alteration, can be minimised. However, this largely depends on the land system involved.

In dry environments, such as dunefields and gibber, the impacts associated with an oil spill are mainly localised, as oil is easier to contain and recover in dry conditions, and therefore the consequence of a spill would be considered negligible.

However, the environmental consequences of oil spills in more sensitive wet environments, like the Cooper and Strzelecki creeks and surrounding floodplains and wetlands, are potentially significant and of major consequence. Of primary concern are flood conditions that can potentially spread oil over large distances and throughout highly sensitive ecosystems.

Nodal compressors are typically situated in dry environments to ensure they are not affected by flooding. Therefore, the consequence of a spill from a compressor would be considered negligible, as discussed previously for dry environments.

Fire and explosion are also possible hazards associated with pipeline operation. A fire or explosion along a pipeline can pose a danger to personnel, contractors and possibly the public and can potentially produce significant amounts of atmospheric emissions.

Regular monitoring of the performance of cathodic protection devices is undertaken to ensure that protection levels are adequate. Major pipelines are also regularly pigged to remove water and sludge that accumulates at low points within pipelines. Sludge often supports sulphide reducing bacteria that are a significant cause of internal corrosion of pipelines in the Cooper Basin. Internal inspection frequencies for oil pipelines are described in Procedure 3.4.1 Oil Pipeline Management System (Santos 1999d).

Aboveground pipelines may come in contact with the ground resulting in the formation of 'long line corrosion cells' and result in rapid pitting of the pipe and possible pipeline rupture. These pipelines are regularly inspected to ensure that they do not come into contact with the ground as a result of soil movements or failure of pipe supports.

The Santos Pipeline Management System and associated procedures and guidelines aim to reduce the potential for explosion or fire and spills or leaks. These procedures are discussed in further detail in Section 8.

Several studies are currently being undertaken, including the Cooper Creek Oil Spill study (Section 8.2.10) and the Oil Spill Remediation End Point Criteria study (Section 8.2.11). These studies aim to determine the consequences of oil spills in both dry and wet conditions and develop appropriate remediation guidelines.

### Table 7-3: Hazards and Potential Consequences Associated with Pipeline Operation

| Hazard | Potential Consequence/s |
|---|---|
| Explosion or fire along an oil or gas pipeline | ▪ Contamination of soil and/or watercourse<br>▪ Atmospheric pollution<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Loss of vegetation and fauna habitat<br>▪ Disruption to land use (eg. grazing) |
| Spill or leak associated with pipeline failure | ▪ Contamination of soil and/or watercourse<br>▪ Disruption to land use (eg. grazing)<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Atmospheric pollution (gas)<br>▪ Access to contaminants by stock and wildlife |
| Spill or leak associated with nodal compressor failure | ▪ Contamination of soil and/or watercourse<br>▪ Disruption to land use (eg. grazing)<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Atmospheric pollution (gas)<br>▪ Access to contaminants by stock and wildlife |
| Spill associated with transport of oil and condensate (via truck) | ▪ Contamination of groundwater, surface water and soil<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Access to contaminants by stock and wildlife |

## 7.2 Satellite Facilities

### 7.2.1 Oil and Gas Satellites

Environmental hazards associated with the operation of oil and gas satellites include production of atmospheric emissions (via fugitive, flare and venting sources), loss of containment of oil or gas and storage of chemicals and fuels.

Emissions of particular environmental significance (ie. known atmospheric pollutants and/or greenhouse gases) are:

- combustion by-products (for example, oxides of nitrogen, carbon monoxide and sulphur dioxide)
- methane and organic carbon from fugitive sources
- flared propane, butane, methane and some ethane
- vented $CO_2$, $H_2S$, and CO.

A total of approximately 10,182 tonnes of propane, butane, methane and some ethane are flared to the atmosphere from satellites each year. The annual quantity of vented $CO_2$, $H_2S$, and CO is not available. Similarly, estimates for fugitive emissions and combustion by-products are not available. As discussed in Section 8.2.12 Air Emissions Management, the SACBJV recognises the importance of maintaining an appropriate standard of air quality and whilst the operations are located in the isolated far north-east of South Australia the SACBJV aims to minimise atmospheric emissions and manage operations to comply with regulatory requirements.

There is the potential for accidental spills or leaks of small amounts of process chemicals (for example, PFW emulsion breakers), cleaning chemicals or fuels during storage or handling and use. However, all chemicals and fuels (including oil storage tanks and waste sump oil pits) are stored on impervious bunded surfaces.

Accidental spills/release of oils or gas may also occur as a result of pipeline failure or leaks from satellite equipment such as the inlet header, trunkline connection or satellite valves.

There is also potential for accidental overflow of oil storage tanks at satellites. Leaks, spills and overflows can potentially lead to localised soil contamination within the satellite site and may be a potential ignition source for fire.

The impacts associated with satellite operations are managed by the SACBJV procedures and guidelines. These are discussed in further detail in Section 8.2.

Regular monitoring of emergency shutdown valves, fire protection, detection and control systems is undertaken to ensure that protection levels are adequate (see Section 8.2.7).

The flooding of surrounding floodplain/watercourses has a number of potential consequences including damage to infrastructure. However, these are minimised through planning and procedures.

**Table 7-4: Hazards and Potential Consequences Associated with Satellite Operation**

| Hazard | Potential Consequence/s |
|---|---|
| Explosion or fire at the satellite | ▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Contamination of soil and/or watercourse<br>▪ Atmospheric pollution (gas) |
| Flooding of surrounding floodplain/watercourses | ▪ Contamination of soil and/or groundwater<br>▪ Damage to infrastructure (eg. evaporation ponds)<br>▪ Access to contaminants by stock and wildlife |
| Spills and leaks associated with chemical and fuel storage | ▪ Contamination of soil, groundwater and/or watercourses<br>▪ Access to contaminants by stock and wildlife |
| Fugitive emissions of methane and organic carbon from the process plant | ▪ Release of greenhouse gases contributing to climatic warming |
| Venting of $CO_2$, $H_2S$ and CO | ▪ Release of greenhouse gases contributing to climatic warming |
| Flaring of propane, butane, methane and ethane from process plants | ▪ Release of greenhouse gases contributing to climatic warming |
| Loss of containment of gas or oil (pipeline rupture or leaks from satellite equipment) | ▪ Contamination of soil and/or watercourse<br>▪ Atmospheric pollution<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Access to contaminants by stock and wildlife<br>▪ Loss of vegetation and fauna habitat |

### 7.2.2 Utilities

There are two satellite camps which house SACBJV employees who work at outlying satellites, Dullingari and Tirrawarra (Figure 2-1). The primary hazard associated with these facilities is the storage of domestic waste and sewage.

Domestic waste is transported to Moomba and is disposed of at the Moomba Waste Facility (Section 7.6.2). Sewage and grey water is treated in septic tanks that are located on site at each camp. There is a potential for localised contamination of soil and groundwater as a result of leaks from septic tanks. Quantities of sewage generated at satellite camps are not currently measured.

**Table 7-5: Hazards and Potential Consequences Associated with Disposal of Domestic Waste and Sewage**

| Hazard | Potential Consequence/s |
|---|---|
| Storage of waste at camps and transport and disposal to landfill (ie. Moomba waste facility) | ▪ Scavenging by native and pest species<br>▪ Pest outbreaks<br>▪ Contamination of soil and/or groundwater |
| Spills or leaks associated with disposal and treatment of sewage in septic tanks | ▪ Localised contamination of soil and/or groundwater |

## 7.3 Produced Formation Water

The most significant hazard associated with the operation of satellites is the storage and treatment of large volumes of produced formation water (PFW). Between 7,000,000m$^3$-9,000,000m$^3$ of PFW is produced each year and is stored in around 36 different evaporation ponds (Table 4-4). This quantity includes PFW from the Moomba plant.

Produced formation water can be highly saline and contain chemicals (both natural and added), residual hydrocarbons and some naturally occurring heavy metals. A current list of known contaminants found in PFW is presented in Table 7-6.

Potential contamination of soil and groundwater may result from leaks in separation tanks, interceptor ponds and bunded or free form evaporation ponds. Subsurface movement can also lead to mounding of PFW outside evaporation ponds.

The potential environmental consequences associated with PFW disposal include:

- contamination of soil and near surface aquifers by any carried over hydrocarbon or process chemicals or naturally occurring metals
- the contamination of soil and associated vegetation with salts and metals naturally occurring, but concentrated in the PFW
- ingestion of contaminants by native fauna or stock.

**Table 7-6: Process Formation Water Contaminants**

| Biological | Nutrients | Inorganic | | Organic |
|---|---|---|---|---|
| Faecal coliforms<br>Blue-green algae<br>Chlorophyll-a | Ammonia-Nitrogen<br>Nitrate-Nitrogen<br>Nitrite-Nitrogen<br>Nitrogen<br>Phosphorus | Aluminium<br>Antimony<br>Arsenic<br>Beryllium<br>Boron<br>Cadmium<br>Chromium<br>Copper<br>Fluoride<br>Iron<br>Lead<br>Mercury<br>Molybdenum<br>Nickel | Selenium<br>Silver<br>Sodium<br>Chloride<br>Vanadium<br>Zinc<br>Sulphate<br>Sulphide | Benzene<br>Benzo(a)pyrene<br>Oil and Grease<br>Pentachlorophenol<br>Phenol<br>Phenolics<br>Phthalate esters<br>Polycyclic aromatic hydrocarbons<br>Polychlorinated biphenyls<br>Tetrachlorophenol<br>Toluene<br>2,4-dichlorophenol<br>1,2,3-trichlorobenzene<br>1,2,4-trichlorobenzene<br>1,3,5-trichlorobenzene<br>2,4,5-trichlorophenol |

Also there is the potential for birds and other wildlife to come into contact with residual hydrocarbons and other contaminants (ie. heavy metals) in interceptor pits. Oiled birds may suffer from restricted movement and distress and often do not survive the effects of ingesting oil and other hydrocarbons.

The SACBJV is currently undertaking a PFW disposal project, outlined in the Santos Action Plan (Santos, January 2000). The project aims to quantify and assess the suitability of current PFW disposal management and to determine potential areas for improvement (refer to Section 8.2.8).

The PFW disposal project comprises:

- a sediment sampling project to determine the presence and levels of contamination in evaporation ponds
- the development of sediment criteria
- a remediation/restoration trial
- development of water quality criteria to ensure the appropriate environmental management of PFW disposal.

Preliminary results of the sediment sampling project indicate that the principal contaminants of concern in the PFW ponds are mercury, polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPH) and total phenolics. Concentrations of these contaminants generally decrease through the PFW pond series (ie. decreasing through the treatment process). Overall concentrations of mercury, PAH and TPH (aliphatic and aromatic) have been found in higher concentrations at gas facilities compared with oil facilities.

The primary purpose of the Action Plan (Santos, January 2000) has been to determine appropriate water quality criteria for the operation of PFW disposal facilities in the South Australian Cooper Basin. The appropriate approach for determining site specific water quality criteria is currently being determined and agreed upon by Santos, PIRSA and the Environment Protection Agency (EPA).

The flooding of PFW ponds and surrounding floodplain/watercourses has a number of potential consequences including contamination to soil and groundwater and damage to infrastructure. However, these are managed and minimised through planning and management procedures.

**Table 7-7: Hazards and Potential Consequences Associated with PFW Disposal**

| Hazard | Potential Consequence/s |
|---|---|
| Storage and disposal of PFW at satellites | ▪ Contamination of soil and/or groundwater<br>▪ Access to contaminants by stock and wildlife |
| Flooding of surrounding floodplain/watercourses | ▪ Contamination of soil and/or groundwater<br>▪ Damage to infrastructure (eg. evaporation ponds)<br>▪ Access to contaminants by stock and wildlife |

## 7.4 Moomba Plant – Process Facilities

Hazards that are common to all facilities and processes include the release of fugitive emissions of methane to the atmosphere and spills or leaks of oils and chemicals.

A Fitness for Purpose report (FFP) for SACBJV operations was prepared in accordance with Regulation 30 of the *Petroleum Act 2000*. This is discussed in greater detail in Section 8.2.7.

Emissions of particular environmental significance (ie. known atmospheric pollutants and/or greenhouse gases) include:

- exhaust gases ($CO_2$, $CH_4$) from compressors, boilers and flares
- hydrocarbons from tank venting and PSV venting required for safety
- hydrogen sulphide from the RGCP
- propane, butane, methane and some ethane flared to atmosphere to maintain safety integrity
- $CO_2$ removed from raw gas to meet the sales gas specification
- combustion by-products (for example, oxides of nitrogen, sulphur dioxide and carbon monoxide) from engines and flares
- methane and organic carbon from fugitive sources
- small quantities of particulate material from flares.

In 2000, a total of 4,639,287 tonnes of $CO_2e$ (greenhouse gas) was produced at the Moomba processing operations. A breakdown of the contributing processes is presented in Table 7-8. Additional emissions, reported as part of National Pollution Inventory (NPI) requirements, are presented in Table E1 (Appendix G).

**Table 7-8: Annual Greenhouse Gas Emissions at Moomba (Measured as CO2e)**

| Process | Source | $CO_2$ e tonnes/yr | % Total Emission |
|---|---|---|---|
| Power Generation (Combustion) Turbines | Gas | 21,489 | 0.46 |
| Process Drivers (Combustion)<br>Turbines<br>Engines | Gas<br>Diesel<br>Gas | 609,436<br>18,819<br>295,656 | 13.17<br>0.41<br>6.37 |
| Furnaces/Heaters/Boilers/Reboilers | Gas Fired Heater | 464,374 | 10.01 |
| Gas Venting | Raw Gas ($CO_2$) Removal<br>Other Process Venting | 2,672,920<br>318,513 | 57.61<br>6.87 |
| Flares | Flare | 219,664 | 4.73 |
| Fugitive Emissions | Fixed Roof Tank (thru-put)<br>Floating Roof Tank (thru-put)<br>General Leaks (thru-put) | 2<br>3<br>7,258 | <0.01<br><0.01<br>0.16 |
| Transport/Loading<br>Land<br>Air (Aviation Fuel Only) | Diesel vehicles<br>Rotary Wing<br>Fixed Wing | 9,526<br>166<br>1,088 | 0.20<br><0.01<br>0.02 |
| Rail/Truck Loading Losses | | 373 | 0.01 |
| **TOTAL** | | **4,639,287** | **100.00** |

### 7.4.1 Gas Processing

The processing of gas at the Moomba plant involves several stages:

- inlet separation
- raw gas conditioning
- liquids recovery.

Inlet Separation

The main hazard associated with the inlet separation process is the disposal of process wastes. Process wastes are disposed of as follows

- Oil sludge is disposed of in land treatment units (LTUs)
- Sour water is piped to Lake Brooks and the northern evaporation pond
- PFW is disposed of in the northern evaporation pond at the Moomba plant.

It is indicated that approximately 3400 $m^3$ of oil sludge is generated at Moomba annually, of which 1300$m^3$ goes to LTUs and 2,100$m^3$ is recovered to process. Quantities of sour water transferred to Lake Brooks are currently unknown, but studies underway to assess its potential contaminants and concentrations. Approximately 300$m^3$/day of PFW (total from all processes) can be treated at the northern evaporation pond (NEP).

The possible consequence of waste handling and disposal at each of the above sites may potentially result in contamination (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 northern evaporation pond and associated interceptor pond also pose a hazard to wildlife (ie. birds). As with interceptor ponds at satellites, there is the potential for birds to ingest contaminants and/or become oiled.

The impacts associated with Moomba plant operations are managed by the SACBJV procedures and guidelines. These are discussed in further detail in Section 8.2.

SACBJV is also currently undertaking a PFW disposal research project, as detailed previously in Section 7.3, to quantify and assess the suitability of current PFW disposal management and to determine possible areas for improvement.

**Table 7-9: Hazards and Potential Consequences Associated with the Inlet Separation Process**

| Hazard | Potential Consequence/s |
|---|---|
| Oil sludge disposal to sludge pit then to LTU | ▪ Contamination of soil and/or groundwater |
| Sour water disposal to sour water pit then Lake Brooks | ▪ Localised acidification of soil |
| PFW disposal to northern evaporation pond | ▪ Contamination of soil and/or groundwater<br>▪ Access to contaminants by stock and wildlife |

Raw Gas Conditioning Plant

The hazards associated with the raw gas conditioning plant include the emission of $CO_2$ and $H_2S$ vented to the atmosphere, and wastewater disposal. Disposal of wastewater associated with the $CO_2$ removal process requires particular attention due to the addition of vanadium as a requirement of the process.

Treated wastewater is currently pumped to Lake Brooks and the northern evaporation pond. There is the potential for soil and groundwater contamination and/or salinisation at both sites.

A fully lined evaporation pond has been constructed adjacent to the existing northern evaporation pond for storage of potentially contaminated waters, and to prevent further vanadium contamination. A study into contaminant concentrations and future use of the original northern evaporation pond is currently being undertaken.

The impacts associated with Moomba plant operations are managed by the SACBJV procedures and guidelines. These are discussed in further detail in Section 8.2. SACBJV is also currently undertaking a PFW disposal research project, as detailed previously in Section 7.3, to quantify and assess the suitability of current PFW disposal management and to determine possible areas for improvement.

A study is also currently being undertaken to investigate wastewater disposal options for the Moomba plant.

Releases of $CO_2$ and $H_2S$ can contribute to atmospheric pollution. Typical composition of air emissions from the $CO_2$ removal process include substantial quantities of $CO_2$ and small amounts of:

- water vapour
- hydrogen sulfide
- methane
- vanadium
- potassium carbonate.

As discussed in Section 8.2.12 Air Emissions Management, the SABJV recognises the importance of maintaining an appropriate standard of air quality. Whilst the operations are located in the isolated far north-east of South Australia, the SABJV aims to minimise atmospheric emissions and manage operations to comply with regulatory requirements.

**Table 7-10: Hazards and Potential Consequences Associated with Operation of the Raw Gas Conditioning Plant**

| Hazard | Potential Consequence/s |
|---|---|
| Air emissions ($CO_2$ and $H_2S$) | ▪ Release of greenhouse gases contributing to climatic warming |
| Disposal of oily water to northern evaporation pond and Lake Brooks | ▪ Contamination of soil and/or groundwater<br>▪ Access to contaminants by stock and wildlife |

Liquids Recovery

Oil sludge and oily water disposal are the primary environmental hazards associated with liquids recovery. Sludge is collected from tank bottoms, sumps and interceptor pits.

Oily water goes to the northern interceptor pit/evaporation pond and oil sludge is deposited in LTUs. In LTUs, bacteria break down much of the oil in the sludge into water and carbon dioxide. Oil sludge may contain elevated levels of naturally occurring heavy metals and contaminants.

As indicated in Table 4-7, the volume of sludge generated by the processing plant each year is $3400m^3$. The volume of sludge generated from the liquids recovery plant is not recorded, nor is it analysed to determine the levels and types of heavy metals and contaminants. However, it is likely that the sludge contains elevated levels of mercury and vanadium, although the quantities are likely to vary greatly on a daily basis due to the rate of production, product sources and interruptions in processing.

There is potential for soil and groundwater contamination at both waste disposal sites. However, it should be noted that the interceptor and sludge pits are lined with impervious liners and therefore the potential for soil and groundwater contamination from these facilities is considered negligible.

The impacts associated with Moomba plant operations are managed by the SACBJV procedures and guidelines. These are discussed in further detail in Section 8.2. The SACBJV is also undertaking a number of studies into the reduction and treatment of sludges and PFW on site including:

- PFW disposal project, as detailed previously in Section 7.3
- centrifuge trial to recover oil and water from oily sludge, therefore reducing the volume of sludge to be treated on site.

As indicated in Section 7.4.1 a new northern evaporation pond has been constructed which is fully lined and a study into contaminant concentrations and future use of the original northern evaporation pond is currently being undertaken.

**Table 7-11: Hazards and Potential Consequences Associated with the Liquids Recovery Process**

| Hazard | Potential Consequence/s |
|---|---|
| Oil sludge disposal to sludge pit and LTU | ▪ Contamination of soil and/or groundwater |
| Disposal of oily water to interceptor pit then northern evaporation pond | ▪ Contamination of soil and/or groundwater<br>▪ Access to contaminants by stock and wildlife |

Interruption to Natural Gas Supply

The potential hazards of explosion or fire and spill or leak at the Moomba Processing Plant that has the potential to disrupt natural gas supply. This issue is discussed in detail in Section 8.2.7, Fitness for Purpose Report.

In addition to the SACBJV's procedures and guidelines (refer Section 8.2) regular monitoring and testing of emergency shutdown systems, fire protection, detection and control systems is undertaken to ensure that protection levels are adequate (see Section 8.2.7).

**Table 7-12: Hazards and Potential Consequences Associated with Gas Supply**

| Hazard | Potential Consequence/s |
|---|---|
| Explosion or fire at the plant | ▪ Disruption to gas supply<br>▪ Danger to health and safety of employees, contractors and possibly the public |
| Loss of containment of gas (pipeline rupture or leaks from plant equipment) | ▪ As above |

### 7.4.2 Liquids Processing (Crude Stabilisation Plant)

Significant hazards associated with liquids processing are the tank farm and truck unloading facilities. The tank farm consists of two oil and condensate storage tanks, one with the capacity to hold 100,000 barrels and the other 300,000 barrels.

Soil contamination from oil leaks or spills during storage and handling (for example, loading and unloading trucks) is a potential consequence of oil and condensate storage. There is also potential for diesel fuel spills and/or leaks from trucks.

The impacts associated with liquids processing are managed by the SACBJV procedures and guidelines. These are discussed in further detail in Section 8.2.

**Table 7-13: Hazards and Potential Consequences Associated with Liquids Processing**

| Hazard | Potential Consequence/s |
|---|---|
| Spills or leaks associated with storage of oil and condensate (tank farm) | ▪ Contamination of soil and/or watercourse<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Access to contaminants by stock and wildlife<br>▪ Loss of vegetation and fauna habitat |
| Spills or leaks associated with chemical and fuel storage and use | ▪ As above |

<u>Diesel Storage and Refuelling</u>

The significant hazard associated with diesel production relates to diesel storage. A leak from a storage tank or spill during handling (for example, refuelling) may lead to localised contamination of soil. Any leak or spill is likely to be localised and relatively small scale.

The impacts associated with diesel storage are managed by the SACBJV procedures and guidelines. These are discussed in further detail in Section 8.2.

**Table 7-14: Hazards and Potential Consequences Associated with Diesel Storage and Refuelling**

| Hazard | Potential Consequence/s |
|---|---|
| Leak or spill associated with storage and handling of diesel fuel | ▪ Contamination of soil and/or watercourse<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Access to contaminants by stock and wildlife<br>▪ Loss of vegetation and fauna habitat |

## 7.5 Moomba Plant - Utilities

### 7.5.1 Water

Water from artesian bores at Gidgealpa is transported 27km via an aboveground pipeline to Moomba. Water is treated by a flash evaporation process, providing the camp and plant with approximately 4080 tonnes of treated water per day.

Plant activities are managed by SACBJV procedures and guidelines in order to reduce the potential for leaks. These pipelines are regularly inspected to assess any leaks or damage.

Hydrochloric acid is used to acid wash the system once per month. Wash water is neutralised with soda ash before being discharged to Lake Brooks. Although wash water is of neutral pH, when it arrives at Lake Brooks it is highly saline and may potentially contribute to increased salinisation of Lake Brooks.

Wastewater from the flash evaporation treatment process also has concentrated salt levels and poses a similar salinity hazard to Lake Brooks.

A study is currently being undertaken to investigate wastewater disposal associated with Moomba plant and associated facilities.

Significant hazards relating to water use include potential depletion of the Great Artesian Basin (GAB), acidification of Lake Brooks and failure of the aboveground pipeline (Table 7-15).

