Arckaringa Basin Geophysical Operations

Environmental Impact Report

Final Report

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1 Introduction

SAPEX Limited (SAPEX) holds a number of Petroleum Exploration Licences (PELs) in the Arckaringa Basin in northern South Australia. SAPEX plans to undertake geophysical and seismic survey activities in these PELs to identify and delineate potential hydrocarbon prospects. This Environmental Impact Report (EIR) has been prepared as a requirement of the *Petroleum Act 2000* to provide information on the proposed activities, the potential environmental impacts and their management.

1.1 Location

The Arckaringa Basin is located 800 km north-west of Adelaide in South Australia and covers an area of approximately 80,000km² (see Figure 1). SAPEX currently holds PELs 117, 118, 119, 121, 122, 123, and 124, which cover approximately 65,000km² of this region.

A limited amount of petroleum exploration was carried out in the basin between the 1960s and the 1980s, including aeromagnetic and gravity surveys, several seismic surveys, stratigraphic drilling (12 drillholes) and four exploration wells. No commercial discoveries of oil or gas have been made.

The Arckaringa Basin contains early Permian–age sediments that are analogous to the Cooper Basin oil and gas productive areas, but are at shallower depths. The main formations are the Mt Toondina (source, reservoir and seal), the Stuart Range (source and seal), and Boorthanna (source, reservoir and some seal). These are SAPEX's proposed targets for oil exploration using modern seismic techniques (as described in this EIR), modern geological interpretation techniques and drilling (as described in a separate EIR for drilling activities). SAPEX also proposes to undertake exploration for coal seam gas (CSG) in the basin, which is also covered in the EIR for drilling activities.

1.2 Project Proponent

SAPEX was formed in 2000 as a private company and was recently listed on the Australian Stock Exchange.

The corporate goals of SAPEX include conducting exploration for conventional oil and gas deposits in the Arckaringa Basin PEL tenements and conducting a through appraisal of the CSG gas potential within the Arckaringa Basin.

1.3 About this Document

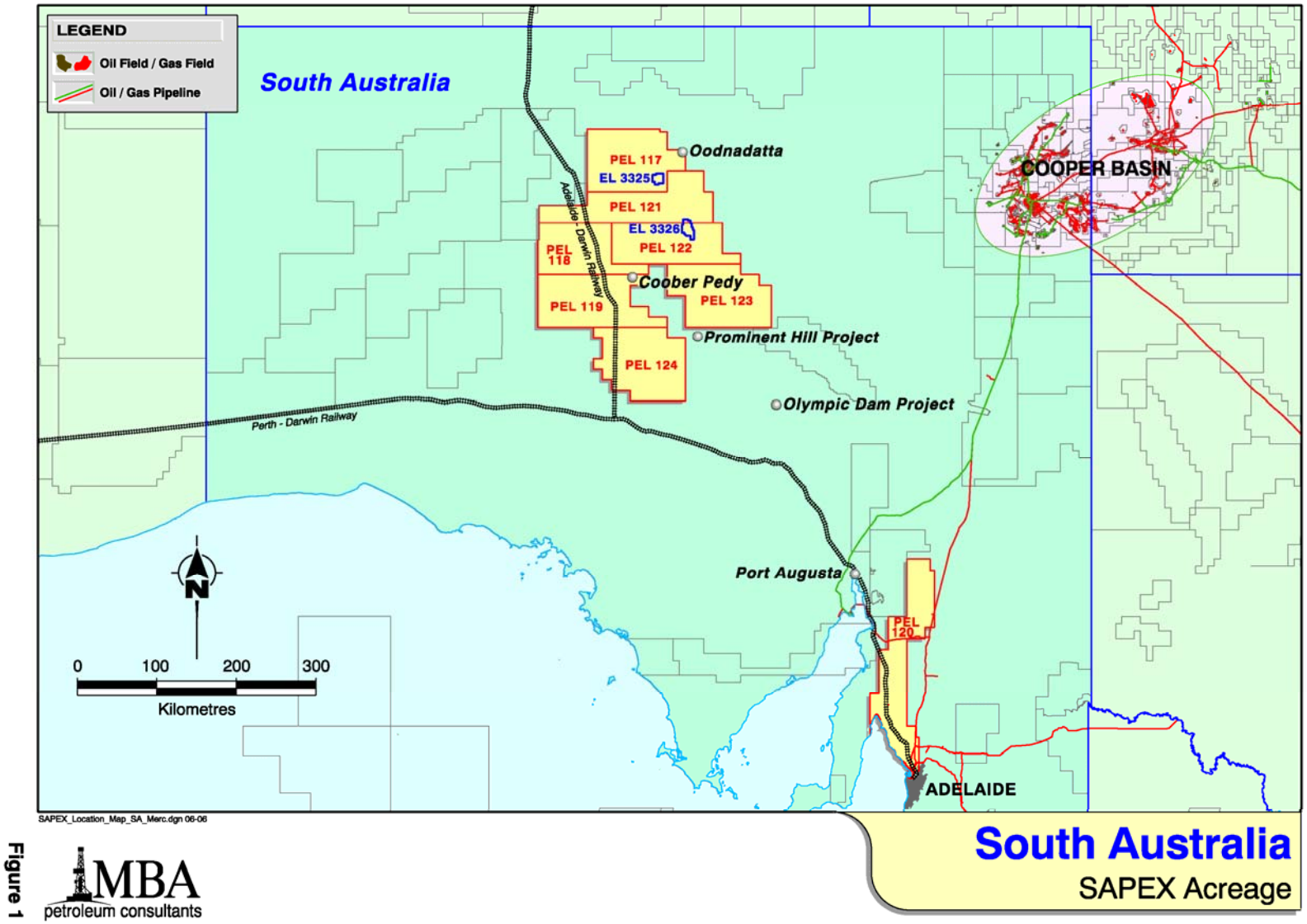
This document has been prepared to fulfil the requirements of an Environmental Impact Report for geophysical operations. It has been prepared in accordance with current legislative requirements, in particular Section 97 of the South Australian *Petroleum Act 2000* and Regulation 10 of the *Petroleum Regulations 2000*.

A Statement of Environmental Objectives (SEO) has also been developed in conjunction with this document. The SEO outlines the environmental objectives that SAPEX is required to achieve and the criteria on which the objectives are to be assessed.

This document relates to geophysical operations carried out in SAPEX's licence areas in the South Australian Arckaringa Basin, which are currently PELs 117, 118, 119, 121, 122, 123, and 124 (see Figure 1).

This document is based on the *South Australian Cooper Basin Operators. Environmental impact report: geophysical operations* (Santos 2006).

Figure 1: Arckaringa Basin



2 Legislative Framework

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

2.1 Petroleum Act and Regulations

The legislation governing onshore petroleum exploration and production in South Australia is the *Petroleum Act 2000* and *Petroleum Regulations 2000*. Key objectives of the 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
- 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, or
- 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, and
- any substance declared by regulation to be a substance to which the Act applies.

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

- exploration for petroleum or another regulated resource
- operations to establish the nature and extent of a discovery of petroleum or another regulated resource, and to establish the commercial feasibility of production and the appropriate production techniques
- production of petroleum or another regulated substance
- utilisation of a natural reservoir to store petroleum or another regulated substance
- 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.

2.2 Statement of Environmental Objectives

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.

SAPEX has developed a SEO for seismic activities, based on this EIR. This has been developed as a "generic" SEO – it relates to potential seismic activities anywhere in the Arckaringa Basin, rather than being specific to an individual survey.

Generic SEOs have been previously prepared by PIRSA, Ecos and Santos for the following regulated activities:

- *Statement of Environmental Objectives for Geophysical Operations in the Otway Basin, South Australia* (Kane 2007)
- *Statement of Environmental Objectives for Pipeline Preliminary Survey Activities in South Australia* (Ecos Consulting (Aust) Pty Ltd 2001)
- *Statement of Environmental Objectives for seismic operations in the Cooper and Eromanga Basins, South Australia* (Cockshell 1998)
- South Australian Cooper Basin operators. *Statement of environmental objectives: drilling and well operations* (Santos 2003a).
- *South Australian Cooper Basin Operators. Statement of environmental objectives: geophysical operations* (Santos 2006).

2.3 Environmental Impact Report

In accordance with Section 97 of the *Petroleum Act 2000*, an Environmental Impact Report (EIR) must:

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

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 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:
  - 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 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.

2.4 EIR / SEO Assessment and Approval

Once the EIR and SEO are submitted to the Department for Primary Industries and Resources, South Australia (PIRSA), 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 PIRSA will be required to undertake prior to final approval of the SEO.

- Low impact activities do not require public consultation and are subjected to a process of internal government consultation on the EIR and SEO prior to approval.
- Medium impact activities require a public consultation process for the EIR and proposed SEO, 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 this EIR and its associated SEO, must be entered on an environmental register. This public Environmental Register is accessible to the community from the PIRSA website.

2.5 Activity Approval

Prior to commencing a regulated activity (e.g. a seismic survey), Section 74(3) of the Petroleum Act requires that:

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

New operators (such as SAPEX) are classified as requiring high level supervision for seismic activities. In order to obtain written approval for a seismic survey, an application and activity notification (in accordance with Regulation 20) must be submitted to the minister at least 35 days prior to the commencement of activities.

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

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

The site-specific detail provided would include an assessment of the environment of the proposed location, investigation of specific issues (such as the likelihood of occurrence of threatened species or locations of mound springs or areas of sensitive landscape) and proposed measures to minimise impacts to key issues (e.g. low impact techniques for sensitive areas, sensitive locations to avoid). On-ground environmental investigations would typically be conducted as part of this assessment, particularly where the potential issues are significant or the operation is in a new area.

2.6 Other Legislation

A variety of legislation applies to petroleum exploration activities. Legislation that is particularly relevant to petroleum exploration is listed below (note that this is not a comprehensive list of all applicable legislation).

Commonwealth
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
Native Title Act 1993
Aboriginal and Torrens Strait Islander Heritage Protection Act 1984

South Australia
Aboriginal Heritage Act 1988
Crown Lands Act 1929
Environment Protection Act 1993
Fire and Emergency Services Act 2005
Heritage Act 1993
Heritage Places Act 1993
National Parks & Wildlife Act 1972
Native Title (South Australia) Act 1994
Native Vegetation Act 1991
Natural Resources Management Act 2004
National Trust of SA Act 1955
Occupational Health, Safety and Welfare Act 1986
Public and Environmental Health Act 1987.

Approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* would be required for activities that impact matters of national environmental significance (e.g. threatened species or communities, Ramsar wetlands, national heritage places). However, the issues that require approval can generally be avoided, by program planning, line selection and field procedures (e.g. deviating seismic lines around significant features).

It is noted that exploration activities that are approved under the Petroleum Act are exempt from requiring approval under the *Native Vegetation Act 1991* for clearance of native vegetation, provided that the activities are in accordance with accepted industry environmental management practices for facilitating the regrowth of native vegetation and there is no practicable alternative involving the clearance of less vegetation or of vegetation that is either less significant or more degraded (see regulation 5(1)(zc) of the *Native Vegetation Regulations 2003*).

3 Proposed Activities

This EIR applies to geophysical operations. Activities associated with geophysical operations are as follows:

- Line and access track preparation (occurs following completion of cultural heritage clearance)
- Line surveying (occurs after line preparation)
- Recording (seismic, gravimetric, ground magnetic, electromagnetic and others)
- Campsites and associated supplies
- Uphole drilling and logging (occurs during or after recording phase, as and when required)
- Monitoring and auditing of selected locations (pre and post line preparation and post restoration)
- Line access track and camp site restoration where required (occurs after completion of recording and uphole drilling/logging).

3.1 Description of Seismic Operations

The following description of seismic operations has been taken from the *Environmental impact report: geophysical operations* (Santos 2006).

3.1.1 Seismic Method

Seismic acquisition provides an explorer with the ability to 'image' below the surface and identify areas where oil and gas may have accumulated. The seismic method uses energy sources such as vibrator trucks or buried explosive charges. The energy source causes sound waves, which travel into the earth and are then reflected from subsurface geological structures. The returning reflections are recorded in a digital format and sent to a seismic data processing centre to produce a 'cross-section' of the layers of the earth's crust. The following sections explain the field procedures for recording seismic data.

3.1.2 Planning

Once the exploration team of an exploration company have proposed a seismic program, the seismic program is plotted onto detailed topographic and/or satellite images. There are two basic types of seismic survey.

- A 2D survey records data along a single line of traverse, giving a cross-sectional 'picture' of the subsurface. 2D seismic lines are normally 10–50 km long and spaced 500–5000 m apart
- A 3D survey records data over a 'grid' of lines simultaneously, giving a three-dimensional view of the subsurface, beneath an area generally covering 15–1500 km². The surveys may have energy source lines at right angles to the geophone lines and have a closer line spacing of 200–400 m.

Seismic lines are usually 4 m wide. The seismic lines are carefully laid out to avoid sensitive sites such as environmental sites, cultural features (e.g. buildings, dams, water wells) and known heritage sites.

The key aspect of field acquisition is to move equipment (usually vehicular based) and personnel along the planned seismic lines and acquire sufficient data to adequately 'image' the subsurface. The safety of field personnel is a key consideration of any field seismic operation. This involves compromise between what is logistically, environmentally and economically possible.

3.1.3 Cultural Heritage Clearance

An indigenous cultural heritage clearance is normally carried out prior to the commencement of on-ground seismic surveys. The heritage clearance usually involves an archaeologist/anthropologist and representatives of the relevant indigenous communities.

For a 2D survey members of the heritage survey team travel the planned seismic line positions using GPS receivers pre-programmed with the key line coordinates. Any cultural heritage sites encountered are clearly flagged off and a detour route located and flagged around the site. For a 3D survey, there

is more of an aerial clearance concept where all routes including selection of samples of the programmed source or receiver line positions, existing tracks, old seismic lines or creek courses can be used to investigate the 3D project area. There is more of a selective approach with high-risk areas selected for detailed investigation while those considered to be of low risk are given less scrutiny. As for 2D surveys, any identified sites are flagged off and a detour route marked around the site.

The personnel and vehicle requirements for a heritage survey vary from project to project. Light 4WD vehicles are normally used and generally any of the vehicles pass only once over a given section of ground, although in the vicinity of identified sites and detours, some backtracking may occur. Existing tracks or old seismic lines are used when possible to gain access into the program areas.

Depending on the location of the proposed seismic survey area, the cultural heritage clearance survey personnel may 'swag out' within the survey area in order to maximise working hours or camp at existing nearby facilities during the survey. This process typically involves approximately eight personnel and three vehicles.

SAPEX have agreements with the relevant native title groups in the region that cover cultural heritage clearance requirements (refer to Section 4.5.6).

3.1.4 Line and Access Track Preparation

Unlike drilling or production operations, the preparation of access tracks is not a normal practice for seismic operations. Access routes may be required in areas with no existing roads or previous seismic, well or production activity, but this normally does not require the same degree of preparation as for drilling operations.

Once the cultural heritage clearance has been obtained for the project and the line positions confirmed the line preparation crew can commence work. This team operates from a central campsite. This site may be moved every few days in 2D mode but could remain static for up to two months on large 3D programs. The camp, on average, accommodates 13 personnel (including surveyors) for 2D surveys and 17 for 3D surveys. The camp units are trailer mounted for easy mobility. Campsites are set up where possible on sites previously used or in areas naturally devoid of vegetation and always adjacent to any existing tracks to minimise impact on the terrain between the camp and tracks. Camp members may also be accommodated at existing nearby facilities.

The line preparation crew usually operate simultaneously on different lines, characteristically using two D6 or D7 bulldozers for 2D surveys and four in 3D surveys. Daily production of prepared line is ~30 km and 60 km respectively (i.e. 15 km/dozer), though this varies with terrain. The dozers will simply walk with the blade up in easily traversable terrain, with the marks of the tracks being sufficient for the surveyors to follow. The line position, plus tolerances for weaving the line around vegetation or other features, are generally pre-programmed into GPS units housed in the dozers. These GPS units are kinematic dual frequency units that allow the dozer operators to get real time position fixes. These are plotted on a pilot display that also indicates the weaving tolerances for the dozer operators. The dozers weave around vegetation stands and on open ground the machines weave every 75–100 m to reduce visual impact.

Blade work is kept to a minimum and generally restricted to sand dunes and floodplain crabhole country. Grader work is likewise kept to a minimum.

Graders are mainly used in floodplain crabhole country to smooth the tracks. A method successfully used has been the 'rill kill' attachment (coiled wire rope) fitted to the blades to minimise windrow development.

All machine operators are given environmental inductions at regular intervals and receive cultural heritage training. Dozer operators are required to keep a very close watch for cultural heritage sites that may have been missed during the clearance survey. Any additional sites discovered are flagged and detoured as above.

Any sensitive environmental features such as wetlands and salt lakes are prepared without the use of heavy machinery. Light brush cutting or slashing is used in the thick vegetation zones of wetland areas to prepare 1–1.5 m wide lines for foot or small vehicle access only.

An example of the amount of machinery use for the various landforms is shown in Table 1 on a scale of 0–5, where 0 represents zero application and 5 represents more or less constant blading or slashing. This table refers to practices undertaken in the Cooper Basin, but is transferable to the Arckaringa Basin.

Access tracks are prepared to the same specification as the seismic lines.

Table 1: Line preparation activity for different landforms in the Cooper Basin (Santos 2006)

Landform	Level of machinery use*		
	Dozer blading	Grader work	Brush cutters / slashing
Gibber plain	0	0	0
Dunes	5	2	0
Dune corridors	1	1	0
Floodplain crabhole	5	5	1
Tableland	0	0	0
Wetlands	0	0	4
Clay pans	0	0	0
Salt lakes	0	0	0
Creek crossing	2	2	1

*Scale: 0 represents zero application, 5 represents more or less constant blading or slashing

3.1.5 Line Surveying

Surveying commences shortly after line preparation. The field surveyors use real time kinematic GPS receivers to position source and receiver points for 3D surveys and receiver points only for 2D surveys. Surveyors insert metal pins with numbered plastic tags to indicate the points. Selected points are marked by a wooden stake. Markers protrude approximately 0.3 m above ground level. These markers are removed on completion of the recording phase.

Line detours are often marked with biodegradable flagging, which is subsequently removed once the detour has been taken. Each survey team (one surveyor in a light 4WD vehicle) generally makes only one pass over any given section of line. Back tracking sometimes occurs in areas where vehicle access routes have deviated from the true line position and markers have to be placed on foot.

3.1.6 Recording

Recording usually commences 1–3 weeks after the start of line preparation depending on whether the survey is 2D or 3D. This operation is the largest part of the seismic operation in terms of personnel and vehicles. A recording crew's strength would normally be:

- For 2D operations: 34 personnel and 16 vehicles.
- For 3D operations: 42 personnel and 20 vehicles.

These figures vary with recording technique, terrain and season.

2D Operations

Work commences with the laying of cable and deployment of geophone bundles from light 4WD vehicles.

Geophone strings normally consist of 12 interconnected geophones and are dropped off at each receiver station. These strings are looped onto metal hangers for ease of handling. The geophones are then pulled off the hanger and planted in the ground by personnel on foot. Once planted, the string (typically 30 or 37.5 m in length to match the distance between receiver points) is connected to a 'take out' on the recording cable. The recording cable is spooled out from the side of the vehicle and offset to one side of the line to prevent damage from following vehicles.

Recording in 2D mode would normally commence when ~8 km of cable and geophones have been laid. This layout is termed 'the spread' and a pre-selected 'live' section of it picks up the acoustic energy reflected from subsurface layers, converts it to electrical energy and transmits it to the instrument recording truck.

The instrument recording truck (see Plate 1) that collects, decodes and amplifies these signals, sets up at a suitable location approximately 100 m from the spread and connects to it. Once the instruments and spread have been satisfactorily tested, recording is ready to commence.

The acoustic energy source is normally an array of three or four truck-mounted vibrator units electronically synchronised to vibrate in phase with each other (see Plate 2). They line up along a source line, a few metres apart, centred on a source point. Each unit, on command from the instrument truck, inputs one or more frequency sweeps into the ground at each source point. Each sweep lasts for only a few seconds. Generally 4 seconds of reflected data is recorded. The source points are typically 30 or 37.5 m apart. On completion of one source point the set of vibrators quickly move to the next source point.

The live section of spread is approximately 4.5 km in length. This is the only part of the spread where signal is recorded for any given source position. The live spread is moved (controlled by the recording truck operator) as the vibrators move up. As spread becomes redundant behind the vibrators (back end of line) it is picked up and transported to the front end of the line. This cycle continues until the line is completed. The recording truck may move once or twice during the day to keep pace with the spread.

All operational vehicles stay on the prepared line, the exceptions being parked vehicles, spare vibrators, vibrator service truck and instrument truck, all of which have to park off line to avoid causing noise on the spread and interference with line traffic.

Along any single line the following vehicle passes can be expected to occur during normal operations:

- Vibrators - 1 pass for each truck
- Instrument truck - 1 pass
- Light vehicles - 15–20 passes in total
- Vibrator service truck - 1 pass.

3D Operations

For 3D surveys, the major differences from 2D operations are that the vibrators vibrate on separate source lines to the cable/geophone lines (now termed receiver lines). Source lines are often designed to be orthogonal to the receiver lines, but other orientations may be employed. The vibrators and associated equipment use the receiver lines for access from one source line to the next, so the amount of traffic on a receiver line will be very similar to a 2D line (as above).

However, the source lines carry limited traffic i.e. the vibrators and their associated equipment plus any supervisory 4WD vehicle passes. Also vibrator marks will only be left on the source lines.

Typically receiver points are 40 m apart on the receiver lines and source points and 80 m apart on the source lines.

Successive receiver lines are 320 m apart as are the source lines. On occasions receiver point intervals may be as low as 35 m or as high as 50 m. This means 280 m and 400 m source and receiver line separations, respectively.

Instead of having one receiver line in 2D surveys there are now generally eight or more receiver lines recording at any time, with a further two redundant (one being picked up and moved to the front, and one at the front ready for use).

Recording in 3D mode would normally commence when about 45–50 km of cable and geophones have been laid.

Despite approximately 70 km of spread being on the ground at any time, the receiver line impact is no more than encountered in 2D mode.

Along any single line the following vehicle passes can be expected to occur during normal operations:

- Vibrators (3 or 4 on line plus spare) - 1 pass for each truck (source lines)
- Vibrator service truck - 1 pass (source lines)
- Instrument truck - 1 pass (receiver lines)
- Light vehicles - 15–20 passes in total (receiver lines)

In areas that are not accessible by heavy machinery, such as salt lakes, wetlands and densely vegetated floodplains, shallow shot holes are drilled using hand held augers. Small explosive charges are used as the seismic source in place of the vibrators.

