Chapter 9
Biological Environment

This chapter reviews the existing biological environment in the region and the project area, and provides an analysis of the predicted project impacts. It includes a brief review of biological diversity, an assessment of the flora and fauna of the region and the project area, and a review of predicted impacts and mitigation.

The discussion in this chapter refers to the following areas (Figure 9.1):

- the project area, which includes all of the land within and adjacent to each of the three potential repository sites
- the Arcoona Tableland as described and delimited by Brandle (1998)
- the region, which comprises all of the Arcoona Tableland and land adjacent to the access route into each of the potential repository sites.

In addition, a wider region is referred to on occasions. This includes the Olympic Dam area to the north of the Arcoona Tableland and includes the Roxby land system.

Much of the region identified and all of the project area lies within the Woomera environmental association of Laut et al. (1977). The remainder of the region is referrable to the Andamooka land system. More recently, the Arcoona Tableland has been recognised as a distinct land system, the Arcoona land system (McDonald 1992). Figure 9.1 shows the locations of land systems within the region.

There have been no previous biological surveys of any of the three potential repository sites or immediately adjacent areas. However, data are available for similar habitats elsewhere on the Arcoona Tableland.

9.1 Biological Diversity

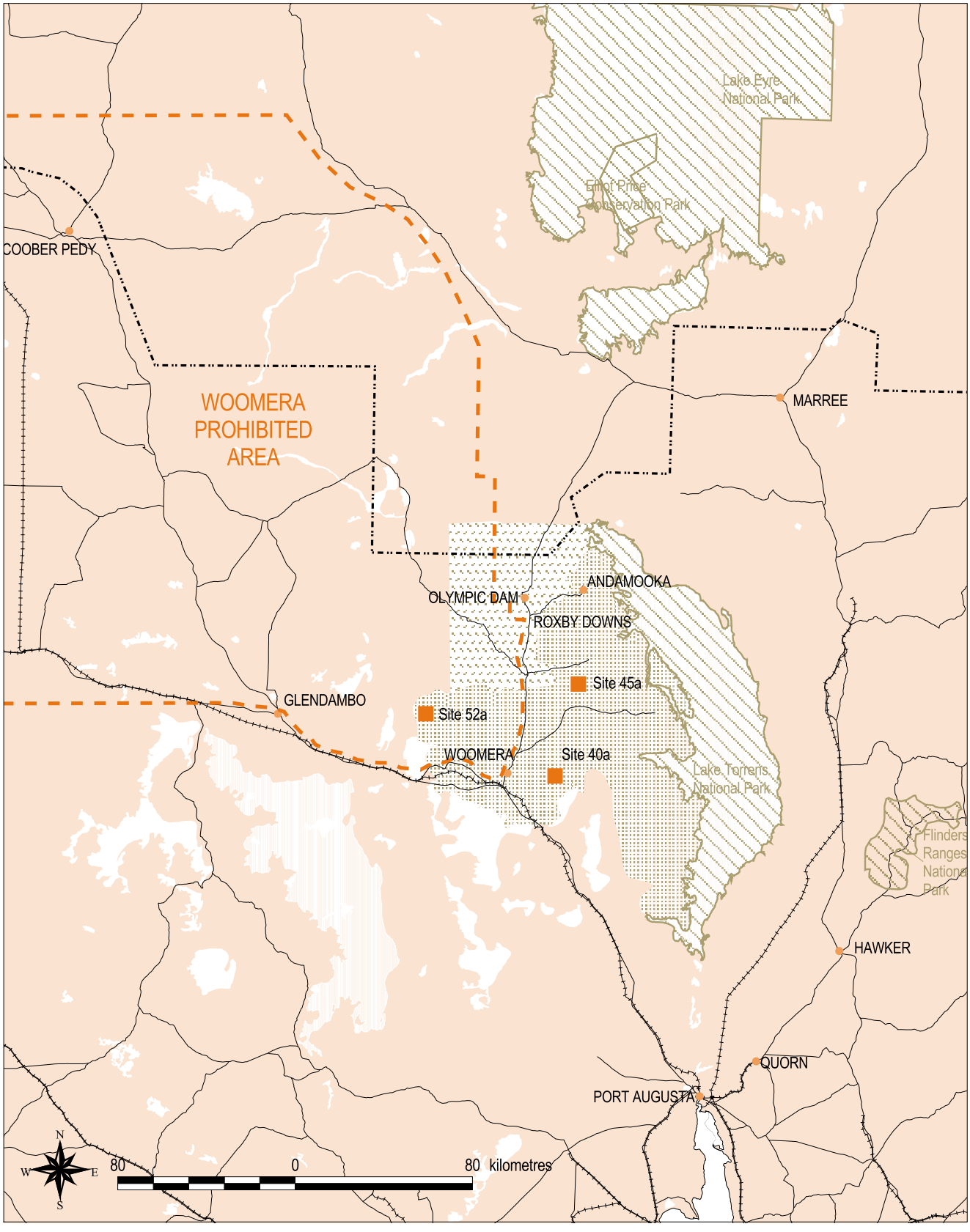
This section provides a brief review of the biological diversity (biodiversity) in the region and the project area.

9.1.1 Biodiversity

Conservation of biodiversity is a foundation of ecologically sustainable development (ESD) and one of the three principal objectives of the *National strategy for ecologically sustainable development* (Environment Australia 1992). Within Australia, the *National strategy for the conservation of Australia's biological diversity* (Department of Environment, Sport and Territories 1996) establishes a link between the current situation and the effective identification, conservation and management of Australia's indigenous biological diversity.

The biological diversity national strategy considers biological diversity at three levels: genetic diversity, species diversity and ecosystem diversity. The strategy contains six target areas:

- conservation of biological diversity across Australia
- integration of biological diversity, conservation and natural resources management
- management of threatening processes
- improvement of knowledge and understanding of biodiversity
- involvement of community
- Australia's international role.



- Towns
- Potential repository sites
- Arcoona Tableland & region
- Wider region
- Railway line
- Woomera Prohibited Area
- Dog fence
- Roads
- Salt lakes
- National parks and reserves

FIGURE 9.1
Regional map

During 2001 the Australian and New Zealand Environment and Conservation Council (ANZECC) published a review of the strategy and defined the national priorities for biodiversity conservation research (ANZECC 2001a, 2001b). In conjunction with the ANZECC reviews, Environment Australia (2001) redefined the ten priority actions, and the attendant objectives and targets for each action, for biodiversity conservation in Australia over 2001–05.

As part of the *National strategy for the conservation of Australia's biological diversity* and the National Land and Water Resources Audit, the South Australian Department for Environment and Heritage (SA DEH) is collating information on the bioregions of the State and preparing regional biodiversity plans. A draft biodiversity plan for the northern part of South Australia, the Rangelands bioregion (which includes the region discussed in this chapter), is expected to be completed by about mid-2002.

Baseline information for the audit is currently being compiled. In compiling information for both projects, SA DEH is primarily considering State information on factors such as threatened species and ecosystems, wetlands of regional and national significance, and areas of conservation (N Neagle, SA DEH, pers. comm. October 2001).

In its management of the national repository, the Department of Education, Science and Training is fully committed to establishing effective management of environmental issues, consistent with the principles of sustainable development. It would comply with relevant State and Commonwealth legislation and policy as a minimum environmental standard.

The environmental monitoring and management plan (EMMP) for the project would adapt elements of environmental management systems designed to improve environmental performance and achieve ESD.

9.2 Vegetation and Flora

This section discusses the terrestrial vegetation present in the region and the project area, the conservation status of the vegetation communities and individual species, introduced (alien) flora, past impacts, potential adverse and beneficial impacts of the proposal and their mitigation, and monitoring programs. The baseline flora report is provided in Appendix D1.