**Table 7-15: Hazards and Potential Consequences associated with Water Treatment**

| Hazard | Potential Consequence/s |
|---|---|
| Discharge of saline washdown water to Lake Brooks | ▪ Localised salinisation of soil as a direct result of process saline washdown water |
| Continual blow down of wastewater to Lake Brooks | ▪ As above |
| Extraction of water from GAB | ▪ Depletion of GAB and sub-artesian water supplies |
| Spills or leaks associated with failure of Gidgealpa to Moomba water pipeline | ▪ Localised acidification and/or salinisation of soil |

### 7.5.2 Compressed Air

There are no significant environmental hazards associated with compressed air.

### 7.5.3 Steam

The significant environmental hazard associated with steam generation relates to the storage and handling of process chemicals (for example, phosphate, sodium sulphite, polymer and hatamine), which may result in small scale leaks or spills and localised soil contamination within the plant area. Spills or leaks are likely to occur in sealed (for example, concreted) work areas and, as such, potential significant consequences are confined to health and safety issues.

**Table 7-16: Hazards and Potential Consequences associated with Steam Generation**

| Hazard | Potential Consequence/s |
|---|---|
| Leaks and/or spills associated with chemical storage and handling | ▪ Danger to health and safety of employees and contractors |

### 7.5.4 Electricity

There are no significant environmental hazards associated with electricity generation or distribution.

## 7.6 General Infrastructure

### 7.6.1 Road Construction & Maintenance

As indicated in Section 4.7, there is approximately 3532km of constructed roads and tracks in the South Australian section of the Cooper Basin. Major hazards associated with road construction are earthworks (Table 7-1), vegetation clearance, chemical and fuel storage and waste disposal.

Earthworks and vegetation clearance can potentially result in soil erosion, interruption of natural drainage patterns, disturbance to cultural heritage sites, introduction and spread of weeds and loss of vegetation. Waste disposal and chemical and fuel storage can lead to localised soil or water contamination.

Hazards associated with road maintenance and operations include earthworks (ie. grading) and introduction of construction material (for example, fill). Earthworks can potentially disturb natural drainage patterns and lead to soil erosion. Similarly the use of fill material can result in altered drainage patterns and possibly the introduction and/or spread of weeds.

There are few hazards associated with road abandonment, hazards including earthworks (ie. ripping) and removal of road construction material (for example, clay). Ripping can lead to soil erosion and alteration of drainage patterns. Disposal of road construction material may potentially spread weeds or alter drainage patterns and vegetation cover at the disposal site.

The potential impacts associated with construction activities are managed by the SACBJV procedures and guidelines. These are discussed in further detail in Section 8.2.

Table 7-17: Hazards and Potential Consequences Associated with Road Construction and Maintenance

| Hazard | Potential Consequence/s |
|---|---|
| Earthworks (eg. grading of ROW) | ▪ Injury or death of fauna in construction zone<br>▪ Loss of visual amenity<br>▪ Damage to native vegetation<br>▪ Introduction and/or spread of weeds<br>▪ Disturbance to natural drainage patterns<br>▪ Damage to third party infrastructure<br>▪ Soil erosion and siltation of watercourses<br>▪ Inversion of soil profile<br>▪ Dust generation<br>▪ Soil compaction<br>▪ Disturbance to cultural heritage sites |
| Movement of machinery and vehicles | ▪ Dust generation<br>▪ Soil compaction<br>▪ Soil erosion<br>▪ Damage to native vegetation<br>▪ Injury or death of native fauna<br>▪ Disturbance to cultural heritage sites<br>▪ Introduction and/or spread of weeds<br>▪ Damage to third party infrastructure<br>▪ Disruption to land use (eg. grazing and recreation)<br>▪ Increased public access to remote areas |
| Spills and leaks associated with fuel and chemical storage and handling | ▪ Contamination of soil and/or watercourse.<br>▪ Access to contaminants by stock and wildlife |
| Ignition of fire along ROW | ▪ Disturbance to cultural heritage sites<br>▪ Loss of vegetation and fauna habitat<br>▪ Release of particulate emissions to the atmosphere<br>▪ Disruption to land use (eg. grazing and recreation) |
| Presence of borrow pits | ▪ Injury to or loss of stock and wildlife<br>▪ Dispersal of watering points and redistribution of stock movements |
| Movement of road construction material | ▪ Introduction and/or spread of weeds |

### 7.6.2 Waste Management

Waste oil, oily sludge and contaminated soil are collected from various fields and transported to Moomba. A land treatment unit (LTU) has been established west of the Moomba plant to treat oily waste as well as waste from the Moomba processing plant. The waste is mixed with existing soil, with the aim of breaking down oil by evaporation, photochemical processes and biological action of naturally occurring soil microorganisms. Once hydrocarbons are broken down, soil is transported by truck to landfill.

Chemical wastes are disposed of in a dedicated licensed disposal facility, which is lined. Similarly, domestic waste is disposed of to a licensed landfill site.

An arsenic repository established at Moomba comprised the placement of arsenic contaminated material contained in sealed steel drums into a concrete lined pit which was then encapsulated with further concrete. No arsenic contaminated material has been deposited at the site since the initial placement.

Asbestos material are disposed of to the asbestos waste depot.

Issues associated with domestic sewage include the treatment of sewage, disposal of sludge, chemical storage and disposal of treated effluent to Lake Brooks. Sludge from the sewage treatment process is occasionally spread onto land adjacent to the sewage treatment plant and may potentially cause localised contamination of soil. Spills and leaks during storage and handling of chemicals (for example, chlorine) can potentially cause localised contamination of soil and/or groundwater. Quantities of sewage and associated wastes (ie. sludge) are not currently measured, and nor are their impacts on nutrient levels of the receiving environment (ie. Lake Brooks). Effluent that has undergone secondary treatment contains elevated levels of nutrients and has the potential to increase nutrient concentrations in the receiving environment. A study into the quality of the sewage effluent is proposed to be undertaken in 2003.

Each of these waste facilities poses an environmental hazard with potential consequences including contamination of soil or groundwater and the introduction and/or spread of weeds. However, it should be noted that the chemical waste depot is clay lined and the arsenic contaminated material is encapsulated in concrete. Therefore, the potential environmental risks associated with these issues are considered negligible.

In the case of the general landfill site, consequences also include outbreaks of pests and scavenging by wildlife, this is minimised through appropriate management practices.

The potential impacts associated with waste management are managed by the SACBJV procedures and guidelines.

**Table 7-18: Hazards and potential consequences associated with Operation of Waste Disposal Facilities**

| Hazard | Potential Consequence/s |
|---|---|
| Domestic waste disposal to Moomba waste facility | ▪ Scavenging by native and pest species<br>▪ Pest outbreaks<br>▪ Contamination of soil |
| Storage and disposal of contaminated soil to LTU | ▪ Localised contamination of soil and/or watercourses |
| Arsenic dump (disused) | ▪ Localised contamination of soil and/or watercourses |
| Disposal of chemical waste to licensed disposal facility | ▪ Localised contamination of soil and/or watercourses |
| Disposal of asbestos to asbestos waste depot | ▪ Contamination of soil |
| Spills or leaks associated with sewage plant chemical storage and handling | ▪ Contamination of soil and/or watercourse.<br>▪ Access to contaminants by stock and wildlife |
| Sewage sludge storage and disposal | ▪ Localised contamination of soil and/or groundwater |
| Disposal of treated effluent to Lake Brooks | ▪ Increased nutrient levels in Lake Brooks |

### 7.6.3 Moomba Airport

The major hazards associated with the Moomba Airport are the storage of fuels and the disruption or injury to fauna, specifically birds. The perimeter of the airport is fenced and vegetation growth restricted.

The potential impacts associated with the Moomba airport are managed by the SACBJV procedures and guidelines. These are discussed in further detail in Section 8.2.

**Table 7-19: Hazards and Potential Consequences Associated with Operation of Moomba Airport**

| Hazard | Potential Consequence/s |
|---|---|
| Leaks and/or spills associated with chemical and fuel storage and handling | ▪ Contamination of soil and/or watercourse.<br>▪ Access to contaminants by stock and wildlife |
| Presence of fauna in vicinity of airport | ▪ Disruption or injury to fauna (ie. birds) |

### 7.6.4 Fire Training Ground

Significant hazards associated with the fire training ground are storage of oil and chemicals on site, and disposal of water and other fire suppressants.

All wastewater from the fire training ground is disposed to the northern interceptor pit and evaporation pond. Disposal of wastes to the evaporation pond may potentially result in contamination of soil and groundwater.

Similarly, leaks from oil storage tanks or spills associated with training exercises may lead to localised contamination of soil.

The potential impacts associated with the fire training ground are managed by the SACBJV procedures and guidelines. These are discussed in further detail in Section 8.2.

**Table 7-20: Hazards and Potential Consequences Associated with Fire Training Ground Activities**

| Hazard | Potential Consequence/s |
|---|---|
| Fire or explosion | ▪ Danger to health and safety of employees and contractors<br>▪ Atmospheric pollution |
| Spills or leaks associated with storage and disposal of oil | ▪ Contamination of soil and/or watercourse<br>▪ Access to contaminants by stock and wildlife |

# 8 Environmental Risks and Management Strategies

## 8.1 Risk Management and Assessment

There are a range of potential environmental risks inherent in the SACBJV's Cooper Basin operations. An **environmental risk** is the chance that an environmental **consequence** will occur as a result of a **hazardous** situation or event. Given appropriate management measures, most risks can be avoided or reduced to a level that is acceptable. However, in some cases there may still be 'residual' risks that are retained after management measures have been implemented.

Environmental risk assessment evaluates the level of environmental risk associated with various operations and activities and provides a framework for assessing risk management priorities and options based on the level of each assessed risk.

The main components of the environmental risk assessment process are illustrated in Figure 8-1.

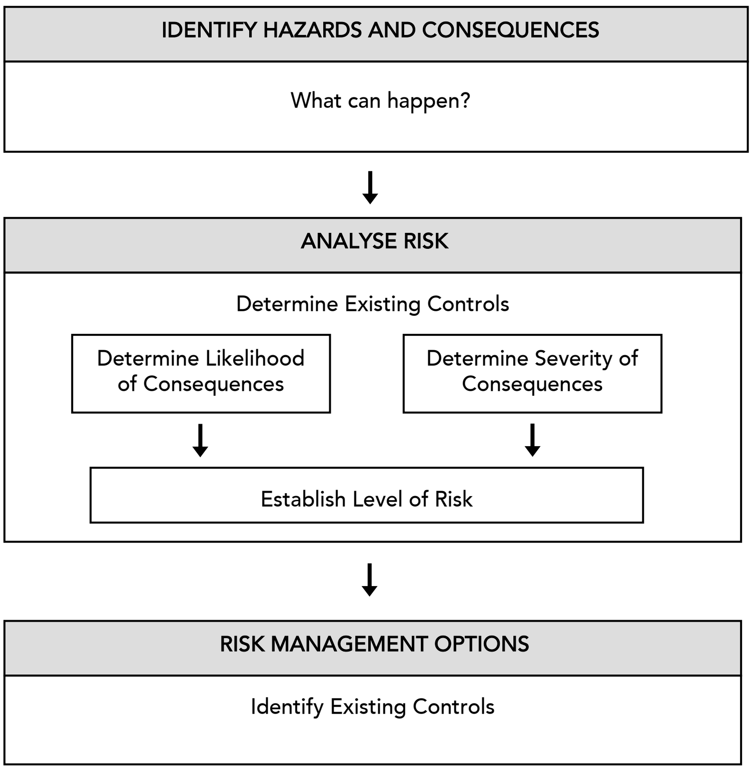



**Figure 8-1: Framework for Environmental Risk Assessment**

Risk assessment may be undertaken to various degrees of refinement, depending upon the information and data available. Where possible, the frequency and severity of potential environmental consequences have been assessed on the basis of existing information. However, this information is not available with regard to all activities and associated consequences. Therefore, a qualitative (ie. descriptive) risk assessment process was considered to be the most appropriate method to adopt. This approach uses descriptive scales to describe the likelihood of consequences (ie. virtually certain to virtually impossible) and their severity (ie. negligible to disastrous) and has been derived from Stoklosa (1999) and the Australian/New Zealand Standard (AS/NZS 4360:1999) for risk management.

**The risk assessment of the SACBJV's production and processing operations was undertaken in accordance with Santos risk assessment guidelines and procedures (based on AS/NZ 4360) and industry experience.**

Each phase of the risk assessment process is discussed further in the following sections.

### 8.1.1 Environmental Hazards

Primary environmental hazards associated with the SACBJV's operations in the Cooper Basin, as identified in Chapter 7, include:

- storage and disposal of process wastes (for example, oil sludge)
- accidental spills or leaks associated with pipeline failure or storage of oil, fuels and chemicals
- disposal of domestic and chemical waste and contaminated soil
- emissions vented from satellites and the Moomba processing plant
- earthworks associated with pipeline and road construction.

### 8.1.2 Consequences

Key potential environmental consequences associated with the above hazards are:

- contamination of soil, groundwater and/or watercourses
- atmospheric pollution
- soil erosion and disturbance to natural drainage patterns
- disturbance to Aboriginal and non-Aboriginal cultural heritage sites
- loss of native vegetation and habitat
- introduction and/or spread of weeds.

To determine the level of risk associated with various hazards and potential consequences, both the likelihood and severity of hazards, and their associated consequences, have to be considered. Categories of likelihood and severity have been determined using subjective estimates of whether or not a particular event or outcome will occur.

The Cooper Basin operation is an existing operation. Hence, environmental hazards and existing management measures are well understood and, as such, both the likelihood and severity of consequences can be confidently predicted based on operating experience in the Cooper Basin and professional judgement (as detailed in Appendix H).

**Both the likelihood and severity of consequences have been assessed in the context of the management practices that have been applied (refer Section 8.2) to reduce the level of risk associated with identified hazards and potential consequences.**

Assessment of Severity

Environmental consequences can be categorised from negligible to disastrous, using the qualitative methodology described by Stoklosa (1999) (Table 8-1). These consequences are based upon definitions contained in AS/NZS 4360, but have been expanded to incorporate impacts to environmental values such as flora, fauna and biomass of biota.

**Table 8-1: Severity of Consequences**

| Severity | Qualitative Description of Environmental Consequences |
|---|---|
| Negligible | Possible incidental impacts to flora and fauna in a locally affected land system but without ecological consequence. |
| Minor | Changes to the abundance or biomass of biota, and existing soil and/or water quality in the affected land system, but no changes to biodiversity or ecological function. |
| Major | Changes to the abundance or biomass of biota, and existing soil and/or water quality in the affected land system, with local changes to biodiversity but no loss of ecological function. |
| Severe | Substantial changes to the abundance or biomass of biota, and existing soil and/or water quality in the affected land system with significant change to biodiversity and change of ecological function. Eventual recovery of ecosystem possible, but not necessarily to the same pre-incident conditions. |
| Disastrous | Irreversible and irrecoverable changes to abundance/biomass in the affected area. Loss of biodiversity on a regional scale. Loss of ecological functioning with little prospect of recovery to pre-incident conditions. |

Assessment of Likelihood

The likelihood of occurrence of potential environmental consequences were qualitatively assessed and categorised according to the criteria outlined in Table 8-2.

**Table 8-2: Likelihood of Consequences**

| Likelihood of Occurrence | Qualitative Description of Exposure |
|---|---|
| Virtually impossible | Has almost never occurred, but conceivably could |
| Rare | Has occurred a few times worldwide |
| Unlikely | Not likely during operation lifetime |
| Likely | Likely to occur during operation lifetime |
| Virtually certain | Includes continuous emissions |

### 8.1.3 Environmental Risk Assessment

Severity and likelihood of consequences are combined to produce a level of risk for any given hazard. Table 8-3 shows an environmental risk assessment matrix that compares likelihood and severity of environmental consequences arising from operations. The severity of consequence is dependant on the receiving environment - however, in most cases this does not alter the risk matrix outcome (Table 8-3).

Table 8-3: Risk Matrix

| | | | LIKELIHOOD OF CONSEQUENCE | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| | | | Virtually Impossible | Rare | Unlikely | Likely | Virtually Certain |
| SEVERITY OF CONSEQUENCE | E | Negligible Effect | LOW | LOW | LOW | LOW | LOW |
| | D | Minor Effect | LOW | LOW | MEDIUM | MEDIUM | MEDIUM |
| | C | Major Effect | MEDIUM | MEDIUM | MEDIUM | MEDIUM | HIGH |
| | B | Severe Effect | MEDIUM | MEDIUM | MEDIUM | HIGH | HIGH |
| | A | Disastrous Effect | MEDIUM | MEDIUM | HIGH | HIGH | HIGH |

*(Source: Stoklosa 1999)*

The objective of the risk assessment process is to separate the minor acceptable risks from the major risks, and to provide data to assist in the evaluation and management of risks.

Table 8-4 provides a summary of all identified hazards and associated risk levels.

Detailed risk assessment and management measures are outlined in Appendix H.

Table 8-4: Summary of Hazards and Risk Levels

| Aspect of Activity/ Source of Risk | Hazard | Severity | Likelihood | Risk |
|---|---|---|---|---|
| Gathering Systems | | | | |
| Pipeline Construction | Movement of machinery and vehicles | Major | Unlikely | MEDIUM |
| | Spills and leaks associated with chemical and fuel storage and handling | Negligible | Unlikely | LOW |
| | Earthworks (eg. grading, trenching and backfilling) | Negligible | Virtually Certain | LOW |
| | Ignition of fire along ROW | Minor | Rare | LOW |
| | Disposal of hydrotest water | Negligible | Virtually Certain | LOW |

## Table 8-5 cont

| Aspect of Activity/ Source of Risk | Hazard | Severity | Likelihood | Risk |
|---|---|---|---|---|
| **Gathering Systems** | | | | |
| Pipeline Operation | Explosion or fire along an Oil pipeline | Minor | Unlikely | LOW |
| | Explosion or fire along an Gas pipeline | Major | Unlikely | MEDIUM |
| | Spill or leak associated with pipeline failure to land | Negligible | Unlikely | LOW |
| | Spill or leak associated with pipeline failure in a creek bed | Major | Unlikely | MEDIUM |
| | Spill or leak associated with nodal compressor failure | Negligible | Rare | LOW |
| | Spill or leak associated with transport of oil/ condensate (via truck) to land | Negligible | Unlikely | LOW |
| | Spill or leak associated with transport of oil/condensate (via truck) to creek bed | Major | Unlikely | MEDIUM |
| **Satellites Facilities** | | | | |
| Gas and Oil Satellites | Explosion or fire at the satellite | Major | Unlikely | MEDIUM |
| | Flooding of surrounding floodplain/watercourses | Negligible | Unlikely | LOW |
| | Minor spills or leaks associated with chemical and fuel storage and handling | Negligible | Unlikely | LOW |
| | Fugitive emissions of methane and organic carbon from the process plant | Negligible | Likely | LOW |
| | Venting of $CO_2$, $H_2S$, and CO | Minor | Likely | LOW |
| | Flaring of propane, butane, methane and ethane from process plants | Negligible | Likely | LOW |
| | Loss of containment of gas (pipeline rupture or leaks from plant equipment) | Major | Rare | MEDIUM |
| | Loss of containment of oil (pipeline rupture or leaks from plant equipment) | Minor | Rare | LOW |
| Utilities (Tirrawarra and Dullingari camps) | Storage of domestic waste at camps and transport and disposal to landfill (ie. Moomba waste facility) | Negligible | Unlikely | LOW |
| | Spills or leaks associated with disposal and treatment of sewage in septic tanks | Negligible | Unlikely | LOW |
| **Produced Formation Water (PFW)** | | | | |
| PFW | Storage and disposal of PFW at satellites | Minor | Unlikely | MEDIUM |
| | Flooding of surrounding floodplain/watercourses | Negligible | Unlikely | LOW |

## Table 8-6 cont

| Aspect of Activity/ Source of Risk | Hazard | Severity | Likelihood | Risk |
|---|---|---|---|---|
| **Moomba Plant – Process Facilities** | | | | |
| **Gas Processing** | | | | |
| Inlet Separation | Oil sludge disposal to sludge pit then to LTU | Minor | Unlikely | **MEDIUM** |
| | PFW disposal to northern evaporation pond | Minor | Unlikely | **MEDIUM** |
| | Sour water disposal to sour water pit then Lake Brooks | Negligible | Unlikely | **LOW** |
| Raw Gas Conditioning Plant | Process air emissions ($CO_2$ and $H_2S$) | Minor | Unlikely | **MEDIUM** |
| | Disposal of oily water to northern evaporation pond and Lake Brooks | Minor | Unlikely | **MEDIUM** |
| Gas Processing - Liquids Recovery Process | Oil sludge disposal to sludge pit and LTU | Minor | Unlikely | **MEDIUM** |
| | Disposal of oily water to interceptor pit then northern evaporation pond | Minor | Unlikely | **MEDIUM** |
| Interruption of Natural Gas Supply | Explosion or fire | Major | Unlikely | **MEDIUM** |
| | Loss of containment of gas (pipeline rupture or leaks from plant equipment) | Major | Rare | **MEDIUM** |
| **Liquid Processing (Crude Stabilisation Plant)** | | | | |
| Liquids Processing | Spills or leaks associated with storage of oil and condensate (tank farm) | Negligible | Unlikely | LOW |
| Liquids Processing cont. | Spills or leaks associated with chemical and fuel storage and handling | Negligible | Unlikely | **LOW** |
| Diesel Storage and Refuelling | Leak or spill associated with storage and handling of diesel fuel | Negligible | Unlikely | **LOW** |
| **Moomba Plant Utilities** | | | | |
| Water | Discharge of saline wash water to Lake Brooks | Negligible | Unlikely | **LOW** |
| | Continual blow down of wastewater to Lake Brooks | Negligible | Unlikely | **LOW** |
| | Extraction of water from GAB | Major | Likely | **MEDIUM** |
| | Spills or leaks associated with failure of Gidgealpa to Moomba pipeline | Negligible | Unlikely | **LOW** |
| Compressed Air | NA | NA | NA | **NA** |
| Steam | Leaks or spills associated with chemical storage and handling | NA | NA | **NA** |
| Electricity | NA | NA | NA | **NA** |

## Table 8-7 cont

| Aspect of Activity/ Source of Risk | Hazard | Severity | Likelihood | Risk |
|---|---|---|---|---|
| **Supporting Infrastructure** | | | | |
| Road Construction and Maintenance | Earthworks (eg. grading of ROW) | Negligible | Rare | LOW |
| | Movement of machinery and vehicles | Major | Rare | MEDIUM |
| | Ignition of fire along ROW | Minor | Rare | LOW |
| | Spills and leaks associated with fuel and chemical storage and handling | Negligible | Unlikely | LOW |
| | Presence of borrow pits | Negligible | Unlikely | LOW |
| | Movement of road construction material | Negligible | Unlikely | LOW |
| Waste Management | Domestic waste disposal to Moomba waste facility | Negligible | Unlikely | LOW |
| | Storage and disposal of contaminated soil to LTU | Minor | Unlikely | MEDIUM |
| | Arsenic dump (disused) | Negligible | Unlikely | LOW |
| | Disposal of chemical waste to licensed disposal facility | Negligible | Unlikely | LOW |
| | Disposal of asbestos to asbestos waste depot | Negligible | Unlikely | LOW |
| | Spills or leaks associated with sewage plant chemical storage and handling | Negligible | Unlikely | LOW |
| | Sewage sludge storage and disposal | Negligible | Unlikely | LOW |
| | Disposal of treated effluent to Lake Brooks | Negligible | Unlikely | LOW |
| Moomba Airport | Leaks and/or spills associated with fuel and chemical storage and handling | Negligible | Rare | LOW |
| | Presence of fauna in vicinity of airport (ie. risk of collision with planes) | Negligible | Likely | LOW |
| Fire Training Ground | Fire or explosion | Minor | Likely | LOW |
| | Spills or leaks associated with storage and disposal of oil | Negligible | Unlikely | LOW |

## 8.2 Management of Environmental Risks

The Environmental Health and Safety Management System (EHSMS) is the key tool in managing the SACBJV's environmental responsibilities, issues and risks. The EHSMS provides a framework for the coordinated and consistent management of environmental issues by:

- establishing an Environmental Policy
- identifying environmental risks and legal and other requirements relevant to the SACBJV's operations
- setting appropriate environmental objectives and targets
- establishing a structure and program to implement the Environmental Policy and achieve objectives and targets
- facilitating planning, control monitoring, corrective action, auditing and review of activities to ensure that the requirements and aspirations of the Environmental Policy are achieved.