Plate 1: Recording Truck

(Source: PIRSA)

Plate 2: Vibrator trucks traversing a seismic line

(Source: PIRSA)

3.1.7 Camp Sites and Associated Activities

There are generally only two campsites in operation on a seismic survey: line preparation/survey camp and main camp. The former is briefly explained in the line preparation section. The main camp houses the recording crew, crew management team and the recording and mechanical back up teams. Campsites are sited on ground conducive to camping, but never on clay pans or salt lakes. Camps are located as near as practical to existing tracks or roads to avoid the need for clearance of native vegetation and subsequent disturbance of habitats. Campsites are located on previously disturbed areas wherever possible.

2D projects result in frequent camp moves but with tenure lasting only a few days. The larger 3D surveys can result in the main camp being static for up to two months. This camp can often house up to 60 personnel and contain more than 20 trailers and about 36 vehicles. As the majority of these vehicles transit from camp to adjacent road and back at least once per day, and some several times, the routes from camp are clearly defined to restrict wheel track impact.

Some campsites may require multiple access routes to minimise the potential of bull dust creation. Vehicles are restricted to the perimeter of the camp and parking areas are also defined.

Putrescible domestic wastes (e.g. food waste, paper) created at campsites are stored on site along with other wastes (such as plastics, cans and glass) prior to transportation to a licensed waste disposal facility. Recyclable materials are segregated for recycling where practicable and are also transported to a licensed waste facility. Storage methods take issues such as scavenging animals into account to avoid litter scattering and impacts on wildlife.

Campsites require the provision of systems for the management of sewage wastes, which must be managed in accordance with the *Public and Environmental Health (Waste Control) Regulations 1995*. Approved environmental treatment units may be utilised where practical and appropriate. Following treatment via an approved system wastewater may be disposed of on-site (onto land, well away from any place from which it is reasonably likely to enter any waters, and well away from any infrastructure) when in remote areas. The method of disposal for wastewater must comply with the *Standard for the Construction, Installation and Operation of Septic Tank Systems in SA*, or be to the satisfaction of the Department of Health.

Drip trays are positioned at the refuelling bowser and mechanical workshop to eliminate fuel and oil ground contamination. Any uncontained spillage is chemically treated or bio-remediated and the ground ripped. Once the campsite has been vacated rehabilitation is undertaken, including ensuring no rubbish or any man made items are left in situ and, when necessary and terrain permitting, the area is tyne ripped to remove compaction and wheel tracks. Shoulders of adjacent formed tracks are reinstated. No ripping is conducted at campsites on sensitive soils (e.g. gibber plain).

3.1.8 Uphole Drilling and Logging

Uphole drilling is carried out to provide data on surface layers for use in processing of seismic data. SAPEX intend to use previously recorded data for the region and do not propose to carry out uphole drilling in the initial seismic surveys, however it may be required at a later stage.

This component of seismic surveys consists of truck mounted uphole drilling rig(s) and logging vehicle(s) (see Plate 3). A support water tanker truck(s) may also be required if mud drilling is undertaken. The support camp may house up to six trailers or more. The rig normally drills 4¾“ diameter holes that vary in depth from project to project. Most holes are in the 30–90 m range. Holes are drilled using mud, air or water injection as required.

The distance between upholes can vary considerably depending on operator requirements, but are normally at 1–5 km spacing along lines, dependant on the level of previously recorded data available for the project region.

Once a hole has been drilled the drill rig moves off the site and a logging vehicle moves in to record seismic measurements in the hole. This involves the lowering of a probe (known as a down hole geophone) to the bottom of the hole and triggering a heavy weight that drops from the back of the

truck to produce an acoustic impulse. The time it takes this impulse to reach the probe is recorded on a set of electronic instruments housed in the logging vehicle (usually a 4WD light vehicle). This process is repeated as the probe is gradually moved up the hole. A picture is thus built up of successive travel times through the near surface layers that provide information on their thickness and velocity (vital information for correcting the Vibroseis™ seismic data).

On completion of logging the drill cuttings are returned to the hole and the hole is capped. Surplus cuttings are then either spread to minimise visual impact or removed in the case of sensitive areas. In some areas, the colour of the cuttings is markedly different from the ground surface and spreading of cuttings exacerbates visual impact rather than minimise it. Removal of cuttings reduces this impact, but trials of adding colouring agent to the drilling mud may assist in this regard, particularly in gibber terrains.

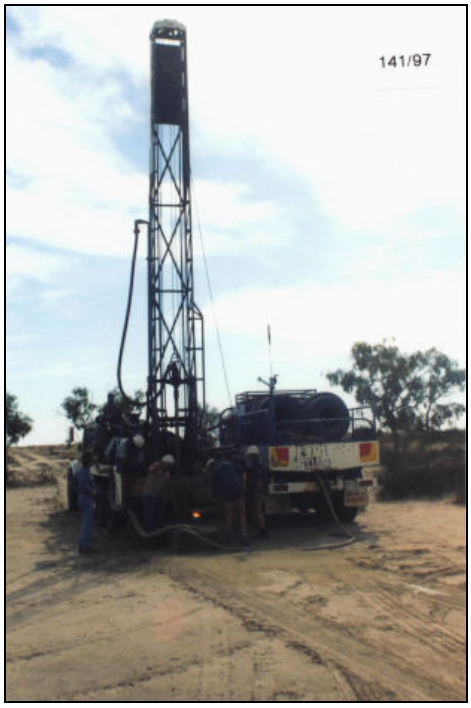


Plate 3: Typical Up-hole Drilling Rig

(Source: PIRSA)

3.1.9 Line/access track and campsite restoration

If undertaken correctly, the majority of seismic lines, access tracks and camp sites do not require restoration work as one of the main objectives is to prepare and utilise them in a way that will facilitate rapid natural recovery. However, restoration activities are required where the following has occurred:

- wheel ruts caused during the crossing wet or soft ground
- grader blade windrows
- the removal of windrows on the edge of public tracks where they were intersected by seismic lines
- soil compaction
- the disturbance of road shoulders on public access tracks
- heavily trafficking of routes between camp sites and the nearest public track
- the generation of bulldust on access tracks due to extensive seismic traffic
- watercourse channel infill and or restriction of natural flows.

Methods used for rehabilitation include:

- ripping of compacted areas where required (note: ripping will not be undertaken on unsuitable soils – e.g. stony plains)
- windrow material pushed onto line and smoothed

- public road windrows reinstated
- wheel rut material used to infill affected areas
- affected watercourse channels and creek banks reinstated.

Restoration and rehabilitation activities will be undertaken in consultation with, and to the satisfaction of the relevant landholder. Seismic lines, access tracks and campsites will be restored and rehabilitated to attain the highest achievable Goal Attainment Scaling (GAS) rating, as defined in the SEO and, where relevant, in PIRSA's *Field Guide for the Environmental Assessment of Recently Completed Seismic Lines in the Cooper Basin, South Australia* (Kane 2006).

3.1.10 Post-survey monitoring and auditing

Prior to, during and following geophysical operations, environmental assessments will be undertaken to ensure that operations have been conducted in compliance with the SEO and any other regulatory requirements. These assessments can be implemented in a number of different ways.

Prior to the commencement of a survey a number of environmental photo-monitoring points are selected to give a balanced representation of the various landform and vegetation type encountered. The location of these points is influenced, to some degree by ground conditions and access (e.g. flooded or restricted wetlands, creeks and salt lakes that cannot be accessed).

These points are recorded (using a GPS) and marked with star droppers prior to the start of line preparation. Photographs are taken at these locations along the proposed line direction to give a view of the terrain prior to line-preparation. All photographs are optimally taken with a 50 mm lens for consistent comparison. The process is repeated after line preparation and again after recording. These environmental monitoring points will be photo monitored for a minimum of 4 years following the completion of the survey to give a visual representation of the recovery process. The revisit intervals are generally one year, two years and four years (eight years if further visits are deemed necessary).

Goal attainment scaling (GAS) audits, using the criteria described in the SEO, are a mandatory requirement of the SEO and are conducted after recording on representative sections of line and at the environmental monitoring point locations.

Both the photo-point recoding and the GAS audits are normally done by one person and one 4WD light vehicle.

3.2 Other geophysical surveying operations

Other geophysical surveys do not have the same extent of operations as seismic surveying. Most use 4WD vehicles or are done on foot and involve taking some measurement along traverses (similar to 2D seismic traverses) but more like activities involved in 'Line surveying' (Section 5.3.5 above). Often no significant line or access track preparation is required. Measurements can be of a passive nature, such as measurement of gravity, magnetic or electromagnetic fields, or involve input of some signal into the earth, such as small electrical or electromagnetic signals.

3.3 SAPEX 2007/08 Seismic Program

This section provides information on SAPEX's proposed seismic program for 2007/2008, in order to give an indication of the scale and location of activities that are likely to be carried out in the PELs. It is important to note that the program has not been finalised, and the exact location and orientation of seismic lines has not been determined.

The initial seismic survey for 2007/2008 will involve three main foci:

- 2D seismic in PEL 117, approximately 15 km south-west of Oodnadatta
- 2D seismic in PEL 121, approximately 70 km south of Oodnadatta
- A number of regional seismic lines, with transects across PEL 122 and PEL 123.

Upholes are not planned for the initial survey.

Indicative locations of proposed survey lines are shown in Figure 2.

The 2D survey areas are located predominantly in the Oodnadatta and Baltana land systems, which are undulating plains of gibber or brown saline clay respectively. Further detail on these land systems is provided in Section 4 and Appendix 1.

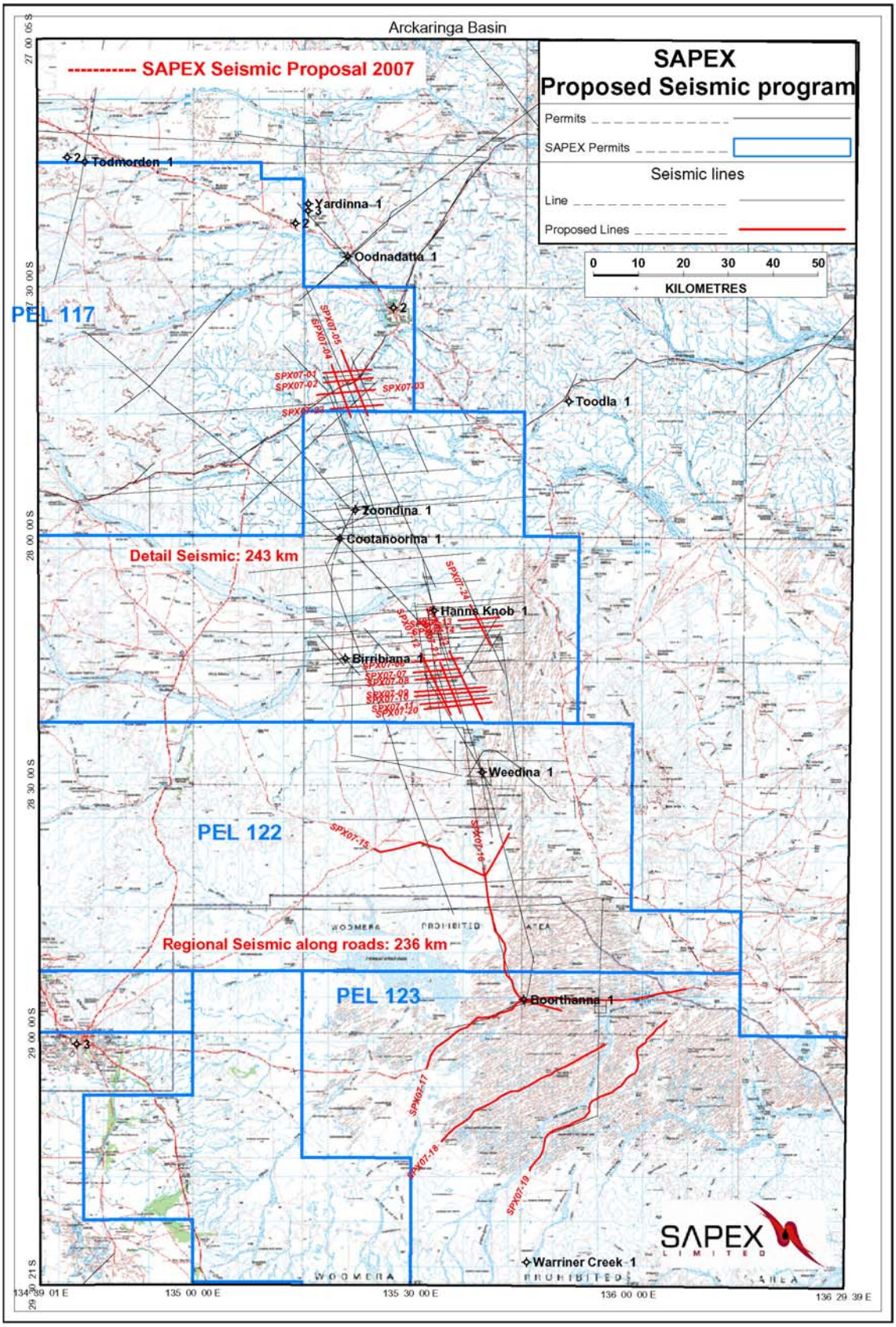
The regional seismic lines will utilise existing roads and tracks and it is expected that very little line preparation will be needed. Because these lines aim to provide a regional seismic profile and are generally not following a specific grid, they do not need to be completely straight and therefore have the flexibility to follow existing roads and tracks.

The proposed seismic lines do not intersect significant areas identified in Section 4 (e.g. heritage listed areas such as the Arckaringa Hills). One mound spring is mapped in the 2D survey area in PEL 121, however seismic lines will be located to avoid any impact.

A detailed assessment of the finalised survey lines will be included in the documents that will be submitted for activity approval when survey planning is at a more advanced stage, as discussed in Section 2.5.

Further seismic survey work may be carried out in the future, depending on the results of exploration drilling and the initial seismic survey. This future work could range from 2D seismic in new areas to 2D or 3D infill in similar areas to initial survey.

Figure 2: Indicative Location of Proposed 2007/08 Seismic Program



Note: The seismic program has not been finalised, and the exact location and orientation of seismic lines may vary from that shown.

4 Existing Environment

4.1 Climate

The climate in the Arckaringa Basin is classified as arid and has a typical desert climate of hot to extremely hot, dry summers and mild, dry winters, with low and erratic rainfall. Average annual rainfall at Coober Pedy, in the centre of the region, is 159 mm. Median annual rainfall, which is a more appropriate measure where rainfall is erratic, is 134 mm. Rainfall can occur at any time of year, but rainfall events often occur in summer, when moist tropical air from the north-west monsoon penetrates the region. Record daily falls of between 100 and 200 mm have been recorded across the region (Marla-Oodnadatta SCB 1997). A summary of climate records for Coober Pedy (Station #016007) is provided in Table 2 (Bureau of Meteorology 2007).

The prevailing winds in the summer are from the south or south-east and the winter winds are more variable and come from either the north or the south to south-west quadrants (Bureau of Meteorology 2007).

Climate can be an important consideration when scheduling geophysical operations, particularly the likelihood of heavy or prolonged rainfall. However, due to the unpredictable and erratic rainfall (which may or may not occur any time of the year) and the predominantly dry conditions experienced in the region, rainfall is not a significant factor in scheduling surveys in this region.

Table 2: Temperature and rainfall records for Coober Pedy

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean Daily Max (^{o}C)	36.2	35.5	32.7	27.6	22.2	18.8	18.7	20.9	24.6	28.8	32.2	34.4	27.5
Mean Daily Min (^{o}C)	20.6	20.7	18.2	14.1	10.1	7.3	6.3	7.4	10.1	13.6	16.6	19.1	13.4
Mean Rainfall (mm)	16.8	23.9	13.5	6.6	13.7	15.0	7.9	9.3	8.6	15.1	11.6	17.0	159.1
Median Rainfall (mm)	5.1	9.4	2.5	1.5	4.6	6.4	3.2	3.5	2.8	6.9	5.1	10.8	133.9

4.2 Biophysical Environment

The area of the SAPEX PELs covers four biogeographical regions (or bioregions), as defined by the Interim Biogeographic Regionalisation for Australia (IBRA). These bioregions, which are broad landscape units based on major geomorphic features, are:

- Stony Plains
- Simpson Strzelecki Dunefields
- Great Victoria Desert
- Gawler.

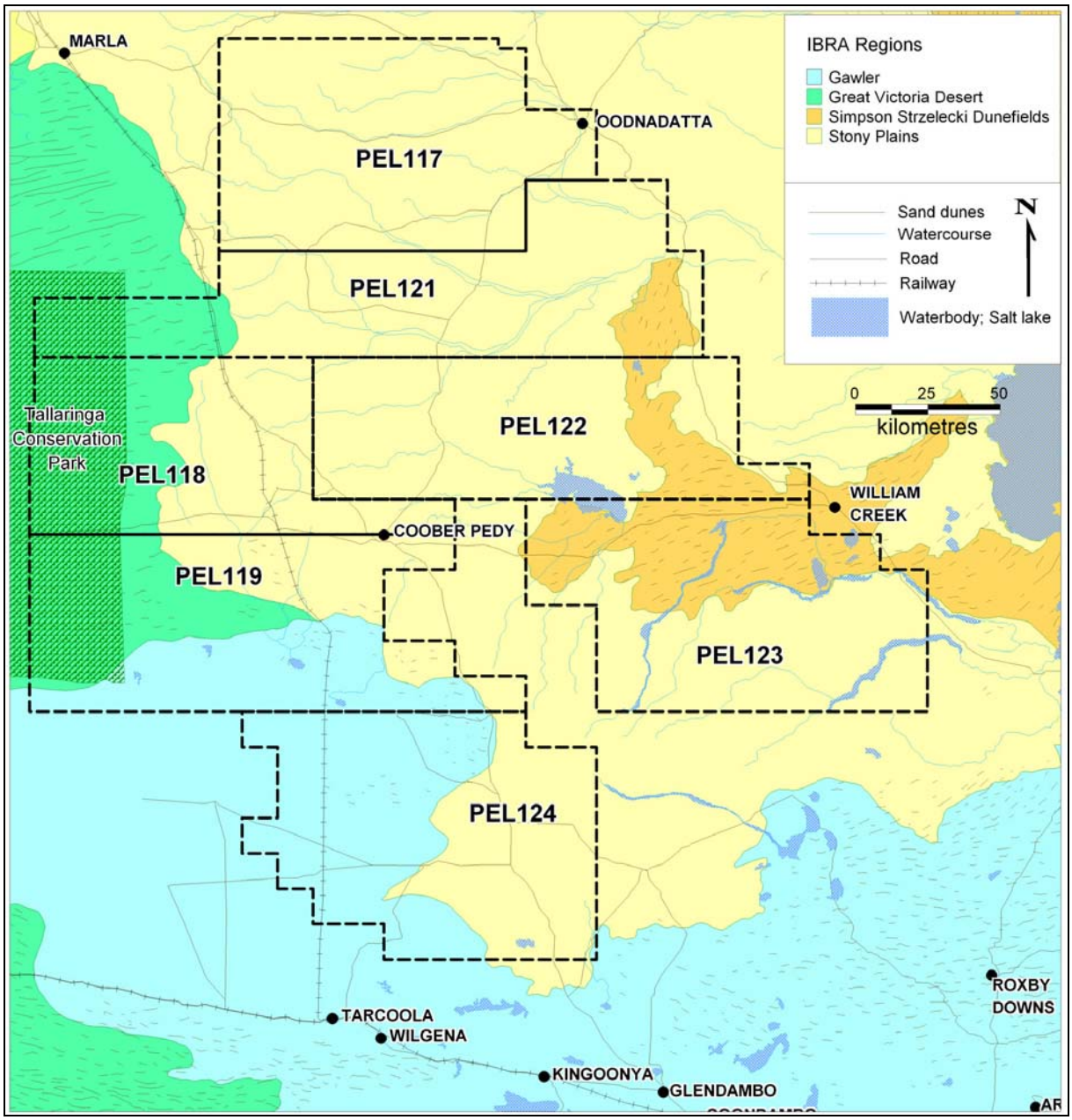
The following sections of this EIR describe the environment within the SAPEX Arckaringa Basin PELs in each of these bioregions. The location of these bioregions is shown in Figure 3.

Each bioregion is divided into subregions under the IBRA classification and can be further divided into land systems, the smallest mapping unit that is used at a national scale (DEH 2005). Land systems are an area, or group of areas, throughout which there is a recurring pattern of geology, topography, soils and vegetation (DEH 2005). The land systems referred to in this document have been used in pastoral management and soil conservation planning and are now being used in regional biodiversity planning (DEH 2005)[1].

[1] The current IBRA boundaries (shown in Figure 3 of this report) do not match the land system boundaries exactly, but are planned to be realigned when IBRA version 7 is released (DEH 2005). Land systems in this report are grouped into IBRA regions on the basis of the provisional, realigned IBRA boundaries (as per DEH 2005).

To assist in the discussion of potential impacts and environmental management measures in subsequent sections of this EIR, the major land forms encountered within each bioregion are also identified and discussed in the following sections.

Figure 3: Bioregions of the Arckaringa Basin



4.2.1 Stony Plains

The entire Stony Plains bioregion covers an area of 129,240km² and represents 24.8% of the South Australian Arid Lands and 13.2% of the state (DEH 2005). It stretches in an arc from the Northern Territory through to south of Lake Eyre and east to the edges of the Strzelecki Desert and Flinders Ranges.

The Stony Plains bioregion occurs in the central third and the north-east corner of the region covered by the SAPEX Arckaringa Basin PELs and constitutes approximately 60% of the area of the PELs .

The land systems present in the Stony Plains bioregion covered by the SAPEX PELs include: Baltana, Breakaway, Buckshot, Christie, Coongra, Glendambo, Lookout, Moon Plain, Mount Margaret, Oodnadatta, Paisley, Wooldridge and a small area of Wattiwarriganna. A full description of each of these land systems in provided in Appendix 1.

Geology, Soils & Landform

The Stony Plains bioregion is generally described as being a series of 'arid stony silcrete tablelands and gibber and gypsum plains with duplex soils and calcareous earths' (DEWR 2007).

The region has gently undulating gibber and gypsum plains as its dominant feature. These are dotted with occasional lakes, claypans, low hills and ephemeral watercourses and floodplains which typically drain into Lake Eyre (Neagle 2003).

The north-west of the region is interspersed by dissected silcrete-capped tablelands and mesas with extensive gibber covered footslopes on deeply weathered shales (Neagle 2003). These tablelands include the 'Breakaways' landform which occurs in several of the SAPEX PELs.

Some watercourses form major drainage systems featuring deep channels and occasional permanent waterholes (Neagle 2003). Wetlands occur throughout this bioregion with the Great Artesian Basin (GAB) springs being the most significant wetland feature.

The SAPEX PELs are a representative subset of the Stony Plans bioregion. They contain a variety of plains and tablelands interspersed with dunefields, hills and plateaus. Seven major landforms occur within the SAPEX PELs based on the landform groupings in DEH (2005):

- Stony plains
- Moon plains
- Breakaways and stony hills
- Dunefields and sand plains
- Drainage lines and flood plains
- Great Artesian Basin springs
- Salt lakes.