Legislation relevant to the project in relation to vegetation communities and species includes:

- *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act)
- *National Parks and Wildlife Act 1972* (SA) (NP&W Act), especially Schedules 7, 8 and 9 as revised in the *National Parks and Wildlife (Miscellaneous) Amendment Act 2000*
- *Native Vegetation Act 1991* (SA).

International, Commonwealth and State agreements, policies and strategies potentially relevant to vegetation communities and species include the:

- Convention on Biological Diversity (ANZECC 1993) and the *National strategy for the conservation of Australia's biological diversity* (Department of the Environment, Sport and Territories 1996)
- National Conservation Strategy for Australia (Department of Home Affairs and Environment 1983)
- *National strategy for the conservation of Australian species and communities threatened with extinction* (Endangered Species Advisory Committee 1992)
- *National framework for the management and monitoring of Australia's native vegetation* (ANZECC 1999a)
- *National principles and guidelines for rangeland management* (ANZECC 1999b), the draft *National strategy for rangeland management* (ANZECC 1996) and the draft *National land and water resources audit on rangelands* (National Land and Water Resource Audit 2000)

- *National weeds strategy: A strategic approach to weeds problems of national significance* (ANZECC 1999c)
- *Wetlands policy of the Commonwealth Government of Australia* (Environment Australia 1997)
- *Draft threatened species strategy for South Australia* (Department of Environment and Natural Resources 1993).

These documents are also applicable to the review and assessment of the fauna of the project area and region (Section 9.3).

9.2.1 Approach, Methods and Materials

The vegetation study was undertaken in three parts:

- A preliminary desktop study examined existing data from published and unpublished sources, including Commonwealth and State conservation schedules. Quantitative data that could be used for direct comparisons with the present survey data include data from the Stony Deserts Biological Survey (Brandle 1998), data collected during a recent review of the land systems of the Kingoonya Soil Conservation District (Badman 2001) and unpublished data held by Badman.
- During a field survey of the three potential sites in August 2001, quantitative data were collected on species composition and abundance, and 13 quadrats were established and sampled at each potential site as illustrated in Figure 9.2. The field survey also assessed potential impacts that could be caused by access to the sites, including the widening of access tracks and the construction of infrastructure such as boundary fences.
- Field data were entered into an Excel spreadsheet and analysed using the CSIRO 'PATN' data analysis program (Belbin 1992). Data from the field survey were compared against themselves, and against data reported in Brandle (1998) and Badman (2001).

Detailed information about all materials and methods are provided in Appendix D1.

Seasonal conditions at the time of the August 2001 survey were excellent for a flora survey. Good general rains of 75–100 mm fell across the whole of the Arcoona Tableland during late May and early June 2001. Most species were in flower and readily identifiable at the time of the survey. Several species were recorded that had not been seen in the district since the exceptional rainfall events of 1989.

9.2.2 Regional Vegetation

The Arcoona Tableland is a mostly treeless plain, with vegetation dominated by chenopod low shrubland that is less than one metre in height. The densest vegetation usually occurs in the gilgais that are a common feature of the tableland. Gilgais are micro-reliefs of soil produced by expansion and contraction through changes in soil moisture. The undulating surfaces are found in soils that contain large amounts of clay. The few trees that do occur often grow in small clumps. No trees are present at any of the three project area survey sites.

Laut et al. (1977) placed the Arcoona Tableland in the Woomera environmental association. This classification was not concerned primarily with vegetation. More recently, the Arcoona Tableland was recognised as forming a distinct land system, the Arcoona land system, by McDonald (1992), Kingoonya Soil Conservation Board (1996) and Badman (2001). The vegetation of the Arcoona land system has similarities with several other gibber plain land systems in the region (Badman 2001). These are principally the Oodnadatta, Paisley and Breakaway land systems to the northwest, although some small sections of the Ebunbanie land system, which occurs to the southwest, also have similar vegetation.

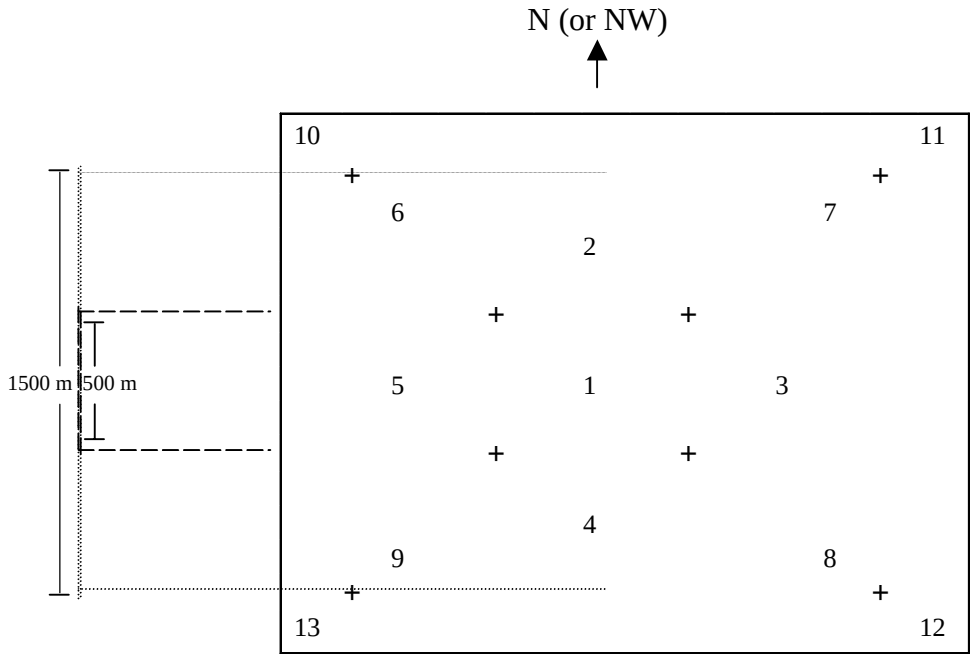


FIGURE 9.2
Sampling strategy for flora quadrats

The vegetation of the Arcoona land system is distinctive, as shown by the analysis of the Kingoonya Soil Conservation District dataset by Badman (2001).

Willis (1981) and Kraehenbuehl (1986) provided a general overview of the history of botanical research in the study area. One of the first publications to mention the plants of the Arcoona Tableland region was that of Cleland (1930) who travelled from Chances Swamp (Roxby Downs homestead) to Andamooka. Murray (1931) gave a more comprehensive report on the vegetation of an area extending as far north as Arcoona. Her studies covered the period 1927–30.

Jessup (1951) established the first quantitative data on the vegetation of the North-West Pastoral District, including the Arcoona Tableland. He listed the plants recorded in various vegetation associations and was the first worker in this region to adopt a vegetation association based approach. Lay (1979) and Maconochie (Maconochie and Lay 1996) subsequently repeated Jessup's surveys.

Preparation of the Environmental Impact Statement for the Olympic Dam Mine (Kinhill-Stearns Roger Joint Venture 1982) provided a focus on the biological values of an area north of the Arcoona Tableland and some northern parts of the tableland. Regional vegetation studies in the early 1980s (Fatchen 1981) were followed by a wide range of subsequent surveys (e.g. Fatchen and Associates 1982; Olympic Dam Operations 1996).

Later studies by or on behalf of WMC that are relevant to the present study include a vegetation survey of a corridor from Olympic Dam to Port Augusta for a new power line (Badman 1992).

Land Systems

Land systems are areas or groups of areas with recurring patterns of differing landforms, soils and vegetation (Christian and Stewart 1953). Each land system contains a combination of land units.

Laut et al. (1977) published a general classification of the environmental associations of South Australia, while McDonald (1992) was the first to publish a detailed description of the land systems of the Kingoonya Soil Conservation District. Kingoonya Soil Conservation Board (1996) made some changes to McDonald's descriptions and Badman (2001) carried out a major review of these land systems.