The EHSMS encompasses corporate as well as requirements. These are further addressed in the more detailed Business Unit sub-systems. Key elements of the EHSMS and the environmental component of the CBU Management System are:

- The Environmental Policy, which is a public declaration of the Company's environmental goals and its commitment to responsible environmental management (Appendix I).
- Codes of Environmental Practice, which detail the Company's specific environmental objectives for seismic drilling and workover, and production and processing operations, and describe methods used to assess environmental performance (for example, Santos Ltd 1998b, Santos 1999e).
- Environmental procedures for numerous activities (for example, construction, operation and abandonment of pipelines), which describe specific management techniques and practices to be followed during production and processing operations.
- Procedures that describe the development of environmental management plans, relevant documentation, auditing protocols, Incident Management System (IMS), Environmental Improvement Plans (EIP), Non-conformance Reports (NCR) and other CBU Management System requirements.
- Various educational bulletins, posters and environmental inductions used to raise the environmental awareness of SACBJV and contractor personnel.

Each of these elements fulfils one or more of the principal requirements of the EHSMS (for example, reporting, auditing, corrective action etc.). The SACBJV's approach to the principal requirements of the EHSMS is outlined in the following sections.

All pipeline design and construction is undertaken in accordance with the following industry accepted Australian codes and standards:
- AS 2885.1-1997 Pipelines - Gas and Liquid Petroleum - Design and Construction
- AS 1978-1987 Pipelines - Gas and liquid Petroleum - Field Pressure Testing

The following Santos design specifications are also applied during pipeline construction:

- 1500-120-S002 Excavation and Backfilling Specification (Santos 1996);
- 1500-50-G007 Pipeline Gathering Systems Design Code (Santos 1999a);
- 1500-120-S020 Buried Field Pipeline System Specification (Santos 1999b); and
- 1500-120-S027 Aboveground Pipeline Systems Specifications (Santos 1999c).

All oil pipelines are designed, constructed, operated and maintained in accordance with the Santos Pipeline Management System.

### 8.2.1 Codes of Environmental Practice

The SACBJV has developed codes of environmental practice that cover a range of activities, including:

- Seismic Operations (Santos, 1998c;1998d)[2]
- Drilling and Workover Operations (Santos 1998b)[2]
- Production and Processing (Santos 1999e).

The codes address issues beyond compliance with legislation or PIRSA codes and are reviewed on a three yearly basis. The codes detail specific environmental objectives and methods used to assess environmental performance.

Other environmental handbooks are:

- Santos Australian Environmental Management System At a Glance (Santos 1998e)
- Field Guide to the Common Plants of the Cooper Basin (Santos 1997c)
- The Arid Zone Field Environmental Handbook (Santos 1997b)
- Stock Proof Fencing Standard (Santos 2000c).

### 8.2.2 Environmental Procedures

The SACBJV has developed environmental procedural manuals that cover a range of activities, including:

- Borrow Pit Management (Santos 1997a)
- Construction, Operation and Abandonment Of Pipelines (Santos 2000d)
- Drilling And Workover Operations (Santos 1998b)[2]
- Environmental Incident Reporting and Investigation (Santos 1997d)
- Management of Aboriginal Heritage Sites (Santos 1998a)
- PFW Procedures (Section 8.2.8)
- Oil Spill Procedures (Section 8.2.10 and 8.2.11)
- Seismic Line Preparation (Dozer Manual; Santos 1998d)[2]
- Seismic line and Operations (Santos 1998c)[2]
- Well Leases Location, Construction and Restoration (Santos 1997e)[2]

Each procedural manual outlines specific environmental management techniques and practices to be followed whilst undertaking various operational activities. For example, Santos' Environmental Procedures for Construction, Operation and Abandonment of Pipelines (Santos 2000d) outline methods for various environmental aspects of pipeline construction and operation including management of road and track development, prevention of weed introduction, vegetation clearance and hydrostatic testing.

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[2] Not relevant to this EIR

### 8.2.3 Awareness and Training

There is an ongoing environmental training and awareness program for all SACBJV personnel and contractors. The program encompasses posters, handbooks, induction video and presentations by internal and external environmental specialists. The program seeks to ensure that everyone working with the SACBJV, including contractors, understands how to fulfil their responsibilities under the EHSMS and have the knowledge to do so.

Specifically, environmental training undertaken by SACBJV includes:

- environmental inductions and refresher sessions
- job-specific and procedure-specific training
- cultural heritage induction and education
- environmental awareness programs.

### 8.2.4 Environmental Monitoring and Audits

Ongoing monitoring and auditing of the SACBJV's operations is necessary to determine whether significant environmental risks are being managed, minimised and, where reasonably possible, eliminated.

Monitoring programs are aimed at detecting any 'off-site' contamination and quantifying environmental issues. Key project elements include:

- monitoring the rate of oil breakdown at selected oil spill sites
- annual monitoring of soil and groundwater quality at the:
  - Moomba oily waste landfarm
  - Moomba waste depot (groundwater only)
  - Moomba chemical waste depot (groundwater only)
- monitoring particulate emissions from the Moomba plant on an ongoing basis, and reporting to the EPA
- annual monitoring of water quality in evaporation ponds.

The CBU also undertakes a range of environmental audits, which focus on aspects of environmental risk, compliance with regulatory or legislative requirements, as well as various specific issues. Audits include:

- system audits to determine whether or not the EHSMS and CBU Management System are being properly implemented, maintained and reviewed
- performance audits to obtain evidence to verify that environmental objectives and targets are being achieved, or legislation is being complied with
- pre-acquisition and divestment audits of operations that SACBJV is about to buy or sell (as required).

External specialists conduct audits of different field activities at least annually and results are circulated to relevant SACBJV personnel. Audits are undertaken on work performed for SACBJV by its employees and contractors. Regulators (ie. PIRSA and EPA) also conduct audits of the operations.

### 8.2.5 Reporting

The SACBJV has implemented both internal and external reporting procedures to ensure that environmental issues and/or incidents are appropriately responded to.

Formal internal reporting and frequency of reporting is outlined in Table 8-8.

**Table 8-8: SACBJV Internal Environmental Reporting**

| Report | Frequency |
|---|---|
| Environmental Management Committee | Monthly |
| CBU Environmental Incident Management System | Daily (IMS) |
| Environmental Improvement Plans | Monthly<br>Annually |
| Moomba Environment Forum | Every six weeks |
| Joint Venture | Quarterly |
| Environmental Committee of the Board | Quarterly<br>Annually |

Internal reporting covers:

- number, severity and close out status of incidents
- monthly summaries of the Environmental Incident Management System
- progress against key performance indicators
- audit schedule and findings
- works in progress (eg. LTU review)
- EPA licensing
- site and task force meetings
- external meetings and / or liaison with key stakeholders (ie. PIRSA).

Formal external reporting and frequency is outlined in Table 8-9.

**Table 8-9: SACBJV External Environmental Reporting**

| Report | Frequency | Type of Report |
|---|---|---|
| EPA | Monthly | Licensing |
| PIRSA | Quarterly<br>Annually | Action plans and key performance indicator targets |
| APPEA | Annually | Greenhouse gas |
| EPA and PIRSA | As required | Report all incidents outside of bunded area (monthly to PIRSA; if greater than important severity, reported at the time of occurrence to EPA) |

The SACBJV's external communications with communities within which it operates include personal contact with individuals on specific, local issues and, move broadly, via the Companies annual report.

### 8.2.6 Inspection and Maintenance

Regular inspections are part of normal operations and are conducted by field operators and environmental personnel. Responsibility for environmental management and performance is a line management function, where all SACBJV personnel, from senior management through to field operators, have a responsibility for complying with environmental requirements.

The following are key components of the inspection and maintenance program.

- Trunklines and field facilities are inspected for corrosion, third party damage, condition of the ROW and evidence of oil leaks or spills as part of a structured program.
- General housekeeping inspections are conducted by field supervisors.
- Field infrastructure is maintained as part of a structured program.
- PFW facilities are inspected and audited once per year by environmental personnel, (water quality monitoring is an important component of this program).

### 8.2.7 Fitness for Purpose Report

A Fitness for Purpose report (FFP) for SACBJV operations has been prepared in accordance with Regulation 30 of the *Petroleum Act 2000*. The report addresses impacts of identified hazards and risks on:

- public health and safety
- environment
- security of supply of natural gas.

for the SACBJV production facilities in the Cooper Basin, South Australia, as defined by the coverage of the Act. The FFP report is available on the PIRSA internet site.

Based on the recent reliability performance of the SACBJV facilities and the most recent independent risk assessment reviews, the main hazards associated with the facilities that are identified as having the greatest collective potential to impact on the security of supply of natural gas and the environment are:

- failures associated with the Moomba plant utility systems
- critical pipeline failures
- corrosion induced environmental incidents
- an Estimated Maximum Loss (EML) incident involving a vapour cloud explosion (VCE) in the Liquids Recovery Plant (LRP).

A significant number of risk reduction mechanisms have already been implemented by the SACBJV, and additional projects and systems are scheduled for implementation. These risk reduction programs include:

- plant and equipment corrosion monitoring and control program
- Moomba plant steam generation reliability and performance improvement
- upgrades to control systems at gas and oil satellites
- review and upgrading Moomba plant and satellite facility operating procedures
- installation of a back-up sales gas line bypassing the LRP
- installation of additional power generation capacity in the Moomba plant
- installation of Emergency Isolation valves at the pig receivers at the inlet to the Moomba plant on four of the major gas trunklines.

Following on from the findings of the FFP, Santos has undertaken a Whole of Plant Risk Assessment (WOPRA) of the Moomba receiving and gas processing plant in order to assess the associated hazards. The draft report including recommendations, submitted to Santos in December 2002, is under review.

#### 8.2.8 Produced Formation Water Management (PFW)

The SACBJV is currently undertaking a PFW disposal water quality research project. This project is outlined in the Santos Action Plan, which was reviewed and agreed to by the SACBJV and PIRSA in July 2001. The research project aims to quantify and assess the suitability of current PFW disposal management and to determine potential areas for improvement.

The PFW disposal water quality research project comprises:

- a sediment sampling project to determine the presence and levels of contamination in evaporation ponds
- the development of sediment criteria
- a remediation/restoration trial
- development of water quality criteria to ensure the appropriate environmental management of formation water disposal.

The development of new chemical concentration criteria or alternate soil health index (SHI) criteria, as discussed in detail in Section 8.2.11, would form the basis for managing soils and sediments in compliance with the National Environment Protection Measure (NEPM) and South Australian EPA requirements. The SHI approach was developed in consultation with the EPA and PIRSA.

The primary purpose of the Action Plan has been to determine appropriate water quality criteria for the operation of PFW disposal facilities in the South Australian Cooper Basin. The SACBJV has only had preliminary discussions to date with PIRSA and the EPA regarding development of appropriate water quality guidelines.

#### 8.2.9 Land Treatment Unit (LTU)

The SACBJV has recently completed a study into the performance of the Moomba LTU. The project aimed to quantify the volume of sludge entering sludge pits and the LTU and assess the contamination level at various stages of treatment. The recently finalised LTU options report details various sludge disposal options and determines any potential areas for improvement, which will enable appropriate bioremediation levels to be achieved.

#### 8.2.10 Cooper Creek Oil Spill Study

The production of oil and gas from reservoirs to the north of Cooper Creek have required the construction of three gas and one oil pipeline across the main channels of the north-west branch of the Cooper Creek. Approval by PIRSA for the construction of the fourth pipeline was conditional on SACBJV undertaking a study into the potential effects of a spill of crude or condensate from any of the four pipelines.

A staged scope of work was developed to undertake this investigation which included:

1. Literature review of physical and environmental characteristics
2. Hydrocarbon assessment (characterisation)
3. Spill Modelling
4. Ecotoxicological testing
5. Summary of effects

Work completed to date includes stages 1, 2 and 4. Completion of the study and any further works will be based upon the findings to date. Details of any additional stages will be discussed and agreed with PIRSA prior to commencement. The final aim will be to determine the nature and extent of impact resulting from a hydrocarbon release from the pipelines crossing the Cooper Creek and to ensure that appropriate additional mitigation measures other than those described in Chapter 7 and Appendix H are implemented where appropriate.

### 8.2.11 Oil Spill Remediation

SACBJV recognises that many of the impacts associated with petroleum operations can be avoided with responsible environmental management. The SACBJV monitors environmental impacts and is continually researching new techniques to further reduce the impact of spills.

Currently, a review of oil spill management is being undertaken to determine appropriate criteria for assessing oil spill remediation in the operations area and to define when management and monitoring activities of a particular spill site can justifiably cease. To reach this stage, the level of contamination would need to be reduced to concentrations that have negligible effects on the health of humans, stock and the environment, and therefore require no further management.

A Level 3 risk based study is currently being undertaken to provide a Soil Health Index (SHI). This study will generate data which will either allow new criteria (site-specific) for acceptable concentrations of contaminants of concern to be identified, or allow alternate criteria for acceptable values of SHI to be identified. The new chemical concentration criteria or alternate SHI criteria, would form the basis for managing soils and sediments in compliance with the National Environment Protection Measure and South Australian EPA requirements. The SHI approach was developed in consultation with the EPA and PIRSA.

### 8.2.12 Air Emissions Management

The SACBJV recognises the importance of maintaining an appropriate standard of air quality. Whilst SACBJV operations are located in the isolated far north-east of South Australia, removed from residences and areas of high public use, the SACBJV aims to minimise atmospheric emissions and manage operations to comply with regulatory requirements.

The National Pollution Inventory (NPI) was established by the Australian Government in February 1998 to phase in compulsory reporting of emissions. In 1999, companies that triggered a threshold for a substance on the NPI reporting list reported their emission levels for the first time. During implementation of the program, it was decided that an initial 36 substances would be reported. From 1 July 2001, industry will report against 90 substances.

The SACBJV utilized the NPI Guide and the Emissions Estimation Manual: Oil and Gas Exploration and Production as a basis for determining reporting requirements and emission levels. The operations were sub-divided into 25 facilities and emissions reported on a facility basis (Appendix G). The majority of the emissions are by-products from the combustion of natural gas. Currently, greenhouse gases are not reported via the NPI.

Greenhouse gases are naturally occurring substances in the atmosphere, which can trap radiated energy from the earth and cause what is known as the 'greenhouse effect'. Currently, there is still a great deal of speculation as to whether the greenhouse effect will lead to an increase in the Earth's temperature and subsequent major environmental impact.

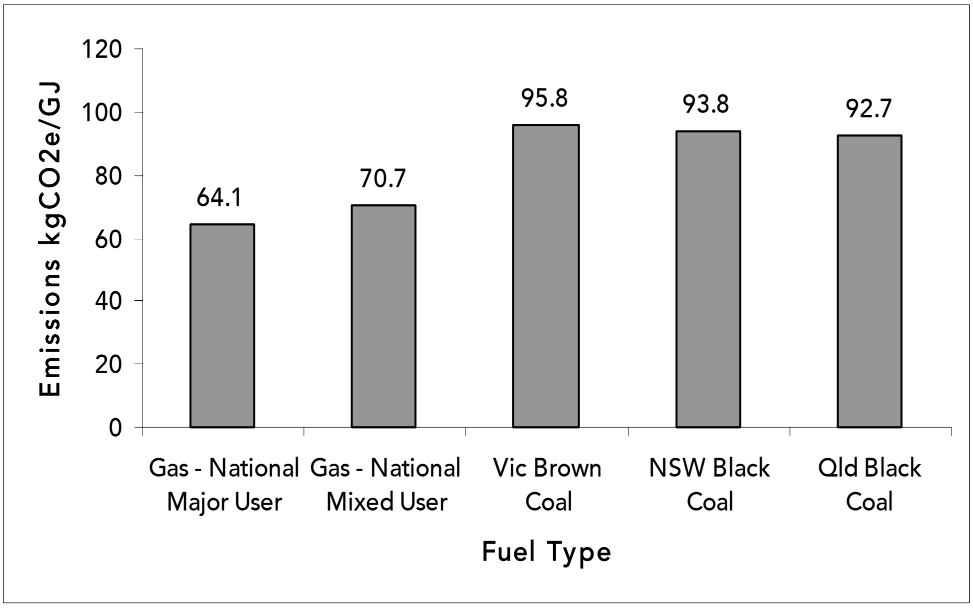
In 1995, a Greenhouse Challenge Office was established as a joint voluntary initiative between the national government and industry to abate greenhouse gas emissions. Participating organisations sign agreements with the government that provide a framework for undertaking and reporting on actions to abate emissions.

The SACBJV prepares a yearly Greenhouse Gas Emissions inventory report and participates in the Greenhouse Challenge Program through Australia Petroleum Producers Explorers Association (APPEA). APPEA is the national organisation representing the oil and gas exploration and production industry in Australia. The Association seeks to promote a competitive Australian petroleum resource industry, which operates at the highest environmental and safety standards.

Emission assessments must be performed for the entire operation upstream of the custody transfer point for petroleum products. APPEA then prepares a report, including the aggregate emissions for its members and summary abatement activities, as part of the Greenhouse Challenge Agreement. There have been four reports to date: 1996; 1998; 1999; 2000. These can be obtained from APPEA.

Natural gas is widely considered to be the cleanest fossil fuel. Figure 8-2 summarises the life cycle emissions from different fuels in electricity production (Energetics 2000), showing that natural gas 'greenhouse gas emissions' are significantly lower than coal. A recent Council of Australian Governments Energy Review Issues Paper identified that natural gas was a preferred fuel for reducing greenhouse gas emissions.

Recognising its importance, the SACBJV is in the process of incorporating the Greenhouse Gas Emissions Inventory System and the NPI reporting system into the Product Accounting System to facilitate automation, accuracy and consistency of calculation methods, as part of a continual improvement process.




(Source: Energetics 2000)

**Figure 8-2: Life Cycle Emissions From Different Fuels in Electricity Production**

### 8.2.13 Incident Management System

The SACBJV implemented an electronic incident management system (IMS) in January 1999 and the environmental IMS in July 1999. In addition to recording, tracking and closing out of incidents, this system provides a mechanism to analyse collated data and identify areas requiring improvement. The IMS reports record the date, location, volume, substance, root cause, event descriptions, remedial taken and close out, for each recorded incident.

The IMS also provides a mechanism to report 'hazards' and 'near misses', which can proactively highlight areas for remedial action and prevent incidents from occurring.

In support of the IMS, Santos published the Environmental Incident Reporting and Investigation Procedure, September 2000, which outlines environmental objectives, responsibilities and notifications, procedure detail, incident and hazard forms, and examples of probability, exposure and consequence categories.

The SACBJV annually reviews incident management and establishes aggressive annual incident reduction targets. Progress against these targets is reported monthly to the Environmental Management Committee and quarterly to the Santos Environmental Committee of the Board. Reportable incidents, as defined under the Petroleum Act and Regulations 2000, are reported quarterly to PIRSA. Any incident with significant environmental impact is reported to the EPA.

### 8.2.14 Safety Features and Systems

The policies, systems and procedures applied by the SACBJV to protect the occupational health and safety of employees and contractors are equally applicable to public health and safety.

This section provides a brief summary of safety features and systems. The SACBJV's Fitness for Purpose report addresses the impacts of identified hazards and risks in terms of public health and safety of the Cooper Basin operation in detail. The report also addresses security of supply of natural gas.

Safety features and systems are fundamental to the prevention or management of incidents that have the potential to:

- detrimentally affect the environment
- damage equipment and processes
- interrupt production or supply of natural gas
- impact on recovery following an incident.

The SACBJV's safety features and system include:

- published general standards for conducting operations
- equipment and facilities designed in accordance with recognised standards and codes
- equipment operated and maintained in accordance with manufacturers' recommendations and recognised condition monitoring practices.

Plant and facility control and shutdown systems include:

- equipment designed to fail in a safe position
- emergency shutdown systems (ESD) integrated, programmable and manual
- uninterrupted power supply (UPS) for selected critical equipment
- pressure safety valves (PSV) on pressurised systems
- emergency shutdown valves strategically positioned to isolate and contain flammable and pressurised materials
- flare systems for the safe disposal of vented hydrocarbons
- fire protection, detection and control systems.

### 8.2.15 Emergency Response

In the course of normal operations, there is always the potential for environmental accidents or incidents to occur. The SACBJV has therefore developed field and office emergency response system plans to guide actions to be taken to minimise the impacts of accidents or incidents. The Environmental Health and Safety Management System (EHSMS) identifies links between plans, environmental management and responsibilities of staff in an emergency.

This section provides a brief summary of the SACBJV's emergency response systems. Emergency response plans and procedures are discussed in detail in SACBJV Fitness for Purpose report.

Emergency plans are reviewed and up-dated to incorporate new information arising from:

- incidents
- near misses
- emergency simulation training sessions.

The SACBJV's emergency planning includes:

- emergency response plans and procedures
- installed emergency response procedures
- dedicated trained emergency response teams
- dedicated emergency response vehicles and equipment
- emergency response exercises
- preventative maintenance program.

### 8.2.16 Pest Plant and Animal Control

Pest plant and animal control is a significant land management issue in the South Australian Cooper Basin. While the region is considered to be relatively free of pest pant species, the SACBJV resources the potential to introduce weed species into the region as a result of the movement of vehicles and construction equipment. Therefore, it is essential that weed management strategies are developed to ensure that vehicles and equipment are washed down if moving from areas of known weed infestations, and that sites are monitored for weed introductions and weed control measures are implemented as required.

Pest animals identified in recent surveys include rabbits, feral cats, pigs, donkeys and camels. A co-ordinated approach is required for the control of these pest animals, involving organisations such as the Marree Soil Conservation Board, the Cooper Creek and Georgina / Diamantina catchment committees, PIRSA and land managers including pastoralists and the oil and gas industry.

### 8.2.17 Abandonment

The SACBJV will progressively rehabilitate facilities that are no longer required (for example, disused roads, pipeline routes and borrow pits). The rehabilitation of these sites will include:

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

Site-specific procedures apply to some facilities. For example, oil pipelines shall be pigged to remove residual hydrocarbons or sludge, and for buried pipelines, aboveground points are cut off and blinded below the surface. Rehabilitation requirements are determined by the relevant regulatory agency at the time of abandonment.

### 8.2.18 Continual Improvement

Continual improvement is the process of enhancing the EHSMS and CBU Management System to achieve improvements in overall environmental performance. The CBU Business Improvement Plan (Environment) and the Cooper Basin (Moomba) Environment Improvement Program aim to assist this process by providing guidelines for the implementation of the CBU Management System and EHSMS and criteria for ongoing assessment of environmental performance. Both plans are to be updated from year-to-year to include changes of procedure, corrective actions and new guidelines.

Major facilities, such as gas and oil satellites, evaporation ponds and the Moomba plant, will also be rehabilitated when they are no longer required. The above process (Section 8.2.17) generally applies to abandonment of all facilities, but specific procedures will apply to some.

A review of waste and process/produced formation water management commenced in 2002. The findings of this review will enable Santos to address future use, reuse and disposal options.