These are discussed further below and photographic examples are provided in Plates 4 to 9.

Stony Plains

This landform is typified by gently sloping plains with a cover of small to large gibber stones. Gilgai are typically present, which are stone-free, often circular depressions with clay soils that receive much of the runoff from the adjacent gibber (Marree SCB 1997). Gibber stones are typically derived from silcrete, but in the Coongra land system the stone cover is comprised of sandstone and shale.

The surface stones generally form a stable pavement that protects the underlying soil from erosion. Grading or removal of the stone cover can result in significant erosion (Marree SCB 1997, Santos 2006).

Stony plains occur in the Oodnadatta, Baltana, Buckshot, Coongra, Lookout and Paisley land systems.

Note: The stony plains landform includes plains formed on elevated plateaus which are often described as “tablelands” (e.g. in DEH (2005) and soil board plans). However, the term “tableland” has been avoided in the landform description to avoid confusion with the Cooper Basin geophysical operations EIR and SEO, which use the term in a slightly different sense to describe dissected residuals or breakaways. Such landforms are classified in this EIR as “breakaways and stony hills”, consistent with DEH (2005).

Moon Plains

Plains with clay soils but without significant stone cover occur in the Moon Plain land system. The Moon Plain (north-east of Coober Pedy) is an undulating plain with soft grey gypseous cracking clay soils and limited drainage.

Breakaways and Stony Hills

This landform includes dissected tablelands and other residual habitats forming mesas or tabletops with a capping of silcrete overlaying various shales (DEH 2005). It is typified by the steep escarpments and mesas of the Breakaway land system, but also includes the stony hills found in a number of land systems and the more rugged ranges such as the Mount Margaret land system.

Breakaways and stony hills occur in the Breakaway, Coongra, Lookout, Paisley (the Stuart Range) and Mount Margaret land systems, with limited occurrences in other land systems including Oodnadatta, Christie and Baltana.

Dunefields and Sand Plains

Dunefields and sand plains occur in limited areas, where they overly the gibber surface or surround rocky outcrops or hills (DEH 2005). Dune soils are typically deep red sands, while soils of plains and interdune swales range from sandy clays to calcareous and siliceous sands.

Land systems with dunefields and sandplains include a small area of Wattiwarriganna (with its extensive dunefields), Woolridge and Paisley (which contain some sand dunes) and Buckshot, Christie and Glendambo.

Drainage Lines and Flood Plains

This land form is typified by ephemeral watercourses, generally draining towards Lake Eyre. In places these form major drainage systems featuring broad flood plains. Large, braided creeks occur throughout the region (e.g. Neales and Arckaringa Creeks).

Drainage lines occur in most land systems; even the less well-drained land systems (such as Moon Plain) tend to be traversed by major drainage lines.

Great Artesian Basin Springs

These high conservation value wetlands are found on the margins of the Great Artesian Basin (GAB). They can take a wide variety of geological forms from large carbonate mounds to sandy seeps (DEH 2005). Typical spring structure includes a vent where it emerges from the ground, a tail which flows from the vent and terminates in the wetland around the base of the spring (if the flow is great enough) and saline spring margins surrounding the spring. GAB springs are discussed further in Section 4.3.1.

GAB Springs in the SAPEX PELs occur predominantly in the Wattiwarriganna and Oodnadatta land systems.

Salt lakes

Salt lakes and salt pans are formed when excess evaporation in interior basins leads to the concentration of soluble salts as a surface crust. Salt lakes occur in limited areas within the SAPEX PELs, including scattered occurrences in the Woolridge land system (in the far north of PEL117) and

in the Moon Plain land system. The largest salt lake in the area is Lake Cadibarrawirracanna (on the boundary of PEL122 & 123). Most other salt lakes in the PELs are relatively small.

Plate 4: Stony Plains (Oodnadatta land system)

(Source: Marla-Oodnadatta SCB 2002)

Plate 5: Moon Plains (Moon Plain land system)

(Source: Marla-Oodnadatta SCB 2002)

Plate 6: Breakaways and Stony Hills (Breakaways land system)

(Source: Marla-Oodnadatta SCB 2002)

Plate 7: Dunefields and Sand Plains (Wattiwarriganna land system)

(Source: Marla-Oodnadatta SCB 2002)

Plate 8: Drainage Lines and Flood Plains (in Oodnadatta land system)

(Source: RPS Ecos)

Plate 9: Great Artesian Basin Springs (in Oodnadatta land system)

(Source: RPS Ecos. Note: This spring, 'The Bubbler', is just outside the SAPEX PELs but is typical of a GAB spring with a tail.)

Flora

The following information has been taken from Brandle (1998), as cited in Neagle (2003).

The stony desert tablelands and gibber plains feature low open shrublands variously dominated by Saltbush (*Atriplex* spp.), Bluebush (*Maireana* spp.) or Samphire (*Sclerostegia medullosa*), short-lived Bindyi (*Sclerolaene* spp.), Thyme Sea-heath (*Frankenia serpyllifolia*) or Bonefruit (*Osteocarpum* spp.) Low Open Shrublands, and Barley Mitchell-grass (*Astrebla pectinata*) or Love-grass (*Eragrostis* spp.) Open Tussock Grasslands.

These plant associations are also present in the breakaways and rocky hills though often with the addition of medium shrubs, such as Wattle (*Acacia* spp.), Emubush (*Eremophila* spp.) and occasionally Silver Needlewood (*Hakea leucoptera ssp. leucoptera*). Also present is Mulga (*Acacia aneura* var. *aneura*) Low Woodland, as well as Beaked Red Mallee (*Eucalyptus socialis*).

Drainage channels in the upper catchments tend to have a denser version of the vegetation of the surrounding hills and breakaways with low woodlands of Wattle including Gidgee (*Acacia cambagei*), Coolibah (*Eucalyptus coolabah* ssp. *arida*) and possibly Northern River Red Gum (*E. camaldulensis* var. *obtusa*).

Floodplains and swamps are a mix of low open shrublands variously dominated by Old-man Saltbush (*Atriplex nummularia* var. *nummularia*), Lignum (*Muehlenbeckia florulenta*), Cottonbush (*Maireana aphylla*) or Samphires, as well as Cane-grass (*Eragrostis australasica*) Tussock Grasslands in swamps, and Mitchell-grass, Love-grass or Bindyi Open Tussock Grasslands. Salt pans are usually bare and salt crusted but often have a halo of Cane-grass Tussock Grassland or Grey Samphire (*Halosarcia halocnemoides*), Slender Samphire (*Sclerostegia tenuis*) Low Open Shrubland.

Where dunefields and sand plains overlay gibber surfaces several other plant associations are prominent. Sandhill Cane-grass (*Zygochloa paradoxa*) Open Hummock Grassland dominates deep sands, especially on dunes, but Umbrella Bush (*Acacia ligulata*) Tall Shrublands and Mulga Tall Shrublands are also common. Sand plains support Nitre-bush (*Nitraria billardierei*) Low Open Shrublands or Sturt's Pigface (*Gunniopsis quadrifida*), Bladder Saltbush (*Atriplex vesicaria*) Low Open Shrublands. Small areas of calcareous loams and clays in the western Lake Eyre Basin support Low Bluebush (*Maireana astrotricha*), Bladder Saltbush, Twinleaf (*Zygophyllum* spp.) and/or Balcarra Spear-grass (*Austrostipa nitida*) Low Open Shrublands.

The Moon Plain has very little plant cover in most years, with only a few perennial species present. Mitchell grasses (*Astrebla* spp.) and Neverfail (*Eragrostis setifolia*) are two of the few perennial

grasses found on the Plain, together with Annual Saltbush (*Atriplex muelleri*.) and Pop Saltbush (*Atriplex spongiosa/holocarpa*), Mulka Grass (*Eragrostis dielsii* var. *dielsii*), Poverty-bushes (*Sclerolaena* spp.) and Buckbush (*Salsola kali*). Several species of Samphire (*Halosarcia* spp.) are common in the drainage lines, along with Prickly Wattle (*Acacia victoriae* ssp. *victoriae*) Old-man Saltbush (*Atriplex nummularia* ssp. *nummularia*), Lignum (*Muehlenbeckia florulenta*), Swamp Canegrass (*Eragrostis australasica*) and a few stunted Coolibahs (*Eucalyptus coolabah* ssp. *arida*) (Marla-Oodnadatta SCB 2002).

The Stony Plains bioregion supports 13 endemic plant species, including Barkers Mulla Mulla (*Ptilotus barkeri*), Johnston's Slipper Plant (*Embadium johnstonii*), Gypsum Groundsel (*Othonna gypsicola*) and Haegi's Stemodia (*Stemodia haegii*) and provides a habitat for 5 nationally threatened species including Salt Pipewort (*Eriocaulon carsonii*) and Sea-heath (*Frankenia plicata*) (Neagle 2003). Many of these species have been recorded, or may occur, in the in SAPEX PELs.

One threatened ecological community listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* is present in the region – "The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin". These communities are associated with the GAB spring wetlands that occur in the region along the margins of the GAB.

Four declared plant species (declared weeds) have been recorded on DEH databases as occurring in the region: African Boxthorn (*Lycium ferocissimum* – PEL121), Caltrop (*Tribulus terrestris* – PEL117, 118, 122, 124), Bathurst Burr (*Xanthium spinosum* – PEL117) and African Rue (*Peganum harmala* – PEL119). Buffel Grass (*Cenchrus ciliaris*) is also prevalent along the Stuart Highway (DTEI, 2007).

Significant Fauna

The diversity of habitats within the Stony Plains bioregion has lead to the occurrence of a wide variety and number of species in the region. Over one hundred and fifty bird species and thirty mammal species have been recorded at biological survey sites (Brandle 1998). More than 100 species of reptile have been recorded in the region including 4 endemic species – the Gibber Dragon (*Ctenophorous gibba*), Ochre Dragon (*C. tjantjalka*), Bronze-back Legless-lizard (*Ophidiocephalus taeniatus*) and Woomera Slider (*Lerista elongata*).

The bioregion also supports 8 nationally threatened species and provides primary habitat for the Thick-billed Grasswren (*Amytornis textillis modestus*), Plains Rat (*Pseudomys australis*) and the Bronze-back Legless-lizard (Neagle 2003).

Rare or threatened flora and fauna species that have been recorded in the SAPEX PELs are listed in Appendix 2.

4.2.2 Simpson-Strzelecki Dunefields

The Simpson-Strzelecki Dunefields bioregion covers an area of 277,876km² and extends across South Australia and the Northern Territory with some overlap into Queensland and New South Wales. The SAPEX PELs lie to the west of the bulk of this bioregion and intersect an outlying tongue that constitutes its western-most extent. Approximately 12% of the area of the SAPEX Arckaringa Basin PELs occurs within this bioregion.

The portion of the Simpson-Strzelecki Dunefields bioregion covered by the SAPEX PELs is comprised of the Wattiwarriganna land system. A full description of this land system is provided in Appendix 1.

Geology, Soils & Landform

The Simpson-Strzelecki Dunefields are characterised by the vast aeolian sand dune systems of the Simpson and Strzelecki Deserts. They contain arid dunefields and sandplains with sparse shrubland and spinifex hummock grassland, and cane grass on deep sands along dune crests (DEWR 2007). In places they are interrupted by large clay pans that grade into a large playa complex of salt lakes and gypsum dunes. The main lakes in this system are located outside the Arckaringa Basin to the east and include Lake Eyre and a chain of interconnected lakes in the south-east.

Throughout the bioregion, the dune systems are generally orientated on a north-north-west to south-south-east longitudinal plane. The orientation varies across the SAPEX PELs and the longitudinal orientation of dunes is east-north-east – west-south-west in the southern part of the bioregion and north-north-east – south-south-west in the northern part.

The bioregion also includes the lower reaches of two of Australia's major inland river systems, Warburton and Cooper Creeks and three wetlands of national significance, Lake Eyre, Inland Salt Lakes and the Strzelecki Creek (Neagle 2003). However all of these features are located in the eastern portion of the bioregion, outside the area covered by the Arckaringa Basin.

The Wattiwarriganna land system (which is the only Simpson-Strzelecki Dunefields land system in the SAPEX PELs) is comprised of an extensive dune field of long parallel dunes and broad inter-dunal corridors which include sandy flats and claypans. Numerous large watercourses dissect the land system and there are several mound springs present. Soils in the region range from deep red sandy soils on the dunes to sandy-clay soils in the swales (Marla-Oodnadatta SCB 2002).

The main types of landforms encountered in the bioregion include:

- Dunefields and sand plains
- Salt lakes
- GAB springs.

Flora

Vegetation of the dunes is dominated by a hummock grassland of Sandhill Canegrass (*Zygochloa paradoxa*)or a tall shrubland of Horse Mulga (*Acacia ramulosa*). Umbrella Bush (*A. ligulata*) occurs in isolated stands and Narrow-leaved Hopbush (*Dodonaea viscosa ssp. angustissima*) is also moderately common. Few understorey species grow under or near these two shrubs. Silver Needlebush (*Hakea leucoptera ssp. leucoptera*) also occurs as scattered plants and mulga occurs on some dune footslopes. The understorey includes Tall Kerosene Grass (*Aristida holathera*), Buckbush (*Salsola kali*) and Cattle Bush (*Trichodesma zeylanicum*) (Marla-Oodnadatta SCB 2002).

Interdune corridors include both sandy flats and claypans. Sandy flats support low shrublands of Sturts pigface (*Gunniopsis quadrifida*), Cottonbush (*Maireana aphylla*), Low Bluebush (*Maireana astrotricha*), Bladder Saltbush (*Atriplex vesicaria*), Emubushes (*Eremophila* sp.), Sennas (*Senna* sp.) and Neverfail (*Eragrostis setifolia*), with Mulga grass (*Aristida contorta*) dominant in the understorey. Some claypans support Swamp Canegrass (*Eragrostis australasica*), Old Man Saltbush (*Atriplex nummularia* ssp. *nummularia*), Cottonbush, Neverfail and Lignum (*Muehlenbeckia florulenta*). Blue rod (*Stemodia florulenta*) is common at claypan margins (Marla-Oodnadatta SCB 2002).

Larger watercourses are usually lined with Coolibah (*Eucalyptus intertexta*), with Sandhill Wattle, Old Man Saltbush, Cottonbush, Sennas, Samphire (*Halosarcia* sp.), Neverfail, Cupgrasses (*Eriochloa* sp.), Silky Browntop (*Eulalia aurea*) and Swamp Canegrass all present in the understorey (Marla-Oodnadatta SCB 2002).

GAB springs support their characteristic vegetation including Common Reed (*Phragmites australis*), Bore-drain Sedge (*Cyperus laevigatus*), Cutting Grass (*Ghania trifida*), Bare Twig Rush (*Baumea juncea*), Sea Rush (*Juncus kraussii*) and Salt Couch (*Sporobolus virginicus*) (Marla-Oodnadatta SCB 2002).

Two proclaimed (weed) plant species have been recorded on DEH databases as occurring in the region: African Boxthorn (*Lycium ferocissimum* – PEL121) and Caltrop (*Tribulus terrestris* – PEL122).

Significant Fauna

Six nationally threatened fauna species have been recorded in the extensive dunefields of this bioregion including Amperta (*Dasycercus cristicaudata hillieri*), Dusky Hopping-mouse (*Notomys fuscus*), Plains Rat (*Pseudomys australis*) and Thick-billed Grasswren (eastern) (*Amytornis textilis modestus*) (Neagle 2003). The latter two species have been recorded within the SAPEX PELs but are usually associated with Stony Plains habitats. The Amperta and Dusky Hopping-mouse occur in the

eastern part of the bioregion and have not been recorded (and are not likely to occur) in the SAPEX PELs.

Rare or threatened flora and fauna species that have been recorded in the SAPEX PELs are listed in Appendix 2.

4.2.3 Great Victoria Desert

The Great Victoria Desert bioregion covers an area of 423,751km² and extends across South Australia and Western Australia. The SAPEX PELs occur at the eastern edge of this bioregion. Approximately 14% of the area of the SAPEX PELs falls within this bioregion.

The Great Victoria Desert is comprised of an old erosional surface on a variety of mostly Archaean rocks, veneered with aeolian sand. It rises from an elevation of about 200 metres above sea level in the south to 700 metres in the north and is characterised by longitudinal dunes that average about 20 m in height and over 100 m in length (CFW 2007).

The land systems present in the area of the Great Victoria Desert bioregion covered by the SAPEX PELs are Mt Willoughby and Tallaringa. A full description of each of these land systems in provided in Appendix 1.

Geology, Soils & Landform

The Great Victoria Desert is characterised by an arid active sand-ridge desert of deep Quaternary aeolian sands overlying Permian and Mesozoic strata of the Officer Basin (DEWR 2007).

The main types of land forms encountered in the region, which occur in both the land systems, are:

- dunefields and sand plains
- drainage lines and floodplains (which are relatively limited in extent).

The Tallaringa land system is comprised of parallel east-west dunes overlying an extensive laterite flat plain with some relief provided by relict ironstone outcrops. The dunes are comprised of red siliceous sands and the plains and silcrete rises are comprised of stony siliceous sands (Kingoonya SCB 1996).

The Mount Willoughby land system is characterised by red pebbly clay plains with occasional low irregular sand dunes. The hard flats contain numerous small swamps or depressions. The drainage systems of the dunes and interdune flats feed into larger swamps such as Wintinna Swamp (Kingoonya SCB 1996).

Flora

The flats and the sandy soils of the dunes and swales are dominated by Mulga (*Acacia aneura* var. *aneura*) Woodland, with Narrow-leaved Hopbush (*Dodonaea viscosa* ssp. *angustissima*) and Emu-bushes (*Eremophila* spp.) and an understorey of Bandicoot Grass (*Monachather paradoxa*) and Kerosene or Mulga grasses (*Aristida* spp.). Neverfail (*Eragrostis setifolia*) and Mulga Grass (*Aristida contorta*) dominant in the understorey of the interdune areas and Woollybutt (*Eragrostis eriopoda*), Woollybutt Wanderrie (*Eriachne helmsii*) and Tall Kerosene Grass (*Aristida holathera*) form the main ground cover on dunes (Marla-Oodnadatta SCB 2002).

The hard flats support sparse to open Mulga, with Rock Emu-bush (*Eremophila freelingii*) also common. The sparser areas support the occasional Tar Bush (*E. neglecta*). These flats contain numerous small swamps or depressions which support dense Mulga Woodland, with Emu-bushes, Sennas (*Senna* spp.), chenopod shrubs and subshrubs. Perennial grasses such as Needle-leaved Threeawn (*Aristida capillifolia*), Cotton Grass (*Digitaria brownie*) and Neverfail and annual grasses such as Mulga Grass and Spear Grass (*Austrostipa* spp.) are also common. After rains the harder flats grow an abundance of Mulga Grass and annuals such as Round-leaf Parakeelya (*Calandrinia remota*) and various everlastings (Marla-Oodnadatta SCB 2002).

Stony siliceous sands of silcrete/calcrete rises and plains are dominated by shrublands of Green Turkey-bush (*Eremophila gilesii*), Crimson Emu-bush (*E. latrobei* ssp. *glabra*) and Green Emu-bush

(*E. serrulata*) with an understorey including Woollybutt Wanderrie, Lovegrasses (*Eragrostis* spp.) and Mulga Grass (Kingoonya SCB 1996).

Drainage systems are predominantly Mulga-lined and support an understorey of Cottonbush (*Maireana aphylla*), Neverfail and Swamp Canegrass (*Eragrostis australasica*) (Marla-Oodnadatta SCB 2002).

Two proclaimed (weed) plant species have been recorded on DEH databases as occurring in the region: African Boxthorn (*Lycium ferocissimum* – PEL121), Caltrop (*Tribulus terrestris* – PEL118). Buffel Grass (Cenchrus ciliaris) is also prevalent along the Stuart Highway (DTEI 2007).

Significant Fauna

The South Australian portion of the Great Victoria Desert bioregion supports a number of endemic species including the dragon *Diporiphora linga* which is endemic to the eastern portion of the bioregion (Morton *et al.* 1995). The Malleefowl (*Leipoa ocellata*) is sparsely distributed throughout the South Australian portion of the bioregion and the bioregion is also considered to be the centre of distribution of the Scarlet-chested Parrot (*Neophema splendida*) (Morton *et al.* 1995). None of these species have been recorded within the SAPEX PELs on DEH databases and are more likely to occur further to the south, however it is noted that limited systematic biological survey work has been completed in this area.

The bioregion supports several reptile species with limited distributions, including the skinks *Lerista elongata* and *L. puncticauda* which occur only in the bioregion and Fraser's Snake Lizard *Delma fraseri*, the eastern population of which be considered restricted (Morton *et al.* 1995).

Rare or threatened flora and fauna species that have been recorded in the SAPEX PELs are listed in Appendix 2.

4.2.4 Gawler

The Gawler bioregion covers an area of 60,308km² in South Australia. The SAPEX PELs (PEL119 and 124) intersect this bioregion at its north-western extent and it lies predominantly south of the PELs. Approximately 14% of the area of the SAPEX Arckaringa Basin PELs occurs within this bioregion.

The Gawler bioregion is characterised by several semi-arid to arid landscapes. In the south of the region (to the south of the SAPEX PELs) there are gently undulating calcrete plains with occasional quartzite or granite hills, a zone of saltlakes and gypsum dunes and the Middleback Ranges. These grade into the Gawler Ranges. At their northern margin is an undulating upland plain with shallow loamy soils underlain by quartzite and sandstone that includes the saltlakes of Lake Torrens, Lake Gairder and Everard (Neagle 2003). Undulating calcareous plains extend across the north of the region, becoming sandier with occasional dunes in the north west (Neagle 2003).

The land systems present in the Gawler bioregion covered by the SAPEX PELs include: Carringallana, Christie, Commonwealth, Dingo, Gina, Glendambo, Indooroopilly, Labyrinth, Mailgate and Phillipson. A full description of each of these land systems in provided in Appendix 1.

Geology, Soils & Landform

The Gawler bioregion is generally described a being comprised of flat-topped to broadly rounded hills of the Gawler Range Volcanics and Proterozoic sediments and depositional plains with salt-encrusted lake beds, with shallow loams, calcareous earths and hard red duplex soils (DEWR 2007).

The bioregion covers an area comprised of a wide variety of rocks with different ages and characteristics. The topography is mainly subdued, there being only a limited number of prominent hills and low ranges. This reflects the dominance of relatively young, flat-lying sediments which have not been subjected to major earth movements or uplift (Kingoonya SCB 2002).

The Christie land system is widespread across the region (including the portion within the SAPEX PELs) and offers some relief from the plains. This system is comprised of ancient silcrete rises that have been formed from granitic and gneissic rocks as well as quartz bedrock and silcrete. The silcrete is often present on hilltops (Kingoonya SCB 2002).