The three sites that form the project area are entirely within the Arcoona land system. Badman (2001) recently reviewed this land system and his description is given below:

> The gently undulating tableland of the Arcoona land system dominates the south-east of the [Kingoonya Soil Conservation] District on Arcoona, Bosworth, Andamooka, Purple Downs, Roxby Downs, Coondambo (Parakylia South block) and Wirraminna stations. A few low hills and escarpments are included within this system. Soils include stony red duplex and stony brown clay soils of the tablelands, stony clay soils over quartzite on hills, skeletal loams on escarpments and alluvial soils along watercourses.

Chenopod low shrublands dominate this land system, with some trees along watercourses and tall shrublands on isolated dunes. *Atriplex vesicaria* (bladder saltbush) dominates the vegetation, with *Sclerostegia* spp. (glassworts) also common. *Sclerolaena ventricosa* (salt bindyi), *Minuria cunninghamii* (bush minuria), *Frankenia serpyllifolia* (bristly sea heath), *Sclerolaena divaricata* (tangled bindyi), *Dissocarpus paradoxus* (ball bindyi) and *Eragrostis setifolia* (neverfail) are widespread, with *Astrebla pectinata* (barley Mitchell grass), *Sporobolus actinocladus* (ray grass) and *Ixiolaena chloroleuca* and *I. leptolepis (*plover daisies) moderately common in some areas but not common across the whole land system.

Isolated dunes, often with associated calcareous rises, have sparse woodland or tall shrubland vegetation where no single species dominates. *Acacia aneura* (mulga), *A. ligulata* (sandhill wattle) and *A. tetragonophylla* (dead finish) are common. The understorey commonly includes *Aristida holathera* and *A. contorta* (kerosene and mulga grasses). *Maireana sedifolia* (pearl bluebush), *M. pyramidata* (black bluebush), *Sclerolaena tatei* (Tate's bindyi) and *Zygophyllum aurantiacum* (shrubby twinleaf) are common on calcareous rises.

Neither sandy rises nor calcareous rises with *Maireana sedifolia* and *Zygophyllum aurantiacum* occur at or near any of the three potential repository sites.

Introduced Flora

McDouall Stuart did not record any alien species during his crossing of Australia during 1861–62 (Mitchell 1978) and the Horn Expedition recorded only one alien plant in 1894 (Tate 1896). Eardley (1946) listed two naturalised taxa among about 350 species collected by the Madigan expedition while crossing the Simpson Desert in 1939 (Madigan 1946). Mitchell (1979) considered that few weeds of any significance existed in Central Australia before 1954. At least 10% of the regional flora now consists of naturalised taxa (Badman 1995, 1999).

The disproportionately high number of alien species recorded in the Gairdner–Torrens botanical region in the last 20 years, when compared to the numbers for the Lake Eyre and North-West pastoral districts (Badman 1995), probably reflects the lack of work done in this area.

Badman (1995) found that sandy habitats and watercourses supported the greatest number of introduced species and gibber plains have a relatively low incidence of introduced taxa. Disturbed areas are the most prone to invasion by introduced species; establishment and maintenance of a perennial ground cover, particularly of native grasses, prevents their large-scale establishment.

Badman (1995) found that heavy summer rainfall at Olympic Dam in conjunction with conservative management practices could significantly decrease the incidence and cover of introduced species. Once summer growing native grasses, particularly perennial species,

become established they occupy the niches that would otherwise have been available for winter growing annual introduced species and prevent these from becoming established in the following winter–spring period. These grasses can remain for several years and continue to exclude introduced species. Several dry years, which can see the elimination of the perennial grasses, followed by a wet winter allow annual introduced species to establish in the niches vacated by the grasses.

9.2.3 Project Area Vegetation and Flora

The August 2001 survey identified 126 individual plant taxa from all three sites (total of 40 monitoring points). These were all recorded from a single habitat on the Arcoona Tableland, the gibber plain. Figure 9.3 illustrates three examples of flora quadrats. (The other significant habitats of watercourses, lake shores and sand dunes were not present in the project area.) This species list represents about 28% of the species listed for all of the Arcoona Tableland (Appendix D1).

The classification and results of the data indicate that the vegetation at all sites be placed into a single floristic assemblage. All monitoring sites at the three potential repository sites fall into the same group as distinguished by Brandle (1998).

There are slight differences between four floristic groups within the single floristic assemblage due to the presence or absence of one (or occasionally more) individual species, as well as to greater or lesser cover scores for individual species. The most obvious difference is in the two adjacent monitoring sites at one corner of Site 52a where the vegetation is dominated by *Maireana astrotricha* rather than *Atriplex vesicaria.* The main differences between the abundance of the most common perennial species at individual sites are shown in Table 9.1.

Most of the common annual and ephemeral species expected to occur were found at all three sites. The only species whose abundance may have influenced the floristic groupings was *Phlegmatospermum cochlearinum*, which was most common at Site 40a and least common at Site 52a.

Comparisons with Other Regional Areas on Similar Landforms

A binary classification (presence or absence of species with no cover scores) carried out on perennial species from sites on the Arcoona Tableland produced similar results to the classification of all species discussed in the previous section. The dendrogram from this classification is shown in Appendix D1.

Ten floristic groups were identified. The level of dissimilarity that distinguished these 10 groups was low, meaning that the vegetation of all of the Arcoona Tableland was similar when classified on the presence or absence of perennial species. The main difference between the first six floristic groups was a paucity of records of *Sclerolaena* spp. among members of these groups, particularly the combination of *Sclerolaena* spp. that was found at most quadrats during the August 2001 survey. Although this genus consists of mainly perennial species, they are short-lived perennials and some or all species may have been absent during the surveys whose data were used in this analysis. None of these past surveys encountered seasonal conditions as good as those of the August 2001 survey.

Similar comments apply to several other short-lived species or genera that were missing from sites that make up the first six groups. These included *Abutilon halophilum, Dissocarpus paradoxus, Euphorbia stevenii* and *Sida* spp*. Maireana appressa* was also missing from the datasets for all the sites in these six groups. This is a shorter-lived species than most of the other members of this genus and its numbers are known to fluctuate in response to seasonal conditions (Badman 2000).

Photo 1: Site 40a, Quadrat 4041

Photo 2: Site 45a, Quadrat 451

Photo 3: Site 52a, Quadrat 52a1

FIGURE 9.3
Three examples of flora quadrats

TABLE 9.1 Comparison of the abundance of the common perennial species at the three sites(1)

Species	Site 40a	Site 45a	Site 52a	Badman (2001)
Astrebla pectinata	Not recorded	Most common	Present	Present
Atriplex vesicaria	Most common	Common	Common	Common
Dissocarpus paradoxus	Present	Present	Least common	Present
Euphorbia stevenii	Present	Present	Least common	Present
Frankenia serpyllifolia	Present	Most common	Least common	Present
Ixiolaena chloroleuca	Not recorded	Most common	Present	Present
Maireana appressa	Present	Present	Least common	Present
Maireana astrotricha	Trace	Present	Present	Present
Minuria cunninghamii	Present	Least common	Most common	Present
Sarcostemma viminale	Not recorded	Not recorded	Present	Present
Sclerolaena brachyptera	Most common	Present	Present	Present
Sclerolaena divaricata	Most common	Present	Least common	Present
Sclerolaena intricata	Present	Present	Least common	Present
Sclerostegia spp.	Most common	Present	Present	Present
Sida spp.	Not recorded	Present	Not recorded	Present

(1) The three potential sites compared to the findings of Badman (2001) for the Arcoona land system as a whole

The 'control' sites are representative of the vegetation of the site as a whole.