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# Appendix A

# PIRSA Oil in Water Content Requirements

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA
191 Greenhill Road, Parkside

TELEPHONE: (08) 274 7500
TELEGRAMS: Dumex
TELEX: AA88692
FACSIMILE No. 272 7597
PLEASE ADDRESS ALL CORRESPONDENCE TO:
The Director-General
PO Box 151
Eastwood, S.A., 5063

RECEIVED
20 SEP
N. R. ADLER

In reply, please quote SR 28/1/3 TA:CH

15 September 1989

Managing Director
Santos Ltd
GPO Box 2319
ADELAIDE SA 5001

ATTENTION: S TUNSTILL

Dear Sir

Re: Water Disposal

We have been requested to clarify our conditions as to water analysis requirements for the Tantanna and Merrimelia produced water disposal facilities in particular, and for all water disposal systems in general.

Our objective in placing conditions on produced water disposal is to obtain the most cost effective, environmentally safe disposal possible. We would also like to ensure that where the quality of the water was high enough and where a stock owner wished it, produced water was available to a pastoral lessee.

There are two types of disposal facilities:

(a) Those in which the apparent final disposal of the water is a bunded area.

(b) Those in which the apparent final disposal of the water is to natural land.

Where water is being disposed of to land - particulary land which may be accessed by stock or native fauna, we believe Santos has a duty to ensure that no components are present in the water which would have a significant chance of being toxic to stock or native fauna. We also believe that Santos should ensure that the local lessee is aware of the quantity and quality of the water being disposed of so that the lessee may make an informed decision on whether or not he/she wishes the

F00547

water disposal area to be fenced off to prevent access by stock.

We are also of the opinion that Santos should keep the Dept of Mines and Energy informed of the quantity and quality of the water being disposed of and again ensure that the Department is able to make an informed decision whether or not to request Santos to prevent access by natural fauna or take other steps required to protect the environment.

We regard the water disposal facilities in the Cooper Basin as consisting of stages:

1) Primary separation stage eg. slug catcher, separator etc

2) Skimming stage eg. API separator, interceptor pond etc.

3) Holding stage eg. the pond or ponds downstream of the skimming stage.

4) Final Disposal stage eg. evaporation pond or natural disposal area in the case of an evaporation pond this may not be seperate from the holding stage.

Each stage may consist of more than one pond etc and local design constraints lead to variations – nonetheless, we believe that the above view is a useful systemisation of the process.

We expect each stage to work as intended eg. the primary separation stage should efficiently prevent large quantities of free petroleum from passing to the skimming stage.

We expect the lined skimming stage ponds to have some visible oil on the surface as the relatively small quantities of petroleum dispersed in the water separate out. We also expect the skimming stage to have oil removed at frequent intervals and would not expect to find the surface covered with oil several centimetres thick.

The holding stage we expect to be free of visible petroleum at all times and to have an oil and grease level of 30 ppm or below.

We would expect the oil and grease to be below 10 ppm in the water entering a natural disposal area.

If the final disposal stage is to land ie. not to a bunded evaporation pond, we would expect Santos to be aware at all times of the chemical composition of the water – particularly of any components which are toxic. If no changes have

F00547

occurred to the system we would regard annual analyses to be sufficient, we would expect Santos to obtain analyses whenever it is considered prudent to do so.

We would expect routine samples for oil and grease to ensure that the system is performing to specifications. Again, your operating experience with the different facilities should give you a very good idea of how frequently such samples should be taken, but we would certainly regard any period longer than annual difficult to justify even on very stable systems with no history of malfunction.

We have no requirements in general as to the laboratory carrying out the work as long as it is competent. In general, we regard the NATA certification procedures as a very sound, cost effective way of giving credibility to statements of competency and would expect, where possible, all water analyses to be by NATA certified laboratories.

Yours faithfully,

for R K JOHNS
DIRECTOR-GENERAL

F00547

# Appendix B

# Threatened Flora and Fauna Species in the Cooper Basin

Table 1: Flora and fauna species listed in the EPBC Act, 1999 and occurring in north eastern South Australia and/or south west Queensland

| Common name | Scientific name | EPBC Act | CAMBA | JAMBA | CMS | Status | Habitat |
|---|---|---|---|---|---|---|---|
| MAMMALS | | | | | | | |
| Kowari | *Dasycercus byrnei* | V | | | | Rare | mi, cl |
| Dusky Hopping-mouse | *Notomys fuscus* | V | | | | Rare | d |
| Plains Mouse | *Pseudomys australis* | V | | | | Rare | mi, cl, lw |
| Greater Bilby | *Macrotis lagotis* | V | | | | ?extinct | mi, gm |
| Greater Stick-nest Rat | *Leporillis conditor* | V | | | | ?extinct | gh |
| Ghost Bat | *Macroderma gigas* | V | | | | ?extinct | gh |
| BIRDS | | | | | | | |
| Northern Shoveler | *Anas clypeata* | | x | x | x | vagrant | cw, lw |
| Great Egret | *Egretta alba* | | x | x | | common, b | cw, lw |
| Cattle Egret | *Egretta ibis* | | x | x | | vagrant | cw, lw |
| Glossy Ibis | *Plegadis falcinellus* | | x | | x | uncommon, b | cw, lw |
| White-bellied Sea-eagle | *Haliaeetus leucogaster* | | x | | | rare, b | cw |
| Plains-wanderer | *Pedionomus torquatus* | V | | | | ?rare | mi, cl |
| Latham's Snipe | *Gallinago lathami* | | x | x | x | rare, nb | lw |
| Pacific Golden Plover | *Pluvialis fulva* | | x | x | x | rare, nb | cw, lw |
| Lesser Sand Plover | *Charadrius mongolus* | | x | x | x | rare, nb | cw, lw |
| Oriental Plover | *Charadrius asiaticus* | | | x | x | rare, nb | cl |
| Oriental Pratincole | *Glareola maldivarum* | | x | x | | rare, nb | cl |
| Whimbrel | *Numenius phaeopus* | | x | x | x | rare, nb | lw |
| Little Curlew | *Numenius minutus* | | x | x | x | vagrant | lw |
| Black-tailed Godwit | *Limosa limosa* | | x | x | x | rare, nb | cw, lw |
| Bar-tailed Godwit | *Limosa lapponica* | | x | x | x | rare, nb | cw, lw |
| Marsh Sandpiper | *Tringa stagnatilis* | | x | x | x | uncommon, nb | cw, lw |
| Common Greenshank | *Tringa nebularia* | | x | x | x | uncommon, nb | cw, lw |
| Wood Sandpiper | *Tringa glareola* | | x | x | x | uncommon, nb | cw, lw |
| Common Sandpiper | *Tringa hypoleucos* | | x | x | x | rare, nb | cw, lw |
| Ruddy Turnstone | *Arenaria interpres* | | x | x | x | rare, nb | cw, lw |
| Red-necked Stint | *Calidris ruficollis* | | x | x | x | uncommon, nb | cw, lw |
| Long-toed Stint | *Calidris subminuta* | | x | x | x | rare, nb | cw, lw |
| Sharp-tailed Sandpiper | *Calidris acuminata* | | x | x | x | uncommon, nb | cw, lw |
| Pectoral Sandpiper | *Calidris melanotus* | | | x | x | rare, nb | cw, lw |
| Curlew Sandpiper | *Callidris ferruginea* | | x | x | x | rare, nb | cw, lw |
| Painted Snipe | *Rostratula benghalensis* | | x | | | rare, ?b | cw, lw |
| White-winged Black Tern | *Chlidonias leucoptera* | | x | x | | rare, nb | cw, lw |
| Caspian Tern | *Hydropogne caspia* | | x | | | uncommon | cw, lw |
| Fork-tailed Swift | *Apus pacificus* | | x | x | | uncommon, nb | aerial |
| Night Parrot | *Pezoporus occidentalis* | E | | | | ?extinct | d, mi, lw |

| Common name | Scientific name | EPBC Act | CAMBA | JAMBA | CMS | Status | Habitat |
|---|---|---|---|---|---|---|---|
| Thick-billed Grasswren | *Amytornis textilis modestus* | V | | | | ?rare, ?b | gh |
| PLANTS | | | | | | | |
| sea-heath | *Frankenia plicata* | E | | | | ? | cl |

**EPBC Act**: Schedules of Environment Protection and Biodiversity Conservation Act, 1999

E=Endangered; V=Vulnerable

**JAMBA:** x=Listed in Japan – Australia Migratory Birds Agreement

**CAMBA:** x=Listed in China – Australia Migratory Birds Agreement

**CMS:** x=Listed in Convention on the Conservation of Migratory Species of wild animals (Bonn Convention).

**Status:** Probable status of listed species within the subject land

?extinct = probably extinct; vagrant=odd individuals recorded well oustide of normal range; rare=sparsely distributed; uncommon=present in small numbers; nb=non-breeding visitor from outside of Australia; common=present in reasonable numbers, b=likely to breed in area (birds only)

**Habitat:** mi=mitchell grass stony downs; gh=gidgee – mulga low woodland on dissected residuals; gm=gidgee mulga low open woodland on stony downs; cl=sparsely vegetated claypans; lw=lignum – Qld bluebush shrubland on floodplains; cw=coolabah woodlands on floodplain (includes waterholes); d=dunefield

# Appendix C

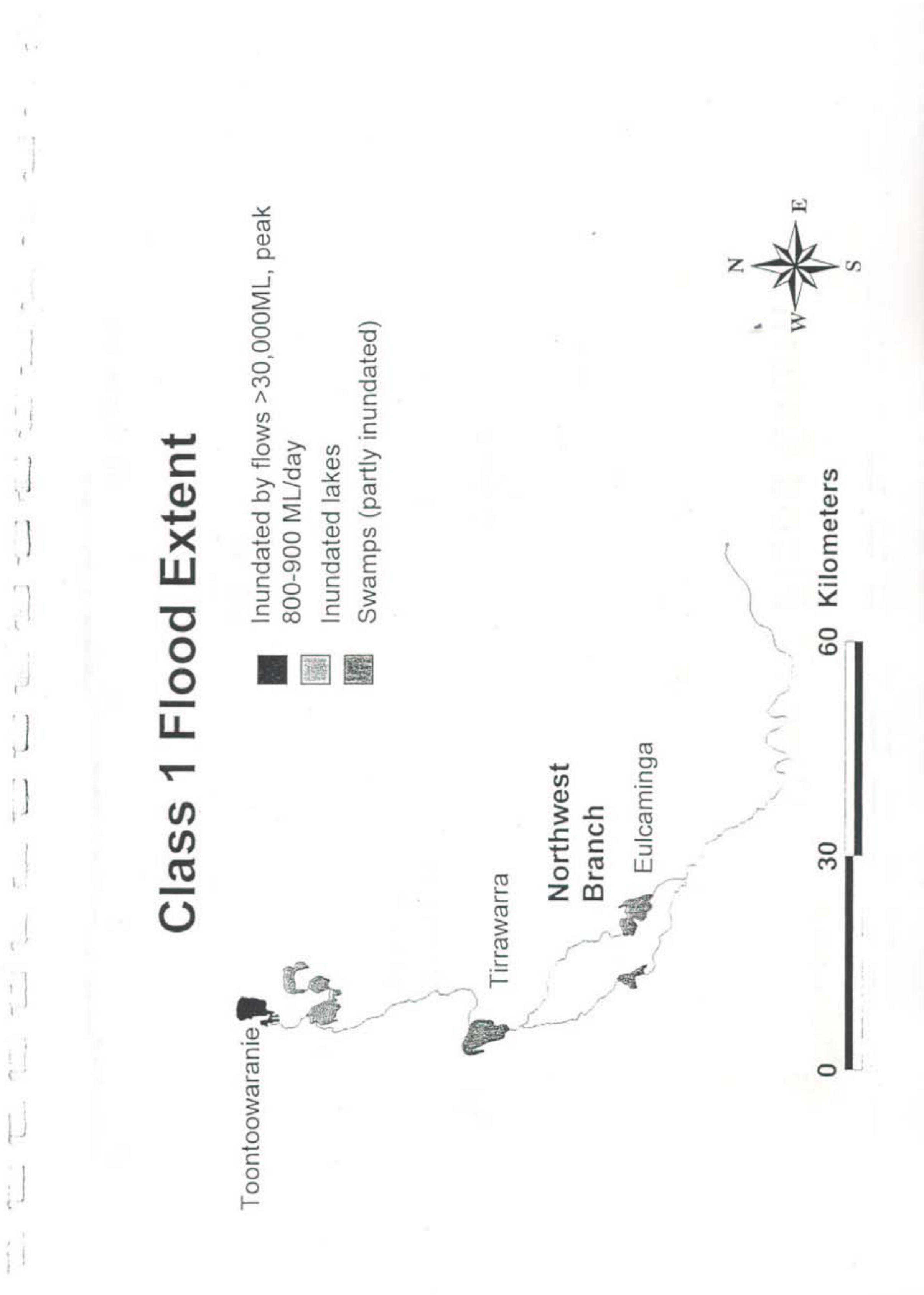
# Common Species Names and Scientific Equivalents

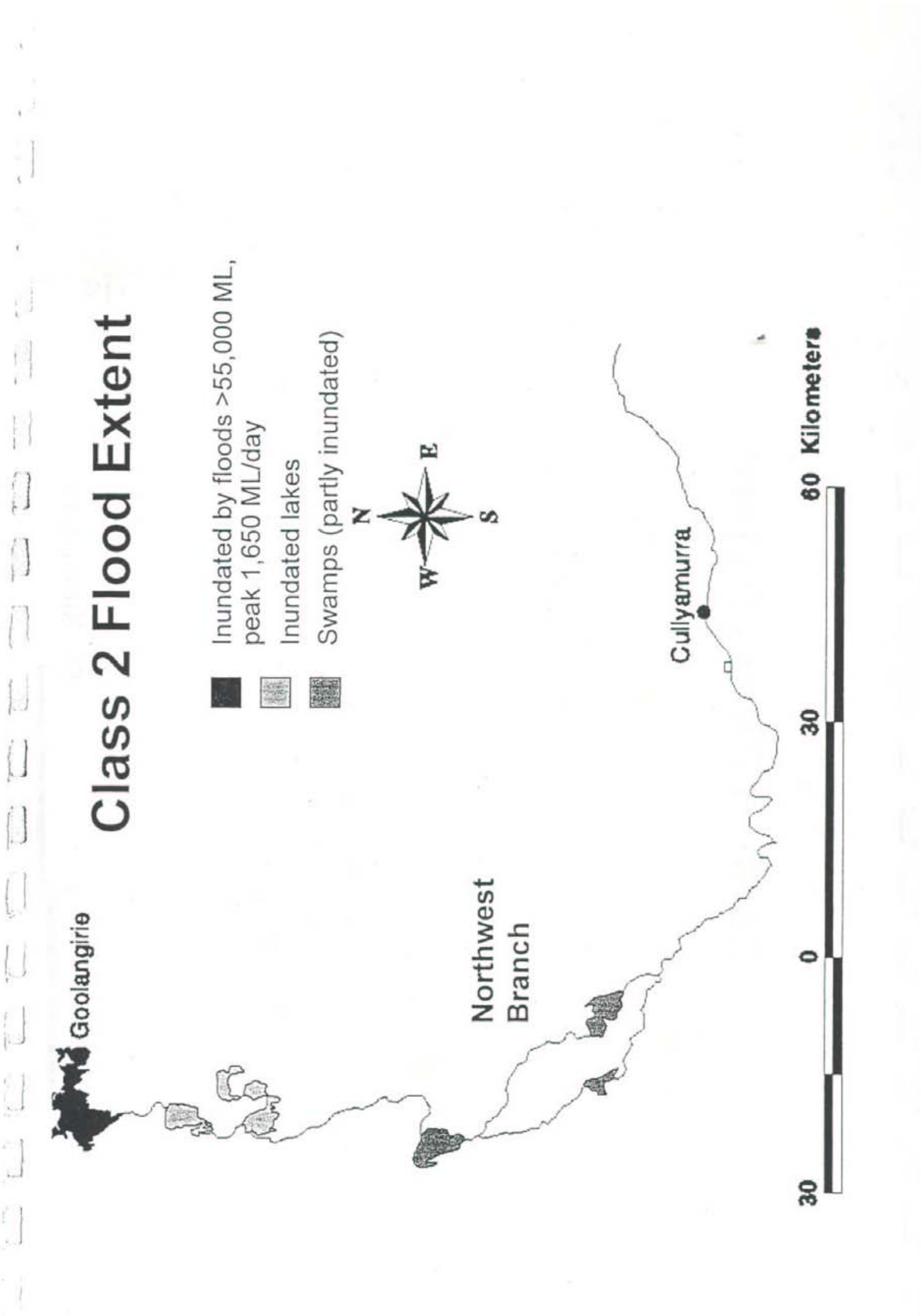
| Common Name | Scientific Name |
|---|---|
| *Plants* | |
| Myriophyllum sp. | Myriophyllum verruccosum |
| Barley mitchell grass | *Astrebla pectinata* |
| Beaked red mallee | *Eucalyptus socialis* |
| Bladder saltbush | *Atriplex vesicaria* |
| Broughton willow | *Acacia salicina* |
| Coolabah | *Eucalyptus coolabah* |
| Copperburrs | *Sclerolaena spp.* |
| Cotton bush | *Maireana aphylla* |
| Emu bush | *Eremophila sp.* |
| Gidgee | *Acacia cambagei* |
| Lignum | *Muehlenbeckia florulenta* |
| Lobbed spinifex | *Triodia basedowii* |
| Narrow-leafed hopbush | *Dodonaea viscosa* ssp. *angustissima* |
| Needlewood | *Hakea leucoptera* |
| Nitrebush | *Nitraria billardierei* |
| Old man saltbush | *Atriplex nummularia nummularia* |
| Prickly wattle | *Acacia victoriae* |
| Queensland Bean tree | *Lysiphyllum gilvum* |
| Queensland bluebush | *Dichanthium sericeum* |
| River red gum | *Eucalyptus camaldulensis* |
| Sandhill canegrass | *Zygochloa paradoxa* |
| Sandhill wattle | *Acacia ligulata* |
| Swamp canegrass | *Eragrostis australasica* |
| Water fern | *Azolla filiculoides* |
| Water weed | *Ludwigia peploides* |
| Whitewood | *Atalaya hemiglauca* |
| *Mammals* | |
| Dusky hopping-mouse | *Notomys fuscus* |
| Yellow-bellied sheath-tailed bat | *Saccolaimus flaviventris* |
| Fat-tailed dunnart | *Sminthopsis crassicaudata* |
| Striped-faced dunnart | *Sminthopsis macroura* |
| Long-haired rat | *Rattus villosissimus* |
| Forrest's mouse | *Leggadina forresti* |
| Water rat | *Hydromys chrysogaster* |
| Dingo | *Canis lupus* |
| Fawn hopping mouse | *Notomys cervinus* |

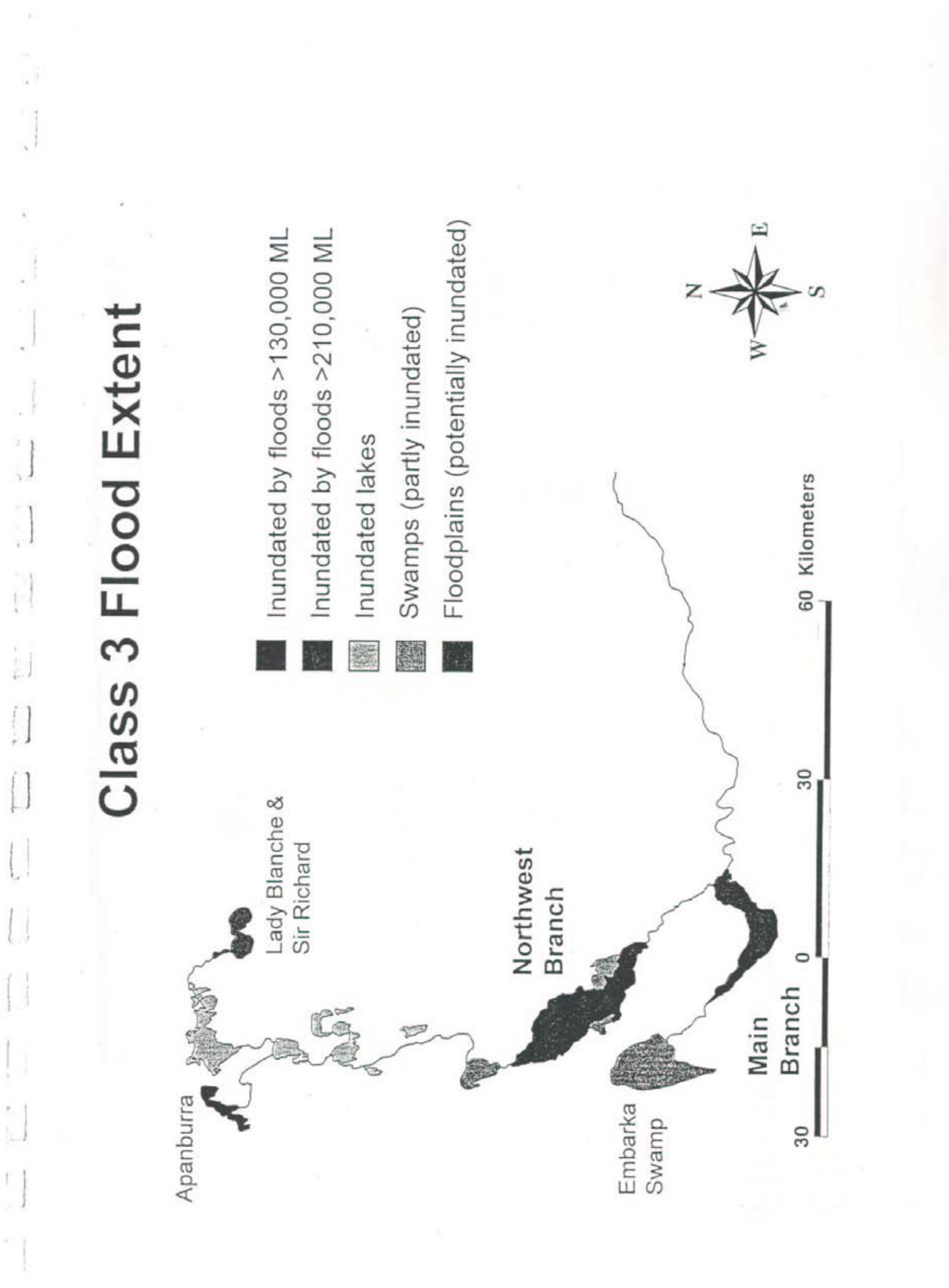
| | |
|---|---|
| Gile's planigale | *Planigale gilesi* |
| Kowari | *Dasycercus byrnei* |
| | |
| *Birds* | |
| Eyrean grasswren | *Amytornis giyderi* |
| White-winged wren | *Malurus leucopterus* |
| White-backed swallows | *Cheramoeca leucosternum* |
| Richard's pipit | *Anthus novaeseelandiae* |
| Brown falcon | *Falco berigora* |
| Barking owl | *Ninox connivens* |
| Mallee ringneck | *Barnadius zonarius barnardi* |
| Grey falcon | *Falco hypoleucos* |
| Black-breasted buzzard | *Hamirostra melanosternon* |
| Letter winged kite | *Elanus scriptus* |
| Freckled duck | *Stictonetta naevosa* |
| Black-tailed native hen | *Gallinula ventralis* |
| Red-necked avocet | *Recurvirostra novaehollandiae* |
| Orange chat | *Epthianura aurifrons* |
| Pelican | *Pelecanus conspicillatus* |
| Gibberbird | *Ashbyia lovensis* |
| Chestnut-breasted whiteface | *Aphelocephala pectoralis* |
| | |
| *Reptiles and Amphibians* | |
| Cooper Creek short-necked tortoise | *Emydura* sp. |
| | |
| *Fish* | |
| Desert rainbow fish | *Melanotaenia splendida* |