The land systems present in the SAPEX PELs occur in a complex mosaic. The main types of land forms encountered in the region include:

- Stony hills
- Dunefields and sand plains
- Drainage lines and flood plains
- Salt lakes.

Stony hills occur in the Christie land system which is an ancient system formed from granitic and gneissic rocks as well as quartz bedrock with silcrete often present on hilltops. Low stony silcrete rises occur in the Mailgate land system.

Dunefields and sand plains are reasonably widespread throughout this part of the bioregion and include the Indooroopilly, Labyrinth, Mailgate, Phillipson dunefield land systems and the Caringallana, Commonwealth, Gina and Glendambo sand plain land systems. Sand plains typically have siliceous sands, sandy red earths or calcareous sandy loams while dune sands are siliceous or calcareous, with gypsiferous dunes bordering salt lakes (e.g. in the Labyrinth and Phillipson land systems.

Drainage lines and floodplains are relatively limited in extent in the areas intersected by the SAPEX PELs, but occur in some land systems such as Caringallana, Commonwealth and Christie. The Dingo land system is a drainage area on alluvial sands and silts around low hills and rises where well-defined watercourses are generally lacking and those that are present do not always go far enough to flow into swamps.

Salt lakes occur predominantly in the Labyrinth and Phillipson land systems. Larger lakes and claypans are either at the end of drainage lines from the Stuart Range, or are a linear series of depressions in ancient river channels that are remnants of a much wetter period than the present.

Flora

The sand plains with occasional dunes in the north-west of this bioregion support Mulga (*Acacia aneura*) Low Open Woodlands and possibly Horse Mulga (*A. ramulosa*) Low Open Woodlands. The swales support a Mulga Low Woodland with Black Oak (*Casuarina pauper*), Bullock Bush (*Alectryon oleifolius*) and Tar Bush (*Eremophila* spp.) and an understorey dominated by grasses with Woolybutt (*Eragrostis eriopoda*), Bandicoot Grass (*Monachather paradoxa*) and Mulga Grass (*Aristida contorta*) being the most common species (Marla-Oodnadatta SCB 2002).

The saline siliceous and gypsiferous sands of dunes or the sand-covered limestone shelves fringing lakes are dominated by Black Oak and Mulga and Horse Mulga woodlands, with Narrow-leaved Hopbush (*Dodonaea viscosa* ssp. *angustissima*) and Boree Tea-tree (*Melaleuca pauperiflora*) are also common. The understorey is often of Bladder Saltbush (*Atriplex vesicaria*) and Kerosene (*Aristida contorta*) or Mulga Grass. Tea-tree (*Melaleuca* spp.), with a common understorey of Neverfail (*Eragrostis setifolia*) often occur on flood-prone swales. Coolabah (*Eucalyptus coolabah* ssp. *coolabah*) woodland occurs in northern parts of the Bioregion on the Ingomar and Mount Penrhyn pastoral leases (Kingoonya SCB 2002).

The calcareous plains north of Lake Gairdner are dominated by Western Myall (*A. papyrocarpa*) Low Open Woodlands and Bluebush (*Maireana sedifolia*), Bladder Saltbush Low Open Shrublands (Kingoonya SCB 2002).

The undulating tablelands west of Lake Eyre support Bladder Saltbush and Low Bluebush (*Maireana astrotricha*) Low Open Shrublands in a mosaic with variable ephemeral communities of Bindyi (*Sclerolaena* spp.) or Love-grass (*Eragrostis* spp.) Low Open Shrublands/Open Tussock Grasslands (Brandle 1998 as cited in Neagle 2003).

Vegetation on low stony rises and slopes is dominated by either Mulga scrub or Bladder Saltbush-Low Bluebush (*Maireana astrotricha*) Low Shrubland, depending on the underlying soils. Shallow stony sandy soils of silcrete rises support Mulga Woodlands with Emu-bushes (*Eremophila* spp) and Cassias (*Senna* spp.), while chenopod shrubs dominate where the sand is deeper or where calcrete or lime are present (Kingoonya SCB 2002).

Chenopod low shrublands dominate the saline alluvial sands and clays at the margins of claypans and salt lakes. These shrublands commonly include Cottonbush (*M. aphylla*), Black Bluebush (*Maireana pyramidata*), Bladder Saltbush, Lignum (*Muehlenbeckia florulenta*), Nitre Goosefoot (*Chenopodium nitrariaceum*) and Swamp Canegrass (*Eragrostis australasica*), with an ephemeral herb understorey Kingoonya SCB 2002). Salt tolerant species such as Samphires (*Halosarcia* spp.) and Glassworts (*Sclerostegia* spp.) are also common and often with an understorey of Mulka Grass (*Eragrostis dielsii* var. *dielsii*) (Marla-Oodnadatta SCB 2002).

Drainage areas around low hills and rises are often dominated by chenopod Low Shrublands. Sugarwood (*Myoporum platycarpum*) Open Woodland occurs on the alluvial sands of some watercourses, often in association with Cassias (*Senna spp*.) and Australian boxthorn (*Lycium australe*), with Satiny Bluebush (*Maireana georgei*), Bindyis and Mulga Grass in the understorey. Other watercourses with firmer alluvial sandy soils are dominated by Mulga Woodland, Tall Shrublands of Cassias and Dead Finish (*Acacia tetragonophylla*) and an understorey of Bindyis. The firm alluvial sands of flood plains often support Mulga Woodlands with chenopod Low Shrubland understorey featuring Bladder Saltbush, Cottonbush and Bindyis.

The well-defined watercourses to the west of the Stuart Range on Ingomar Station are generally tree-lined, with Coolabah, Boree Tea-tree, Umbrella bush (*Acacia ligulata*), Dead Finish and Narrow-leaved Hopbush common in the overstorey, and Sturt's Pigface (*Gunniopsis quadrifida*), Cottonbush and Goathead burr (*Sclerolaena bicornis*) dominating the understorey.

One proclaimed (weed) plant species has been recorded on DEH databases as occurring in the region: Caltrop (*Tribulus terrestris* – PEL124). Buffel Grass (Cenchrus ciliaris) is also prevalent along the Stuart Highway (DTEI 2007).

Significant Fauna

The Gawler bioregion provides a habitat for two endemic fauna species, the Pernatty Knob-tailed Gecko (*Nephrurus deleani*) (which is restricted to an area that lies outside the SAPEX PELs) and the Thick-billed Grasswren (*Amytornis textillis modestus*). Fourteen nationally threatened fauna species have also been recorded in the bioregion including the Slender-billed Thornbill (*Acanthiza iredalei iredalei*) and Malleefowl (*Leipoa ocellata*) (Neagle 2003).

Rare or threatened flora and fauna species that have been recorded in the SAPEX PELs are listed in Appendix 2.

4.3 Water Resources

Surface water features in the region include rivers, creeks, associated flood plains, salt lakes, internally draining dunefield clay pans and Great Artesian Basin (GAB) springs. The majority of the major rivers in the north of the region drain into Lake Eyre, while rivers and creeks in the southern portion terminate in salt lakes or clay pans.

Surface water in the region is generally ephemeral and is only present following localised rainfall. Several of the rivers and creeks in the region, including the Neales River, Arckaringa Creek, Peake Creek and Margaret Creek, contain semi-permanent and permanent waterholes (DEH 2005). Water in these waterholes may persist for six months or more, some lasting over 12 months (Marla-Oodnadatta SCB 2002).

Permanent surface water can be found at points where artesian water flows to the surface, such as pastoral bores or the GAB springs.

4.3.1 GAB Springs

The most north-easterly portion of the area of the PELs overlies the western edge of the Great Artesian Basin (GAB) and is within the South Australian groundwater provinces of the Lake Eyre Basin and the Eromanga Basin (DWLBC 2006). The GAB aquifer outcrops at the surface to the west of Coober Pedy and deepens in a north-easterly direction to around 250m at Lake Eyre (Marla-Oodnadatta SCB 2002). Vertical leakage from the GAB occurs via a series of springs (known as GAB springs or mound springs) which appear around the southern and south-western margins of the basin (Armstrong 1990).

The salinity and mineral content of the GAB aquifer increases to the south-west with increasing distance from discharge areas as the water dissolves salts from the aquifer material. However salinity is generally low and is suitable for stock water with the exception of the area south of Coober Pedy (Marla-Oodnadatta SCB 2002).

GAB springs have been described as “oases in the desert” and are foci for plant, animal and human life. They have very high biological and cultural significance (Boyd 1990). They support unique flora and fauna, some of which is endemic to the springs and is considered threatened on a national level. As indicated in Section **Error! Reference source not found.**, the ecological community associated with GAB springs is protected under the *Environment Protection and Biodiversity Conservation Act 1999.* Many of the springs are significant Aboriginal places with abundant archaeological material (Boyd 1990).

GAB spring structure is highly variable, but typically includes a vent where it emerges from the ground, a tail which flows from the vent and terminates in the wetland around the base of the spring (if the flow is great enough) and saline spring margins surrounding the spring (DEH 2005). Mounds can develop at the spring vent by the deposition of carbonate or trapping of windblown material by spring vegetation (Marree SCB 1997).

There are a number of GAB springs present in the eastern portion of PEL121, PEL 123 and PEL124, many of which have been identified as features of high biological and cultural significance.

4.4 Heritage

A search of the National and State heritage registers has indicated that a number of heritage sites occur within the SAPEX PELs. A summary of these sites is provided in Table 3. Further information on these sites is provided in the sections following the table.

Table 3: Registered heritage sites in the Arckaringa Basin region

Register Source	Site Type	Name	Location
Register of the National Estate (RNE)	Indigenous	The Breakaways Reserve	PEL118, PEL122
RNE	Indigenous	Lake Philipson Area	PEL119
RNE	Indigenous	Ngampayiwalhuku	PEL121
RNE	Historic	Stony Creek Rail Bridge	5.5km SSE of Oodnadatta PEL117
RNE, State Heritage Register (SHR)	Historic	Oodnadatta Museum (formerly Railway Station & Station Masters Residence)	Oodnadatta township PEL117
RNE, SHR	Historic	Strangways Springs Site	PEL123
RNE, SHR	Historic	The Peake Ruins	PEL121
RNE, SHR	Historic	Underground Houses & Church (Coober Pedy Catholic Church)	Coober Pedy township PEL118, PEL119

Register Source	Site Type	Name	Location
SHR	Historic	Three-roomed dugout (Henryk's Old Dugout)	Coober Pedy township PEL118, PEL119
SHR	Historic	Marree to Alice Springs Railway	Extends from Marree to Oodnadatta PEL117, PEL121, PEL122, PEL123
RNE	Natural	*Swainsona minutiflora*-Coorikanna Site	PEL117
RNE	Natural	Big Cadna-owie Spring	PEL121
RNE	Natural	Moon Plains	PEL118, PEL122, PEL123
RNE	Natural	*Hemichroa mesembryanthena* Site	PEL123
RNE	Natural	Billa Kalina Spring	PEL123
RNE SHR	Natural	Arckaringa Hills State Heritage Area	PEL117, EL325
Dept of Transport, Energy and Infrastructure Roadside Significant Site Database (RSSD)	Rare Flora	*Embadium johnstonii*	Oodnadatta – Coober Pedy Road PEL117
DTEI RSSD	Rare Flora	*Embadium johnstonii*	Cadney Park – Oodnadatta Road PEL117
DTEI RSSD	Indigenous Heritage	Stone working sites	Coober Pedy – William Creek Road PEL123
DTEI RSSD	Indigenous Heritage	Artefact scatter	Coober Pedy – William Creek Road PEL123

4.4.1 Indigenous Heritage

There are a number of indigenous heritage sites located throughout the Arckaringa Basin. Many of these sites are of cultural significance and reflect Aboriginal occupation of the region. The more prominent sites include The Breakaways formation to the north of Coober Pedy and the Lake Phillipson area to the south-west of Coober Pedy. Many of the GAB Springs in the region are also an important component of Aboriginal culture. Much of the history of Aboriginal occupation of the land is also evident throughout the landscape in the form of middens, quarries, worksites, campsites and burial sites.

The Mount Willoughby Indigenous Protected Area (discussed in Section 4.5.3), falls within the SAPEX PELs and has a number of identified sites of importance to Aboriginal cultural heritage which are being recorded and preserved. The Pitjantjatjara and Maralinga Tjarutja Aboriginal Lands are located along the western and south-western edges of the region, outside the PELs.

4.4.2 Historical Heritage

Non-indigenous heritage in the region dates back to early exploration of the region in the mid to late 1800's and the expansion of pastoralism. The GAB springs along the south-west margin of the Great Artesian Basin were influential in this expansion, particularly in providing access to permanent water. The overland telegraph line and the Marree to Alice Springs railway line also passed through region of the GAB springs. Other heritage sites in the region are associated with early mineral exploration and the discovery of opal in Coober Pedy in the Stuart Ranges in 1915.

Many of the historical heritage sites in the region are associated with the exploration and development of the region by Europeans in the past 160 years. Prominent historical heritage includes the 'Old Ghan' or Marree to Alice Springs Railway and associated settlements, settlements associated with the Overland Telegraph Line (e.g. Strangways Spring site, The Peake Group), and settlements associated with early pastoral expansion and mining developments (e.g. housing in Coober Pedy, The Peake Group).

4.4.3 Natural Heritage

Natural heritage sites in the region identified in Table 3 include the geologically significant Arckaringa Hills (130 km north of Coober Pedy), the Moon Plains (10 km north-east of Coober Pedy) which supports a high diversity of rare species, a number of GAB Spring complexes along the western edge of the Great Artesian Basin (e.g. Big Cadna-owie Spring and Billa Kalina Spring) which provide important habitat for a number of indigenous plant and animal species, and sites providing habitat for listed rare flora (e.g. *Swainsona minutiflora, Hemichroa mesembryanthena* sites).

4.5 Land Use

The current land uses in the project area include pastoralism, mining, conservation, tourism and defence.

4.5.1 Pastoralism

The main land use in the Arckaringa Basin is pastoralism with sheep and cattle grazing having been carried out over the past century. Cattle are grazed throughout the north of the region on large pastoral leases, while sheep are restricted to leases south of the Dog Fence, which crosses the SAPEX PELs north and east of Coober Pedy. A limited number of properties are certified for organic production.

Pastoral leases in the PELs include:

- Lambina
- Welbourn Hill
- Todmorden
- Wintinna
- Evelyn Downs
- Arckaringa (including Coorikiana)
- Allandale (including Toondina, Toondina East)
- Mount Willoughby
- Mount Barry
- Nilpinna
- Anna Creek (including The Peak)
- Mabel Creek
- Mount Clarence
- Commonwealth Hill (including Mobella, Pt Commonwealth Hill, Pt McDouall Creek, Pt Mulgathing, Pt Woorong Downs)
- Bulgunnia
- Ingomar (including Lake Wirrida)
- Mount Penrhyn
- McDouall Peak (including Belta Beltana South)
- Billa Kalina
- Millers Creek
- Stuarts Creek
- Mt Eba
- Bon Bon
- Wilgena (including North Well).

4.5.2 Mining

Currently the most significant mining activities in the Arckaringa Basin are opal mining at Coober Pedy and the Prominent Hill mining operation, which has recently been established 130 km south east of Coober Pedy.

Petroleum and mineral exploration also occurs across the region. Of particular note is the Arckaringa Coal Project (operated by Altona Resources) which has commenced an exploration program north of Coober Pedy in the Arckaringa Basin. This project aims to develop Arckaringa Basin coal resources to provide suitable coal feed stock for the gasification and subsequent production of synthetic fuels.

4.5.3 Conservation

The region has two areas formally designated for conservation:

- Tallaringa Conservation Park
- Mount Willoughby Indigenous Protected Area.

Tallaringa Conservation Park is 1,246,000 ha in area. It was proclaimed under the South Australian *National Parks and Wildlife Act 1972* in 1991 and is managed by the Department for Environment and Heritage. It is located 100 km due west of Coober Pedy, on the fringe of the Great Victoria Desert, and contains a vast wilderness of vegetated dunes and gibber rises (DEH 2007). The park supports a variety of important species that have adapted to live in the dry arid area, including a Mulga woodland, found to be different from others already conserved because of the absence of Porcupine Grass (*Triodia*) from the understorey. This was a major consideration when this area was recommended for conservation (SATC 2007). Mining and petroleum exploration activities are permitted in this park.

The Mount Willoughby Indigenous Protected Area (IPA) was declared in 2002. It is 386,500 ha in area and is located approximately 30 km north of Coober Pedy (DEWR 2007a). It shares a boundary with Tallaringa Conservation Park to the west. The area was developed for the protection of cultural and biodiversity values. The lease was purchased on behalf of Tjyrilia Aboriginal Corporation by the Indigenous Land Corporation in 1996. Management activities have included fencing off areas of high cultural significance from the rest of the property to limit access and to ensure adequate protection. Since 1991 the number of cattle has been reduced in order to begin restoring land condition. The IPA has been divided into two zones for management purposes:

- Zone A (the East Side Paddock) which is managed under IUCN Category VI: Managed Resource Protected Area i.e. it is managed mainly for the sustainable use of natural ecosystems.
- Zone B (the West Side Paddock) which is managed under IUCN Category II for conservation, tourism and recreation.

The Indigenous Protected Areas (IPA) program is part of Australia's National Reserve System Program which aims to establish a network of protected areas which includes a representative sample of all types of ecosystems across the country. The National Reserve System Program is itself a part of the Australian Government's Natural Heritage Trust. With support from the IPA program, Indigenous landowners commit themselves to manage their lands for the protection of natural and cultural features in accordance with internationally recognised standards and guidelines.

SAPEX does not plan to undertake geophysical operations in Tallaringa Conservation Park or Mount Willoughby Indigenous Protected Area in the near future, however it is possible that they may occur in these areas at a later date. Any geophysical operations in these areas would be planned and conducted in consultation with the relevant landowner and would aim to avoid impacts on the areas' conservation or biodiversity values.

4.5.4 Tourism

Significant tourist attractions within the region include Coober Pedy and its opal mining, the Breakaways, the Painted Desert, GAB springs and historical infrastructure associated with the Old Ghan Railway and the Overland Telegraph Line. Nature tourism, bush walking, wildlife, 4WD experiences, camping and indigenous tourism all occur throughout the region across all land tenures.

Tourism visitation in the region is largely restricted to townships, parks and the main network of sealed and unsealed roads connecting them including the Stuart Highway and the Oodnadatta Track.

4.5.5 Defence

The southern part of the area of the SAPEX PELs lies within the Woomera Prohibited Area. There is limited Defence activity across most of this area but entry to the Prohibited Area (except on main road corridors) requires permission from the Commonwealth Department of Defence, in accordance with Regulation 35 of the *Defence Force Regulations 1952*.

The Woomera Prohibited Area intersects PEL118, PEL119, PEL122, PEL123 and PEL124.

4.5.6 Native Title

There are three active native title claims across the PELs:

- SC97/9 – Yankunytjatjara/Antakirinja Native Title Claim
- SC95/7 – Antakirinja Matu-Yankunytjatjara
- SC98/2 – The Arabunna People's Native Title Claim.

The Yankunytjatjara/Antakirinja claim (with the exception of the Marla township) was settled by a consent determination in August 2006 and the Yankunytjatjara/Antakirinja are consequently native title holders in PEL117. The Arabunna People's claim intersects five out of the seven PELs, and the Antakirinja Matu-Yankunytjatjara claim intersects all seven PELs

Native title agreements between SAPEX and these three groups were signed off by the Minister in October 2006. All agreements are conjunctive and cover activities from exploration through to development and production. Under the requirements of these agreements, heritage clearances for any field work will be undertaken prior to the commencement of field activities.

4.6 Socio-Economic

4.6.1 Population Centres

The major town in the region is Coober Pedy, which is located approximately 800 km north-west of Adelaide, and has a population of approximately 3,100 people (ABS 2007).

Regional townships or population centres in the region include:

- Oodnadatta (within PEL117) – population 160
- Marla (50 km west of PEL117) – population 132
- William Creek (10km west of PEL123)
- Glendambo (65 km south of PEL124)
- Cadney Park Roadhouse (10km west of PEL117).

4.6.2 Infrastructure

There is extensive transport infrastructure present in the region including the Stuart Highway (part of the national highway network) and the Adelaide-Darwin Railway, both of which are primary transport routes between South Australia and the Northern Territory. There are also a number of unsealed public roads. Major roads within the SAPEX PELs include:

- Stuart Highway (sealed)
- Oodnadatta Track (Marla-Oodnadatta – unsealed)
- Painted Desert Road (Cadney Park-Oodnadatta - unsealed)
- The Kempe Road (Coober Pedy-Oodnadatta - unsealed)
- William Creek Road (Coober Pedy-William Creek - unsealed)
- Oodnadatta-Marree Track (unsealed).

The major roads in the region are multiple use roads. These roads carry a relatively high traffic volume that is predominantly a mix of heavy vehicles, light industrial/pastoral vehicles and tourist vehicles. Station access roads and internal tracks are generally restricted to pastoral use or occasional tourist traffic and carry a low of volume traffic.

The Dog Fence, constructed to allow sheep grazing in the southern portion of the state, crosses PEL 118, PEL 119, PEL 122 and PEL123.

5 Environmental Hazards & Consequences

This section of the EIR identifies and discusses potential environmental hazards and their consequences resulting from geophysical operations in the Arckaringa Basin. The subsequent sections of the EIR then outline the measures that will be implemented to manage the hazards (Section 6) and provide a risk assessment of drilling and well operations (Section 7).

5.1 Hazards

A hazard is defined as "a source of potential harm" (Australian/New Zealand Standard AS/NZS 4360:2004 *Risk management*).

The environmental hazards associated with seismic activities that have potential to result in the most prominent environmental consequences are identified as:

- earthworks associated with line and access track preparation and reparation
- vehicle movement
- seismic source activation
- uphole drilling
- spills or leaks associated with storage of oil, fuels and chemicals, refuelling operations and high pressure hydraulic systems
- disposal of domestic and chemical waste (Santos 2006).

Hazards from other geophysical operations can be viewed as a subset of these seismic activity hazards.

Key hazards are discussed in Section 5.3.

5.2 Consequences

A consequence is "an outcome or impact of an event" (AS/NZS 4360:2004 *Risk management*).

The key potential environmental consequences associated with the above hazards are:

- visual impact
- loss of native vegetation and habitat
- introduction and or spread of weeds, pest plants or animals
- soil compaction/disruption/deflation, wheel tracks, wheel ruts, bulldust generation
- generation of dust
- soil erosion and disturbance to natural drainage patterns
- contamination of soil, groundwater and/or water courses
- disturbance of Aboriginal, cultural or natural heritage sites
- disturbance, injury or death to native fauna
- disturbance, injury or death to livestock
- generation of noise
- damage to landholder infrastructure
- third-party access to seismic lines
- loss of organic beef certification.