Comparisons with Different Regional Landforms

A comparison of the floristic data from the three potential repository sites with floristic data from the rest of the Kingoonya Soil Conservation District (Badman 2001) showed distinct similarities between the potential repository sites' data and several other sites in different land systems.

This classification was based on data for 450 sites and used cover scores for all perennial species. All but three of the vegetation monitoring sites from the August 2001 survey were in the same floristic assemblage (see above).

The three different monitoring sites were all from Site 52a. These were placed in a different floristic group mainly because of their higher cover of *Maireana astrotricha.* Other differences were a greater cover of *Astrebla pectinata, Dissocarpus biflorus* and *Osteocarpum dipterocarpum* than the rest of the August 2001 survey sites, and lower cover of *Eragrostis setifolia*, *Euphorbia stevenii, Frankenia serpyllifolia, Sclerolaena divaricata* and *Sclerolaena intricata.*

Both floristic groups containing the August 2001 vegetation data were almost entirely from the Arcoona land system, with a few representatives from the Paisley, Oodnadatta, Wattiwarriganna and Ebunbanie land systems.

Comparisons with Previous Surveys

Data from three surveys are considered here, namely, those of Jessup (1951), Brandle (1998) and Badman (2001). A comparison of the floristic composition of the vegetation reported by these authors is given in Appendix D1 and a summary of the most numerous species (key or character species) in Table 9.2.

Jessup (1951) described two shrub–steppe vegetation associations from the Arcoona Tableland, the *Atriplex vesicaria–Ixiolaena leptolepis* association and the *Atriplex nummularia* ssp. *omissa* association. The former is the more common, while the latter is largely restricted to northern parts of the tableland.

Jessup (1951) described two vegetation units from the Arcoona Tableland: gilgais and the gibber-covered shelves between the gilgais. He reported that these shelves were mostly devoid of vegetation, a statement that is no longer true. Maconochie and Lay (1996) reported on the improvement in vegetation cover of the country since the time of Jessup's surveys.

It is more difficult to make direct comparisons with Brandle (1998), since this report covered almost 1100 sites from all of the stony deserts of northern South Australia. The floristic groups recognised for the Arcoona Tableland also included data from other areas. Four of Brandle's groups were widespread on the Arcoona Tableland, although none was restricted to this area. These were group 28 (*Sclerolaena ventricosa* low open sub-shrubland), group 34 (*Maireana astrotricha/Atriplex vesicaria/M. pyramidata* low open shrubland), group 35 (*Sclerolaena divaricata/Eragrostis setifolia/Atriplex vesicaria* low open shrubland), and group 36 (*Atriplex vesicaria/Sclerostegia medullosa* low very open shrubland).

Components of all of these groups were found, although, perhaps because of better seasonal conditions, none were found to form separate floristic groups. Brandle's groups 35 and 36 appear to be closest to the vegetation recorded during the current survey.

Seasonal conditions play a large part in the composition of the understorey at any given time. As an example, *Brachycome dichromosomatica* was recorded only once by Brandle (1998) and not at all by Jessup (1951) yet this was one of the most common species during the August 2001 survey. Similarly, *Phlegmatospermum cochlearinum* was not recorded by Jessup or Brandle but was quite common in August 2001. *Erodium crinitum* was also far more common during August 2001 than was reported from these earlier surveys.

Jessup (1951) reported the summer-growing grasses *Astrebla pectinata* and *Eragrostis setifolia* as being more common than in recent surveys. This may be due to subsequent grazing pressure, but is more likely to be due to the fact that none of the latter surveys, including the August 2001 survey, was undertaken after a wet summer. More recent work does not support the 'fairly rare' status of *Eragrostis australasica* reported by Jessup. This species is mainly summer growing but also depends on standing water in swamps which usually occur following heavy summer rainfall. Two shorter-lived grasses, *Panicum decompositum* and *Sporobolus actinocladus,* were also reported to be more common by Jessup than by later workers. This may be due to increased grazing pressure, although the summer rainfall factor may again be the main reason for this.

Several species listed in Table 9.2 have increased in abundance over the past 50 years since Jessup's survey. These include *Euphorbia stevenii, Frankenia serpyllifolia, Maireana aphylla, M. appressa, M. astrotricha, Osteocarpum dipterocarpum, Sclerolaena divaricata, S. intricata* and *S. ventricosa.* The increased abundance of the palatable *Maireana* spp. would suggest a decrease in grazing pressure, while the increase of the less palatable *Sclerolaena* spp. would suggest the opposite.

No introduced taxa were recorded by Jessup (1951). It is not known whether this is because these species were not then present or whether they were just ignored by Jessup. Badman (1995, 1999) reported that many of the present naturalised species were collected in the area before the 1950s but concluded that many of the early workers simply ignored 'weeds' because they did not form part of the native vegetation.

TABLE 9.2 Key species from the Arcoona Tableland

Species	Jessup (1951)	Brandle (1998) group no.				Badman (2001)	This survey		
		28	34	35	36		40a	45a	52a
Abutilon halophilum	FC	C		FC	FC	U	U	U	U
Astrebla pectinata	VC	C		C		FC		C	U
Atriplex vesicaria	D	C	D	D	D	D	D	D	D
Dissocarpus paradoxus	R	C		C	U	C	C	C	FC
Eragrostis australasica	FR	FC				U	FC	FC	U
Eragrostis setifolia	VC	FC	C	D	FC	C	FC	FC	FC
Euphorbia stevenii	FR	FC				U	FC	FC	U
Frankenia serpyllifolia	R	FC		C	C	C	FC	C	FC
Ixiolaena chloroleuca		FC						FC	U
Ixiolaena leptolepis	D(1)	C		U	U	FC		U	
Maireana aphylla	R	C	FC	U		U	U	C	FC
Maireana appressa	VR	+				U	FC	FC	FC
Maireana astrotricha	VR		D		U	FC	U		C
Maireana georgei	VR	+				U	U	U	U
Minuria cunninghamii		FC			C	C	FC	FC	FC
Minuria denticulata	FC	FC					R		
Minuria leptophylla	C								
Osteocarpum dipterocarpum	R	FC				U	FC	FC	FC
Panicum decompositum	VC	+							
Sclerolaena brachyptera	FC	FC	C	FC	FC	C	FC	FC	U
Sclerolaena divaricata	R			D	C	C	C	FC	U
Sclerolaena intricata				C	FC	FC	FC	FC	U
Sclerolaena ventricosa	FR	D	C	C	FC	C	C	C	C
Sclerostegia medullosa		FC	U	C	D		C		C
Sclerostegia sp.				U		C			
Sclerostegia tenuis	C				U			C	
Sida trichopoda	C	C						FC	
Sporobolus actinocladus	VC		FC	FC		FC	U	U	

D = dominant, C = common, FC = fairly common, FR = fairly rare, R = rare, VR = very rare, U = uncommon (see Appendix D for further explanation of how ratings were allocated)
(1) Ixiolaena leptolepis in Jessup's list includes *Ixiolaena chloroleuca*
A complete list of species recorded during the various surveys is given in Appendix D.

9.2.4 Conservation Status of Vegetation Communities

There are no vegetation communities with a recognised conservation status (Davies 1982; Neagle 1995; Specht et al. 1995; Schedules to EPBC Act and NP&W Act) at or near any of the sites examined during the current survey, nor on the Arcoona Tableland as a whole.

9.2.5 Conservation Status of Individual Species

One species, *Frankenia plicata,* is listed as Endangered in Schedule 1 of the EPBC Act. One species that has been recorded from the Arcoona Tableland is listed as Vulnerable under Schedule 8 and six species are listed as Rare under Schedule 9 of the National Parks and Wildlife (Miscellaneous) Amendment Act (SA). The species listed as Vulnerable is *Atriplex kochiana* and the Rare species are *Brachycome eriogona*, *Embadium stagnense, Frankenia plicata, Gratwickia monochaeta, Sclerolaena holtiana* and *Zygophyllum humillimum. Atriplex kochiana, Brachyscome eriogona, Embadium stagnense, Gratwickia monochaeta, Sclerolaena holtiana* and *Zygophyllum humillimum* are listed by Briggs and Leigh (1995) to be of national significance.