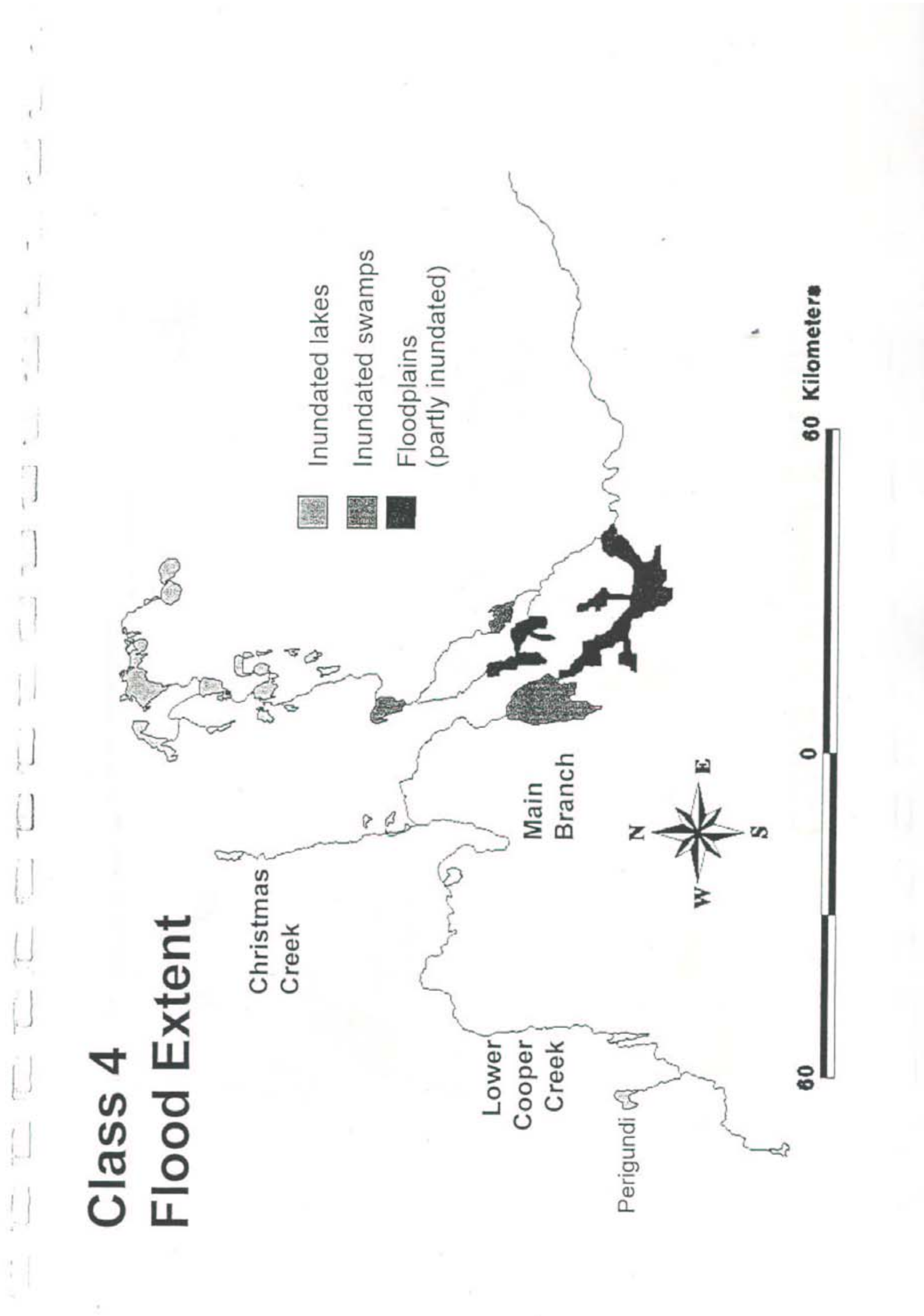
# Appendix D

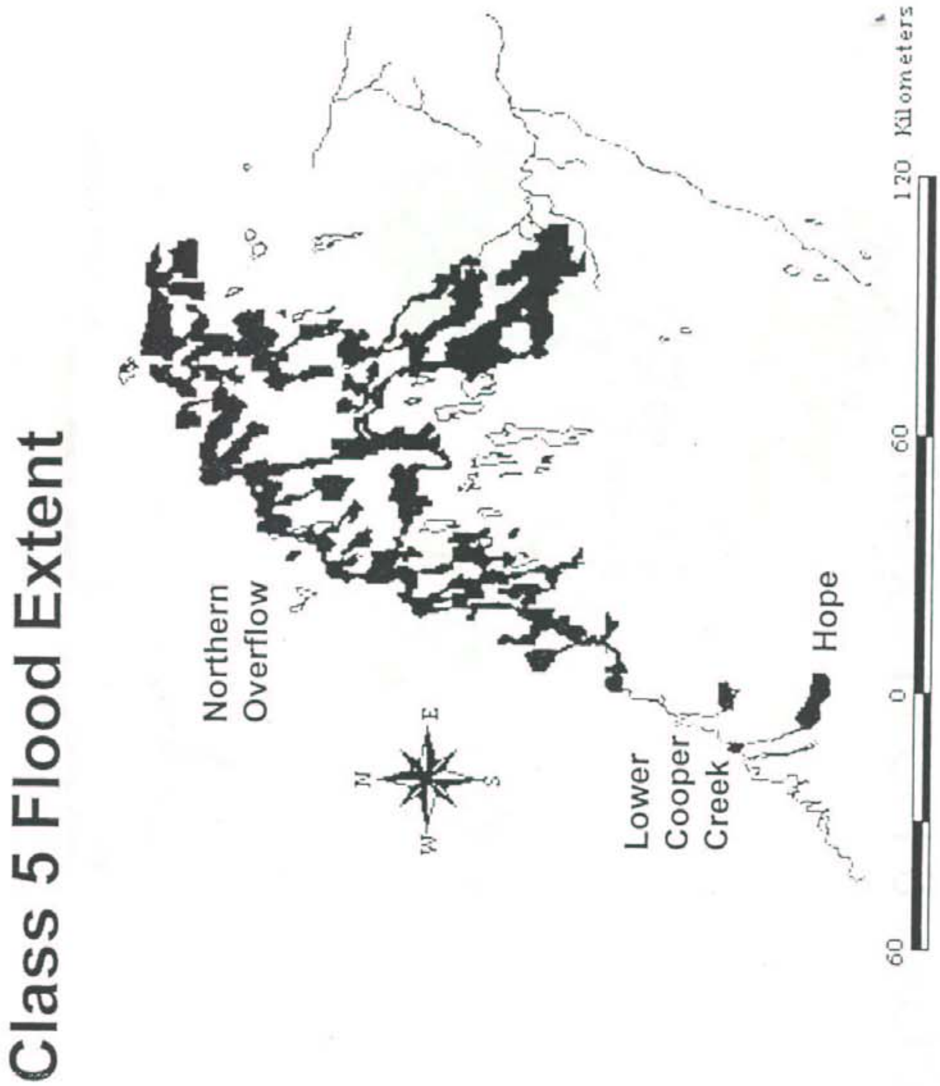
# Cooper Creek Flood Classes & Extent of Inundation

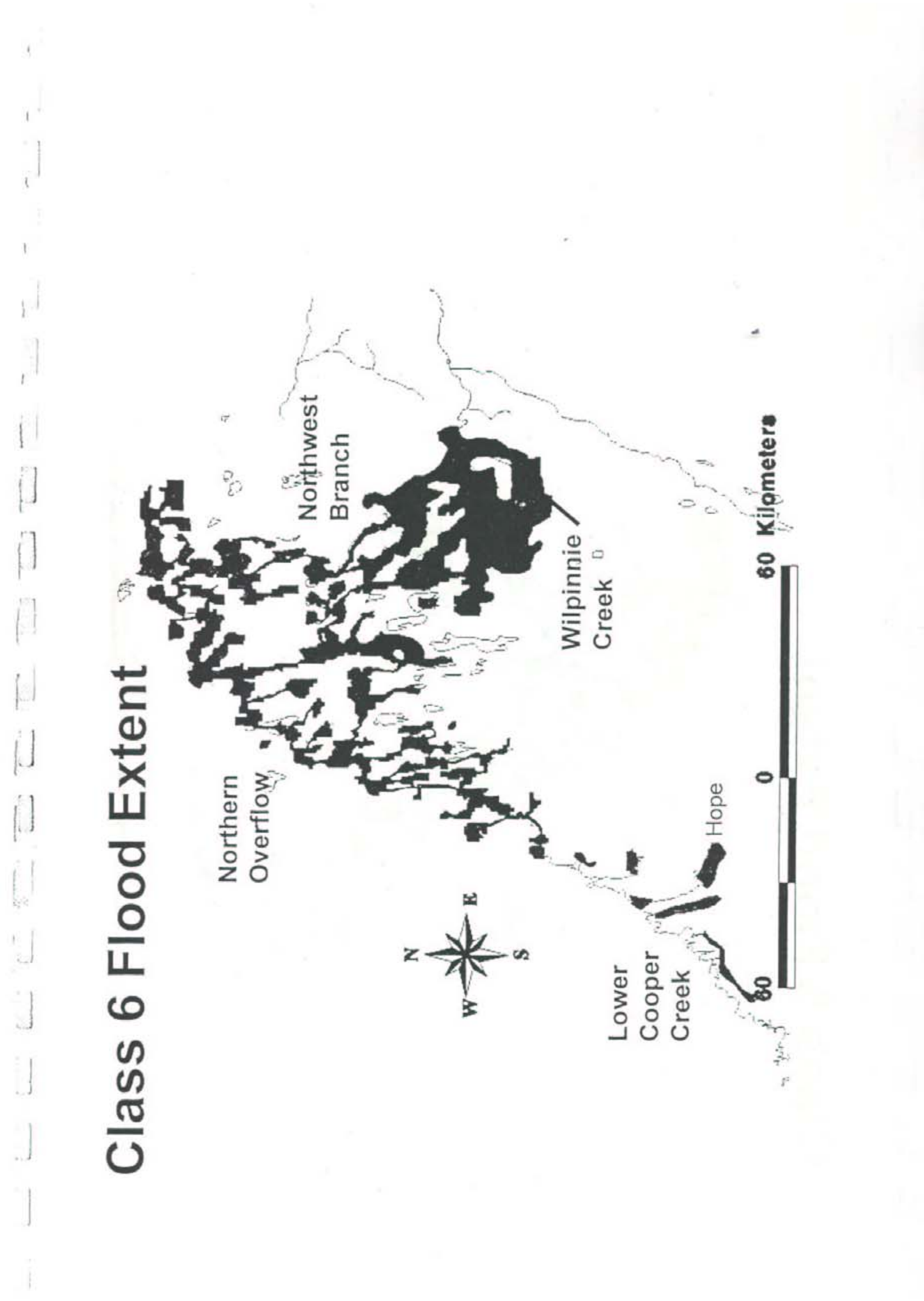

Class 1 Flood Extent
Inundated by flows >30,000ML, peak 800-900 ML/day
Inundated lakes
Swamps (partly inundated)
Toontoowaranie
Tirrawarra
Northwest Branch
Eulcaminga
N
E
S
W
0
30
60
Kilometers

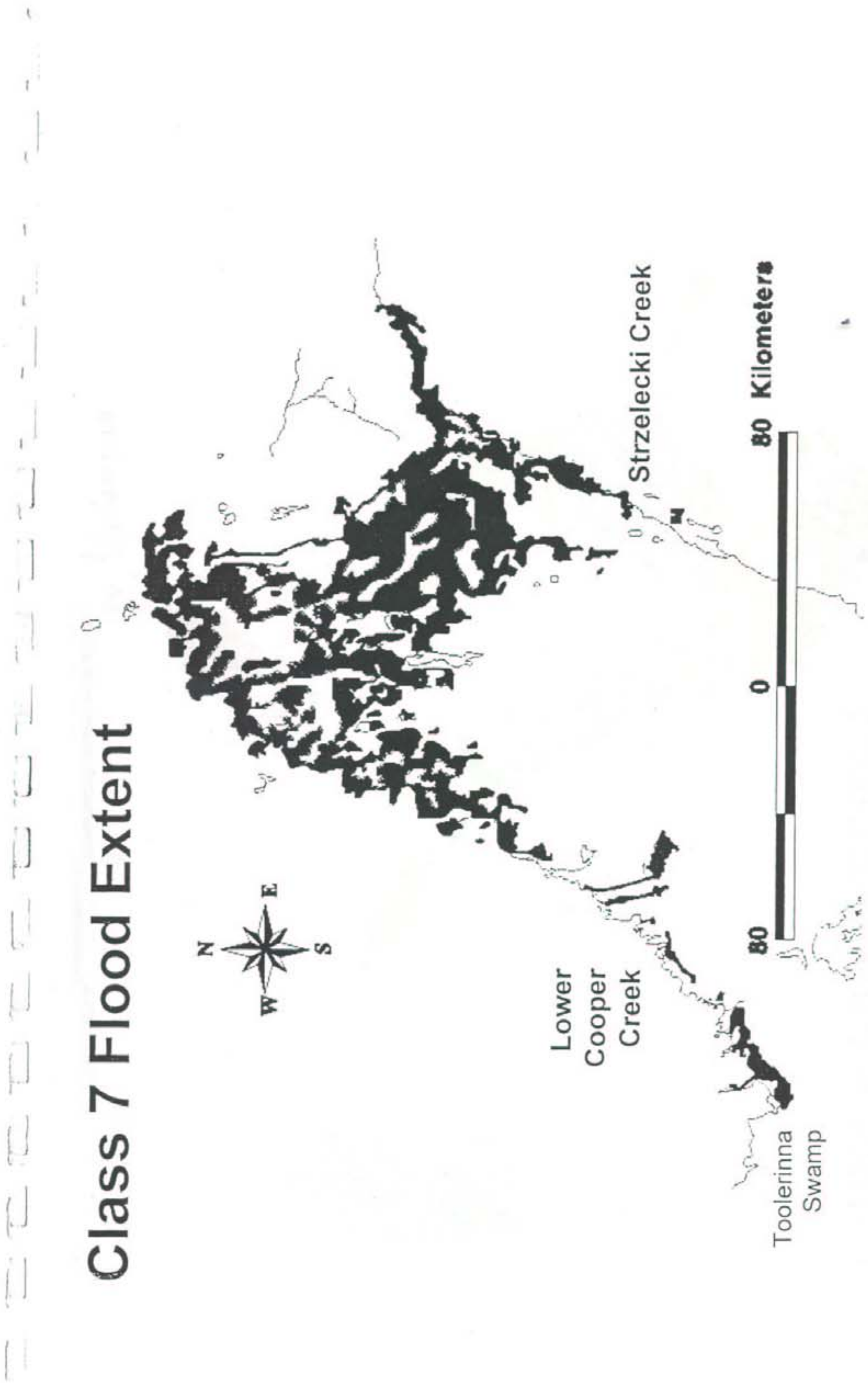

Class 2 Flood Extent
Inundated by floods >55,000 ML, peak 1,650 ML/day
Inundated lakes
Swamps (partly inundated)
N
E
S
W
Goolangirie
Northwest Branch
Cullyamurra
30
0
30
60
Kilometers

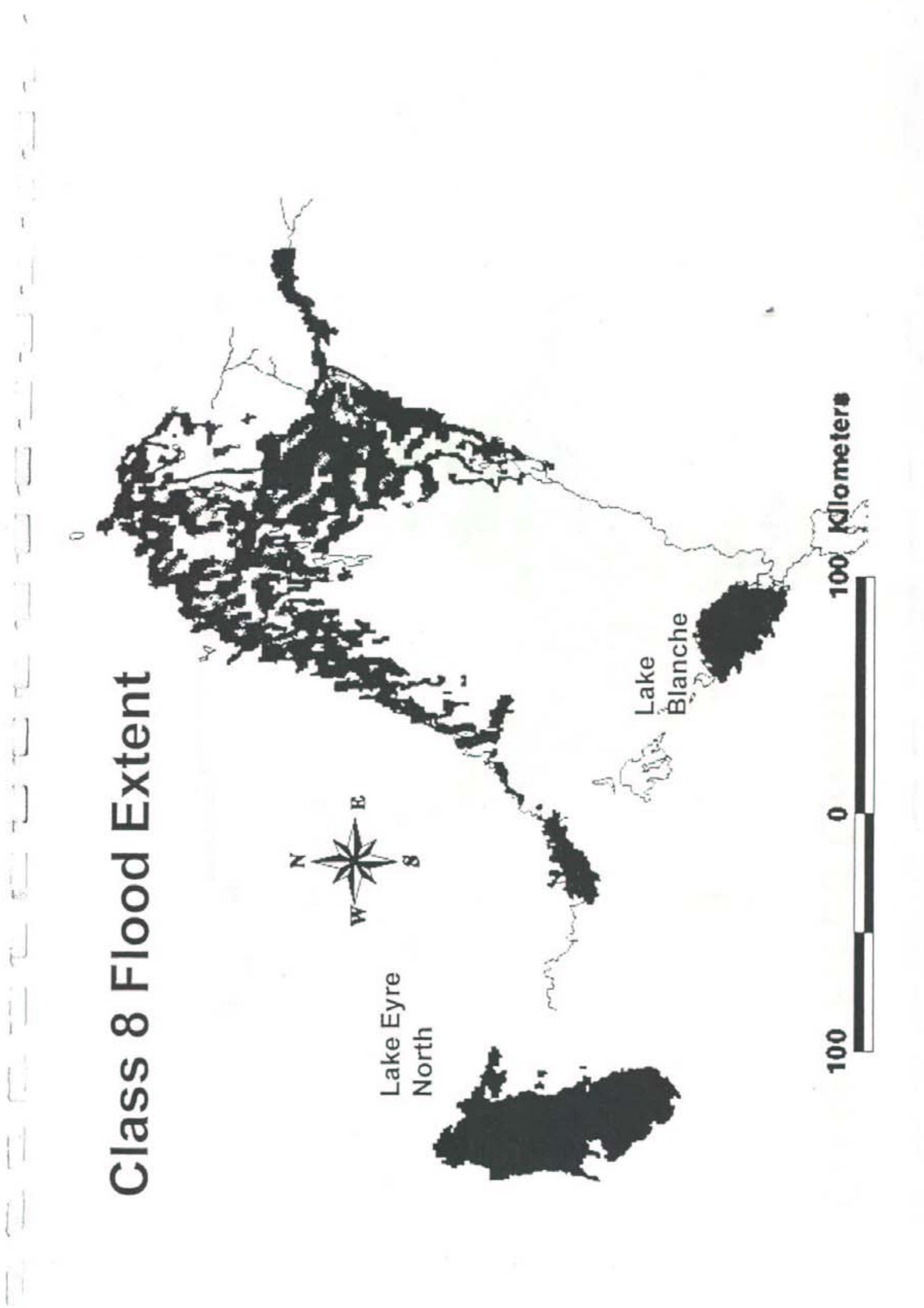

Class 3 Flood Extent
Inundated by floods >130,000 ML
Inundated by floods >210,000 ML
Inundated lakes
Swamps (partly inundated)
Floodplains (potentially inundated)
Lady Blanche &
Sir Richard
Apanburra
Northwest
Branch
Main
Branch
Embarka
Swamp
30
0
30
60
Kilometers
N
E
S
W


Class 4
Flood Extent
Inundated lakes
Inundated swamps
Floodplains
(partly inundated)
Christmas
Creek
Main
Branch
Lower
Cooper
Creek
Perigundi
N
E
S
W
60
0
60
Kilometers


Class 5 Flood Extent
Northern Overflow
Lower Cooper Creek
Hope
N
E
S
W
60
0
60
120 Kilometers


Class 6 Flood Extent
Northwest Branch
Northern Overflow
Wilpinnie Creek
Hope
Lower Cooper Creek
N
E
S
W
60
0
60 Kilometers


Class 7 Flood Extent
N
E
S
W
Strzelecki Creek
Lower
Cooper
Creek
Toolerinna
Swamp
80
0
80
Kilometers


Class 8 Flood Extent
Lake Eyre North
Lake Blanche
N
E
S
W
100
0
100
Kilometers

# Appendix E

# Overview of Stakeholder Consultation Process

NATALIE FULLER
& Associates
ACN 080 625 083

Consultation and Social Planning Consultants

17 DEC 2002

Mr Peter Klaosen
Santos Ltd
GPO Box 2319
ADELAIDE SA 5001

12 December 2002

Dear Peter

**RE: REPORT ON EIR/SEO STAKEHOLDER CONSULTATION**

Please find enclosed the report on the consultation process conducted between September and November 2002 regarding the draft Environmental Impact Reports (EIRs) and the Statement of Environmental Objectives (SEOs) for:

- Drilling & Well Operations in the Cooper Basin; and
- Production &Processing Operations in the Cooper Basin.

The report details the key components of the consultation process namely:

- Disseminating information to identified key stakeholders;
- Conducting a series of workshops;
- Inviting written responses.

Key outcomes from the consultation workshops were recorded by GHD and have been forwarded separately to Santos.

Yours sincerely,

Nat Fuller.

Natalie Fuller

Telephone (08) 8373 6466 • Mobile Telephone 0419 823 137 • Facsimile (08) 8373 6400
E-mail: naf@senet.com.au • Post Office Box 907 Unley • South Australia 5061

NATALIE FULLER
& Associates
ACN 080 625 083

# Drilling & Well and Production &Processing Operations in the Cooper Basin – Outcomes of Stakeholder Consultation Process

## 1 Introduction

Santos Ltd conducted a stakeholder consultation process between September and November 2002 regarding the draft Environmental Impact Reports (EIRs) and the Statement of Environmental Objectives (SEOs) for:

- Drilling & Well Operations in the Cooper Basin; and
- Production &Processing Operations in the Cooper Basin.

Documents relating to Drilling &Well Operations were prepared by Santos on behalf of other petroleum companies, while those relating to Production &Processing Operations were prepared solely for and by Santos.

The purpose of the consultation was to:

- Provide information about the draft documents as well as the approval process as required under the South Australian Petroleum Act 2000;
- Seek comments on the draft documents, particularly regarding:
  - the hazards and consequences, management strategies and level of risk identified in the EIRs;
  - the environmental objectives and associated indicators in the SEOs.

The consultation process involved:

- Disseminating information to identified key stakeholders;
- Conducting a series of workshops;
- Inviting written responses.

Natalie Fuller and Associates Pty Ltd was engaged to facilitate the consultation process with technical support provided by the Principal Environmental Scientist of GHD.

This report summarises the consultation process. Key outcomes from the consultation workshops were recorded by GHD for further consideration by Santos.

## 2 Dissemination of Information

The draft EIR and SEO for both Drilling & Well and Production & Processing Operations in the Cooper Basin, together with a guide explaining all the documents, were sent by Santos in the week starting 19 August 2002 to a comprehensive range of stakeholder groups from:

- Government Departments
- Statutory Bodies
- Non-Government Organisations
- Pastoral Interests
- Joint venture partners
- Petroleum Companies
- relevant Government Ministers and Shadow Ministers.

A full list of stakeholder groups is detailed in Appendix 1.

In addition, members of the public were informed via an advertisement (see Appendix 2) explaining the release of documents and inviting written responses placed in 'The Advertiser', the 'Stock Journal' and the 'Transcontinental' in the last week of August 2002.

## 3 Workshops

The information sent to the above groups included a letter inviting representatives to attend one of the following three workshops:

- Friday 13th September in Adelaide from 9.00 am – 2.00pm in Adelaide regarding Production & Processing Operations;
- Monday 16th September in Adelaide from 1.00 – 5.00pm regarding Drilling & Well Operations;
- Tuesday 17th September at Moomba from 2.00 – 7.00 pm regarding both Drilling & Well Operations and Production & Processing Operations.

The date for the latter workshop was subsequently changed to Monday 23 September so as not to clash with a local rural event.

Follow up phone calls were made to all stakeholder groups encouraging their representatives to attend a workshop, or if this was not possible to forward a written response.

A fourth workshop was held on Monday 4th November 2002 with representatives of the Aboriginal Legal Rights Movement.