The hazards and consequences of the various seismic activities are summarised in Table 4.

Table 4: Hazard and consequence classifications for seismic activities

Geophysical Operations	Hazard	Consequence
Line and access track preparation	Earthworks Vehicle movement Spills and leaks Excavations	Contamination of soil, surface water Loss of vegetation and habitat Soil erosion and disturbance of natural drainage patterns Soil compaction/disruption/deflation, wheel tracks Dust generation Soil inversion Impact and/or damage to cultural/heritage sites Disturbance to native fauna Disturbance to stock Introduction and spread of weeds Visual impact Damage to infrastructure Facilitation of third party access Loss of organic beef certification Noise generation
Line surveying	Vehicle movement Spills and leaks	Contamination of soil, surface water Disturbance to native fauna Disturbance to stock Spread of weeds Risk to third parties Soil disturbance/compaction, dust generation Visual impact
Recording	Vehicle movement Vibrator movement/ operations Spills and leaks	Contamination of soil, surface water Soil erosion/ disturbed drainage patterns Soil compaction/disruption/deflation, wheel tracks, dust Disturbance to native fauna Disturbance to stock Spread of weeds Impact and/or damage to cultural/heritage sites Visual impact Damage to infrastructure Noise generation Loss of organic beef certification Dust generation
Campsites and associated supplies	Vehicle movement Spills and leaks Disposal of domestic and chemical waste Fire	Contamination of soil, surface water and groundwater Soil inversion Loss of vegetation and habitat Soil compaction/disruption/deflation, wheel tracks Dust generation Soil erosion/ disturbed drainage patterns Visual impact Litter Risk to public health Fire damage to vegetation and habitat Noise generation Loss of organic beef certification

Geophysical Operations	Hazard	Consequence
Uphole drilling and logging	Vehicle movement Uphole drilling activity Spills and leaks Disposal of chemical waste	Contamination of soil, surface water and groundwater Soil compaction/disruption/deflation, wheel tracks Dust generation Soil inversion Loss of vegetation and habitat Disturbance to native fauna Disturbance to stock Introduction and spread of weeds Visual impact Damage to infrastructure Impact and/or damage to cultural/heritage sites Uncontrolled discharge or contamination of aquifers Noise generation
Line and access track and campsite restoration	Earthworks Vehicle movement Spills and leaks	Contamination of soil, surface water Soil inversion Disturbance to native fauna Disturbance to stock Introduction and spread of weeds Visual impact Damage to infrastructure Impact and/or damage to cultural/heritage sites Loss of organic beef certification Noise generation Dust generation
Monitoring of selected locations	Vehicle movement	Soil compaction/disruption/deflation, wheel tracks Dust generation Introduction and spread of weeds Impact and/or damage to cultural/heritage sites Damage to infrastructure

5.3 Discussion of Key Hazards

5.3.1 Earthworks for Line & Access Track Preparation

The type and severity of the potential impacts of preparation of access tracks and survey lines is dependent to a certain extent on the land system in which the activities are being carried out. Disturbance to soils (e.g. by grading) in some land systems, such as gibber plains and tablelands, can lead to substantial erosion by water (Fatchen & Woodburn 2000) while other systems, such as dune fields, are generally more resilient and less likely to suffer any long-term impacts from soil disturbance.

The potential impacts of specific earthwork activities on different land systems are summarised below and in Table 5.

Wetlands

Wetlands, including the GAB Springs, are highly sensitive environments that can easily be damaged as a result of vegetation clearing, alteration of drainage patterns, spills of oil, fuel or chemicals or fire. Wetlands are avoided under most circumstances as they are generally of high ecological value and sensitivity.

If sensitive environmental features such as wetlands or salt lakes cannot be avoided, they are usually traversed/surveyed without the use of heavy machinery.

Drainage Lines and Flood Plains

Drainage line and flood plains experience periodic natural disturbance and soil erosion as a result of rainfall and flood events. However the movement of soil, alteration of surface profiles or the removal of vegetation associated with drainage lines and flood areas can lead to the accelerated erosion of soil or the alteration of surface flows.

Moon Plains

The light gypsiferous and saline soils of the Moon Plain are highly prone to rutting as a result of vehicle movement. This is turn can lead to soil erosion as the underlying soils are compacted or exposed to wind and water.

Breakaways and Stony Hills

The steeper slopes and escarpments of these landforms can be unstable and have high erosion potential when disturbed. Heavy vehicle trafficking and ground disturbing activity is avoided on such slopes.

Stony Plains

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

Dunefields and Sandy Plains

Dunefields are generally resilient and less likely to suffer long term impacts from soil disturbance. Removal of vegetative cover has the potential lead to blowouts and deflation, however a study of seismic lines in the Cooper Basin concluded that natural rates of erosion on dunes were not accelerated as a result of disturbance to the soil surface (Santos 2003).

Salt Lakes

Salt lakes are often comprised of a thin salty crust overlying a wet clay. As a result trafficking salt lakes is difficult and can result in deep and persistent rutting.

Salt lakes are avoided under most circumstances as they very difficult to rehabilitate once disturbed and are therefore likely to be scarred by any activity on their surface.

Table 5: Impacts associated with line/access track preparation in various land systems

Land System	Preparation of survey lines/access tracks
Wetlands (including GAB springs)	Not applicable (line preparation in wetlands is avoided due to environmental sensitivity)
Drainage Lines & Floodplains	▪ Vegetation clearance ▪ Soil erosion (wind and water) ▪ Soil compaction ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites (generally low density of sites in floodplains)
Moon Plains	▪ Vegetation clearance ▪ Soil erosion (wind and water) ▪ Soil compaction ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites
Breakaways & Stony Hills	Note: Not applicable for steeper slopes (grading should not occur) ▪ Vegetation clearance ▪ Soil erosion (wind and water) ▪ Soil compaction ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites
Stony Plains	Note: Not applicable for steeper slopes on tablelands or on gibber plains (grading should not occur on these terrain types) ▪ Vegetation clearance ▪ Soil erosion (particularly susceptible to water erosion eg. severe gullying) ▪ Disturbance of natural drainage systems (e.g. siltation) ▪ Inversion of the soil profile ▪ Disturbance to cultural heritage sites
Dunefields & Sandy Plains	▪ Vegetation clearance ▪ Soil erosion (wind and water erosion) ▪ Disturbance to cultural heritage sites (dune fields near waterholes are typically of high cultural significance)
Salt lakes	Not applicable (line preparation should not occur on salt lakes)

5.3.2 Vegetation Clearance

The clearance of vegetation during line and access track preparation cannot be entirely avoided. Vegetation clearance can result in loss of vegetation and fauna habitat, siltation of natural drainage lines and watercourses, destabilisation of creek crossings or watercourses, weed invasion and damage to heritage sites. Vegetation clearance may also impede the movement of fauna, particularly small mammals or reptiles across cleared areas. However, this is considered unlikely in most land systems in the region due to the presence of naturally bare or unsheltered locations (Moss and Low 1996).

During the preparation of survey lines and access tracks, particular care will be taken to minimise the clearance of vegetation in heavily wooded areas (e.g. River Red gum or Coolibah woodlands associated with drainage lines).

The significance of vegetation clearance for seismic lines needs to be considered in the context of the temporary nature of the impact, the small proportion of the land surface affected and other ongoing

activities (e.g. grazing) that are affecting the local environment. With appropriate planning and management measures (as outlined in Section 6) the impact is generally not significant.

5.3.3 Campsites

Campsites have the potential to result in the disturbance or clearance of vegetation to accommodate buildings and laydown areas. Vehicle traffic can cause soil compaction and damage to vegetation. Where practical, campsites will be located in naturally clear areas to reduce potential hazards. Vehicle access will be confined to defined routes to restrict wheel track impact.

Campsites require the provision of systems for the management of sewage wastes, which must be managed in accordance with the *Public and Environmental Health (Waste Control) Regulations 1995*. Approved environmental treatment units may be utilised where practical and appropriate. Following treatment via an approved system, waste water may be disposed of on-site (onto land, well away from any place from which it is reasonably likely to enter any waters, and well away from infrastructure) when in remote areas. The method of disposal for wastewater must comply with the *Standard for the Construction, Installation and Operation of Septic Tank Systems in SA*, or be to the satisfaction of the Department of Health.

A variety of chemicals and wastes are also stored at campsites which have the potential to result in soil or water contamination in the event of a spill.

The storage of domestic waste, including food scraps also has the potential to attract scavenging animals (e.g. crows, black kites and dingoes) and lead to issues such as the spread of rubbish or fauna injury.

With appropriate management (see Section 6), significant impacts from these activities can be avoided.

6 Environmental Risk Management

This chapter describes the accepted best practice measures that will be undertaken to minimise environmental risks.

6.1 Movement Through Terrain

6.1.1 Sensitive Areas

The following sensitive land systems or areas will, where possible, be avoided by seismic activities:

- GAB (mound) springs
- Mesa/breakaway slopes and hilltops.

In the event that seismic activities need to be undertaken in these areas, the following actions will be undertaken prior to the commencement of activities:

- Specific consultation with appropriate authorities on best practice measures
- Development of specific management procedures (e.g. avoidance of use of heavy machinery)
- Education of seismic personnel on the management procedures.

6.1.2 Wheel Tracks

To avoid the creation of excessive wheel tracks:

- Where possible, existing tracks, roads or seismic lines will be used for access.
- Off line driving for the main crew is banned. No 'bush bashing' or short cuts are permitted.
- Campsites will be positioned close to existing roads where possible.

6.1.3 Wheel Ruts

To minimise the creation of excessive wheel tracks:

- Operations will be shut down during wet weather or flooding and only restarted once potential for extensive damage has passed. Unavoidable damage will be reported and reinstated on completion of work.
- Traversing soft friable soils such as gypsiferous clays and soft gibber will be minimised.
- No vehicles will be allowed on salt lakes other than specialised low-pressure wide profile tyre vehicles.

6.1.4 Compaction

To minimise compaction:

- The following of previous off-line wheel tracks is banned.
- Unavoidable compaction will be reported and, in areas without a stony mantle (e.g. gibber), ripped on completion of work.
- A minimal number of campsites as possible will be used — the aim will be to share existing sites if possible.
- With the exception of locations with a stony mantle (e.g. gibber), camp sites will be ripped if necessary on completion of work.

6.1.5 Erosion

To minimise compaction:

- Blade work is banned on gibber, tablelands, claypans or flat easy terrain.
- Minimal blade work is permitted elsewhere e.g. sand dunes and crabhole floodplains.
- All windrows will be removed either during or on completion of work.
- Dune side cuts will be minimised.
- Removed sand will be ramped to the side of dune cuts, as opposed to the base of the dune.
- Creek bank vegetation will be left intact and detours sought if too dense to pass through.

6.1.6 Air Quality (Bulldust)

To minimise the generation of bulldust:

- Susceptible tracks or soils will be avoided where possible. If not possible then the track will be reinstated after rain.

6.1.7 Visual Amenity

To minimise the visual impact of seismic operations:

- Lines will be prepared to a single blade width (approximately 4–5 m only).
- Lines will be smoothly weaved at least every 75–100 m about the general line of traverse and stands of vegetation.
- Lines will be doglegged at road and track crossings, preferably around vegetation.
- Dozers will be walked with blade up wherever possible.
- Cuts will be minimised at dune crests and base of dunes.
- Dune side cuts will be minimised.
- No cutting will be done on dunes adjacent to public roads.

6.1.8 Natural Drainage

To minimise the disturbance of surface waters and natural drainage:

- Creek bank vegetation will be left intact and detours sought if too dense to pass through.
- Creek crossings will be boxed and filled to original bed level when hard fill required.
- Any windrows or other disturbance to drainage patterns will be removed from creek bed crossings and swales.
- Camps will not be established near major watercourses, creeks or surface water bodies.
- No campsite will be located within 1 km of any stock watering place.
- All windrows will be removed either during or on completion of work.
- No blading will be undertaken in gibber.

6.2 Native vegetation

To minimise disturbance of vegetation:

- Off line driving is banned. No bush bashing or short cuts are permitted.
- Vegetation will only be removed when absolutely necessary and will be minimised/avoided by weaving lines through vegetated areas.
- Significant plant species will be prioritised for avoidance (see Appendix 3 and SEO)
- Root stock, topsoil and seeds will be left on line during line preparation.
- Creek bank vegetation will be left intact and detours located if dense.
- All vehicles will be thoroughly cleaned prior to commencing work in the basin to prevent the introduction of weeds into the survey area.

6.3 Fauna / Habitat

To minimise impacts on native fauna and stock:

- Upholes will be capped and backfilled to prevent injury to or death of wildlife and stock.
- No heavy line preparation machinery will be used in wetlands areas.
- Creek bank vegetation will be left intact and detours located if dense.
- All vehicles will be thoroughly cleaned prior to commencing work in the basin to prevent the introduction of weeds into the survey area.

6.4 Pest Plants and Animals

To prevent the spread of pest plants and animals:

- All vehicles will be thoroughly cleaned prior to commencing work in the basin to prevent the introduction of weeds into the survey area.
- Where relevant, weed management strategies will be developed to ensure that vehicles and equipment are washed down if moving to and from areas of known weed infestations.

- Weed control measures will be implemented as required following consultation with relevant authorities.
- All domestic wastes, including food scraps, will be managed to prevent the encouragement of pest animals.

6.5 Pollution

To avoid the pollution of soil or water:

- All operational equipment will be inspected and maintained in accordance with industry-accepted standards and product operational requirements.
- Fuel and oil spills will be reported, chemically treated or bio-remediated and the ground ripped.
- Domestic wastes (e.g. food waste, paper) and rubbish (including plastics, cans, glass, etc) will be securely stored on site prior to transportation to a licensed waste disposal facility
- Campsite wastewater will be disposed of in accordance with the *Public and Environmental Health (Waste Control) Regulations 1995*. The waste water disposal system will either comply with the *Standard for the Construction, Installation and Operation of Septic Tank Systems in South Australia* or be operated to the satisfaction of the Department of Health. All waste disposal systems shall be approved by the Department of Health.
- Approved mobile chemical toilets or biocycle pits may be used at camps.
- Markers and litter will not be left in work area after completion.
- Drill cuttings will be returned to hole or removed for dump disposal.
- Vehicles will travel at slow speed in the vicinity of dwellings.

6.6 Landholder/Third Party Infrastructure

To minimise impacts on landholders, third parties and infrastructure:

- Landholders will be consulted prior to the survey and formally notified in accordance with Petroleum Act requirements
- Lines will be planned prior to the survey or deviated in the field to avoid homesteads, associated buildings, stockyards, airstrips, dams, bores and tanks.
- Gates will be left as found.
- Fences will not be laid down unless specific permission has been obtained from the landholder.
- Water will only be sourced from authorised sources.
- No camp will be set up within 1 km of a stock watering point.
- Work will be scheduled to fit in with stock locations and mustering schedules.
- Waste management policies will be enforced.
- Infrastructure such as pipelines, powerlines and roads, etc shall only be crossed in accordance with the appropriate standards and with the permission of the owner.
- Signage and safety precautions will be implemented if survey activities are concentrated on public roads

To minimise the impact on petroleum or mining infrastructure:

- Below ground pipelines will only crossed at existing or authorised crossing points.
- Above ground pipelines will be detoured around rather than ramped.
- No seismic energy source will be used within 30 m of pipelines or wellheads.
- Lines will be deviated to miss wellheads by at least 30 m.
- Other production plant will be avoided and proposed activities discussed with the plant operator.

6.7 Third Party Access

To minimise third part access to seismic activities:

- No line preparation will be carried out on dunes adjacent to public roads.
- Lines will be doglegged at road and track crossings preferably using existing vegetation as a screen.
- Windrows/shoulders on public tracks will be reinstated on completion of work.
- Lines adjacent to public roads may also be blocked with timber as an access deterrent.

6.8 Heritage

To minimise impacts to Indigenous Heritage:

- Lines will be cleared by appropriate cultural heritage personnel prior to commencement of line preparation.
- Sites of cultural significance will flagged and lines deviated around them.
- Receiver lines may be laid out only by foot through some sites and all vehicles excluded, if agreed during heritage clearance.
- All line preparation personnel and crew supervisors will receive cultural heritage training prior to commencing work.

To minimise impacts to Non-Indigenous and Natural Heritage:

- Sites of non-indigenous or natural significance will identified prior to the survey to allow them to be deviated around during the survey.
- Sites and areas of heritage significance will be completely avoided where possible (however it is noted that some heritage areas are large (e.g. Moon Plains RNE area) and may overlap survey locations).
- In the event that traversing a non-indigenous or natural heritage site or area is required, permission to do so will be obtained from the relevant authority prior to the commencement of the survey.
- Specific techniques for minimising impacts to heritage sites or areas that are to be traversed will be developed in consultation with the relevant authority.

6.9 Environmental Management System

Geophysical operations in the Arckaringa Basin will be undertaken in accordance with the principles of an Environmental Management System (EMS). An EMS is a key tool in the management of the proponent and associated contractors' environmental responsibilities, issues and risks. An EMS also provides a framework for the coordinated and consistent management of environmental issues by ensuring the.

- establishment of environmental policy
- identification of environmental risks and legal and other requirements relevant to seismic operations
- setting of appropriate environmental objectives and targets
- delineation of responsibilities
- establishment of a structure and program to implement environmental policy and achieve objectives and targets, including the development of procedures or guidelines for specific activities and education and induction programs
- facilitation of planning, control monitoring, corrective action, auditing and review of activities to ensure that the requirements and aspirations of the environmental policy are achieved.

SAPEX's and its contractors' geophysical operating standards will follow or lead accepted best practice and industry-accepted standards. Ongoing audits of the EMS and associated systems will be conducted on a regular basis to ensure that systems are maintained and being successfully implemented.

Key components of an EMS are discussed in the following sections.

6.9.1 Environmental Training

Prior to the start of field operations all field personnel will be required to undertake an environmental induction to ensure they understand their role in protecting the environment. This induction will be part of a general induction process also including safety procedures. The induction shall include notification of environmental objectives and environmental requirements and include the distribution and explanation of any site specific environmental material.

A record of induction and attendees will be maintained.

6.9.2 Emergency Response and Contingency Planning

In the course of normal operations, there is always the potential for environmental incidents and accidents to occur. To manage these incidents emergency response plans will be developed to guide actions to be taken to minimise the impacts of accidents and incidents. Emergency response plans will be reviewed and updated on a regular basis to incorporate new information arising from any incidents, near misses and hazards and emergency response simulation training sessions. These plans will also include the facilitation of fire danger season restrictions and requirements.

Emergency response drills will also be undertaken at regular intervals to ensure that personnel are familiar with the plans and the types of emergencies to which it applies, and that there will be a rapid and effective response in the event of a real emergency occurring.

6.9.3 Environmental Monitoring and Audits

Ongoing monitoring and auditing of geohpysical operations will be undertaken to determine whether significant environmental risks are being managed, minimised and where reasonably possible, eliminated.

Monitoring programs will be designed to assess:

- compliance with regulatory requirements
- visual impact of the operations
- impact upon flora and fauna and general biodiversity
- site contamination
- site revegetation following program completion and any restoration activity
- potential future problems.

6.9.4 Incident Management, Recording and Corrective Actions

SAPEX and its contractors will have a system in place to record environmental incidents, near misses and hazards, track the implementation and close out of corrective actions, and allow analysis of such incidents to identify areas requiring improvement. Such review should be undertaken at least annually. The system will also provide a mechanism for recording ‘reportable’ incidents, as defined under the *Petroleum Act 2000* and associated regulations.

6.9.5 Reporting

Internal and external reporting procedures will be implemented to ensure that environmental issues and/or incidents are appropriately responded to. A key component of the internal reporting will be contractors’ progress and incident reports to SAPEX.

External reporting (e.g. incidents, annual reports) will be carried out in accordance with Petroleum Act requirements and the SEO.

7 Environmental Risk Assessment

Environmental risk is the chance of something happening that will result in impact to an aspect of the environment. Risk is measured in terms of the consequences of an event and their likelihood.

Given appropriate management measures (i.e. those identified in Section 6), most risks can be avoided or reduced to a level that is as low as reasonably practical (ALARP). This is a risk of something happening that is considered to have a minimal impact and which will recover. These parameters are defined within the goal attainment scaling system (defined in the SEO). However, in some cases there may still be 'residual' risks that remain after management measures have been implemented.

An environmental risk assessment of SAPEX's proposed activities has been undertaken to evaluate the level of environmental risk associated with various activities and provides a framework for assessing risk management priorities and options based on the level of each assessed risk.

The environmental risk assessment was conducted using methodology based on AS/NZ 4360:2004 *Risk Management*.

The first stage of the risk assessment involved identifying the activities that may be a source of risk (hazards) and the possible associated environmental impacts (consequences). The hazards and consequences associated with seismic activities in the Arckaringa Basin have been summarised in Table 5 in Section 5.

Once the consequences were identified, the severity of the consequences (Table 6) and the likelihood of the consequences occurring (Table 7) were allotted. A risk matrix (Table 8) was then used to undertake an environmental risk assessment of each consequence and determine a risk ranking. Results of the risk assessment are presented in Table 9.

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

7.1 Hazards and Consequences

Primary environmental hazards and the key potential environmental consequences associated with seismic activities in the Arckaringa Basin (with other geophysical operations forming a subset of these activities) are identified in Sections 5.1and 5.2.

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. Geophysical operations have been undertaken in the nearby Cooper and Eromanga basins for many years and as a result the environmental hazards and existing management measures are generally well understood. As a consequence the likelihood and severity of consequences of the majority of geophysical activities can be confidently predicted based on past experience and professional judgement.

Both the likelihood and severity of consequences have been assessed in the context of the management practices that are currently applied to reduce the level of risk associated with identified hazards and potential consequences.

7.1.1 Severity of Consequences

Environmental consequences can be categorised from negligible to catastrophic (Table 6). These consequences are based upon definitions described by Stoklosa 1999 and in AS/NZS 4360:2004, but have been expanded to incorporate impacts to environmental values such as flora, fauna and biomass and the socio-economic environment.

Table 6: Severity of consequences

Category of Effect	Qualitative Description of Environmental Effects	
	Natural environment	**Socio-economic environment**
Negligible	Possible incidental impacts to flora & fauna in a locally affected land system but no ecological consequence	Community is aware of operations and concerns have been addressed
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. Land system has a small amount of change but no long-term impact that will alter the terrain surface.	Temporary disturbance to the community.
Moderate	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. Land system surface has localised changes that may cause long-term impacts.	Longer term disturbance able to be managed with communication to affected community
Major	Substantial changes to the abundance or biomass of biota, 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. Changes to terrain surface that will substantially alter the terrain surface and drainage patterns.	Significant effect which can be mitigated by extensive rehabilitation and negotiation with community
Catastrophic	Irreversible and irrecoverable changes to abundance/biomass or aquifers in the affected area. Loss of biodiversity on a regional scale. Loss of ecological functioning with little prospect of recovery to pre-incident conditions. Widespread impact upon the terrain surface and drainage patterns.	Significant and long lasting negative economic and social effects.