Table 9.3 summarises the species of conservation significance recorded from the Arcoona Tableland.

TABLE 9.3 Conservation status of individual species

Species	National Status		
	EPBC Act	**Briggs and Leigh (1995)**	**NP&W Act, NP&WMA Act**
Atriplex kochiana		Poorly known	Vulnerable
Brachyscome erogona		Rare	Rare
Embadium stagnense		Poorly known	Rare
Frankenia plicata	Endangered		Rare
Gratwickia monochaeta		Rare	Rare
Sclerolaena holtiana		Poorly known	Rare
Zygophyllum lumillimum		Poorly known	Rare

More detailed information about these species is provided in Appendix D1.

9.2.6 Non-Vascular Plants

A number of non-vascular plants have been recorded in the region, although much of the limited work done on this group of plants has been undertaken north and south of both the region and project area. Groups represented include fungi, cyanobacteria ('blue-green algae'), algae, lichens, liverworts and mosses. During the field work undertaken for this environmental impact study only lichens, liverworts and mosses were collected.

Compared with vascular plants, there has been very little survey of and interest in these plants, both in the region and Australia-wide. Consequently, there is limited understanding of their taxonomy and ecology.

Catcheside (1980), Filson and Rogers (1979), Flora of Australia (1992, 1994, 2001) Scott (1980), Scott and Stone (1976) and Lumbsch et al. (2001) documented some aspects of the taxonomy of these plants. Rogers (1972a, 1972b, 1982) and more recently Brock (1999), Eldridge (1996) and Eldridge and Tozer (1996, 1997) considered information about the

functional ecological values of the non-vascular plants that provide a 'biological soil crust' in the arid zone of Australia.

Within the region there have been a few collections, the most recent of which was well to the north of the project area (Brock 1999). Seppelt, Rogers, Filson and Donner are known to have made collections on or immediately adjacent to the Arcoona Tableland.

The lichen, liverwort and moss flora was collected at each of the sites. In all, 19 taxa of lichen, growing on both soil and rock substrates, were observed. Site 52a exhibited a greater abundance and slightly higher diversity in lichens, with 18 taxa recorded compared to 16 and 8 for Sites 40a and 45a respectively. Site 52a lichen flora was characterised by a large number of species growing on both silcrete and quartzite rock. Site 45a has a slightly lower diversity and lower abundance of soil lichens (five species) than either of the other two sites. The diversity of species growing on rocks was limited at Site 45a.

Liverworts were represented by one species only, *Riccia crystallina,* and this species was confined to canegrass swamp areas. It was present at all three sites.

Two species of moss were recorded from each of Sites 40a and 52a, and one at Site 45a.

These data indicate that the non-vascular plant flora of Site 45a was typical of a site that had been more heavily disturbed and had a less intact soil surface than either of the other sites (Eldridge and Tozer 1997).

No published data are available on the conservation status of arid zone non-vascular flora.

9.2.7 Access Roads

Two land systems would be traversed by the access roads described below. These are the Arcoona land system, described above, and the Roxby land system. (Access routes are also described in Section 7.4 and shown in Figure 7.2). Badman (2001) described the Roxby land system, to the north and west of the Arcoona Tableland on Roxby Downs, Parakylia, Billa Kalina, Andamooka, Purple Downs, Arcoona and Wirraminna stations, as:

> …a large dunefield overlying older alluvial plains or ancient basement limestone. Limestone is often very close to the surface or occurs as outcrops. Red duplex soils or firm calcareous sands overlie the limestone, while siliceous sands occur on dunes and firm calcareous sands occur on rises. Alluvial silts and clays are associated with drainage channels, claypans and swamps.
>
> Mulga *(Acacia aneura)* woodlands are dominant in the main vegetation association, with white cypress pines *(Callitris glaucophylla)* also common on the larger dunes and horse mulga *(Acacia ramulosa)* common on siliceous sands of both large and small dunes. Tall shrublands of sandhill wattle *(Acacia ligulata)*, narrow-leaved hopbush *(Dodonaea viscosa* ssp. *angustissima)* and bullock bush *(Alectryon oleifolius)* are also common on dunes.
>
> Understorey is often dominated by kerosene grass *(Aristida holathera)*, with sand sida *(Sida ammophila)*, ruby saltbush *(Enchylaena tomentosa)* and rosy bluebush *(Maireana erioclada)* all widespread but not common throughout the whole unit. Western myall *(Acacia papyrocarpa)* and mulga woodlands are common in swales and white cypress pine occurs in some swales with deep sandy soils.
>
> Tall shrubland [sic] of senna (*Senna artemisioides* ssp.) are widespread and low shrublands of bladder saltbush (*Atriplex vesicaria*) and low bluebush (*Maireana astrotricha*) are common in the understorey of swales, although these are usually dominated by mulga grass (*Aristida contorta*). Australian boxthorn (*Lycium australe*), ball bindyi (*Dissocarpus paradoxus*), oblique-spined bindyi (*Sclerolaena obliquicuspis*) and desert lantern bush (*Abutilon otocarpum*) are widespread but not common throughout the whole association.

The other floristic groups represent changes in abundance of particular species rather than distinct land units. Small swamps are often bordered by *Melaleuca xerophila* (tea tree) low woodlands and *Eragrostis australasica* (swamp canegrass) is also common in or bordering

such places. These areas are usually quite small. Claypans are more common than swamps but very little vegetation grows on them. They are often bordered by halophytic species, particularly chenopods, but these areas usually support the same species as the surrounding swales.

The proposal is for an upgrading of the access roads within the existing disturbed corridor and using existing materials. In this case the biological environmental impacts are likely to be minimal.

All access roads described below begin at the point where they leave the bitumen of the Woomera to Olympic Dam road, having proceeded from Woomera, and are shown in (see Figure 7.2).

Site 40a

The track used for access to this site is nearly twice as long as the straight-line distance between the site and Woomera. It traverses the undulating gibber plains of the Arcoona Tableland (Arcoona land system), a number of tableland escarpments and would also have to cross one large watercourse and several minor ones. Watercourse crossings are sandy.

This route does not encounter any vegetation that is significantly different from that recorded at other monitoring sites on the tableland.

Site 45a

The current access track proceeds along the Andamooka Homestead access road and then the old Arcoona to Andamooka opal field access road. It crosses areas of both the Roxby and Arcoona land systems.

Providing that all road material was obtained from the existing, defined road area only, upgrading the track would be practicable.

Site 52a

The access to this site follows existing major roads through the Woomera Prohibited Area (Arcoona land system). Most of these roads have a bitumen surface or fair to good quality unsealed surface. There would be no effect on native vegetation other than that which already occurs during routine road maintenance activities.

9.2.8 Introduced Plants

Ten of the 126 species (8%) recorded during the August 2001 survey are introduced taxa. This figure is lower than the overall percentage of introduced taxa recorded on the Arcoona Tableland. Appendix D1 lists 453 taxa for the Arcoona Tableland, of which 57 (13%) are introduced. Badman (1999) considered that introduced species made up about 10% of the total flora of northern South Australia (excluding the Flinders Ranges). Badman (1999) also reported 13% of flora as introduced for the Olympic Dam region, just north of the present study area, but including a different land system and greater diversity of habitats.