The format for each workshop was essentially the same with:

- a welcome and introductory remarks;
- a presentation by PIRSA representatives regarding the approval process under the SA Petroleum Act 2000;
- a brief presentation by Santos staff regarding current operations and associated risks;
- facilitated discussion in smaller groups critiquing:
  - the hazards and consequences, management strategies and level of risk identified in the EIRs;
  - the environmental objectives and associated indicators in the SEOs.
- large group feedback and discussion;
- information about the next steps of the consultation process.

The workshops were well attended, as shown in Appendix 3.

## 4 Written Responses

Written responses were received from

- SA Tourism Commission
- Department of Water, Land and Biodiversity Conservation
- Transport SA
- Arid Areas Catchment Water Management Board
- Aboriginal Legal Rights Movements Incorporated
- Kidman Holding Ltd – leasees of Innamincka Station
- Peter S Lewis

# Appendix 1: Key Stakeholder Groups Sent Information

**GOVERNMENT DEPARTMENTS**

- Environmental Australia
- Department of Environment and Heritage
- Environmental Protection Authority
- National Parks and Wildlife Service
- Department of State Aboriginal Affairs (DOSSA)
- Heritage SA
- Department of Water, Land and Biodiversity Conservation
- Transport SA
- SA Tourism Commission
- Planning SA
- Greenhouse Office

**STATUTORY BODIES**

- Pastoral Management Board
- Great Artesian Basin Consultative Council
- Marree Soil Conservation Board
- Arid Areas Catchment Water Management Board
- Aboriginal Legal Rights Movements Incorporated (ALMA)

**NON-GOVERNMENT ORGANISATIONS**

- Australian Conservation Foundation
- Conservation Council of South Australia
- Wilderness Society
- Nature Conservation Society
- Innamincka Progress Association
- Cooper Creek Catchment Committee
- Lake Eyre Basin Co-ordinating Group
- SA Farmers Federation

**PASTORAL INTERESTS**

- Clifton Hills PL
- Pandie Pandie Station
- Cordillo Downs Station
- Merty Merty Station
- Mungerannie Station
- Bollards Lagoon Station
- Innaminncka Station
- Doce Pty Ltd

**JOINT VENTURE PARTNERS**

- South Australia Chamber of Mines and Energy (SACOME)
- Origin Energy Resources Limited
- Basin Oil Pty Ltd
- SE Asia & Australasia Region, Novus Australia Resources NL
- Delhi Petroleum Pty Ltd

**PETROLEUM COMPANIES**

- Origin Energy Resources Limited
- Beach Oil & Gas Pty Ltd
- Stuart Petroleum NL
- Geodynamics Ltd
- Oil Company of Australia Ltd
- Cooper Energy
- Epic Energy

**MINISTERS**

- Minister for Mineral Resources Development
- Minister for Environment & Conservation
- Shadow Minister for Energy & Minerals & Petroleum Resources
- Shadow Minister for Environment & Conservation

# Appendix 2: Advertisement

**Santos**

## STAKEHOLDER CONSULTATION RE PETROLEUM OPERATIONS IN THE SA COOPER BASIN

*Members of the public are invited to comment on the:*

- draft Environmental Impact Report (EIR) and draft Statement of Environmental Objectives (SEO) for **Drilling & Well Operations**; and
- draft EIR and draft SEO for **Production & Processing Operations**

recently prepared by Santos either independently or on behalf of other petroleum companies relating operating in the South Australian sector of the Cooper Basin.

These documents have been prepared in accordance with Section 97 and Regulation 10 of the SA Petroleum Act and Regulations 2000.

The Environmental Impact Reports (EIR) outline management strategies developed in response to potential operational risks/hazards and associated consequences; while the Statement of Environmental Objectives (SEO) documents outline environmental objectives as well as the criteria to measure the attainment of objectives.

Santos is keen to get feedback on the issues covered in the draft documents so that they can be addressed prior to the documents being submitted to the Department of Primary Industries and Resources SA (PIRSA) for consideration and approval by the Minister for Mines and Energy.

Further information about how to view or get a copy of the documents, please contact Julie Mitchell, Manager Corporate Affairs Santos, on 8218 5111.

*Written comments are due by Friday 20th September 2002.*

SANTOS24-8 3115300

## Appendix 3: Attendance at Workshops

**FRIDAY 13TH SEPT: PRODUCTION AND PROCESSING OPERATIONS**

Arid Areas Catchment Water Management Board: David Leek, Lynn Brake,

Beach Petroleum: Nick Dunstan, Gordon Moseby

Cooper Energy: Chris Porter, Tony Wright

Environment Australia: Karl Heiden

EPA: Nicholas Fox

Epic Energy: Alex Blood, David Fotheringham

National Parks and Wildlife: Brian Moore

Stuart Petroleum: Tim Fatchen

**MONDAY 16TH SEPT: DRILLING AND WELL OPERATIONS**

Beach Petroleum: Nick Dunstan, Gordon Moseby

Cooper Energy: Chris Porter, Tony Wright

Dept of Water, Land and Biodiversity Conservation: Lloyd Sampson, Brigette Soreson

EPA: Nicholas Fox

National Parks and Wildlife: Brian Moore

**MONDAY 23RD SEPT: MOOMBA**

Beach Petroleum: Gordon Moseby

Cooper Creek Catchment Committee: Nora Brandli, Marree Morton

Gidgealpa: Jason Barnes

Innamincka Progress Association: Joan Osborne, John Osborne

Merty Merty Station: Pam Rieck

Mungerannie Station: Graham Bett

National Parks and Wildlife: Christine Crafter, Brian Moore

**WEDNESDAY 4TH NOVEMBER: ADELAIDE**

Aboriginal Legal Rights Movement: Parry Agius, Andrew Beckworth, Sandy Jarvis Sharon Lucas

# Appendix F

# Stakeholder Comments & Responses

**Comments on EIR**

| ISSUE | RELEVANT PAGE/SECTION | RESPONSE |
|---|---|---|
| **ROADS** | | |
| **Route selection:**<br><br>Explanation of how duplication of field roads is avoided. | Section 8.2.2 (Environmental Procedures)<br><br>Appendix G | ▪ Addressed through planning and management of projects and field development.<br>▪ Standard procedures and practices aim to utilise previously disturbed areas where possible to ensure that both costs and the level of environmental disturbance is maintained.<br>▪ Route selection does not just choose the shortest route (least impact, least clay material required and cost reduction are important factors also). |
| **Public safety:**<br><br>▪ Public safety is big concern – how is this taken into account in route selection, construction, maintenance and use.<br>▪ Tourists often get lost due to confusion between Santos roads and public roads. Suggested that signage needed to be upgraded to assist (colour coded etc).<br>▪ Due to risks to tourists vehicle movements should be minimised during school holidays.<br>▪ Request for wider roads, minimised off-road driving and no unauthorised tracks. | Appendix G: Tables G-1, G-3 and G-54 | ▪ Appropriate signage, education and road rules (ie 80km/hr speed limit for all employees and contractors on all roads in the Cooper Basin).<br>▪ Distribution of an information brochure to National Parks, Innamincka Pub and the Store advising tourists and other third parties of potential hazards and safe driving techniques (ie speed and headlights on)<br>▪ There is a recognised trade-off between the level of environmental disturbance, maintenance requirements and safety of roads. Standards have been developed with different classes of roads (including width requirements) for particular activities.<br>▪ Signage to prevent tourist access to field roads is the most appropriate management strategy for management of third party safety.<br>▪ Education and induction for all employees and contractors includes advice that there should be no off-road driving or shortcuts within fields.<br>▪ Traffic volumes are dependent upon level of activity in a particular area. It is difficult to alter drilling rig or maintenance schedules to completely avoid tourist season within the Innamincka Regional Reserve.<br>▪ Notices of rig moves broadcast of HF radio Channel 9 for Santos employees and contractors. |
| **Dust:**<br><br>▪ Transportation of rigs along roads and dust caused by this and other vehicular activity (one particular concern associated with truck movements near homesteads being very dusty).<br>▪ Problem associated particularly with the movement of rigs. Much of vegetation along roads unacceptable to stock.<br>▪ Third party hazard and nuisance. | As above | ▪ Vehicle speed restriction to minimise dust creation.<br>▪ Unable to assess likely impact of this on grazing capacity, particularly when grazing occurs on the broad scale occurring in this region. This issue cannot be addressed effectively through any management strategies or compensatory measures. Risk of cattle feeding close to roads and associated hazards for both vehicles and stock may be mitigated by this factor. |

Comments on EIR

| ISSUE | RELEVANT PAGE/SECTION | RESPONSE |
|---|---|---|
| Vegetation clearance during well lease and access track construction / movement of heavy machinery and equipment – it is considered that the likelihood is LIKELY or VIRTUALLY CERTAIN (rather than unlikely) | n/a | ▪ The assessment of risk is based on the likelihood of the consequences listed occurring rather than the actual hazard occurring. Therefore the risk here is considered LOW. |
| Seed stock becomes unviable when stockpiled for a significant period of time. | Section 8.2.2 (Environmental Procedures) | ▪ This is recognised and is the reason why if a well is successful all stockpile topsoil and cleared vegetation is respread over the restored areas during partial restoration as it will be of limited value for restoration purposes at final abandonment of a producing well. |
| BORROW PITS | | |
| Placement to avoid risks to public safety (i.e. away from roads and edges battered to remove steep slopes). | Section 8.2.2 (Environmental Procedures) | ▪ Borrow pits >75m from roads and access tracks. |
| To restore or to not restore – issue of grazing pressure distribution. | N/A | ▪ The current approach to borrow pit restoration requiring landholder sign-off on unrestored borrow pits) has been previously agreed between Santos, landholders, PIRSA and the Pastoral Management Branch. No alteration would be appropriate until issue of grazing pressures has been resolved and without input of all stakeholders. This is considered out side of the scope of this EIR. |
| Risk of injury through accidents if borrow pits are located too close to roads. | Section 8.2.2 (Environmental Procedures) | ▪ The risk to public safety associated with borrow pits is considered to be low and is managed through Santos procedures i.e. borrow pits are constructed a minimum of 75m from roads, access tracks and other facilities. |
| CULTURAL HERITAGE | | |
| Identification of aboriginal heritage sites during initial clearance and rehabilitation. | Section 6.1 (Aboriginal Consultation) | ▪ All sites are surveyed prior to any works.<br>▪ Rehabilitation activities are unlikely to affect/impact on additional areas than those surveyed during the initial site survey. |
| Notification of environmental incidents to Aboriginal groups and consultation on spills categorised as serious. | Section 8.2.5 (Reporting) SEO Section 4 (Reporting) | Serious incidents are notified to PIRSA and the EPA as they are the regulatory agencies that licence the activities. These incidents are available on the PIRSA public record. |

Comments on EIR

| ISSUE | RELEVANT PAGE/SECTION | RESPONSE |
|---|---|---|
| Santos procedures should be adhered to for the avoidance of archaeological sites. More sites should be identified and fewer destroyed. Improve awareness/education. | Section 8.2.2 (Environmental Procedures) Section 8.2.3 (Awareness & Training)<br>Appendix G: Tables G-1 & G-3<br>SEO objective #5 | Education and training of appropriate personnel is a required management strategy and environmental objective. No sites are 'destroyed' when they have been identified. |
| Santos procedures should be adhered to for the avoidance of archaeological sites. More sites should be identified and fewer destroyed. | As above | ▪ Education and training of appropriate personnel is a required management strategy and environmental objective. No sites are 'destroyed' when they have been identified. |
| PIPELINES / GATHERING LINES | | |
| Definition of "regular" should be explained with respect to inspection frequency. | Section 8.2 (Management of Environmental Risks) | ▪ This is addressed by the Santos Pipeline Management Strategy which was designed in accordance with the requirements of AS2885.<br>▪ Pipeline and flowline inspection frequency is based upon the level of risk ascribed to each pipeline/flowline. |
| With regard to failure of gathering lines and loss to ground, the risk associated with this issue was perceived as HIGH as a result of past experience. | Section 7.1 (Gathering Systems), Section 8.1 (Risk Management & Assessment), Section 8.2.2 (Management of Environmental Risks) and Appendix G (Table G8) | ▪ The risk is addressed through appropriate management strategies, as indicated, and therefore assigned a risk level – LOW.<br>▪ Also further studies relating to pipeline management and materials are being undertaken.<br>▪ Santos Pipeline Management Strategy, all pipelines managed and assessed in accordance with AS2885. |
| Pits and trenches hazard to small animals that may become trapped or stock movements impeded.<br>- Possible death of trapped animals.<br>- Restriction of stock access to watering points leading to lost productivity or death. | Section 8.2.2 (Environmental Procedures) | ▪ well cellars are covered<br>▪ pipeline trenches left open for minimum possible while open (generally less that 3 days) and prior to backfilling.<br>▪ ladders and ramps are provided at regular intervals to assist trapped animals for escape<br>▪ trench plugs left at regular intervals, particularly coinciding with cattle "pads" leading to waters etc |
| WATER / FORMATION WATER MANAGEMENT | | |
| Water should be seen as valuable resources as well as something to be dealt with. | Section 5.4 (Aquifer Use) | ▪ The importance of water in the arid Cooper Basin environment is recognised, however management strategies and assessment criteria are required for formation waters due to variable water quality and large volumes associated with oil and gas extraction. |

Comments on EIR

| ISSUE | RELEVANT PAGE/SECTION | RESPONSE |
|---|---|---|
| Formation water as water source for stock.<br>- Testing to determine applicability.<br>- Implication for flora and fauna.<br>- Increases in grazing pressure in areas not previously grazed.<br>- Level of risk is perceived as HIGH. | | ▪ This has historically been addressed through agreements with landholders, PIRSA, and the Pastoral Management Board, which allowed for the use of PFW as a stock watering source by landholders if required.<br>▪ Formation water is utilised for stock watering purposes.<br>▪ Formation water access agreements are being progressed with landholders requiring access to stock water. Tanks and troughs are being supplied in those instances where agreements are in place to prevent damage to formation water evaporation pond bund walls.<br>▪ The issue of increased grazing pressure is considered to be outside of the scope of the EIR and SEO documents as it is addressed by legislation other that the Petroleum Act and should be addressed jointly by all stakeholders involved to seek a resolution. If access to water is not required stock proof fencing can be installed to prevent access to evaporation ponds.<br>▪ Annual water quality monitoring of formation water is undertaken (these results are available under the terms of formation water access agreements). |
| Inappropriate water quality for stock watering (eg contaminants and fluoride) may result in:<br>- loss of Cattle Care or Organic Beef Certification; and/or<br>- loss of stock productivity. | | ▪ Annual monitoring of water quality (results available to landholders).<br>▪ Produced formation water agreements with landholders with respect to stock usage.<br>▪ Stock proof fencing or facilities where the water quality is considered unacceptable. |
| Options for re-use (in addition to stock water) i.e. waterflood or reinjection. | Refer to Drilling & Well Operations and Waterflood Pilot EIR and SEO documents | ▪ The possible reinjection of produced formation water for either disposal or enhanced recovery is the subject of ongoing review within Santos. A separate EIR and SEO for a waterflood trial have been submitted to PIRSA for approval (February 2003). In addition the Drilling and Well Operations EIR and SEO include discussion waterflood or reinjection and reference should be made to these documents. |
| The diversion of storm/flood waters around Moomba and Moomba Creek is facilitated by a bund north of airport (possible impacts on local flooding regime). | n/a | ▪ The potential impact of the bund on the infrequent flooding regimes is recognised however the bund was constructed in 1996 following consultation with downstream users. This bund replaced numerous small bunds that were place and was constructed to prevent flooding and the associated hazard to the Moomba plant to ensure security of supply. |

**Comments on EIR**

| ISSUE | RELEVANT PAGE/SECTION | RESPONSE |
|---|---|---|
| Flooding - Expand on Table G22 – management strategies as per Table G21 | | ▪ Refer to Tables G21 and G22. |
| Expand on detail of current studies (i.e. formation water action plan), define guidelines and remediation targets and continual improvement. | Section 8.2.8 (Produced Formation Water Management) | ▪ The Formation Water Action Plan is currently in progress. The outcomes of the study will be to define evaporation pond sediment remediation criteria (to address all contaminants and issues such as salinity) and eventually water disposal criteria for produced formation water. The EIR is not considered the appropriate place for a high level of detail on each of these studies. |
| **GAB water (Moomba Plant):**<br>Reuse/efficiency – targets and timeframes.<br>Free flowing bores (none in Santos area) | Section 7.5.1 (Water)<br><br>Section 8.2.18 | ▪ A waste water study has been initiated for the Moomba Plant.<br>▪ There are no uncontrolled free flowing bores in Santos' permit areas.<br>▪ Issues of aquifer pressure depletion and contamination are covered in the Drilling and Well Operations EIR and SEO. |
| The risk of aquifer pressure reduction is perceived as HIGH. | Sections 5.4 (Aquifer Use) 7.5.1 (Water)<br><br>Appendix G: Table G8 | ▪ Assigned Risk Level – MEDIUM<br>▪ This is addressed through:<br>- appropriate management strategies, as indicated.<br>- water minimisation and conservation<br>- cleaner production<br>- usage monitoring |
| SPILL MANAGEMENT / CONTINGENCY PLANNING / EMERGENCY RESPONSE PLANS | | |
| Detail on the management of spills is lacking with particular concern on spills to creeks (from pipelines or truck rollover). | Section 4.2<br>Section 8.2.15 (Emergency Response)<br><br>Appendix G: Table G-8, G-11 and G-12. | ▪ Spill contingency plans and emergency response plans are in place for response to large spills.<br>▪ Routine annual spill response exercises are planned. Evaluation of response procedures is also undertaken annually.<br>▪ Land transport procedures apply.<br>▪ Flood management plans provide warning of flood events, with no transportation during flood periods.<br>▪ Dry break couplings etc for spill prevention at load in and load out.<br>▪ The Cooper Creek Spill Study will provide recommendations for spill prevention and mitigation.<br>▪ All fuels etc stored and transported in accordance with AS 1940 and the Australian Dangerous Goods Code (ADG Code). |
| Likelihood of spills perceived to be LIKELY rather than UNLIKELY based on past operational performance. | | ▪ Appropriate systems are in place to ensure that spills/leaks do not occur, therefore, this the likelihood of this occurring is considered unlikely. |
| Risk associated with contamination of | Section 8.1 | ▪ Whilst the consequence of such an event is |

Comments on EIR

| ISSUE | RELEVANT PAGE/SECTION | RESPONSE |
|---|---|---|
| watercourses is perceived as HIGH. | (Risk Assessment) Section 8.2 (Management of Environmental Risks) | considered to be MAJOR, the likelihood is considered UNLIKELY (refer above) and therefore the overall level of risk is MEDIUM (rather than HIGH). |
| Chemical spills are perceived by landholders as a higher risk. This needs to be recognised as significant risk to cattle accreditation. | As above | ▪ The significance of this hazard is recognised in the EIR and SEO and as a result management strategies have been developed to address this. For example chemicals covered during transportation, contaminated areas and drilling sumps fenced off. These strategies have resulted in an overall lowering of the level of risk. |
| Spill (and cumulative spills) management is an issue. Spills should be avoided and contingency/remediation plans implemented. | As above | ▪ These issues are included in the EIR and SEO (avoid contamination of soils, water and groundwater and remediate where necessary).<br>▪ Spill volume recording and reduction in incident numbers and volumes is a management and assessment criteria.<br>▪ Clean up and remediation is undertaken and should meet agreed criteria. |
| A system is required for tracking improvements in spill performance. | Section 8.2.13 (Incident Management System) Section 8.2.4 (Incident Management and Recording) | ▪ Santos has developed the Incident Management System for this purpose.<br>▪ Other operators should have a system as discussed within the EIR. |
| Spill (and cumulative spills) management is an issue. Spills should be avoided and contingency/remediation plans implemented. | Section 8.2 (Management of Environmental Risks) | ▪ These issues are included in the EIR and SEO (avoid contamination of soils, water and groundwater and remediate where necessary).<br>▪ Spill volume recording and reduction in incident numbers and volumes is a management and assessment criteria.<br>▪ Clean up and remediation is undertaken and should meet agreed criteria. |
| Contamination of Soil, Groundwater or Watercourses.<br>▪ Chemical awareness to ensure no chemicals can leave trace residue.<br>▪ Sites are fenced and infrastructure is installed away from flood plains and water courses | SEO Objectives 2, 4 &11. | ▪ Hazardous material stored, used and disposed of in accordance with relevant legislation and standards for dangerous substances<br>▪ Inspection and review. |
| PASTORAL IMPACTS / STOCK DISTURBANCE | | |
| List of environmental consequences in Chapter 7 does not include disturbance to livestock. | Chapter 7 | ▪ List updated “disturbance or injury to native fauna and livestock”. |

Comments on EIR

| ISSUE | RELEVANT PAGE/SECTION | RESPONSE |
|---|---|---|
| Leaving gates open and stock disturbance:<br>- mixing of stock.<br>- financial and time costs to pastoral operations. | Chapter 7 (Environmental Hazards and Consequences), Appendix G & SEO Objective 10 | ▪ Where valid, claims can be made for costs incurred due to oil and gas exploration and production activity.<br>▪ Education and induction programs for all staff and contractor personnel working in the Cooper Basin.<br>▪ Compensate landholders for lost stock, lost time for remustering. |
| Helicopter use results in disturbance to stock. | n/a | ▪ The amount of low flying is minimised wherever possible to reduce risks to the safety of personnel in helicopter.<br>▪ Helicopter use is avoided where possible (alternative means of transportation utilised) due to cost.<br>▪ Pipeline inspection activities require flights be undertaken at relative low altitudes, however this is a key management strategy for the identification of any possible leaks in pipeline infrastructure and is therefore unavoidable.<br>▪ Maximise flying height wherever possible to avoid disturbance. |
| Movement of materials (chemicals etc via truck transportation) | Appendix G: Table G-2<br>SEO Objectives 2, 8, & 11 | ▪ Movement of chemicals was raised by landholders as a significant concern. Appropriate packaging, loading and tie down procedures must be followed to ensure that this does not occur. Appropriate procedures are covered in the EIR as management strategies. |
| To avoid contamination requires awareness of chemicals to ensure that no trace residue is left and sites are fenced and infrastructure installed away from floodplains and watercourses. | Appendix G | ▪ Storage and handling in accordance with AS1940 and Australian Dangerous Goods (ADG) Code. |
| **ABANDONMENT / REHABILITATION** | | |
| Issue of facility abandonment needs to be reviewed, with more detail provided (for example the ability to effectively remediate evaporation ponds?). | Sections 8.2.8, 8.2.11 and 8.2.17. (Produced Formation Water Mgmt, Oil Spill Remediation & Abandonment) | ▪ Santos is in the process of preparing a remediation and abandonment plan for the SA Cooper Basin.<br>▪ Soil Health Index (SHI) criteria are currently being developed for the remediation of contaminated soils and evaporation pond sediments. |
| Aesthetics or visual amenity should be taken into account for abandonment and remediation. | Refer SEO Environmental Objectives and Assessment Criteria | ▪ Established criteria include and assessment of visual impact following remediation. Any new criteria will also include visual amenity. |
| Visual amenity should be an important assessment criterion. | Section 8.2.2 (Environmental Procedures) | ▪ Current practices outlined in procedures (i.e. dog legging of pipelines access tracks at road intersections) are aimed at reducing visual impact of operations). This issue is also addressed at abandonment (see above).<br>▪ Loss of visual amenity is identified as a potential hazard. |