The distinction between temporary and long-term impact depends on many factors, but is ultimately a value judgement based on scientific evaluation and the level of community acceptance. These factors are generally related to climatic events, differing terrain units, vegetation units and timing of activities/operations. Dependent on these factors, a general guideline is that the community should expect recovery from seismic impacts in the north of South Australia after about five to ten years when current techniques are employed. Impacts that are irreversible or are expected to take significantly longer to recover are defined as ‘long-term impacts’.

7.1.2 Likelihood of occurrence

The likelihood of potential environmental consequences occurring was qualitatively assessed and categorised according to the criteria outlined in Table 7. This table is based on Table 4(A) of HB 203:2004 (AS/NZS 2004c).

Table 7: Assessment of likelihood

Likelihood	Description
Almost certain	Is expected to occur in most circumstances
Likely	Will probably occur in most circumstances
Possible	Could occur
Unlikely	Could occur but not expected
Rare	Occurs only in exceptional circumstances

7.2 Risk Assessment

The level of risk has been determined by combining the likelihood and severity of consequences using a risk matrix. Table 8 shows the risk matrix that has been used in this risk assessment. This matrix is based on example matrices provided in AS/NZ 4360:2004 and supporting documentation.

Table 8: Risk matrix

		SEVERITY OF CONSEQUENCE				
		Negligible Effect	**Minor Effect**	**Moderate Effect**	**Major Effect**	**Catastrophic Effect**
LIKELIHOOD	**Almost certain**	MEDIUM	HIGH	HIGH	VERY HIGH	VERY HIGH
	Likely	LOW	MEDIUM	HIGH	HIGH	VERY HIGH
	Possible	LOW	MEDIUM	MEDIUM	HIGH	HIGH
	Unlikely	LOW	LOW	MEDIUM	MEDIUM	HIGH
	Rare	LOW	LOW	MEDIUM	MEDIUM	HIGH

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.

A summary of the risk levels for seismic activities is provided in Table 9. This risk assessment takes into account the mitigation methods and practices described earlier within this EIR.

The results of the risk assessment indicate that the risk levels for geophysical activities are classified as either ‘Low’ or ‘Medium’. No high or very high risks were identified. This indicates that with appropriate planning and management (in accordance with previous sections of this EIR), environmental risks are not at an unacceptable level.

Table 9: Summary of impacts and risk levels for seismic operations[2]

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
Line and access track preparation	*Earthworks* *Excavations* *Vehicle movement*	Loss of vegetation and habitat	Minor	Possible	Medium
		Soil erosion and disturbance to natural drainage patterns	Minor	Unlikely	Low
		Soil inversion	Minor	Unlikely	Low
		Soil compaction/disruption/deflation, wheel tracks	Minor	Unlikely	Low
		Dust generation	Negligible	Likely	Low
		Noise generation	Negligible	Likely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Disturbance to stock	Minor	Unlikely	Low
		Introduction and spread of weeds	Major	Rare	Medium
		Visual Impact	Minor	Likely	Medium
		Damage to infrastructure	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium
		Facilitation of third party access	Minor	Unlikely	Low
	Spills and leaks	Contamination of soil, surface water	Minor	Unlikely	Low
		Loss of organic beef certification	Moderate	Rare	Medium
Line Surveying and Recording	*Vehicle movement*	Disturbance to native fauna	Minor	Unlikely	Low
		Disturbance to stock	Minor	Unlikely	Low
		Introduction and spread of weeds	Major	Rare	Medium
		Damage to infrastructure	Minor	Unlikely	Low
		Soil compaction/disruption/deflation, wheel tracks	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium

[2] Assumes all activities avoid sensitive areas as described in Section 4 and Section 6 (e.g. GAB Springs).

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
		Visual impact	Minor	Likely	Medium
		Dust generation	Negligible	Likely	Low
	Vibrator Operations/Movement	Soil compaction/disruption/deflation, wheel tracks	Minor	Unlikely	Low
		Dust generation	Negligible	Possible	Low
		Noise generation	Negligible	Likely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Disturbance to stock	Minor	Unlikely	Low
		Introduction and spread of weeds	Major	Rare	Medium
		Damage to infrastructure	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium
	Spills and leaks	Contamination of soil, surface water	Minor	Unlikely	Low
		Loss of organic beef certification	Moderate	Rare	Medium
Campsites and associated supply logistics	*Vehicle movements*	Soil compaction/disruption/deflation, wheel tracks	Minor	Possible	Medium
		Dust generation	Negligible	Likely	Low
		Visual Impact	Minor	Unlikely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Disturbance to stock	Minor	Unlikely	Low
		Introduction and spread of weeds	Major	Rare	Medium
	Camp site *Disturbance of vegetation and habitat*	Loss of vegetation and habitat, damage to tree root structures	Minor	Unlikely	Low
		Soil erosion and disturbance to natural drainage patterns	Minor	Unlikely	Low
		Noise generation	Negligible	Likely	Low
		Visual Impact	Minor	Unlikely	Low
	Disposal of domestic and chemical waste	Soil inversion	Minor	Unlikely	Low
		Contamination of soil, surface water, groundwater	Minor	Unlikely	Low

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
	Spills and leaks	Loss of organic beef certification	Moderate	Rare	Medium
		Litter	Minor	Unlikely	Low
		Risk to public health	Minor	Unlikely	Low
		Visual Impact	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium
	Fire	Fire damage to vegetation and habitat	Major	Unlikely	Medium
Uphole drilling and logging	*Vehicle movement*	Soil compaction/disruption/deflation, wheel tracks	Minor	Unlikely	Low
		Dust generation	Negligible	Likely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Disturbance to stock	Minor	Unlikely	Low
		Introduction and spread of weeds	Major	Rare	Medium
		Damage to infrastructure	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium
	Up Hole Drilling activity	Soil inversion	Minor	Unlikely	Low
		Loss of vegetation and habitat	Negligible	Unlikely	Low
		Contamination of soil, surface water and groundwater	Minor	Unlikely	Low
		Uncontrolled discharge or contamination of aquifer	Moderate	Unlikely	Medium
		Disturbance to native fauna	Minor	Unlikely	Low
		Disturbance to stock	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium
		Dust generation	Negligible	Likely	Low
		Noise generation	Negligible	Likely	Low
		Visual Impact	Minor	Unlikely	Low
	Disposal of chemical waste	Soil inversion	Minor	Unlikely	Low

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
	Spills and leaks	Contamination of soil, surface water and groundwater	Minor	Unlikely	Low
		Loss of organic beef certification	Moderate	Rare	Medium
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium
		Visual Impact	Minor	Unlikely	Low
Line and access track restoration	*Earthworks* *Vehicle movement*	Soil inversion	Minor	Unlikely	Low
		Dust generation	Negligible	Likely	Low
		Noise generation	Negligible	Likely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Disturbance to stock	Minor	Unlikely	Low
		Introduction and spread of weeds	Major	Rare	Medium
		Visual Impact	Minor	Unlikely	Low
		Damage to infrastructure	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium
	Spills and leaks	Contamination of soil, surface water	Minor	Unlikely	Low
		Loss of organic beef certification	Moderate	Rare	Medium
Monitoring	*Vehicle movement*	Soil compaction/disruption/deflation, wheel tracks	Minor	Unlikely	Low
		Dust generation	Negligible	Likely	Low
		Introduction and spread of weeds	Major	Rare	Medium
		Damage to infrastructure	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Minor	Unlikely	Low

8 Consultation

SAPEX will conduct targeted consultation with relevant interested parties, during both the development of this EIR (and accompanying SEO) and during planning for specific geophysical exploration programs. This consultation will assist SAPEX in identifying potential impacts and the best form of mitigation or management measures.

SAPEX is committed to maintaining effective communication and good relations with all stakeholders.

8.1 Key Stakeholders

The following stakeholders have been identified as having a direct interest in geophysical activities in the Arckaringa Basin:

- State regulatory agencies
- Landholders
- Local government
- Native title / Aboriginal groups

Stakeholder consultation carried out for the development of this EIR is summarised in Table 10. Where future stakeholder consultation is planned but had not been undertaken at the time of writing, the entry has been left blank.

A major part of the consultation is the public consultation process under the Petroleum Act that was coordinated by PIRSA in 2007. The submissions received during the public consultation on the EIR and SEO are contained in Appendix 5, along with SAPEX's responses.

Table 10: Stakeholder consultation

Stakeholder Category	Organisation/Agency	Key Issues
Regulatory Authority	Department of Primary Industries & Resources (PIRSA)	Ongoing liaison regarding approvals, environment, safety, etc.
	Environment Protection Authority (EPA)	See Appendix 5
Government Departments	Department for Environment & Heritage (DEH)	Flora/fauna database records Tallaringa Conservation Park See Appendix 5
	DEH – Heritage Branch	State Heritage Register
	Department of Health	See Appendix 5
	Department of Water, Land & Biodiversity Conservation (DWLBC)	See Appendix 5
	Department of Water, Land & Biodiversity Conservation (DWLBC) – Native Vegetation	See Appendix 5
	Department for Transport, Energy & Infrastructure (DTEI)	RSSD Database, weeds
	South Australian Arid Lands NRM Board	
Commonwealth Government	Department of the Environment & Water Resources (DEWR)	
	Department of Defence	Access to Woomera Prohibited Area
Local Government	District Council of Coober Pedy	

Stakeholder Category	Organisation/Agency	Key Issues
Heritage / Native Title	State Aboriginal Heritage Committee (Aboriginal Affairs & Reconciliation Division, Department of the Premier and Cabinet (AARD))	
	Yankunytjatjara/ Antakirinja Native Title Group	Native title agreements (signed in 2006). (Further consultation will occur prior to Work Area Clearances for exploration programs)
	Antakirinja Matu-Yankunytjatjara Native Title Group	
	The Arabunna People's Native Titile Group	
	Tjyrilia Aboriginal Corporation (Mount Willoughby Indigenous Protected Area)	

8.2 Landholder Consultation

Landholders (land owners or occupiers) within the SAPEX Arckaringa Basin PELs will be informed of the proposed exploration activities and the management of these activities will be discussed. Close liaison will be carried out with landholders directly affected by seismic activities to ensure that activities are planned and carried out to minimise impacts to land use activities. Land occupiers will be formally notified prior to entry in accordance with Petroleum Act requirements, and SAPEX will continue to work closely with landholders throughout the duration of its exploration programs.

A list of landholders in the Arckaringa Basin is provided in Appendix 4. These landholders were provided with an information brochure prepared by SAPEX that explained the proposed exploration activities and were also contacted by PIRSA during the public consultation period and provided the opportunity to comment on the EIR and SEO. Closer liaison has commenced with those landholders affected by the initial exploration activities.

8.3 On-going Consultation

SAPEX aims to continue to engage stakeholders for the duration of its exploration activities to ensure that all potential concerns are identified and appropriately addressed. Stakeholder correspondence will be registered and documented to ensure that issues are appropriately addressed.

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10 Abbreviations

ºC	Degrees Centigrade
BOM	Bureau of Meteorology
DEH	Department for Environment and Heritage (South Australia)
DEWR	Department of the Environment and Water Resources (Commonwealth) (formerly the Department of the Environment and Heritage)
DTEI	Department of Transport Energy and Infrastructure (South Australia)
DWLBC	Department of Water, Land & Biodiversity Conservation (South Australia)
EIR	Environmental Impact Report prepared in accordance with Section 97 of the South Australian *Petroleum Act 2000* and Regulation 10
EMS	Environmental Management System
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
GAB	Great Artesian Basin
h	hours
ha	hectares
kg	kilogram
km	kilometre
L	litre
m	metre
mg	milligram
NPW Act	*National Parks and Wildlife Act* 1972 (South Australia)
PEL	Petroleum Exploration Licence
PIRSA	Primary Industries and Resources, South Australia
ppm	Parts per million
RNE	Register of the National Estate
s	seconds
SCB	Soil Conservation Board
SEB	Significant Environmental Benefit
SEO	Statement of Environmental Objectives

Appendix 1:

Land Systems in the Arckaringa Basin

Land Systems in the Arckaringa Basin

This document provides a detailed description of the land systems in the Arckaringa Basin that are briefly discussed in the EIR. The descriptions are taken from relevant Soil Conservation Board District Plans. The Department of Water, Land and Biodiversity Conservation supplied data used in the map.

Figure A1-1: Land Systems in SAPEX PELs

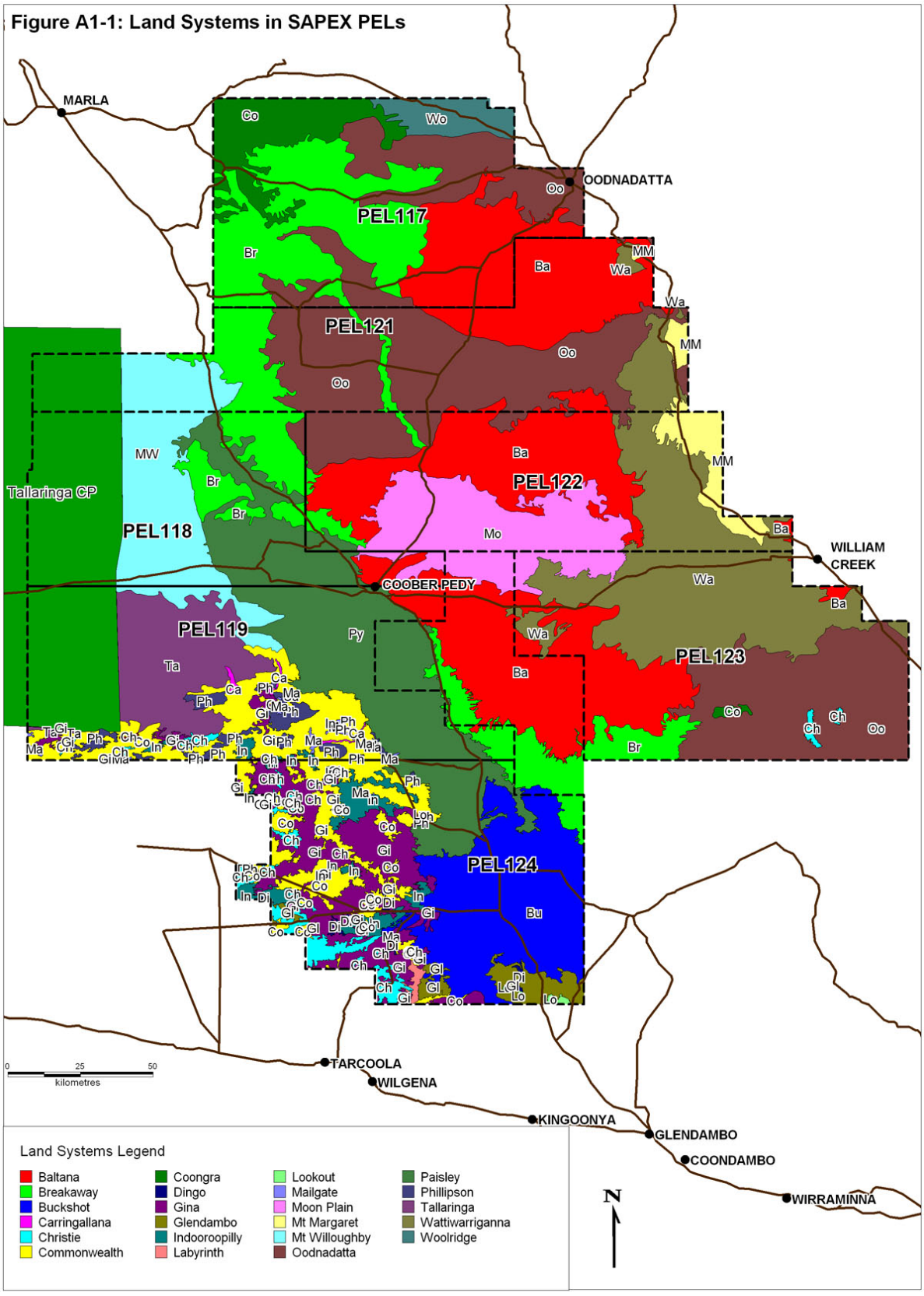

Table A1: Land system summary

Name	Land form	Land features	IBRA Region			
			STP	SSD	GVD	GAW
Baltana	P	Moon plain, Drainage lines/watercourses	X			
Breakaway	U	Tablelands, Drainage lines/watercourses	X			
Buckshot	P	Plains, Drainage lines/watercourses	X			
Carringallana	FP	Drainage lines/watercourses				X
Christie	U	Stony plain	X			X
Commonwealth	SP	Sand plain, Drainage lines/watercourses				X
Coongra	StP / U	Stony plain, Stony Hills, Drainage lines/watercourses	X			
Dingo	FP	Drainage lines/watercourses				X
Gina	P	Plain				X
Glendambo	P	Sand plain	X			X
Indooroopilly	D	Dunes, Swales, Claypans				X
Labyrinth	D	Dunes, Swales, Claypans, Salt lakes				X
Lookout	U	Stony Hills	X			
Mailgate	U	Dunes, Stony Hills				X
Moon Plain	P	Moon plain, Drainage lines/watercourses	X			
Mt Margaret	U	Ranges, Tableland, Stony plain (footslopes)	X			
Mt Willoughby	P	Stony plain, Dunes			X	
Oodnadatta	P	Stony plain, Drainage lines/watercourses, Stony Hills	X			
Paisley	U	Stony Hills, Drainage lines/watercourses	X			
Phillipson	D	Swales, Dunes, Claypans, Salt lakes				X
Tallaringa	StP/D	Dunes, Stony plain			X	
Wattiwarriganna	D	Dunes, Swales, Drainage lines/watercourses, GAB Springs	X	X		
Wooldridge	P, D	Swales, Dunes, Claypans, Salt lakes, Drainage lines/watercourses	X			

Key to Landform

FP = Flood plain including alluvial plains

D = Dunefield (dunes with clay swales, occasional claypans, salt lakes)

StP - Stony Pain

SP = Sand plain (sand over silty clays)

P = Plain

U = uplands including hills, mesas

Key to IBRA Regions

STP = Stony Plains

GVD = Great Victoria Desert

SSD = Simpson Strzelecki Dunefields

GAW = Gawler

General Land System Descriptions from SCB District Plans[3]

Baltana Land System (K, Ma)

The Baltana land system occupies a large area to the east and south of the Stuart Range on McDouall Peak station. It also occurs on Billa Kalina Station.

This land system has formed where erosion of the silcrete capping has exposed the softer Bulldog Shale which has mixed with alluvium from the ranges. This has resulted in the formation of extensive undulating plains with numerous gilgais and some areas of sandsheet. This is known locally as "moon" or "loomy" country. It has distinct similarities with the nearby Oodnadatta land system. Soils, which include silts, sands and grey clays, are covered with a lag of silcrete and quartzite gibbers. The soils comprise brown saline clay which separates it from the softer grey clays of the Moon Plain land system.

No perennial species truly dominate the vegetation on plains and there are often large bare areas, which support ephemeral species following rain, between patches of perennial vegetation. The dominant plant species on the plains are Oodnadatta saltbush, bladder saltbush, neverfail, Mitchell grasses, Flinders grass, button grass, Cooper clover, pale poverty-bush, tangled poverty-bush and samphires (glassworts).

Creeks and watercourses have alluvial sand and cracking clay soils and contain large amounts of shales and gypsum and support very little vegetation. Prickly wattle is the dominant species in the creeks with coolibah, cottonbush and silky browntop also common. Verbine and Cooper clover grow following good rains. Old man saltbush occurs in swamps and some creeks.

Plains, watercourses and run-on flats are all dominated by chenopod low shrublands. Bladder saltbush, woolly bluebush, barley Mitchell grass, neverfail and pale poverty-bush are common on plains with brown clay or silty soils. Watercourses with brown cracking clays and alluvial sands support cottonbush and showy groundsel. Run-on flats have saline grey-brown clays and are characterised by black bluebush, cottonbush, samphire, showy groundsel and swamp canegrass, with barley Mitchell grass and neverfail occurring where gilgais are present.

Sandsheets have formed in some areas from residual yellow sands deposited on the underlying gibber plain. These areas support low open shrublands with Sturt's pigface prominent in the vegetation. Elegant wattle (prickly wattle) and bladder saltbush also occur here.

Breakaway (Ma)

This land system has formed from an eroding basement of Bulldog Shale. Eroding shales and silcretes have resulted in mixtures of silcrete gibber, grey shales and other variously coloured hard and soft shales. The various colours result from the amount of leaching of iron from the shales, with red coloured shales containing more iron and paler ones containing less.

Vegetation of all land units except broad watercourses is dominated by chenopod low shrubland. Tall shrublands of bastard mulga, mulga, northern myall and emubushes are also common. Clay soils over silicified shales of tablelands and low hills are dominated by bladder saltbush, low bluebush and three-winged bluebush, sometimes with mulga and sennas. Vegetation of footslopes also includes bristly sea-heath and samphires, reflecting the more saline nature of the soils, and has fewer trees and tall shrubs.

Solonized red duplex soils of plains support bladder saltbush, low bluebush, samphire and bristly sea-heath, but also have barley Mitchell grass in the gilgais. Alluvial soils of smaller watercourses support bladder saltbush, cottonbush, spiny saltbush, round-leaf emubush, native apricot and showy

[3] Information taken from the Kingoonya (K), Marla-Oodnadatta (Ma) and Marree (M) Soil Conservation Boards' District Plans.

groundsel. Larger watercourses have mulga or coolibah woodland, with marpoo and bullock bush also present.

Buckshot Land System (K)

The Buckshot land system was formed from erosion of parts of the Stuart Range and is widespread in central parts of the Kingoonya SCB district. Land units comprise very flat plains and broad shallow watercourses.

Between buckshot clad sandy clay plains, red earth and desert loam soils support mulga groves and scrub, with dead finish, crimson turkey bush, round-leaf emubush and low bluebush also present. Gravelly clay plains with desert loam or brown clay soils are dominated by chenopod low shrublands, with cottonbush, bladder saltbush and low bluebush; the understorey is of barley Mitchell grass, neverfail and long-spined poverty-bush. Sandy earth soils of watercourses support mulga woodlands, with dead finish, crimson turkey bush and round-leaf emubush.

Carringallana Land System (K)

The Carringallana land system occupies small areas of sandy country to the west of the Stuart Range on Ingomar Station. Despite the sandy nature of the soil, well-defined watercourses are maintained and these characterise this land system. These watercourses, with their alluvial sandy soils, are similar to the watercourses of the Brumby land system. They are generally tree-lined, with coolibah, boree tea-tree, umbrella bush, dead finish and narrow-leaved hopbush common in the overstorey, and Sturt's pigface, cottonbush and goathead burr dominating the understorey.