The low incidence of introduced taxa recorded during the current assessment may be partly due to the relatively undisturbed condition of the study sites. However, none of these sites are completely undisturbed and Laut et al. (1977) described the whole area as being in a ‘disturbed natural’ condition. The whole region has a long history of grazing by native, domestic and feral herbivores, as well as being subject to the operations and infrastructure of sheep and cattle stations. In addition, Site 52a has been heavily disturbed by the operations of the Woomera rocket range, as demonstrated by the many pieces of old infrastructure scattered across and adjacent to the site. Despite this, all of the sites remain relatively undisturbed by ground disturbing activities other than the feet of animals.

9.3 Fauna

This section details the fauna component of the biological environment for the region and the project area including threatened species and the status of threats and threatening processes, pest species, plus predicted impacts and mitigation measures.

9.3.1 Approach, Methods and Materials

The fauna assessment was established in three parts:

- a review and synthesis of published and unpublished data
- field surveys during August and October 2001
- analysis of results from the field information in relation to existing data to provide an assessment of actual and potential impacts of the proposal on faunal habitats and species.

Detailed information on all aspects of the field surveys, including all field data, is provided in Appendix D2.

9.3.2 Existing Information

The broad scale information most relevant to the current study comes from a biological survey of the Stony Deserts (Brandle 1998), and the studies associated with the design, construction, operation and expansion of WMC Limited's Olympic Dam Project from 1981 to present.

The area reviewed by Brandle (1998) encompassed a significant portion of northern South Australia and included all of the Arcoona Tableland. The environmental impact statements for the Olympic Dam mine, and its subsequent expansion, assessed an area approximately 40 km north of Site 45a (Kinhill-Sterns Roger Joint Venture 1982; Kinhill Engineers 1997). However, some of the data are directly relevant to the Arcoona Tableland, especially the assessment of infrastructure corridors south of Olympic Dam. The latter reference also reviewed and summarised the massive amount of baseline data that had been acquired over the previous 16 years of operation and monitoring at Olympic Dam.

In addition, Dr John Read has undertaken a extensive range of ecological studies in the region, both as an employee of WMC and as part of his own research interests (J Read Ecological Horizons, pers. comm. October 2001). The Lake Eyre South Monograph Series (Slaytor 1999a,b) provided detailed environmental information for the arid zone north of Olympic Dam, including the whole of the northeast of South Australia west of the Stuart Highway. However, some of the habitat and species distribution information for vertebrates is directly relevant to the current assessment.

Ehmann and Tynan (1997) provided a useful summary of the native and introduced vertebrate species recorded in the Gawler and Kingoonya soil conservation districts.

The listing of vertebrate species and their distribution for all of South Australia in Robinson et al. (2000) forms the basis of the taxonomy for the fauna species referred to in the section.

These studies and records from various sources, such as SA Museum, SA DEH and Birds Australia databases, form the basis of the predictive model for vertebrates in the project area and region.

(Note: Reference to specific studies and publications about individual areas and species in the region is made in the relevant section of the text.)

Photo 1: Site 40a, Fauna Survey Site No. 3

Photo 2: Site 45a, Fauna Survey Site No. 3

Photo 3: Site 52a, Fauna Survey Site No. 3

FIGURE 9.4
Example fauna survey sites

Although in recent times the quality and quantity of data for vertebrate species and their ecology in the region has significantly increased, little attention has been paid to invertebrate species. This is primarily due to the lack of qualified scientists and amateurs with the interest to undertake the requisite detailed studies into their taxonomy and ecology. Most of WMC's well-documented studies on invertebrates have been associated with the macro-invertebrates of the mound springs.

Extensive collections of terrestrial invertebrates have been made at some sites in the region, and the wider region, and lodged with the SA Museum and specialist taxonomists. These include the work done by Brandle (1998), studies for the Lake Eyre South monograph series, monitoring and research programs by WMC, and specific collections by staff from the SA Museum and the University of Adelaide. However, most of this material remains to be reviewed in detail. Of particular relevance to the current study is the potential use of some groups, primarily ants, as bio-indicators (Andersen 1990, 1993; Greenslade 1979; Read 1996; Read and Andersen 2000).

9.3.3 Regional Perspective

All three sites of the project area are characterised by a flat to gently undulating gibber plain on red duplex soils (Laut et al. 1977). All three potential repository sites are located on gibber plains and are, or have been, grazed by sheep. Sites 40a and 52a are located on gently undulating plains, while the landform of Site 45a is a flat plain with little immediate change in relief, notably to the east and south.

The sites are also characterised by low chenopod shrubland vegetation, with areas of gibber plain, canegrass swamp and gilgai. Figure 9.4 illustrates typical habitats in each of the three sites.

All three sites are similar to each other but differ in several aspects, namely:

- the relative proportion of canegrass swamp, which is greatest at 40a and least at 52a, with 45a being intermediate
- type and extent of gibber cover — Sites 40a and 45a are dominated by quartzite and Site 52a is dominated by silcrete
- the type and size of gilgai — Site 40a has several very large (1–2 ha) powdery, deep cracking gilgais with a large percentage of quartzite cobbles and boulders; Site 45a has smaller areas, with smaller quartzite rocks and often with gypsum in the subsoil; Site 52a gilgai areas are much smaller and often linearly oriented with small silcrete rocks in situ and as a surface scatter
- soil type and distribution, especially the type of soil cracks, with the deepest, widest cracking soils being in Sites 40a and 45a, while Site 52a generally has deep, relatively narrow cracks.

9.3.4 Climate

The climate and weather conditions of the region and, therefore, the project area exert a large influence on the distribution and abundance of the region's wildlife. The regional rainfall regime, in particular, has major implications for the region's faunal groups, often affecting the distribution and abundance of many species, and consequently the region's species richness (Owens and Read 1999; Read and Owens 1999a). The climate of the region is discussed in some detail in Section 8.6.

Large rainfall events are especially critical for seasonal birds, including wetland species, but they also influence the populations of sedentary birds. The heavy rainfall of 1989 highlighted the direct relationships of population and rainfall, and the life history strategies for many species (Read and Ebdon 1998). These events begin a medium term cycle of population growth and reproduction that provides benefits to species higher on the food chain.

Reptile diversity is not only influenced by rainfall but by seasonality, amount of sunshine and evapotranspiration. All are considered to be significant determining factors on diversity and abundance (Read 1995). Mammals, birds and invertebrates are probably also affected by these factors.

9.3.5 Predictive Fauna Model for the Region, Arcoona Tableland and Project Area

This section provides a summary of the actual and potential vertebrate fauna present in the region, Arcoona Tableland and at each of the three potential repository sites.

Mammals

The Australian arid zone fauna has experienced enormous changes in the assemblage of species since European settlement, and particularly since the introduction of *Oryctolagus cuniculus* (European rabbit), *Vulpes vulpes* (red fox), and *Felis catus* (feral cat). WMC (Olympic Dam Corporation) Ltd (1997) indicated that almost half of the arid zone terrestrial mammals were extinct on the Australian mainland and Owens and Read (1999) considered 15 species to be locally extinct. Owens and Read (1999) reported that 35 mammal species were extant for the Lake Eyre South region, while Kinhill Engineers (1997) recorded 26 mammal species for the Olympic Dam expansion project area.

Research by Brandle (1998) on the Arcoona Tableland and Owens and Read (1999) in the Lake Eyre South region found that cracking clay soils supported the highest species richness per site for small mammals, and chenopod shrublands and gibber tablelands supported the highest habitat richness of the six sampled habitat groups.

Short-beaked Echidna

Tachyglossus aculeatus (short-beaked echidna) is sparsely distributed within the region, with Brandle (1998) only recording the species once on the Arcoona Tableland. Furthermore, Kinhill Engineers (1997) recorded it for the first time in the Olympic Dam and Andamooka region in 1996, following 16 years of monitoring. Within arid regions, Strahan (1998) indicated that the species shelters in caves or crevices to avoid temperature extremes. One animal only was recorded at Site 40a.