Comments on EIR

| ISSUE | RELEVANT PAGE/SECTION | RESPONSE |
|---|---|---|
| **PEST PLANTS AND ANIMALS** | | |
| Feral animals need to be included with respect to pests. The spread of pest plants and animals needs further assessment/review. | Section 8.2.7 (Pest Plant and Animal Control) | ▪ Feral animal management programs are co-ordinated with local landholders, the Marree Soil Conservation Board and Catchment Management Boards.<br>▪ Greatest level of risk is given to the possible transfer of weeds from Queensland operational areas into South Australia which is considered relatively weed free. A weed management plan should be developed in order to ensure co-ordinate management procedures are in place to reduce this risk. |
| Interstate movement of rigs should have washing prior to entering SA for weed eradication and control of feral animals. Tourists also a problem but uncontrollable unless washing stations made available at borders. | Section 8.2.7 (Pest Plant and Animal Control)<br>Appendix G | ▪ Risks are managed by ensuring that rigs are washed when leaving areas of known infestations. Complete rig washdown is a time consuming and very costly exercise and is considered unwarranted for every border crossing.<br>▪ Continual review and monitoring of weed infestations is required to ensure that this does not change. GAS criteria in place to deal with weed spread for well sites. |
| **GENERAL** | | |
| **Fires and Explosions:**<br>Exclude petrol vehicles, Adhere to Santos procedures, Continued Zero tolerance for fires in open pastoral country. Proper signage. | SEO Objective #1 | ▪ Effective emergency response plan and procedures are in place in the event of a fire or explosion. |
| What are management strategies for avoiding fires and explosions (well operations). | Appendix G | ▪ Personnel are trained to supervise and instruct individuals entering lease to conduct work.<br>▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct work on a lease.<br>▪ Equipment spacing criteria is followed. No smoking or safe smoking areas away from equipment or well.<br>▪ Petrol vehicles to be excluded from well sites.<br>▪ Emergency response procedures should contain a bushfire scenario. |
| **Air quality:**<br>Fugitive emissions and flaring resulting in increase $CO_2$ to atmosphere. | Section 7.4 (Moomba Plant – Process Facilities), Section 8.2.12 (Air Emissions Management) & Appendix G: Tables G16-18 | ▪ This is addressed in the EIR, however, it is noted that continual improvement and monitoring is required, as is additional information to address public awareness and perception.<br>- management of emission sources.<br>- monitoring of emissions<br>- continual improvement |

Comments on EIR

| ISSUE | RELEVANT PAGE/SECTION | RESPONSE |
|---|---|---|
| | | - public education |
| **Gaseous Emissions**<br><br>Make less smoke (it contributes to air pollution and the Greenhouse Effect) | As above | ▪ Annual auditing of current volumes vented and planning for reductions in those volumes.<br>▪ Well testing and blowdown are conducted in accordance with accepted industry standards and appropriate emergency response procedures are implemented in the case of a gas leak.<br>▪ Where relevant emissions should be reported as part of annual NPI reporting. Any issues that are identified should be addressed in accordance with relevant guidelines, industry standards and the principles of ecologically sustainable development.<br>▪ Inline testing is conducted as often as possible to reduce flaring |
| **Contractor training:**<br><br>Ensure that it is clear in the document that this is an important component of Santos education and induction programs. | Section 8.2.3 (Awareness and Training) | ▪ Contractors and staff are required to undergo education, induction and training programs (initial induction and annual review is required). |
| **Impact of flood events on construction and operations**<br><br>How is the flood potential monitored/managed. | Section 4 and 8 | There are two likely flood events in the Cooper Basin these include:<br>1. Local rain events, which are managed through reviewing local weather forecasts and planning/managing events to ensure potential impacts are unlikely and minimised (i.e. removal of fuel/chemical sources during event)<br>2. Significant flood of Cooper Catchment, which is managed using historical data to estimate the potential flow and coverage of the flood and enables precautionary measures/management strategies to be employed. |
| **Fencing of operational areas**<br><br>Inappropriate fence posts may cause loss of Cattle Care of Organic Beef Certification. | Section 8.2.1 (Management Systems) | ▪ Use alternate (non chemically treated i.e. creosote and "perma-pine" posts) posts for new installations |

# Appendix G

# Summary of NPI Submissions

## Table F 1: Summary NPI Submissions for Reporting Period 1st July 1999 to 30th June 2000

| Satellite | Emissions kg/yr | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Arsenic & compounds | Benzene | Cadmium & compounds | Carbon Monoxide | Chromium (VI) compounds | Lead & compounds | Mercury & compounds | Oxides of Nitrogen | Particulate Matter 10.0 um | Polycyclic hydrocarbons | Toluene | Xylenes |
| **South Australia** | **1.9829** | **35351** | **11.794** | **2194335** | **0.75** | **2.908** | **2.787** | **10855228** | **115807** | **18.3** | **25853** | **14305** |
| Big Lake Gas | 0.0179 | 1991 | 0.984 | 142396 | 0.063 | 0.243 | 0.233 | 390185 | 6799 | | 1169 | 312 |
| Bookabourdie | 0.038 | 1655 | 0.209 | 90646 | 0.013 | 0.051 | 0.049 | 689901 | 1442 | | 960 | 252 |
| Daralingie Gas | 0.029 | 39 | 0.159 | 68898 | 0.01 | 0.039 | 0.037 | 524378 | 1096 | | 57 | 32 |
| Della Gas | 0.049 | | 0.272 | 118173 | 0.017 | 0.067 | 0.064 | 899413 | 1879 | | 998 | 341 |
| Dullingari Gas | 0.073 | 7198 | 0.402 | 174595 | 0.026 | 0.099 | 0.095 | 1328842 | 2777 | | 4260 | 1162 |
| Gidgealpa Gas | 0.037 | 75 | 0.206 | 63304 | 0.013 | 0.051 | 0.049 | 417991 | 1424 | | 111 | 62 |
| Kidman | 0.015 | 134 | 0.082 | 35515 | 0.005 | 0.02 | 0.019 | 270306 | 565 | | 201 | 113 |
| Merrimelia Gas | 0.019 | 241 | 0.106 | 45875 | 0.007 | 0.026 | 0.025 | 349155 | 730 | | 137 | 34 |
| Moomba South Central | 0.101 | | 0.556 | 109943 | 0.035 | 0.137 | 0.131 | 516538 | 3842 | | 431 | 111 |
| Strzelecki Gas | 0.017 | | 0.091 | 39708 | 0.006 | 0.023 | 0.022 | 302219 | 631 | | 554 | 172 |
| Tirrawarra | 0.187 | 1272 | 1.028 | 265787 | 0.065 | 0.253 | 0.243 | 1583162 | 7102 | | 782 | 255 |
| Toolachee | 0.075 | 2213 | 0.413 | 179249 | 0.026 | 0.102 | 0.098 | 1364262 | 2851 | | 1479 | 484 |
| Moomba Plant | 1.299 | 358 | 7.146 | 661707 | 0.455 | 1.762 | 1.689 | 1087343 | 49372 | | 157 | 131 |
| Big Lake Oil | | 537 | | | | | | | | | 247 | 232 |
| Dullingari Oil | | 311 | | 17683 | | | | 140397 | 280 | | 139 | 134 |
| Gidgealpa Oil | | 2109 | | 21608 | | | | 107419 | 4976 | 2.637 | 2050 | 1343 |
| Keleary Oil | | 818 | | 20813 | | | | 76920 | 6715 | 3.635 | 542 | 419 |
| Limestone Creek | | 1850 | | 21734 | | | | 80323 | 7012 | 3.795 | 1059 | 884 |
| Merrimelia Oil | | 1301 | | 23301 | | | | 120910 | 5003 | 2.637 | 866 | 670 |
| Moomba Oil | | 6657 | | | | | | | | | 2769 | 2775 |
| Meranji Oil | 0.014 | 2052 | 0.076 | 33243 | 0.005 | 0.019 | 0.018 | 263950 | 526 | | 2300 | 1429 |
| Muteroo/Spencer | | 658 | | 11327 | | | | 41863 | 3655 | 1.978 | 784 | 475 |
| Narcoonowie | | 340 | | | | | | | | | 278 | 196 |
| Strzelecki Oil | 0.012 | 1002 | 0.064 | 28109 | 0.004 | 0.016 | 0.015 | 223172 | 445 | | 886 | 604 |
| Tantanna Oil | | 2540 | | 20721 | | | | 76579 | 6685 | 3.618 | 2637 | 1683 |
| | | | | | | | | | | | | |

# Appendix H

# Risk Assessment and Management Summaries

This appendix contains tabular summaries of risk assessments that have been undertaken for all environmental hazards associated with the Cooper Basin operations. Each table details information used to assess risk levels and the key management measures that are in place to manage risks.

Each table specifically outlines:

- The potential consequences of a hazard;
- An outline of risk management measures.
- The potential severity of the consequences of a hazard given the management measures in place;
- The qualitative likelihood of a consequence occurrencing, allowing for the management measures; and
- The level of assessed risk based on potential seveverity and likelihood of the consequence.

This appendix provides information required to qualitatively assess environmental risks and provides relevant background information for future review of risks and management priorities.

In addition to the environmental management measures (risk controls) that are outlined in Table D1 - D53 SACBJV has produced the following documents which further outline environmental management measures:

- Code of Environmental Practice Drilling and Workover Operations (Santos 1998b);
- Code of Environmental Practice Production and Processing (Santos 1999e);
- Environmental Incident Reporting and Investigation Procedure (Santos 1997d);
- Environmental Procedures for Borrow Pit Management (Santos 1997a);
- Environmental Procedures for Construction, Operation and Abandonment of Pipelines in the Cooper Basin (Santos 2000d);
- Environmental Procedures for the Management of Aboriginal Heritage Sites (Santos 1998a);
- Environmental Procedures for Seismic Exploration in the Cooper Basin, South Australia and Queensland (Santos 1998e);
- Environmental Procedures for Seismic Line Preparation (Santos 1998d);
- Environmental Procedures for Well Lease Location, Construction and Restoration in the Cooper Basin, South Australia (PELs 5&6) (Santos, 1997e);
- Field Guide to Common Plants of the Cooper Basin (Santos 1997c);
- Santos Australian Environmental Management System at a Glance (Santos 1998c);
- Stock Proof Fencing Standard (Santos 2000c);
- The Arid Zone Field Environmental Handbook (Santos 1997b);
- The Santos Australian Environmental Management System and Corporate Requirements (Santos 2000b); and
- Inland Spill Response Manual (Santos 2001).

# GATHERING SYSTEMS

## PIPELINE CONSTRUCTION

### Table G 1: Movement of heavy machinery and vehicles along ROW and access tracks

| Risk Element | Details/Conclusions |
|---|---|
| Consequence | ▪ Dust generation<br>▪ Soil compaction<br>▪ Soil erosion<br>▪ Damage to native vegetation<br>▪ Injury or death of native fauna<br>▪ Disturbance to cultural heritage sites<br>▪ Introduction and/or spread of weeds<br>▪ Damage to third party infrastructure<br>▪ Disruption to land use (eg. grazing and recreation)<br>▪ Increased public access to remote areas |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Vehicle washdown prior to commencing work to prevent the spread of weeds<br>▪ Driving only on access tracks and pipeline easement<br>▪ Rip areas of compacted soil (not on gibber plains and tablelands) |
| Severity | Negligible |
| Likelihood | Unlikely |
| **Level of Risk** | LOW |

### Table G 2: Spills and leaks associated with chemical and fuel storage and handling

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or watercourse.<br>▪ Access to contaminants by stock and wildlife |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Implementation of appropriate fuel and chemical storage and handling procedures (eg. bunding and shut-off valves) in accordance with relevant standards, including AS 1940 and the Australian Dangerous Goods (ADG) Code<br>▪ Establishment of appropriate emergency/spill response procedures for spills or leaks to soil and water<br>▪ Annual review and exercise of response equipment and procedures to ensure preparedness<br>▪ Immediate clean-up and remediation to minimise contamination to soil/water<br>▪ Fencing of contaminated areas if threat is posed to stock or wildlife<br>▪ Regularly educate staff of product, review and monitor chemical and fuel storage, including signage/labelling, proper packing and tie downs.<br>▪ Maintain a register of spills and/or leaks and implement corrective actions based on analysis of spill events |
| Severity | Negligible |
| Likelihood | Unlikely |
| **Level of Risk** | LOW |

## Table G 3: Earthworks (eg. clearing of ROW, grading, trenching and backfilling)

| Risk Element | Details |
|---|---|
| Consequence | ▪ Injury or death of fauna in construction zone<br>▪ Impeded fauna movement through the construction zone<br>▪ Loss of visual amenity<br>▪ Damage to native vegetation<br>▪ Introduction and/or spread of weeds<br>▪ Disturbance to natural drainage patterns<br>▪ Damage to third party infrastructure<br>▪ Soil erosion and siltation of watercourses<br>▪ Inversion of soil profile<br>▪ Dust generation<br>▪ Soil compaction<br>▪ Disturbance to cultural heritage sites |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Minimise impact on the environment by appropriate route selection to minimise or avoid sensitive land systems, vegetation and cultural heritage sites<br>▪ Observation of procedures and guidelines for the identification, management and protection of cultural heritage sites<br>▪ When establishing line of sight, trim vegetation rather than clearing where possible<br>▪ Where possible conceal line of sight along access tracks to minimise visual impact<br>▪ Reinstate construction areas including ROW as soon as possible<br>▪ Rip areas of compacted soil (except on gibber plains and tableland environments)<br>▪ Respread topsoil and stockpiled vegetation<br>▪ Restore borrow pits<br>▪ Restore natural contours to minimise impacts to natural drainage patterns<br>▪ Minimise vegetation disturbance, and plan construction to avoid vegetated areas<br>▪ Avoid significant or "priority" vegetation<br>▪ Use existing easements where possible<br>▪ Stockpile and cleared vegetation and respread following construction works to facilitate revegetation.<br>▪ Where possible trim vegetation rather than clearing<br>▪ Stockpile vegetation that is cleared from ROW and respread following construction works<br>▪ Minimise impacts to fauna by leaving trenched areas open for as little time as possible<br>▪ Utilise trench plugs and fauna ladders (sticks etc.) to facilitate the movement of fauna out of and across trench<br>▪ Vehicle and equipment washdown when operations have been undertaken in areas of known weed infestations<br>▪ Removal of waste to minimise visual impact<br>▪ Liaison with landowners regarding notification and management of works and site issues including livestock management. |
| Severity | Negligible |
| Likelihood | Rare |
| **Level of Risk** | LOW |

## Table G 4: Ignition of fire along ROW

| Risk Element | Details |
|---|---|
| Consequence | ▪ Disturbance to cultural heritage sites<br>▪ Loss of vegetation and fauna habitat<br>▪ Release of particulate emissions to the atmosphere<br>▪ Disruption to land use (eg. grazing and recreation) |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Operation under bushfire permit requirements, including appropriate clearing of ROW<br>▪ No smoking or safe smoking areas away from equipment or activity.<br>▪ Personnel are trained to supervise and instruct individuals entering area to conduct work.<br>▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct works.<br>▪ Petrol vehicles to be excluded from sites.<br>▪ Emergency response procedures should contain a bushfire scenario.<br>▪ Safety, testing, maintenance and inspection procedures are implemented |
| Severity | Minor |
| Likelihood | Rare |
| **Level of Risk** | LOW |

## Table G 5: Disposal of hydrotest water

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or watercourse<br>▪ Loss of vegetation and fauna habitat as a result of soil or water contamination |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Use of biocides and toxic chemicals are kept to a minimum and where practicable biocide THPS, which degrades rapidly when exposed to UV, shall be used<br>▪ Disposal of hydrostatic test water, which contains biocide and other chemicals, may be into existing lined and fenced evaporation ponds, or to specifically constructed pits sited to prevent the contamination of surface or near surface waters |
| Severity | Negligible |
| Likelihood | Rare |
| **Level of Risk** | LOW |

## PIPELINE OPERATION

### Table G 6: Explosion or fire along an Oil pipeline

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or watercourse<br>▪ Atmospheric pollution<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Loss of vegetation and fauna habitat<br>▪ Disruption to land use (eg. grazing) |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ As detailed per Section 4.2.1, all pipelines are designed, constructed and operated in accordance with the Santos Pipeline Management System including pipeline inspections and maintenance.<br>▪ No smoking or safe smoking areas away from equipment or activity.<br>▪ Personnel are trained to supervise and instruct individuals entering area to conduct work.<br>▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct works.<br>▪ Immediate clean-up and remediation to minimise contamination to soil/water<br>▪ Petrol vehicles to be excluded from gas well/pipeline sites.<br>▪ Emergency response procedures should contain a bushfire scenario.<br>▪ Safety, testing, maintenance and inspection procedures are implemented |
| Severity | Due to the low volatility and flammability of oil the potential for explosion or fire is considered low, therefore the potential severity of the consequences is considered:<br>**Minor** |
| Likelihood | Through the implementation of operational procedures and guidelines, pipelines being designed in accordance with AS2885 Standards, and the low volatility content of the product the likelihood of the above consequences occurring are considered:<br>**Unlikely** |
| **Level of Risk** | **LOW** |

### Table G 7: Explosion or fire along a Gas pipeline

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil, groundwater and/or watercourse<br>▪ Atmospheric pollution<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Loss of vegetation and fauna habitat<br>▪ Disruption to land use (eg. grazing) |
| Management Strategies | As per Table G-6 |
| Severity | The potential severity of an explosion to health and safety is considered major, whilst the potential severity of other consequences are considered to be negligible or minor. Based on this the assigned severity is:<br>**Major** |
| Likelihood | Through the implementation of operational procedures and guidelines, pipelines being designed in accordance with AS2885 Standards, and the low volatility content of the product the likelihood of the above consequences occurring are considered:<br>**Unlikely** |
| **Level of Risk** | **MEDIUM** |

### Table G 8: Spill or leak associated with pipeline failure to land

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or watercourse<br>▪ Disruption to land use (eg. grazing)<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Atmospheric pollution (gas)<br>▪ Access to contaminants by stock and wildlife |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ All pipelines are designed, constructed and operated in accordance with the Santos Pipeline Management System including pipeline inspections and maintenance.<br>▪ Establishment of appropriate emergency/spill response procedures for spills or leaks to soil and water<br>▪ Annual review and exercise of response equipment and procedures<br>▪ Immediate clean-up and remediation to minimise contamination to soil/water<br>▪ Fencing of contaminated areas if threat is posed to stock or wildlife<br>▪ Regularly educate staff of product, review and monitor chemical and fuel storage, including signage/labelling, proper packing and tie downs.<br>▪ Maintain a register of spills and/or leaks and implement corrective actions based on analysis of spill events |
| Potential Severity | Negligible |
| Likelihood | Through the implementation of operational procedures and guidelines the potential for a spill into the open environment and therefore the likelihood of the above consequences is considered<br>Unlikely |
| **Level of Risk** | LOW |

### Table G 9: Spill or leak associated with pipeline failure in a creek bed

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of groundwater, surface water, soil and other riparian systems<br>▪ Danger to health and safety of employees, contractors and possibly the public |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ All pipelines are designed, constructed and operated in accordance with the Santos Pipeline Management System including pipeline inspections and maintenance.<br>▪ Implementation of appropriate fuel and chemical storage and handling procedures (eg. bunding and shut-off valves) in accordance with relevant standards, including AS 1940 and the Australian Dangerous Goods (ADG) Code<br>▪ Establishment of appropriate emergency/spill response procedures for spills or leaks<br>▪ Annual review and exercise of response equipment and procedures<br>▪ Immediate clean-up and remediation to minimise contamination to soil/water<br>▪ Fencing of contaminated areas if threat is posed to stock or wildlife<br>▪ Regularly educate staff of product, review and monitor chemical and fuel storage, including signage/labelling, proper packing and tie downs.<br>▪ Maintain a register of spills and/or leaks and implement corrective actions based on analysis of spill events<br><br>As indicated in Section 8.2.10, a study is currently being undertaken to assess the potential effects of an oil spill on the Cooper Creek and provide recommendations for operational or infrastructure changes, as required. |
| Potential Severity | Due to the potential severity of the impact on the Cooper Creek and surrounding environment the consequence is considered<br>Major |
| Likelihood | Unlikely |
| **Level of Risk** | MEDIUM |

### Table G 10: Spill or leak associated with nodal compressor failure to land

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or watercourse<br>▪ Disruption to land use (eg. grazing)<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Atmospheric pollution (gas)<br>▪ Access to contaminants by stock and wildlife |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ All pipelines are designed, constructed and operated in accordance with the Santos Pipeline Management System including pipeline inspections and maintenance.<br>▪ Implementation of appropriate fuel and chemical storage and handling procedures (eg. bunding and shut-off valves) in accordance with relevant standards, including AS 1940 and the Australian Dangerous Goods (ADG) Code<br>▪ Establishment of appropriate emergency/spill response procedures for spills or leaks<br>▪ Annual review and exercise of response equipment and procedures<br>▪ Immediate clean-up and remediation to minimise contamination to soil/water<br>▪ Fencing of contaminated areas if threat is posed to stock or wildlife<br>▪ Regularly educate staff of product, review and monitor chemical and fuel storage, including signage/labelling, proper packing and tie downs.<br>▪ Maintain a register of spills and/or leaks and implement corrective actions based on analysis of spill events |
| Severity | Negligible |
| Likelihood | Through the implementation of operational procedures and guidelines the potential for a spill into the open environment and therefore the likelihood of the above consequences is considered<br>Rare |
| **Level of Risk** | LOW |

### Table G 11: Spill associated with transport of oil/condensate (via truck) to land

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of groundwater, surface water and soil<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Access to contaminants by stock and wildlife |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Transportation of chemicals, fuels and oils in accordance with ADG Code<br>▪ Establishment of appropriate emergency/spill response procedures for spills or leaks to soil and water<br>▪ Annual review and exercise of response equipment and procedures to ensure preparedness<br>▪ Immediate clean-up and remediation to minimise contamination to soil/water<br>▪ Fencing of contaminated areas if threat is posed to stock or wildlife<br>▪ Regularly educate staff of product, review and monitor chemical and fuel transportation, including signage/labelling, proper packing and tie downs.<br>▪ Maintain a register of spills and/or leaks and implement corrective actions based on analysis of spill events |
| Severity | Negligible |
| Likelihood | Through the implementation of operational procedures and guidelines the potential for a spill into the open environment and therefore the likelihood of the above consequences is considered<br>Unlikely |
| Level of Risk | LOW |

### Table G 12: Spill associated with transport of oil/condensate (via truck) to creek bed

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of groundwater, surface water and soil<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Access to contaminants by stock and wildlife |
| Management Strategies | As per Table G-11<br>Also As indicated in Section 8.2.10 a study is being undertaken to assess the potential impacts of a hydrocarbon spill on the Cooper Creek. |
| Potential Severity | Due to the potential severity of the impact on the Cooper Creek and surrounding environment the consequence is considered<br>Major |
| Likelihood | Unlikely |
| Level of Risk | MEDIUM |

# SATELLITE STATIONS

## Plant

### Table G 13: Explosion or fire at satellite

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or watercourse<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Atmospheric pollution (gas) |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ As detailed per Section 4.2.1, all pipelines are designed, constructed and operated in accordance with the Santos Pipeline Management System including pipeline inspections and maintenance.<br>▪ No smoking or safe smoking areas away from equipment or activity.<br>▪ Personnel are trained to supervise and instruct individuals entering area to conduct work.<br>▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct works.<br>▪ Immediate clean-up and remediation to minimise contamination to soil/water<br>▪ Petrol vehicles to be excluded from gas well/pipeline sites.<br>▪ Establishment of appropriate emergency/spill response procedures for explosion or fire<br>▪ Safety, testing, maintenance and inspection procedures are implemented |
| Potential Severity | The potential severity of an explosion to health and safety is considered major, whilst the potential severity of other consequences is considered to be negligible or minor. Based on this the assigned severity is:<br>Major |
| Likelihood | Through the implementation of operational procedures and guidelines the potential for an explosion or fire and therefore the likelihood of the above consequences is considered<br>Unlikely |
| Level of Risk | MEDIUM |

### Table G 14: Flooding of surrounding floodplain/watercourses

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or groundwater<br>▪ Damage to infrastructure (eg. evaporation ponds)<br>▪ Access to contaminants by stock and wildlife |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ General fluid containment strategies have been developed<br>▪ Flood Control Management Plan |
| Severity | **Negligible** |
| Likelihood | Through the implementation of operational procedures/guidelines the likelihood of these consequences are considered<br>**Unlikely** |
| **Level of Risk** | **LOW** |

### Table G 15: Spills and leaks associated with chemical and fuel storage and handling

Refer to Table G2.