Christie Land System (K)

The Christie land system is an ancient system formed from granitic and gneissic rocks as well as quartz bedrock and silcrete, with silcrete often present on hilltops. It is widespread in the western half of the Kingoonya SCB district.

Mulga scrub dominates on shallow stony sandy loams and stony earthy sands on outwash slopes. Tall shrublands of crimson turkey-bush, green turkey-bush, round-leaf emubush, three-wing bluebush and cassias are also present, often with an understorey of perennial grasses including woollybutt and bandicoot grass. Chenopod low shrublands dominate three land units within this land system; silcrete rises with shallow stony sandy loams, silcrete rises with shallow calcareous loams, and valley plains with sandy earth soils. Bladder saltbush and low bluebush are common in all three of these units, with black bluebush joining them on valley plains. Round-leaf emubush and cassias occur in both units featuring silcrete rises, with pearl bluebush present on calcareous soils, and three-wing bluebush and silky bluebush present on non-calcareous soils. Mulga scrub is also found on shallow alluvial sands of watercourses, with dead finish and spiny saltbush.

Commonwealth Land System (K, Ma)

An extensive sand plain, which is quite young in geological terms, occurs in the western part of the Kingoonya SCB district and south-western corner of the Marree-Oodnadatta SCB district, between the Great Victoria Desert in the west and the Stuart Range in the east. It forms the Commonwealth land system.

There are a few well defined watercourses, largely restricted to the eastern margins. Some low sandy rises have formed from the same sediments, but there are no dunes. Numerous claypans collect any runoff, although most rainfall is quickly absorbed into the sandplain. Soils are mostly light and often shallow, and are comprised of siliceous sands, earthy sand or sandy red earths, with bedrock or calcrete close to the surface. Some hardpan soils also occur. Small areas of other land systems are often found surrounded by the sand plains of the Commonwealth land system.

Vegetation of the sand plain is dominated by mulga low open woodland on siliceous sands, earthy sands or sandy red earths, with emubushes, cassias and mulga grass also present. In places where lime and salts are close to the surface, the ground cover is dominated by chenopod species, particularly bladder saltbush and pearl bluebush, with emubushes, cassias and silver tails also

present. Perennial grasses, especially woollybutt and bandicoot grass, dominate the understorey where salts and basement rocks are more than about 60 cm below the surface. Chenopods are more common in the south and east of this land system, reflecting the more saline nature of the soils in these areas.

Salt tolerant species such as samphires, glassworts, black bluebush and cottonbush are common on clay and silty soils at the margins of claypans where salinity is higher than on the sandplain. Mulka grass is often common in the understorey in such places.

Coongra (Ma)

This land system consists of vast sandstone and shale covered slopes, plateaus and plains dominated by bladder saltbush. Undulating stony tablelands with gilgais are dissected by an extensive drainage system although much of the initial drainage is into gilgais. Stones are rounded or angular and range in size from 3 to 30cm in diameter and these form an erosion resistant layer unless they are disturbed.

The slopes are treeless except for the occasional rock emubush tall shrubs. Sparse mulga occurs along shallow creek lines, with this species accompanied or replaced by gidgea on the eastern side of the land system. Coolibahs occur with river red gums along the larger watercourses, often with an understorey of Australian cupgrass.

On the tablelands bladder saltbush grows in association with the perennial grasses like the Mitchell grasses, native millet, katoora, the perennial shrub bristly sea-heath and occasional rock everlastings. Understorey plants include mulga grass, bottlewashers and bogan flea. The majority of perennial plants growing here are the same as those growing on the Oodnadatta land system, with the major difference being that Oodnadatta saltbush is uncommon in the Coongra land system and is a dominant plant in the Oodnadatta land system.

After rain, the Coongra land system is very productive, growing a wide variety of annual, ephemeral and short lived perennials, even in dry times. This system is relatively productive due to its perennial plant component.

Dingo Land System (K)

Drainage areas around low hills and rises in the Mulgathing, Bulgunnia and Wilgena areas, and also to the south of the Stuart Range on Mount Eba Station, comprise the Dingo land system. Well-defined watercourses are generally lacking and those that are present do not always go far enough to flow into swamps.

Vegetation is often dominated by chenopod low shrublands. Sugarwood open woodland occurs on the alluvial sands of some watercourses, often in association with cassias and Australian boxthorn, with satiny bluebush, bindyis and mulga grass in the understorey. Other watercourses with firmer alluvial sandy soils are dominated by mulga woodland, tall shrublands of cassias and dead finish, and an understorey of bindyis. Claypans with saline alluvial sands and silts are often fringed by tea-tree scrub comprising boree tea-tree and broombush, with chenopod low shrublands of black bluebush, cottonbush and nitre goosefoot and grasslands of swamp canegrass. The firm alluvial sands of flood plains often support mulga woodlands with chenopod low shrubland understorey featuring bladder saltbush, cottonbush and bindyis.

Gina Land System (K)

The Gina land system is widespread in the western half of the Kingoonya SCB district. Vegetation of the calcareous sandy loams on plains is dominated by chenopod low shrublands of pearl bluebush and bladder saltbush, with taller shrublands of narrow-leaved hopbush and cassias and an understorey of grasses, particularly bottlewashers. Run-on flats support mulga woodlands with a grass understorey, dominated by neverfail, on sandy earths and sandy red earths. Sand spreads with sandy earth soils also support mulga woodlands with a grassy understorey; also included are cassias and the grasses woollybutt and bandicoot grass.

Glendambo Land System (K)

Glendambo land system is similar to the Gina land system, which occurs further to the west, but differs in having an overstorey of western myall and less perennial grasses on the run-on flats.

Vegetation on the deep earthy sands and shallow siliceous sands of sand spreads is dominated by western myall and mulga woodland, and also includes tall shrublands of bullock bush and cassias. The understorey includes pearl bluebush and Australian boxthorn, with bandicoot grass and woollybutt.

Plains with calcareous earths support western myall woodlands over chenopod low shrublands with an understorey of cassias, bladder saltbush, Australian boxthorn and spiny goosefoot. Plains with red duplex soils support bladder saltbush, low bluebush, cottonbush, black bluebush and Sturt's pigface.

Rises with calcareous sand soils support an open woodland of western myall and chenopod low shrublands of pearl bluebush, bladder saltbush, round-leaf emubush, low bluebush and three-wing bluebush. Run-on flats with sandy red earth soils are dominated by mulga woodlands, with dead finish, crimson turkey bush, spiny saltbush, black bluebush and bladder saltbush also commonly present.

Indooroopilly Land System (K)

The Indooroopilly land system occurs mainly in the far west of the Kingoonya SCB district, with smaller areas having formed on the windward margins of the Stuart Range. Parallel dunes up to 10 m high have formed in the west and are typical of this land system, although parallel ridges and sand spreads less than 5 m high have formed in the east.

Vegetation of the sand dunes is dominated by horse mulga tall shrublands with crimson turkey-bush and narrow-leaved hopbush and an understorey of woollybutt, bandicoot grass and kerosene grass. Mallee occurs in some western parts of this land system. The swales support a mulga low woodland with black oak, bullock bush and tar bush and an understorey dominated by grasses, with woollybutt, bandicoot grass and mulga grass being the most common species.

A few claypans occur in this land system, and these support mulga scrub with swamp chenopods such as cottonbush and black bluebush.

Labyrinth Land System (K)

The Labyrinth land system is widespread in southern central parts of the Kingoonya SCB district, particularly in the Tarcoola and Kingoonya areas. It is made up of a series of small salt lakes and claypans with adjoining sand dunes. It is similar to the Phillipson land system, but also includes a large sand plain supporting bladder saltbush and low bluebush, with native apricot and bullock bush occurring as isolated plants or small thickets.

Vegetation of the dunes is dominated by mulga and horse mulga woodlands, with narrow-leaved hopbush and broom emubush and an understorey of woollybutt and bandicoot grass. Red mallee, twin-leaves and bladder saltbush are also present on gypsiferous sandy dunes bordering the lakes. Low shrublands of bladder saltbush, samphire and Sturts pigface occur in saline sands, silts and clays bordering salt-lakes and claypans. Low chenopod shrublands dominated by bladder saltbush and low bluebush occur on deep siliceous sands of sand plains.

Lookout Land System (K)

The Lookout land system includes areas to the south of the Stuart Range in the central parts of the Kingoonya SCB district. Erosion of underlying bedrock, particularly Bulldog Shale, has created a system of low silcrete-capped hills with adjacent plains.

Calcareous loams and calcareous earths of silicified shales of plains, and calcareous loams of silicified shales on rises, both support chenopod low shrubland with open western myall woodland. Pearl bluebush, three-wing bluebush, bladder saltbush, spiny goosefoot, silver tails and limestone

copperburr occur in both landform units. Vegetation of the plains also includes low bluebush. Mulga is sometimes present in the few small watercourses.

Mailgate Land System (K)

Mailgate land system has formed in hilly country, with sand drift and dunes covering or encroaching on hillsides and rises. The dunes usually lack regular patterns, with their shape and orientation being determined by that of the underlying hills, although on the foot slopes of the Stuart Range they are usually parallel or almost parallel. Sandy country occupies over half the area of this land system. The Mailgate land system occurs in the western half of the Kingoonya SCB district.

Vegetation on low stony rises and slopes is dominated by either mulga scrub or saltbush-low bluebush low shrubland, depending on the underlying soils. Shallow stony sandy soils of silcrete rises support mulga woodlands with emubushes and cassias, while chenopod shrubs dominate where the sand is deeper or where calcrete or lime are present.

Dunes and sand sheets support mulga or horse mulga woodlands and tall shrublands of narrow-leaved hopbush, emubush and cassias. Understorey on dunes and sand sheets is often of bandicoot grass and woollybutt.

Pearl bluebush sometimes occurs on calcareous soils. Bladder saltbush and low bluebush dominate flats between the dunes in areas near the Stuart Range. Mallee species sometimes grow on sandy soils in the south-west of the district.

Moon Plain (Ma)

This land system occurs north-west of Coober Pedy. Its dominant feature is an undulating plain with soft grey cracking gypseous clay soils which generally lack any cover of gibber or other stones. This soil type separates it from the heavier brown clays of the Baltana land system, which it abuts to the west, south and east. The Moon Plain has little drainage and becomes very boggy after rain. However, two major drainage lines run through this system and provide drainage following very heavy rain. They also provide a habitat for the majority of perennial shrubs found in this land system.

The Moon Plain has very little plant cover in most years, with only a few perennial species present. Mitchell grasses and neverfail are two of the few perennial grasses found on the Plain, together with annual and pop saltbushes, mulka grass, pale poverty-bush, tangled poverty-bush, Blacks copperburr and buckbush.

Several species of samphire are common in the drainage lines, along with prickly wattle, old man saltbush, lignum, swamp canegrass and a few stunted coolibahs. Annual saltbush, pop saltbush, limestone bottle-washers, Darling pea, mulka grass, buckbush and various copperburr's also occur. Numerous ephemerals, including Cooper clover, flourish after good soaking rains of more than 50mm.

Mount Margaret (Ma)

This is a small land system located 100 km west of Lake Eyre North. It consists of rugged ranges with deep gorges, a deeply dissected plateau on top of the range, and long-lasting rock holes. The slopes of the range are rough and rocky. These ranges were once part of an inland sea and tidal ripple marks can be seen on rocks at the top of the range. The stripping process of the ancient soils is far more advanced here than in the Breakaway land system, although residual formations of up to 50 m or more above the level of the surrounding Oodnadatta land system are present. Soils may be up to several metres in depth.

The footslopes of this land system can be separated from the adjoining Oodnadatta land system by the presence of ferruginous rather than quartzite gibbers in the Mount Margaret land system.

The upper parts of creeks which begin in the ranges support the northern form of the river red gum, but this tree is replaced by coolibah when the creeks leave the ranges and become wider and the soils are sandier. The creeks also support dead finish and chenopod shrubs and perennial grasses which include lemon-scented grass, cotton grass and swamp wanderrie, often on skeletal rocky soils. The

steep rocky gorges at the head of many of the creeks support mountain wanderrie and spinifex on shallower soils.

An undulating gibber tableland occurs on top of the range, with clay soils and numerous deep drainage lines. This tableland is covered with bladder saltbush, short-winged copperburr, salt copperburr and Mitchell grasses and is similar to the Oodnadatta land system, but lacks the Oodnadatta saltbush.

Steep hill slopes support a tall open shrubland of bastard mulga, mulga, emubushes, sennas, silver tails and perennial sunray, with other daisies, paper daisies and mulga grass. The lower undulating footslopes surrounding the ranges contain gilgais and support numerous chenopods (dominated by Oodnadatta saltbush), mulga grass, Mitchell grasses and other vegetation similar to the Oodnadatta land system.

Mount Willoughby (Ma)

This land system is characterised by red pebbly clay plains with occasional low irregular sand dunes.

The hard flats support sparse to open mulga, with rock emubush also common. The sparser areas support the occasional tar bush. These flats contain numerous small swamps or depressions which support dense mulga woodland, with emubushes, sennas, chenopod shrubs and subshrubs. Perennial grasses such as needle-leaved threeawn, cotton grass and neverfail and annual grasses such as mulga grass and spear grass are also common. After rains the harder flats grow an abundance of mulga grass and annuals such as round-leaf parakeelya and various everlastings.

Mulga woodland occurs on both the dunes and interdune flats, with neverfail and mulga grass dominant in the understorey of the interdune areas and woollybutt, woollybutt wanderrie and tall kerosene grass being the main ground cover on dunes.

There are several predominantly mulga-lined drainage systems which feed into larger swamps, such as Wintinna Swamp, and these support cottonbush, neverfail and swamp canegrass.

Oodnadatta (Ma, M)

The Oodnadatta land system is the largest and most extensive land system found in the Marla - Oodnadatta Soil Conservation District. This extremely extensive land system extends from Dalhousie southward along the western side of Lake Eyre and into the south-west of the Marree SCD.

This land system is comprised of extensive undulating plains with a lag of silcrete and quartzite gibbers with numerous gilgais and occasional plateaus. It has an extensive drainage system with large braided creeks such as the Neales and Arckaringa Creek.

As for similar tableland land systems, the major soils are the duplex loams over clays of the gibber "shelf" areas, and the self-mulching clays of the gibber-free gilgais. Gibber soils are saline and dispersive, being either deep red clays or clay loams. Much of the soil salinity is now thought to have arisen through vertical leakage at the margins of the Great Artesian Basin, which this land system follows. Gilgais have much lower salinity. Gibber cover may be derived from silcrete or gypcrete, and there are areas with a very high gypseous content south of Lake Eyre South

Gilgais are the most productive component of this land system due to the combination of water run-on from shelves, cracking clays which do not seal until much of the profile has been wetted and the lower salinity. They are able to trap water run-off from the impervious stony flats which surround them. This water is then retained for extended periods by the clayey soil. Gilgais vary in size from only a few metres to approximately 10 metres in diameter and may be irregular in shape. The densest vegetation occurs in gilgais and on gilgai fringes or along watercourses. The stony shelves between the gilgais are often bare or covered only with a few bindyis or sparsely distributed samphire.

Gilgais support perennial low shrubs, Oodnadatta saltbush and / or samphire depending on salinity, and perennial grasses particularly native millet, barley Mitchell grass and katoora. Other common species include fairy grass, neverfail, plains lantern-bush, five-minute grass, bladder saltbush and

occasionally cottonbush. The irrigation from adjoining shelves results in dense growth of ephemerals after rain, particularly windmill grasses, Australian cup-grass, Flinders grasses and bottlewasher. The edges of gilgais support perennial shrubs such as bladder saltbush and bristly seaheath. Trees and tall shrubs are usually absent, whether because of limited water storage, salinity or excessive gypsum at depth.

Predominantly perennial plants such as bladder saltbush, katoora, neverfail, bristly sea-heath and rock everlasting grow on the less productive gilgai fringes. A sparse scattering of ephemeral herbs and forbs occur after winter rainfall.

Gibber areas between gilgais are by comparison almost unvegetated. Ephemerals appear after major rains which are sufficiently heavy to leach salts out of the upper soil profile. Such rains have to be major and prolonged, since the gibber soil surface seals rapidly when wet, and most water runs off into gilgais.

Low hills and escarpments, (jump-ups) have gypseous clay loam soils, without gilgai formation. Bladder saltbush, low bluebush, black bluebush, harlequin fuchsia-bush typically occur. Annual species include Tate's bindyi, spear grass, kerosene / mulga grass, and common and jointed bottlewasher.

Gidgee is common along creek lines in northern parts of the land system and mulga grows along creek lines throughout the land system. Coolibah grows along the larger watercourses, sometimes in association with river red gums.

Alluvial soils of watercourses support coolibah, river red gum, Broughton willow, prickly wattle and gidgea, and mineritchie in the north of the District. The shrub layer is dominated by old man saltbush, cottonbush and lignum with an understorey of grasses which may include swamp canegrass, neverfail, Mitchell grasses, silky brown tops, and perennial cupgrass. Cooper clover and verbine are common in wet seasons. The sandy floodouts adjacent to the creek support gidgea, coolibah and Mitchell grasses. Claypans with heavy brown clays are generally bare other than at their margins.

Numerous mound springs occur in this land system. Springs vary from active with visible flows to extinct and include the whole range between the two extremes. Mound springs often support dense grasslands of common reed when they are not subject to persistent grazing. Prolonged grazing removes the common reed and the more resilient but much smaller bore-drain sedge replaces it.

Paisley Land System (K, Ma)

The Paisley land system describes the Stuart Range which extends north-west from Coober Pedy. Bulldog Shale commonly underlies the heavy clay soils, with infrequent silcrete outcrops. Silicified bands in the Bulldog Shale are the source of opals in the Coober Pedy area. Soils include texture contrast soils and brown clays, alluvial sands and loams. Chenopod low shrubland dominates on all units except watercourses.

Vegetation on silcrete rises is characterised by a low shrubland of bladder saltbush, low bluebush, three-wing bluebush, silky copperburr and round-leaf emubush on stony sandy-loam soils. Bladder saltbush, low bluebush, barley Mitchell grass, neverfail, long-spined poverty-bush, silky copperburr and native apricot are found on stony red duplex and brown clay soils of low hills and rises and on the heavier soils of gilgais.

Outwash slopes, with stony red duplex soils, are characterised by bladder saltbush, low bluebush, round-leaf emubush, three-wing bluebush, limestone cassia and pale poverty-bush. Mulga scrub occurs on alluvial sands and skeletal loams of watercourses, with dead finish, bladder saltbush, black bluebush, cottonbush, Sturt’s pigface and spiny saltbush all being common in this unit.

On Mabel Creek, a specific unit exists which describes the floodout areas from Mabel and Woorong Creeks, with the floodout flats having silty clay soils and being overlain in places by longitudinal dunes which run parallel to the direction of water flows creating flood channels between the dunes. A few fresh waterholes occur in the main channels of the creek.

Vegetation is dominated by coolibah, with weeping emubush and an extensive understorey of neverfail, umbrella grass, native millet and nardoos, with ephemeral herbs and grasses also present following flooding. There are many claypans around which grow tea-tree and lignum and the occasional nitre goosefoot.

Phillipson Land System (K)

Phillipson land system is quite variable in its composition. It is widespread throughout the Kingoonya SCB district, although most common in the north and west, particularly on Commonwealth Hill Station, where it occupies the lowest areas of the regional landscape. It is absent from the south-east corner of the district. It is characterised by salt-lakes and claypans with associated lunettes and sand dunes. Low limestone and gypsum cliffs border many of the lakes, especially in the west of the district. This limestone often forms a shelf around some of the larger lakes and this has allowed sand to accumulate and form dunes at the lake's edge. Larger lakes and claypans are either at the end of drainage lines from the Stuart Range, or are a linear series of depressions in ancient river channels that are remnants of a much wetter period than the present. Vegetation includes both salt tolerant species and those which can stand periods of inundation.

Vegetation on siliceous sands of dunes is dominated by mulga and horse mulga woodlands, with a grass understorey of mainly bandicoot grass and woollybutt. Narrow-leaved hopbush and turpentine bush are also common. Saline siliceous and gypsiferous sands of dunes fringing lakes are dominated by mulga and horse mulga woodlands, with narrow-leaved hopbush and boree tea-tree are also common. The understorey is often of bladder saltbush and kerosene or mulga grass.

Chenopod low shrublands dominate the saline alluvial sands and clays at the margins of claypans and salt lakes. These shrublands commonly include cottonbush, black bluebush, bladder saltbush, lignum, nitre goosefoot and swamp canegrass, with an ephemeral herb understorey. Black oak - mulga woodland occurs on the gypsiferous sands of dunes and on sand-covered limestone shelves bordering claypans and salt-lakes.

Tea-tree often occurs on flood-prone swales, with mulga woodland dominating on swales with deeper sandy soils. Some calcareous swales are dominated by bladder saltbush and black bluebush. Neverfail is common in the understorey of flood-prone swales. Coolabah woodland occurs in northern parts of the district on Ingomar and Mount Penrhyn leases, but is not found in the south of the district.

Tallaringa Land System (K)

The Tallaringa land system occurs where parallel east-west dunes of red siliceous sands overlie an extensive laterite plain. Relict ironstone outcrops provide some relief to this almost flat plain. This land system occurs on Mobella and Commonwealth Hill stations, but is more extensive to the north-west of Mabel Creek and north of the Kingoonya Soil Conservation District.

This land system is dominated by mulga woodland, with narrow-leaved hopbush and emubushes on the sandy soils of dunes and swales, or by shrublands of green turkey-bush, crimson emubush and green fuchsia-bush on stony siliceous sands of silcrete rises and plains. Understorey on sandy soils is commonly bandicoot grass and kerosene or mulga grasses, while on calcrete rises and plains it often includes woollybutt wanderrie, lovegrasses and mulga grass.

Wattiwarriganna (Ma)

The Wattiwarriganna land system is formed from a series of large parallel sand ridges overlying an older gibber plain, with swales usually containing a gibber pavement. Dunes are generally from 100 m to 500 m apart and up to 10 m in height.

The quartzite and silcrete gibbers are gravel rather than scree size because they have been sorted as they travelled further from their source. Numerous large watercourses dissect the land system. Dunes usually have deep red sandy soils, although dunes in this land system on Billa Kalina Station are generally paler. Sandy or clay-loam soils occur in the swales, which are generally flat, but may contain low sandy or calcareous clay rises.

The swamps have brown clay, or cracking grey or brown clay, or yellow or red sandyloam soils. Numerous large watercourses dissect the land system.

Vegetation of the dunes is dominated by a hummock grassland of sandhill canegrass or a tall shrubland of horse mulga. Marpoo occurs in isolated stands and narrow-leaved hopbush is also moderately common. Few understorey species grow under or near these two shrubs. Silver needlebush also occurs as scattered plants and mulga occurs on some dune footslopes. The understorey includes tall kerosene grass, buckbush and cattle bush.