Dasyurids

Four species of dasyurid, *Planigale gilesi* (paucident planigale), *P. tenuirostris* (narrow-nosed planigale), *Sminthopsis crassicaudata* (fat-tailed dunnart) and *S. macroura* (striped-faced dunnart), are known to occur on the Arcoona Tableland and further north in the Lake Eyre South region.

Cracking clay soils (gilgai) were significant habitat for all species, particularly *Planigale* spp. which were more selective in their habitat requirements (Owens and Read 1999). *Sminthopsis* spp. were more widespread, with *S. macroura* recorded in all habitat types including gibber tableland, sand dunes and chenopod shrubland. *S. crassicaudata* was less selective and was principally recorded on gibber tableland and cracking soils. Field results during the present survey confirmed these habitat preferences.

Kinhill Engineers (1997) and Owens and Read (1999) agreed that *P. gilesi* is locally rare, while both dunnarts appeared to be common.

Within the project area, *P. tenuirostris* was recorded for Sites 40a and 45a, *S. crassicaudata* from Sites 45a and 52a, and *S. macroura* from all three sites. The last species was the most numerous small mammal captured during the survey. *P. gilesi* was not recorded but is likely to be present at Site 40a and probably at Site 45a. The deep cracking soils of gilgais and areas adjacent to canegrass swamps were the preferred habitats.

Kinhill Engineers (1997) suggested that *Antechinomys laniger* (kultarr) was potentially present in the region of Olympic Dam. This species has a preferred habitat of sand dune, gibber tableland and mulga scrub. Consequently, it could also occur further south, although it would be at the very southern limit of its distribution. The species is considered rare over its range; it is noted for being evasive, solitary and nomadic.

Macropods

Macropus fuliginosus (western grey kangaroo), *M. robustus* (euro) and *M. rufus* (red kangaroo) occur in the region. *M. fuliginosus* is abundant in the south-central and south-western portion of Australia and has a secure conservation status. *M. rufus* and *M. robustus* are common but the euro is generally restricted to escarpments and rocky outcrops. The species has also been recorded on cracking soils and woodland, and is essentially solitary. In contrast, *M. rufus* is most abundant in gibber tablelands but occurs in most habitats. Population numbers vary markedly depending upon water supply and seasonal conditions. *M. fuliginosus* and *M. rufus* were common at all sites. *M. robustus* was present adjacent to Site 52a and would be likely to occur in and adjacent to the other sites.

Bats (Molossids and Vespertilids)

Eleven species of bat are known to occur in the region (Ehmann and Tynan 1997; Kinhill Engineers 1997). The Lake Eyre South (Slaytor 1999a,b) surveys recorded four species, none of which were associated with gibber areas. The apparent absence of bats in these habitats was also noted in Brandle (1998).

Woodland habitats, such as myall woodland and mulga scrub, are favoured by many species of bat because roost sites (tree hollows and under tree bark) are available. However, arid zone bats will travel up to 20 km from such habitat to drink from and forage over bodies of fresh water (Reardon 2001). Consequently, gibber habitats would be used during foraging activities but at low densities.

Field surveys in the vicinity of the three sites have confirmed the low abundance and diversity of bats in the region, a consequence of sparsely distributed roosting habitat (Reardon 2001). Species present in the Arcoona Tableland and the project area were *Nyctinomus australis, Mormopterus* sp., *Nyctophilus geoffroyi* and *Vespadelus baverstocki.* All species were recorded over water sources or in suitable roosting habitat adjacent to the sites. The abundance of bats in the project area was comparable to that recorded for the Lake Eyre South region (Owens and Read 1999) and for the Arcoona Tableland (Brandle 1998).

Studies to the north of the project area around Olympic Dam have recorded additional species including *Nyctinomus australis* in woodland habitats (Owens and Read 1999; Kinhill Engineers 1997), while *Chalinolobus gouldii* was recorded equally in rocky outcrop and woodland habitat. *Vespadelus baverstocki* preferentially used woodland habitat with a limited number of records over chenopod shrubland. *Nyctophilus geoffroyi*, a common species, was recorded in sand dune and rocky outcrop habitat.

Many of the bat species recorded at Olympic Dam appear to have a seasonal presence within the region. *Nyctinomus australis* has only been recorded during autumn and winter months; *Mormopterus planiceps* and *Scotorepens greyii* are common in spring; and *Nyctophilus geoffroyi* is common in spring and summer.

Nyctophilus timoriensis (greater long-eared bat) and *Saccolaimus flaviventris* (yellow-bellied sheathtail-bat) are listed as being State Vulnerable and Rare respectively. Both species, although recorded in the wider region, have not previously been recorded on the Arcoona Tableland.

Murids

Seven native murid species potentially occur within the region. Brandle (1998) suggested that *Leggadina forresti* (Forrest's mouse) had a preference for stony plains, but Owens and Read (1999) indicated that cracking soils and chenopod shrubland were favoured. Kinhill Engineers (1997) suggested the preferred habitat was tussock grassland and low chenopod shrubland. Surveys at each potential repository site indicate gilgai–gibber ecotone habitat was locally favoured. Consequently, the species probably occupies a number of habitats across the Arcoona Tableland. The species is recorded to have low capture rates, although this was not evident at Site 45a. *L. forresti* has been secure over its range (Brandle 1998; Lee et al. 1995), although it is listed as Rare under State legislation.

Brandle (1998) recorded *Pseudomys bolami* (Bolam's mouse) and *Pseudomys hermannsburgensis* (sandy inland mouse) on the Arcoona Tableland. Although Brandle (1998) only recorded *P. bolami* on the Arcoona Tableland and in the Lake Eyre South region, its preferred habitat was not gibber plain or gilgai. Owens and Read (1999) recorded the species in low chenopod shrubland and Kinhill Engineers (1997) indicated the habitat to be sandy to loamy soils in sparse mallee or Acacia woodland. It is unlikely that this species occurs in the project area.

P. hermannsburgensis is a species of the gibber plains and sand dunes and, though marginal habitat may be present adjacent to all sites, it would be at the southern-most edge of its distribution. It is unlikely to occur at any of the sites.

Pseudomys australis (plains rat), a nationally Vulnerable species, preferentially inhabits gibber plains and gilgai (Brandle 1998). This species is at risk due to introduced competitors and predators (Lee et al. 1995).

P. australis has been recently recorded at a number of sites north of the region and project area (e.g. Dismal Plain), with the Lake Eyre South region contributing a significant amount of suitable habitat for the species (Owens and Read 1999). The species has also been recorded in the Olympic Dam area (Kinhill Engineers 1997). There is a very recent record for this species in the Woomera Prohibited Area, at Ashton Hill, about 18 km south of Site 52a (A Starkey, Defence, pers. comm. August 2001). The species was not recorded at Site 52a but further research may indicate its presence adjacent to the site.

Until the current field survey, the species had not been recorded in the central area of the tableland in recent history. Specimens were captured in a variety of habitats but particularly on and adjacent to large areas of rocky, cracking clay gilgai. Brandle et al. (1999) considered this to be a secondary type of habitat. However, for the population of Site 40a, gilgai habitat appears to be preferred habitat and required for their continued existence (Appendix D2).

Kinhill Engineers (1997) recorded *Notomys fuscus* (dusky hopping-mouse) from near the Olympic Dam project area. The species is associated with sand dune habitat, and consequently is unlikely to be present at any of the sites under investigation. *Notomys alexis* has recently colonised sand dune habitat around Olympic Dam (J Read, Ecological Horizons, pers. comm. November 2001) but is unlikely to occur at any of the three potential repository sites. Similarly, *Pseudomys desertor* (desert mouse) is a species of the sandplains, dunes and vegetated floodouts well to the north of the project area (Brandle 1998) and is unlikely to be present at the sites. However, suitable habitat for the species is present on the Arcoona Tableland.