### Table G 16: Fugitive emissions of methane and organic carbon from the process plant

| Risk Element | Details |
|---|---|
| Consequence | ▪ Release of greenhouse gases contributing to climatic warming |
| Management Strategies | Relevant procedures and guidelines include:<br>▪ Continual review and improvement of operations<br>▪ Environmental training to audit volumes emitted and to reduce annual volumes emitted each year. |
| Severity | **Negligible** |
| Likelihood | **Likely** |
| **Level of Risk** | **LOW** |

### Table G 17: Venting of CO2, H2S, and CO

| Risk Element | Details |
|---|---|
| Consequence | ▪ Release of greenhouse gases contributing to climatic warming |
| Management Strategies | Relevant procedures and guidelines include:<br>▪ Continual review and improvement of operations<br>▪ Environmental training to audit volumes vented and to reduce annual volumes vented each year. |
| Severity | **Negligible** |
| Likelihood | **Likely** |
| **Level of Risk** | **LOW** |

## Table G 18: Flaring of propane, butane, methane and ethane from process plants

| Risk Element | Details |
|---|---|
| Consequence | ▪ Release of greenhouse gases contributing to climatic warming |
| Management Strategies | Relevant procedures and guidelines include:<br>▪ Continual review and improvement of operations<br>▪ Environmental training to audit volumes flared and to reduce annual volumes flared each year. |
| Severity | **Negligible** |
| Likelihood | **Likely** |
| **Level of Risk** | **LOW** |

## Table G 19: Loss of containment of gas (pipeline rupture or leaks from plant equipment)

| | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or watercourse<br>▪ Atmospheric pollution<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Access to contaminants by stock and wildlife<br>▪ Loss of vegetation and fauna habitat |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ As detailed per Section 4.2.1, all pipelines are designed, constructed and operated in accordance with the Santos Pipeline Management System including pipeline inspections and maintenance.<br>▪ No smoking or safe smoking areas away from equipment or activity.<br>▪ Personnel are trained to supervise and instruct individuals entering area to conduct work.<br>▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct works.<br>▪ Immediate clean-up and remediation to minimise contamination to soil/water<br>▪ Petrol vehicles to be excluded from gas well/pipeline sites.<br>▪ Establishment of appropriate emergency/spill response procedures for explosion or fire<br>▪ Safety, testing, maintenance and inspection procedures are implemented |
| Severity | The potential severity of an explosion to health and safety is considered major, whilst the potential severity of other consequences is considered to be negligible or minor. Based on this the assigned severity is:<br>**Major** |
| Likelihood | Through the implementation of operational procedures and guidelines the potential for loss of containment and therefore the likelihood of the above consequences is considered<br>**Rare** |
| Level of Risk | **MEDIUM** |

## Table G 20: Loss of containment of oil (pipeline rupture or leaks from plant equipment)

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or watercourse<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Access to contaminants by stock and wildlife<br>▪ Loss of vegetation and fauna habitat |
| Management Strategies | As per Table G-19 |
| Severity | Through the implementation of operational procedures and guidelines the likelihood of the above consequences occurring are considered:<br>**Minor** |
| Likelihood | Through the implementation of operational procedures and guidelines the potential for loss of containment and therefore the likelihood of the above consequences is considered<br>**Rare** |
| Level of Risk | **LOW** |

## Production Formation Water

## Table G 21: Storage and disposal of PFW at satellites

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or groundwater<br>▪ Access to contaminants by stock and wildlife |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Monitor ponds for surrounding upwelling of PFW<br>▪ Do not overfill evaporation ponds<br>▪ Ensure that tanks are well maintained and regularly emptied<br>▪ Skim interceptor pits<br>▪ Ensure that interceptor pits are lined as required<br>▪ Monitor and audit evaporation pond sludge and water annually<br>▪ Annual review of PFW and implementation of audit recommendations<br>▪ Fence off contaminated water sources<br>▪ Repair any damaged fences or gates<br>▪ Maintain a register of spills and/or leaks |
| Severity | Through the implementation of operational procedures and guidelines the likelihood of the above consequences occurring are considered:<br>**Minor** |
| Likelihood | Through the implementation of operational procedures and guidelines the potential for loss of containment and therefore the likelihood of the above consequences is considered<br>**Rare** |
| Level of Risk | **LOW** |

### Table G 22: Flooding of surrounding floodplain/watercourses

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or groundwater<br>▪ Damage to infrastructure (eg. evaporation ponds)<br>▪ Access to contaminants by stock and wildlife |
| Management Strategies | Relevant procedures and guidelines include:<br>▪ Flood Control Management Plan<br>▪ General fluid containment strategies have been developed |
| Severity | **Negligible** |
| Likelihood | Through the implementation of operational procedures/guidelines the likelihood of these consequences are considered<br>**Unlikely** |
| **Level of Risk** | **LOW** |

## UTILITIES

### Table G 23: Storage of domestic waste at camps and transport and disposal to landfill (ie. Moomba waste facility)

| Risk Element | Details |
|---|---|
| Consequence | ▪ Scavenging by native and pest species<br>▪ Pest outbreaks<br>▪ Localised contamination of soil and/or groundwater |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Minimise generation of waste where practicable<br>▪ Provide suitable covered bins for the collection and storage of wastes<br>▪ All waste are collected in one area at each camp site<br>▪ Cover all loads of rubbish leaving camps to ensure no spillage |
| Severity | **Negligible** |
| Likelihood | Storage of waste and transport to landfill is a standard waste management practice. Unlikely to result in significant pest problems due to the transient nature of drilling operations and therefore storage.<br>**Unlikely** |
| Level of Risk | **LOW** |

### Table G 24: Spills or leaks associated with disposal and treatment of sewage in septic tanks

| Risk Element | Details |
|---|---|
| Consequence | ▪ Localised contamination of soil and/or groundwater |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Containment of all sewage wastes within earthen pits.<br>▪ Backfill of all pits upon completion of well site operations. |
| Severity | **Negligible** |
| Likelihood | Due to the depth to groundwater and the short term nature of operations the consequence is considered<br>**Unlikely** |
| Level of Risk | **LOW** |

# MOOMBA PROCESSING PLANT

## INLET SEPARATION

### Table G 25: Oil sludge disposal to sludge pit then to LTU

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or groundwater |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Appropriate disposal of oils sludge to sludge pit and LTU<br>▪ Management of sludge pits to ensure no overflow<br>▪ Monitoring of surrounding soil and groundwater for contaminants annually<br>▪ Development of remediation plans for the sludge pits and LTU<br>As detailed in Section 8.2.9, disposal and management options are currently being investigated and reviewed including the trial of a centrifuge to reduce the volume of sludge by separation of the oil and water. |
| Severity | Minor |
| Likelihood | Through the implementation of operational procedures/guidelines the likelihood of these consequences are considered<br>Unlikely |
| Level of Risk | LOW |

### Table G 26: PFW disposal to Northern Evaporation Pond

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or groundwater<br>▪ Injury to wildlife |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Recovery of hydrocarbons at sludge pits and interceptor pits prior to disposal to northern evaporation pond<br>▪ Monitor northern evaporation pond for surrounding upwelling of PFW<br>▪ Do not overfill evaporation pond<br>▪ Ensure that interceptor pits are lined as required<br>▪ Monitor and audit evaporation pond sludge and water annually<br>▪ Annual review of PFW and implementation of audit recommendations<br>▪ Fence off contaminated water sources<br>As detailed in Section 8.2.8, a study is currently being undertaken into PFW management in order to manage potential contaminants. |
| Severity | Through the implementation of operational procedures and guidelines the potential for contamination of the open environment is minimised,<br>Minor |
| Likelihood | Through the implementation of operational procedures/guidelines the likelihood of these consequences are considered<br>Unlikely |
| Level of Risk | MEDIUM |

## Table G 27: Sour water disposal to sour water pit then Lake Brooks

| Risk Element | Details |
|---|---|
| Consequence | ▪ Localised acidification of soil |
| Management Strategies | Relevant SACBJV procedures and guidelines include:<br>▪ Addition of lime to sour water prior to disposal to neutralise pH<br>▪ Annual audit and water quality sampling at Lake Brooks<br>A study has been commissioned to assess wastewater management options at the Moomba site, including assessment of potential contamination and disposal options. |
| Potential Severity | **Negligible** |
| Likelihood | Through the implementation of operational procedures/guidelines the likelihood of these consequences are considered<br>**Unlikely** |
| Level of Risk | **LOW** |

## <u>RAW GAS CONDITIONING PLANT</u>

## Table G 28: Air Emissions (CO2 and H2S)

Refer Table G17

## Table G 29: Disposal of oily water to Northern Evaporation Pond and Lake Brooks

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or groundwater<br>▪ Injury to wildlife |
| Management Strategies | Relevant SACBJV procedures and guidelines for contamination include:<br>▪ Recovery of hydrocarbons at sludge pits and interceptor pits prior to disposal to northern evaporation pond<br>▪ Monitor and audit evaporation pond sludge and water annually<br>▪ Monitor northern evaporation pond for surrounding upwelling of PFW<br>▪ Do not overfill evaporation pond<br>▪ Annual review of PFW and implementation of audit recommendations<br>▪ Fence off contaminated water sources<br>As detailed in Section 8.2.8, a study is currently being undertaken into PFW management in order to manage potential contaminants.<br>A study has been commissioned to assess wastewater management options at the Moomba site, including assessment of potential contamination and disposal options. |
| Severity | **Minor** |
| Likelihood | Through the implementation of operational procedures/guidelines the likelihood of these consequences are considered<br>**Unlikely** |
| Level of Risk | **MEDIUM** |

### Liquids Recovery

**Table G 30: Oil sludge disposal to sludge pit then to LTU**

Refer Table G25

**Table G 31: Disposal of oily water to interceptor pit then northern evaporation pond**

Refer to Table G29

### Liquids Processing (Crude Stabilisation Plant)

**Table G 32: Spills or leaks associated with storage of oil and condensate (tank farm)**

| Risk Element | Details |
|---|---|
| Consequence | ▪ Contamination of soil and/or watercourse<br>▪ Danger to health and safety of employees, contractors and possibly the public<br>▪ Access to contaminants by stock and wildlife<br>▪ Loss of vegetation and fauna habitat |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Implementation of appropriate fuel and chemical storage and handling procedures (eg. bunding and shut-off valves) in accordance with relevant standards, including AS 1940 and the Australian Dangerous Goods (ADG) Code<br>▪ Establishment of appropriate emergency/spill response procedures for spills or leaks to soil and water<br>▪ Annual review and exercise of response equipment and procedures to ensure preparedness<br>▪ Immediate clean-up and remediation to minimise contamination to soil/water<br>▪ Fencing of contaminated areas if threat is posed to stock or wildlife<br>▪ Regularly educate staff of product, review and monitor chemical and fuel storage, including signage/labelling, proper packing and tie downs.<br>▪ Maintain a register of spills and/or leaks and implement corrective actions based on analysis of spill events |
| Severity | Negligible |
| Likelihood | Through the implementation of operational procedures and guidelines the potential for a spill into the open environment and therefore the likelihood of the above consequences is considered<br>Unlikely |
| Level of Risk | LOW |

**Table G 33: Spills or leaks associated with chemical and fuel storage and handling**

Refer Table G32.

## DIESEL STORAGE AND REFUELLING

**Table G 34: Leak or spill associated with storage and handling of diesel fuel**

Refer Table G32.

## INTERRUPTION OF NATURAL GAS SUPPLY

### Table G 35: Explosion or fire

| Risk Element | Details |
|---|---|
| Consequence | ▪ Disruption to gas supply<br>▪ Danger to health and safety of employees, contractors and possibly the public |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ As detailed per Section 4.2.1, all pipelines are designed, constructed and operated in accordance with the Santos Pipeline Management System including pipeline inspections and maintenance.<br>▪ No smoking or safe smoking areas away from equipment or activity.<br>▪ Personnel are trained to supervise and instruct individuals entering area to conduct work.<br>▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct works.<br>▪ Immediate clean-up and remediation to minimise contamination to soil/water<br>▪ Petrol vehicles to be excluded from gas well/pipeline sites.<br>▪ Establishment of appropriate emergency/spill response procedures for explosion or fire<br>▪ Safety, testing, maintenance and inspection procedures are implemented<br><br>A significant number of risk reduction mechanisms have been put in place as detailed in Section 8.2.7, and a hazard analysis of the Moomba Plant is currently being undertaken to further address these issues. |
| Potential Severity | The potential severity of an explosion to health and safety is considered major, whilst the potential severity of other consequences are considered to be negligible or minor. Based on this the assigned severity is:<br>**Major** |
| Likelihood | Through the implementation of operational procedures and guidelines the potential for an explosion or fire and therefore the likelihood of the above consequences is considered<br>**Unlikely** |
| **Level of Risk** | **MEDIUM** |

## Table G 36: Loss of containment of gas (pipeline rupture or leak)

| Risk Element | Details |
|---|---|
| Consequence | ▪ Disruption to gas supply<br>▪ Danger to health and safety of employees, contractors and possibly the public |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ As detailed per Section 4.2.1, all pipelines are designed, constructed and operated in accordance with the Santos Pipeline Management System including pipeline inspections and maintenance.<br>▪ No smoking or safe smoking areas away from equipment or activity.<br>▪ Personnel are trained to supervise and instruct individuals entering area to conduct work.<br>▪ Safe work permits must be obtained to ensure only individuals with proper clearance can conduct works.<br>▪ Immediate clean-up and remediation to minimise contamination to soil/water<br>▪ Petrol vehicles to be excluded from gas well/pipeline sites.<br>▪ Establishment of appropriate emergency/spill response procedures for explosion or fire<br>▪ Safety, testing, maintenance and inspection procedures are implemented<br><br>A significant number of risk reduction mechanisms have been put in place as detailed in Section 8.2.7, and a hazard analysis of the Moomba Plant is currently being undertaken to further address these issues. |
| Potential Severity | The potential severity of an explosion to health and safety is considered major, whilst the potential severity of other consequences are considered to be negligible or minor. Based on this the assigned severity is:<br>**Major** |
| Likelihood | Through the implementation of operational procedures and guidelines the potential for an explosion or fire and therefore the likelihood of the above consequences is considered<br>**Rare** |
| **Level of Risk** | **MEDIUM** |

# MOOMBA PLANT UTILITIES

## WATER

### Table G 37: Discharge of saline washdown water to Lake Brooks

| Risk Element | Details |
|---|---|
| Consequence | ▪ Localised salinisation of soil as a direct result of process saline washdown water |
| Management Strategies | Relevant SACBJV procedures and guidelines include:<br>▪ Annual audit and water quality sampling at Lake Brooks<br>A study has been commissioned to assess wastewater management options at the Moomba site, including assessment of potential contamination and disposal options. |
| Severity | Due to the lake already being a highly saline environment, the severity of the consequence is considered<br>**Negligible** |
| Likelihood | Given the saline nature of the receiving environment the likelihood of these consequences are considered<br>**Unlikely** |
| Level of Risk | **LOW** |

### Table G 38: Continual blow down of waste water to Lake Brooks

Refer Table G37.

### Table G 39: Extraction of water from GAB

| Risk Element | Details |
|---|---|
| Consequence | Depletion of GAB and sub-artesian water supplies |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Minimisation of water use during drilling and workover operations by minimising sump sizes and recirculating water<br>▪ Lining of water storage pits to prevent water loss through infiltration<br>▪ Monitoring of well production and minimise water content where possible (when water is produced with oil and gas) |
| Severity | **Major** |
| Likelihood | **Likely** |
| Level of Risk | **MEDIUM** |

### Table G 40: Spills or leaks associated with failure of Gidgealpa to Moomba water pipeline

| Risk Element | Details |
|---|---|
| Consequence | Localised acidification and/or salinisation of soil |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Conduct of regular pipeline inspections<br>▪ Maintain register of spills/leaks<br>▪ Immediate clean-up and remediation |
| Severity | **Negligible** |
| Likelihood | Given the nature of the receiving environment and low potential water volumes these consequences are considered unlikely<br>**Unlikely** |
| Level of Risk | **LOW** |

## STEAM

### Table G 41: Leaks and/or spills associated with chemical storage and handling

(Spills or leaks are likely to occur in sealed (eg. concreted) work areas and as such there are no significant environmental consequences).

## SEWAGE

### Table G 42: Spills or leaks associated with chemical storage and handling

Refer Table G2.

### Table G 43: Sludge storage and disposal

Refer Table G24.

### Table G 44: Disposal of treated effluent to Lake Brooks

| Risk Element | Details |
|---|---|
| Consequence | ▪ Increased nutrient levels in Lake Brooks |
| Management Strategies | Relevant SACBJV procedures and guidelines for management of impact of increased nutrient load in Lake Brooks include:<br>▪ Sewage effluent is treated to a secondary level prior to disposal to Lake Brooks<br>▪ Monitoring of water quality at Sewage Treatment Plant prior to disposal<br>▪ Monitoring of water quality at Lakes Brooks annually<br><br>A study has been commissioned to assess wastewater management options at the Moomba site, including assessment of potential contamination and disposal options. |
| Severity | **Negligible** |
| Likelihood | Given the nature of the receiving environment the likelihood of these consequences are considered<br>**Unlikely** |
| Level of Risk | **LOW** |

## WASTE DISPOSAL FACILITIES

### Table G 45: Domestic waste disposal to Moomba waste facility

| Risk Element | Details |
|---|---|
| Consequence | ▪ Scavenging by native and pest species<br>▪ Pest outbreaks<br>▪ Contamination of soil |
| Management Strategies | Relevant SACBJV procedures and guidelines include:<br>▪ Disposal of all uncontaminated and non-hazardous waste to licensed landfill facility |
| Potential Severity | Negligible |
| Likelihood | Unlikely |
| Level of Risk | LOW |

### Table G 46: Storage and disposal of contaminated soil to LTU

Refer Table G25.

### Table G 47: Arsenic dump (disused)

| Risk Element | Details |
|---|---|
| Consequence | ▪ Localised contamination of soil and/or watercourses |
| Management Strategies | Relevant SACBJV procedures and guidelines include:<br>▪ Arsenic is in sealed drums, in a lined concrete pit<br>▪ Disposal facility is regularly inspected |
| Potential Severity | Negligible |
| Likelihood | Unlikely |
| Level of Risk | LOW |

### Table G 48: Disposal of chemical waste to licensed disposal facility

| Risk Element | Details |
|---|---|
| Consequence | ▪ Localised contamination of soil, groundwater and/or watercourses |
| Management Strategies | Relevant SACBJV procedures and guidelines include:<br>▪ The chemical waste site is licensed and follows relevant regulatory standards<br>▪ The chemical waste depot is in a fenced and locked compound<br>▪ Records of disposal kept and maintained<br>▪ Chemical waste depot is clay lined |
| Severity | Negligible |
| Likelihood | Unlikely |
| Level of Risk | LOW |

### Table G 49: Disposal of asbestos to asbestos waste depot

| Risk Element | Details |
|---|---|
| Consequence | ▪ Localised contamination of soil |
| Management Strategies | Relevant SACBJV procedures and guidelines include:<br>▪ Regular inspection of asbestos waste facility |
| Severity | **Negligible** |
| Likelihood | **Unlikely** |
| Level of Risk | **LOW** |

## ROAD NETWORKS

### Table G 50: Earthworks (eg. clearing of ROW, grading, trenching and backfilling)

Refer Table G3.

### Table G 51: Movement of heavy machinery and vehicles along ROW and access tracks

Refer Table G1.

### Table G 52: Spills and leaks associated with chemical and fuel storage and handling

Refer Table G2.

### Table G 53: Ignition of fire along ROW

Refer Table G4.

### Table G 54: Presence of borrow pits

| Risk Element | Details |
|---|---|
| Consequence | ▪ Injury to or loss of stock and wildlife<br>▪ Dispersal of watering points and redistribution of stock movements |
| Management Strategies | Appropriate procedures and guidelines include:<br>▪ Existing unrestored borrow pits are used in preference to establishing new pits<br>▪ Reworking of pits, or construction of new pits occurs a minimum of 75m from existing facilities, including stock yards<br>▪ Pits are not to be established in locations which pose and unacceptable hazard to stock or wildlife<br>▪ Borrow pits are restored as soon as practicable after material extraction is complete and to a standard consistent with the surrounding land use<br>Should a pastoral lessee request that a specific borrow pit be left unrestored, appropriate procedures shall be followed. |
| Severity | **Negligible** |
| Likelihood | **Unlikely** |
| Level of Risk | **LOW** |

### Table G 55: Movement of road construction material

| Risk Element | Details |
|---|---|
| Consequence | ▪ Introduction and/or spread of weeds |
| Management Strategies | Relevant SACBJV procedures and guidelines include:<br>▪ Monitor weeds within the construction area for outbreaks to enable control measures to be undertaken<br>▪ Ensure that imported material is weed/disease free |
| Severity | Negligible |
| Likelihood | Unlikely |
| Level of Risk | LOW |

## MOOMBA AIRPORT

### Table G 56: Leaks and/or spills associated with fuel and chemical storage and handling

Refer Table G2.

### Table G 57: Presence of fauna in vicinity of airport (ie. risk of collision with planes)

| Risk Element | Details |
|---|---|
| Consequence | ▪ Disruption or injury to fauna (ie. birds) |
| Management Strategies | Relevant SACBJV procedures and guidelines include:<br>▪ Monitor bird numbers on site<br>▪ If large numbers of birds become established on site remove them using scare methods |
| Severity | Negligible |
| Likelihood | Likely |
| Level of Risk | LOW |

## FIRE TRAINING GROUND

### Table G 58: Fire or Explosion

| Risk Element | Details |
|---|---|
| Consequence | ▪ Danger to health and safety of employees and contractors<br>▪ Atmospheric pollution |
| Management Strategies | Relevant SACBJV procedures and guidelines include:<br>▪ Operational safety and fire management and containment procedures are implemeted |
| Severity | Negligible |
| Likelihood | Likely |
| Level of Risk | LOW |

### Table G 59: Spills or leaks associated with storage and disposal of oil

Refer Table G2.

# Appendix I:

# Santos Environmental Policy

Santos

# Environmental Vision, Commitment & Policy

As Santos' Managing Director, I am personally committed to working with our Environmental Committee of the Board, management and supervisors to ensure that the staff and contractors working for the Company have the knowledge and tools to act with high levels of environmental responsibility and achieve a standard of excellence in this field.

At Santos, the term Environment encompasses not only nature and the physical environment in which we work, but includes people, their work and the things they value. We believe that people are part of the environment - part of the problems but also very much a part of innovative solutions.

We intend to shrink and lighten the environmental footprint of our operations. We will build on past successes and continue to learn from past mistakes. This requires us to work together, strengthen the partnerships with our stakeholders and admit our dissatisfaction with the status quo.

As with safety, environmental stewardship is the responsibility of all Santos employees and contractors. Environmental and cultural heritage induction and training will continue to receive high priority and will be supplemented with a renewed focus on our Company-wide goal of meeting our corporate responsibilities in full.

New ideas and new ways of avoiding or minimising our environmental impacts will be encouraged and rewarded. Our prime objective of growing Santos will be nurtured not at the expense of, but on the basis of, ethical behaviour, safe operations, partnerships with the community and an environmental objective of continuous improvement.

We intend to be a leader in the petroleum industry. Excellence in environmental performance, safety and community partnerships will be a fundamental component of this goal.

J. Ellice-Flint
Managing Director

November 2001

Santos Ltd ABN 80 007 550 923

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