Interdune corridors include both sandy flats and claypans. Sandy flats support low shrublands of Sturts pigface, cottonbush, low bluebush, bladder saltbush, emubushes, sennas and neverfail, with mulga grass dominant in the understorey. Some claypans support swamp canegrass, old man saltbush, cottonbush, neverfail and lignum. Blue rod is common at claypan margins.

Larger watercourses are usually lined with coolibah, with marpoo, old man saltbush, cottonbush, sennas, samphire, neverfail, cupgrasses, silky browntop and swamp canegrass all present in the understorey. Cane-grass (swamp cane-grass) is common at some swamps and claypans. Swamps have similar understorey vegetation to watercourses but usually lack the associated riparian woodlands.

Several mound springs occur within this land system and support their characteristic vegetation including common reed, bore-drain sedge, cutting grass, bare twig rush, sea rush and salt couch.

Wooldridge (Ma)

This land system forms a transition between the gibber plains and plateaus of the Oodnadatta land system and the mulga woodlands of the Pedirka land system. It contains a combination of highly calcareous open flats, wide braided watercourses fringed by sand dunes and clay pans. There are also some coolibah swamps and salt pans. Dune soils are typically deep red sands, with alluvial silts and clays in flooded areas and hard red clay on the flats.

The calcareous flats grow open communities of sparse mulga and dead finish, with low bluebush and/or bladder saltbush. Individuals of both species are separated by areas of bare ground which grow predominantly annual grasses and herbs after rain. These annual grasses are usually dominated by mulga grass and bottlewashers. Cannonballs, poverty-bush, buckbush and various emubushes and sennas also occur.

The dunes between the open flats support a greater variety of perennial plants, most of which are palatable to livestock. The overstorey vegetation is dominated by mulga, with marpoo sometimes more frequent than the mulga, especially on sand dunes. Dead finish is also present, as are emubushes. The understorey is dominated by grasses, especially mulga grass, limestone bottlewashers and tall kerosene grass. A wide variety of annual and ephemeral plants which are considered valuable for fattening livestock also occur after rain.

Watercourses contain gidgea, mulga, dead finish, river red gum and coolibah, with understorey shrubs including cottonbush, lignum and Queensland bluebush. Mitchell grasses, swamp canegrass, silky browntop and native millet are the most common perennial grass species. After flooding, watercourses and low lying areas grow an abundance of annuals which include button grass, verbine, Cooper clover and munyeroo.

Western myall occurs in greyish loam over limestone on the hard plateau near Mount Alice, although this area is dominated by a low shrubland of bladder saltbush and low bluebush. Mitchell grasses, spear grass and bottlewashers occur in the understorey.

Appendix 2:

Rare or Threatened Species Recorded in the Region

Rare or Threatened Species in the Arckaringa Basin

A search of the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) database and the South Australian Department for Environment and Heritage (DEH) databases has identified the following rare or threatened flora and fauna species as being present or likely to occur within the SAPEX PEL's.

Where an entry in the table is based on a predicted occurrence in the EPBC database rather than an actual record, it has been marked with an asterisk (*).

Species Name[4]	**Common Name**	**Conservation Status**	
		C'wlth (EPBC)	**SA (NPW Act)**
Mammals			
*Dasycercus cristicauda**	Mulgara	Vulnerable	Endangered
*Notoryctes typhlops**	Southern Marsupial Mole, Yitjarritjarri	Endangered	Endangered
*Petrogale lateralis**	Black-footed Rock-wallaby (MacDonnell Ranges race), Warru	Vulnerable	Endangered
Pseudomys australis	Plains Rat	Vulnerable	Vulnerable
Reptiles			
Ophidiocephalus taeniatus	Bronzeback Snake-lizard	Vulnerable	Vulnerable
Birds			
Acanthiza iredalei iredalei	Slender-billed Thornbill (western)	Vulnerable	Vulnerable
Acanthiza robustirostris	Slaty-backed Thornbill		Rare
Amytornis textilis modestus	Thick-billed Grasswren (eastern)	Vulnerable	Vulnerable
Anas rhynchotis	Australasian Shoveler		Rare
Aphelocephala pectoralis	Chestnut-breasted Whiteface		Rare
Ardeotis australis	Australian Bustard		Vulnerable
Biziura lobata	Musk Duck		Rare
Cacatua leadbeateri	Major Mitchell's Cockatoo		Vulnerable
Cinclosoma castanotus	Chestnut Quail-thrush		Rare
Climacteris affinis	White-browed Treecreeper		Rare
Coturnix ypsilophora	Brown Quail		Vulnerable
Emblema pictum	Painted Finch		Rare
Falco hypoleucos	Grey Falcon		Rare
Gerygone fusca	Western Gerygone		Rare
Grus rubicunda	Brolga		Vulnerable
Hamirostra melanosternon	Black-breasted Buzzard		Rare
*Leipoa ocellata**	Malleefowl	Vulnerable	Vulnerable
Neophema chrysostoma	Blue-winged Parrot		Vulnerable
Pachycephala rufogularis	Red-lored Whistler	Vulnerable	Vulnerable
Phaps histrionica	Flock Bronzewing		Vulnerable

[4] A * indicates that a species has been predicted as likely to occur in the Arckaringa Basin but has not actually been recorded in PELs.

Species Name[4]	Common Name	Conservation Status	
		C'wlth (EPBC)	SA (NPW Act)
Pomatostomus temporalis	Grey-crowned Babbler		Rare
Pyrrholaemus brunneus	Redthroat		Rare
Stictonetta naevosa	Freckled Duck		Vulnerable
Flora			
Acacia rhodophloia	Minni Ritchi		Rare
Aristida arida			Rare
Atriplex humifusa			Vulnerable
Atriplex kochiana	Koch's Saltbush		Vulnerable
Bergia occultipetala			Vulnerable
Blechnum nudum	Fishbone Water-fern		Rare
Brachyscome eriogona			Rare
Bulbostylis turbinata			Rare
Callitriche sonderi	Matted Water Starwort		Rare
Ceratogyne obionoides	Wingwort		Rare
Cyperus bifax	Downs Flat-sedge		Rare
Embadium johnstonii	Johnston's Slipper-plant		Vulnerable
Eragrostis lacunaria	Purple Love-grass		Rare
Eremophila pentaptera			Rare
Frankenia cupularis			Rare
Frankenia plicata		Endangered	-
Goodenia anfracta			Rare
Goodenia chambersii			Rare
Goodenia lobata			Rare
Goodenia saccata	Flinders Ranges Goodenia		Rare
Gunniopsis kochii	Koch's Pigface		Rare
Halosarcia cupuliformis			Vulnerable
Hemichroa mesembryanthema	Pigface Hemichroa		Vulnerable
Maireana melanocarpa	Black-fruit Bluebush	Vulnerable	Rare
Nicotiana truncata			Rare
Nymphoides crenata	Wavy Marshwort		Rare
Ophioglossum polyphyllum	Large Adder's-tongue		Rare
Osteocarpum acropterum var. deminutum	Wingless Bonefruit		Rare
Poa fax	Scaly Poa		Rare
Ptilotus aristatus var. eichlerianus			Vulnerable
Ptilotus barkeri	Barker's Mulla Mulla		Rare
Pycnosorus chrysanthes			Endangered
Pycnosorus globosus	Drumsticks		Vulnerable
Santalum spicatum	Sandalwood		Vulnerable

Species Name[4]	Common Name	Conservation Status	
		C'wlth (EPBC)	SA (NPW Act)
Sclerolaena blackiana	Black's Bindyi		Rare
Senecio gypsicola	Gypsum Groundsel		Rare
Stemodia sp. Haegii (J.Z.Weber 9055)	Haegi's Stemodia	Endangered	Rare
*Austrostipa nullanulla**	Club Spear-grass	Vulnerable	-
Swainsona vestita			Vulnerable
Swainsona minutiflora	Small-flower Swainson-pea		Vulnerable
Swainsona oligophylla			Rare
Typhonium alismifolium			Rare
Wurmbea stellata	Star Nancy		Rare
Zygophyllum crassissimum	Thick Twinleaf		Rare
Zygophyllum humillimum	Small-fruit Twinleaf		Rare
Zygophyllum hybridum			Rare

Appendix 3:

Priority Plant Species

Priority Plant Species

Exploration activities often require the clearance of vegetation to facilitate access to areas of interest. Where possible the clearance of vegetation is avoided, however when clearance is required it is important that steps be taken to minimise the clearing of important species.

To assist with determining which plant species should be avoided or minimally cleared, four categories of conservation priority have been defined for the Arckaringa Basin. These conservation priorities take into account characteristics such as longevity, growth rate, regeneration rate and abundance, and any State or Commonwealth listing.

These priorities provide a general guide, however the significance of some species will depend to some extent on the species' location and the characteristics of the land form in which it is located. Site specific assessments will be used to refine the priorities for a given activity or location.

The conservation priorities are as follows:

Table A3-1: Conservation Priorities

Priority	Typical Plant Type/Characteristics[5]	Clearance
Priority 1	Long time to reach maturity Slow growth rate Poor regeneration from seed or rootstock May be uncommon State or Commonwealth listed species	Avoid clearance of mature trees Very high conservation priority
Priority 2	Long time to reach maturity Slow growth rate May be relatively uncommon May regenerate from seed &/or rootstock	Avoid clearance wherever possible High conservation priority
Priority 3	Short to moderate time to maturity Moderate growth rate Regenerates from seed &/or rootstock Relatively abundant	Clear only the minimum necessary Moderate conservation priority
Priority 4	Short time to maturity Fast growth rate Good regeneration from seed &/or rootstock Abundant Short-lived annuals and ephemerals generally fall in this category	May be cleared if necessary Low conservation priority

[5] A specific plant species may not necessarily exhibit all of these characteristics

The following table provides some examples of plant species in each category of priority.

Prior to the commencement of activities relevant personnel will be provided with information sheets (including photographs) to assist in the identification and management of priority plant species present at the location.

Table A3-2: Examples of plant species for each conservation priority

Priority	Common Name	Scientific Name
Priority 1	Western Myall River Red Gum Coolibah Black Oak	*Acacia papyrocarpa* *Eucalyptus camaldulensis* *Eucalyptus coolabah* *Casuarina pauper*
Priority 2	Mulga Dead Finish Old Man Saltbush Bluebush Bullock Bush White Cypress-pine	*Acacia aneura* *Acacia tetragonophylla* *Atriplex nummularia* *Maireana sedifolia* *Alectryon oleifolius ssp. canescens* *Callitris glaucophylla*
Priority 3	Tar Bush Samphire	*Eremophila glabra* *Halosarcia sp.*
Priority 4	Sandhill Canegrass Most grasses	*Zygochloa paradoxa* Graminae sp.

Appendix 4:

List of Relevant Land Owners

Relevant Land Owners in the Arckaringa Basin

Pastoral Leases

Property Name	Contact Details
Welbourn Hill	*Details removed from public version*
Todmorden	
Wintinna West (Wintinna)	
Evelyn Downs	
Arckaringa (including Coorikiana)	
Allandale (including Toondina, Toondina East)	
Mt Barry	
Nilpinna	
Anna Creek (including The Peak)	
Mabel Creek	
Mount Clarence	
Commonwealth Hill (including Mobella, Pt Commonwealth Hill, Pt McDouall Creek, Pt Mulgathing, Pt Woorong Downs)	
Bulgunnia	
Ingomar (including Lake Wirrida)	
Mount Penrhyn	
McDouall Peak (including Belta Beltana South)	
Billa Kalina	
Stuarts Creek	
Mt Eba	
Bon Bon	
Wilgena (including North Well)	
Mount Willoughby	
Lambina	
Millers Creek	

Conservation Reserves

Property Name	Contact Details
Tallaringa Conservation Park	*Details removed from public version*

Native Title Groups

Name	Contact Details
Arabunna People	*Details removed from public version*
Antakirinja Matu-Yankunytjatjara	
Yankunytjatjara/Antakirinja	
Aboriginal Legal Rights Movement	

Appendix 5:

Consultation Submissions and Responses

No.	Agency or Individual	Issues Raised or Comments Made	Response
1.	Dept of Health	Comment 4 EIR 3.1.7 Domestic waste – para 4 of the EIR could also reflect the requirements for Food Safety Standard 3.2.3. to have a facility for the storage of garbage & recyclable matter that adequately contains & encloses all matter & can be & effectively cleaned. Therefore it is recommended that the flowing be added; "*There will be facilities for the storage of garbage and recyclable matter that adequately contains and encloses all matter and can be easily and effectively cleaned prior to approved disposal onsite or transportation offsite*."	SAPEX acknowledges that it and its contractors have a responsibility to comply with all relevant legislation and standards, including the Food Act and Food Safety Standard. However, the EIR and SEO are not considered by SAPEX or PIRSA to be the appropriate place to reflect this detail, as it is more of an occupational health and safety matter.
2.	Dept of Health	Comment 5 EIR 3.1.7 Wastewater, para 5 – last sentence states that "Following treatment via an approved system, wastewater may be disposed of on-site (well away from watercourses or infrastructure) when in remote areas." It is preferable to state that: "The method of disposal for wastewater must comply with the *Standard for the Construction, Installation and Operation of Septic Tank Systems in SA*, or be to the satisfaction of the Department of Health". This would then reflect what is contained in section 6.5 of the EIR.	Suggested sentence added to Section 3.1.7.
3.	Dept of Health	Comment 6 EIR p.36 Table 4 Campsites & associated supplies – this should reflect that the *consequence* to the *hazard* of disposal of domestic waste is an extreme risk to public health.	"Risk to public health" has been added as a consequence in this table.
4.	Dept of Health	Comment 7 EIR 5.3.3 Wastewater, para 2 – last sentence states that "Following treatment via an approved system, wastewater may be disposed of on-site (well away from watercourses or infrastructure) when in remote areas. "It is preferable to state that: "The method of disposal for wastewater must comply with the *Standard for the Construction, Installation and Operation of Septic Tank Systems in SA*, or be to the satisfaction of the Department of Health". This would then reflect what is contained in section 6.5 of the EIR.	Suggested sentence added to Section 5.3.3.

No.	Agency or Individual	Issues Raised or Comments Made	Response
5.	Dept of Health	Comment 8 SEO Objective 9 – It would be preferred if an additional objective or an addition to objective 9 could reflect: *"Minimise the risks to public health & maximise the benefits to public health".* This could also include compliance with the *Food Act 2001* to ensure safe food & water is provided to all employees. To tie in with comment 4, an additional objective could also include the removal of all waste & ensuring safe food & water (reflecting comments regarding 3.1.7 above).	See response for Comment 4.
6.	EPA	EIR 3.17 Waste Management – SAPEX should maximise waste recovery, re-use & recycling. Plastics, cans & glass are also recyclable & should also be segregated on site & transported to a licensed waste transfer facility with CDL bottles, cans & cartons.	SAPEX will aim to maximise waste recovery, re-use & recycling. Where practicable, plastics, cans and glass will also be recycled. It is noted that this may not always be practicable due to the remote nature of the region and limited availability of nearby recycling facilities. Section 3.1.7 of EIR has been modified to clarify this point.
7.	EPA	EIR 3.18 Sewage Waste Water – Following treatment via an approved sewage management system, waste water must be removed from the site by a licensed waste transporter in order to comply with Clause 11 of the *Environment Protection (Water Quality) Policy 2003*: 11 – General obligation to avoid discharge etc into waters (1) A person who is undertaking an activity, or is an occupier of land, must take all reasonable and practicable measures (not being measures that themselves cause environmental harm) to avoid the discharge or deposit of waste from that activity or land— (a) into any waters; or (b) onto land in a place from which it is reasonably likely to enter any waters (including by processes such as seepage or infiltration or carriage by wind, rain, sea spray, or stormwater or by the rising of the water table), and, in taking those measures, must apply the waste management hierarchy.	SAPEX will comply with Clause 11 by ensuring that waste water is discharged onto land, well away from any place from which it is reasonably likely to enter any waters. Section 3.1.7 of the EIR and the "Guide to how..." for Objective 9 in the SEO has been modified to mirror this wording. It is also noted that geophysical operations will be occurring in very remote areas and the removal of treated waste water from campsites' sewage management system is not practical.
8.	EPA	EIR p.36 Table 4 – the hazard & consequence classification for seismic activities, line surveying (second row) should also include the consequence of contamination to soil & surface water.	Table 4 has been amended to include this potential consequence.

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9.	EPA	These amendments should be made in the EIR, the EIR reviewed thoroughly accordingly & the amendments subsequently addressed in the SEO.	Acknowledged
10.	EPA	SEO Appendix 1 – Environmental Objectives & Assessment Criteria – for each instance that the assessment criteria for fuel & chemical spill management is provided, an additional assessment criterion should be added **– "***All staff & contractors receive training in the use of the spill response equipment***."**	The requirement that "Personnel have received training in the use of spill response equipment" has been added to the "Guide to how… column of Appendix 1 for Objectives 2, 4 & 5.
11.	EPA	SEO Objective 4 - The management of waste water from the campsites is not addressed under Objective 4 – Minimise disturbance & avoid contamination to soil resources. This must be revised accordingly.	The management of waste water is dealt with under Objective 9 and Objective 4 cross-references Objective 9 in relation to waste management. Cross-referencing has been used to minimise duplication within the SEO.
12.	DEH	EIR 3.1.9 – Rehabilitation should be undertaken in consultation with, and to the satisfaction of the landowner.	Document edited to reflect this.
13.	DEH	EIR 4.3.1 – The proponent should note that the ecological community associated with GAB mound springs is protected under the *Environment Protection and Biodiversity Conservation Act 1999.*	Noted. This is already stated in Section 4.2.1 but has been added to section 4.3.1.
14.	DEH	EIR p.49, Table 9 – Campsites & associated supply logistics: Camp site – question that "*loss of vegetation and habitat, damage to tree structures*" is "*negligible*". This is in light of the rehabilitation method of ripping being likely to damage root structures. Suggest re-evaluation of the severity classification or more closely address the issue of ripping and its effect on tree roots in the rehabilitation section.	The severity classification has been re-evaluated to "minor" based on the possibility of damage to root structures. However, it is noted that this damage is considered unlikely to occur, due to the following factors: ▪ Campsites are preferentially located in areas devoid of vegetation ▪ Positioning campsite facilities in close proximity to trees is generally avoided ▪ The use of ripping for reinstatement of campsites is only undertaken if compaction has occurred and if the soil is suitable for ripping. Ripping is not undertaken in close proximity to trees.
15.	DEH	SEO 1.2 Scope – PEL124 should be included in the first paragraph.	This section has been amended.
16.	DEH	SEO Objective 1 – include within Guide to how Objectives can be Achieved. – "Prior to activity approval, the Heritage Branch, DEH, is to be consulted and provided with the locations of proposed activity in order that they may provide advice on protecting non-indigenous heritage sites"	Added "Consult with Heritage Branch, DEH regarding location of non-indigenous heritage sites" to "Guide to how…".
17.	DEH	SEO Objective 2 – Under a new sub-category "*Operations in the Tallaringa Conservation Park*", include under Assessment Criteria: ▪ "The impact on the environmental values of Tallaringa Conservation Park will be minimised."	First dot point has been included under Assessment Criteria. Second, third and fourth dot points have been included under "Guide to how..." and a new Assessment Criteria added: "DEH requirements for notification and operation in Tallaringa CP are met" in order to keep the

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		▪ "The licensee and contractors are cognitive of all regulatory requirements regarding correct conduct in the park, strictly adhering to the *National Parks and Wildlife Act 1972* and associated Regulations". ▪ "The District Ranger is notified of the commencement date of activities at lease ten days prior to work commencing and communication with the District Ranger is maintained whilst activities are being carried out".. ▪ "Firewood collection is not permitted within Tallaringa Conservation Park".	Assessment Criteria high level.
18.	DEH	SEO Assessment Criteria: campsite and survey line preparation – include the following: "Exploration activity should not be carried out within Vegetation Heritage Agreement areas unless there is consultation with PIRSA, the Native Vegetation Council and DEH prior to the activity approval"	Included as a "Guide to how…". It is noted that there is only one such area within the PELs and it is not likely that activity will occur in this area.
19.	DEH	SEO Objectives 2 & 3 **–** include "No domestic camp pets are allowed at campsites or work sites" within Assessment Criteria.	Included as a "Guide to how…" for Objective 2. The Assessment Criteria are relatively high-level compliance measures and this is considered more appropriate at the "Guide to how..." level.
20.	DEH	SEO Objective 4 **–** include "*No contamination of topsoil from groundwater*" within Assessment Criteria and address this issue in Guide to how Objectives can be Achieved.	The potential for groundwater flows to the surface during drilling of upholes is covered by Objective 5, which has listed under assessment criteria "No uncontrolled flows to surface from aquifers intersected in upholes/shallow boreholes". The "Guide to how…" specifies that artesian flows are to be immediately plugged and monitored to ensure effectiveness. Consequently, the contamination of soil by (saline) groundwater is not a likely occurrence during geophysical operations and it is considered that the requirements under Objective 5 adequately address the issue of groundwater flows and that a separate criteria under Objective 4 is not necessary.
21.	DEH	SEO Objective 6 **–** include "The speed limit within Tallaringa Conservation Park of 40 km/hr will be observed" within Guide to how Objectives can be Achieved	Included as a "Guide to how…" for Objectives 2 and 6.
22.	DEH	SEO Objective 8 **–** include "Entrances to access tracks will be disguised to discourage third party users" in Guide to How Objectives can be Achieved.	Added "and discourage third party access" following "Maximise use of vegetation or land forms to disguise operations".
23.	DEH	SEO Objective 10 **–** include "Rehabilitation/abandonment plans for surface activities will be developed in consultation with relevant stakeholders" within Guide to how Objectives can be Achieved.	Document edited to reflect this

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24.	DWLBC	EIR Weeds – The Animal & Plant Control Group regard the section on weed control as comprehensive & commend SAPEX on their engagement with regional NRM boards and landowners.	Acknowledged
25.	DWLBC	EIR & SEO Vertebrates – management of vertebrates, particularly dingos, is not covered in the plan. Dingos can become a significant hazard and an OHS&W and animal welfare problem in remote camps outside the Dog Fence. The plan should include consideration of operating procedures to avoid attracting dingos to camps by managing waste appropriately; staff should also be warned not to feed dingos.	Acknowledged. The waste management objective 9 includes a reference to the coverage of bins to prevent access by fauna and the EIRs refer to waste attracting scavenging animals such as dingoes. The SEOs have been modified to include “No domestic pets will be allowed on site” and “Feeding of wildlife (e.g. dingoes) will not be permitted” in the “Guide to how …”
26.	DWLBC	EIR & SEO It is recommended that the company adopt clear policies on dingos and dogs in camps.	Acknowledged. See comment above.
27.	Native Vegetation Council	EIR & SEO No issues to raise.	Acknowledged