Dingo

The study area is just south of the dog fence, and under the *Dog Fence Act 1946* (SA), *Canis lupus dingo* (dingo) and dingo–dog hybrids are classified as vermin. Dingoes are abundant north of the dog fence and, although present in low densities, the species does occur in the region, tableland and project area.

Avifauna

Kinhill Engineers (1997) reported 175 bird species for the Olympic Dam region, while Read and Badman (1999) reported 187 species for Lake Eyre South region. Recent work by Read and Ebdon (1998) on the lakes of the Arcoona Tableland identified 56 species of waterbirds in the five-year period following the filling of many of the lakes (in 1989). Based on all sources of information, 118 bird species have been recorded on the Arcoona Tableland.

The research by Read and Badman (1999) highlights the importance of water bodies and structurally diverse communities in the wider region for bird fauna. Woodland communities, such as those associated with sandy rises, and wetland communities are structurally and compositionally more diverse than the chenopod shrublands of the gibber plains, and consequently provide a greater diversity of niches and habitat for a larger number of species. In contrast, bird assemblages of the gibber plains and cracking clays are reduced in species richness due to the less structurally diverse vegetation.

The lack of habitat complexity associated with the gibber plains and cracking clay soils vegetation suggests that a large proportion of the species recorded are nomadic, vagrant or migratory birds moving between resources or exploiting environmental fluctuations (e.g. flooding of inland lakes).

Table 9.4 summarises the habits of the species recorded for the Arcoona Tableland.

TABLE 9.4 Habit characteristics of Arcoona Tableland bird species

	No. of potential species
Permanent residents	28
Nomadic or with a moderate chance of being resident	67
Migratory or seasonal visitors	18
Vagrant	4
Total	**117**

Of those species recorded on the Arcoona Tableland (SA Museum, Birds Australia and SA DEH database records; Brandle 1998), more than half are considered to be opportunistic or moderately sedentary. Such species include *Charadrius australis* (inland dotterel), *Ardeotis australis* (Australian bustard) and *Epthianura aurifrons* (orange chat) (Brandle 1998). Permanent residents of the gibber tablelands include *Calamanthus campestris* (rufous fieldwren), *Malurus leucopterus* (white-winged fairy-wren), *Anthus novaeseelandiae* (Richard's pipit) and *Cinclosoma cinnamomeum (*cinnamon quail-thrush). The Arcoona Tableland provides key habitat for these species and consequently they will be more affected by development proposals than opportunistic species.

Populations of sedentary bird species experience fluctuations as a result of seasonal and annual variability in the abundance and availability of resources on the tableland. Invertebrate and vertebrate breeding following rains provide indirect benefits for sedentary species of the surrounding tableland as occurred during 2001. Drier years bring lower bird densities and thus less chance of detecting the species' presence. Furthermore, drier years will result in fewer individual opportunistic species, particularly those associated with ephemeral water sources.

The location of the Arcoona Lakes in the region is significant for the presence of many species, particularly waterbirds, migratory species and many opportunistic species. Read and Ebdon (1998) recorded 56 species over a period of five years, 15 of which bred during this time.

A number of species potentially present in the region are of listed conservation significance. Approximately 22% of arid-zone birds have declined since European settlement and 8% are of national conservation significance (WMC (Olympic Dam Operations) Ltd 1997). Most of these species are ground breeding birds and consequently have been heavily impacted by the introduced predators, the feral cat and red fox. However, no arid-zone birds are recorded as being extinct (WMC (Olympic Dam Operations) Ltd 1997). Table 9.5 summarises the conservation rating for bird species of the Arcoona Tableland. Eleven of these species are associated with wetland areas and the project area does not provide suitable habitat. *Ardeotis australis* (Australian bustard) and *Falco peregrinus* (peregrine falcon) are threatened species. Both were observed at or near Site 45a while the former species was also recorded at Site 40a. Both species are unlikely to be breeding in the area and future sightings will probably be infrequent.

In contrast to those species that have declined since European settlement, a number of species have benefited. The establishment of a network of permanent water sources (principally stock watering points) has contributed to the increase in abundance of species such as galah, crested pigeon, yellow-throated miner, Australian raven and white-plumed honeyeater. Water sources have also concentrated the distribution of predators and subsequently those bird species of conservation significance have declined in these immediate localities (Read and Badman 1999).

TABLE 9.5 Bird species and their conservation status

Species name	Common name	EPBC Act	NP&W Act	Distribution status
Anas rhynchotis	Australian shoveler		Rare	N
Ardea intermedia	Intermediate egret		Rare	N
Ardeotis australis	Australian bustard		Vulnerable	N
Biziura lobata	Musk duck		Rare	N
Cacatua leadbeateri(1)	Pink cockatoo		Vulnerable	N
Falco peregrinus(1)	Peregrine falcon	M	Rare	Va
Gallinago hardwickii(1)	Latham's snipe		Vulnerable	S/Va
Grus rubicunda(1)	Brolga		Vulnerable	Va
Hamirostra melanosternon	Black-breasted buzzard		Rare	N
Neophema chrysostoma	Blue-winged parrot		Vulnerable	N/S
Numenius madagascariensis	Eastern curlew	M	Vulnerable	S/Va
Oxyura australis	Blue-billed duck		Rare	N
Pedionomus torquatus(1)	Plains-wanderer	Vulnerable	Endangered	Va
Phaps histrionica(1)	Flock bronzewing		Vulnerable	N/Va
Plegadis falcinellus	Glossy ibis	M	Rare	N
Podiceps cristatus	Great-crested grebe		Rare	N/Va
Porzana pusilla(1)	Baillon's crake		Rare	N/Va
Stictonetta naevosa	Freckled duck		Vulnerable	N

N = nomadic, M = migratory species, Va = vagrant, S = seasonal

(1) Not recorded by Brandle (1998), Read and Ebdon (1998), nor SA Museum as occurring on the Arcoona Tableland

Herpetofauna (Reptiles and Amphibians)

Australia's arid zone is characterised by an abundant and diverse reptile fauna and a few amphibian species.

Kinhill-Stearns Roger Joint Venture (1982) suggested that in the area west of Lake Torrens 63 species of reptiles were found, while studies in the Olympic Dam project area have recorded 41 species. Across all habitats of the Arcoona Tableland, 56 species have been recorded.

Reptile species richness in the region is greatest in sandy habitats; clay soil habitats and those communities with low structural diversity (e.g. some shrublands) have the lowest

number of species (Brandle 1998; Read and Owens 1999b). This contrasts to mammals which have the greatest species diversity on clay soils. The low structural complexity and predominance of clay soils suggests that species diversity will be relatively low at sites on the Arcoona Tableland.

No species recorded for the region are listed as being of particular conservation significance under the EPBC Act and NP&W Act or Cogger et al. (1993). However, Brandle (1998) notes that three species maybe of future taxonomic significance: *Cyclodomorphus venustus* (samphire slender-bluetongue), *Ctenotus olympicus* (saltbush ctenotus) and populations of the *Lerista dorsalis* (four-toed slider) from the Arcoona Tableland, which are characterised by a brilliant red-orange tail.

More detailed population genetic studies by WMC on this last species indicate that this is not sufficiently distinctive to be recognised as a new species (Kinhill Engineers 1997).

Brandle (1998) also listed *Antaresia stimsoni* to be of Indeterminate status within South Australia and Uncertain nationally. The species is probably restricted to rocky ranges and is unlikely to occur at any of the proposed sites. It could be present along the rocky water courses adjacent to the access tracks to all project area sites.

Ctenotus taeniatus is also of taxonomic interest, as it is possibly a separate species, currently referred to as *C. brooksi taeniatus* (M Hutchinson, SA Museum, pers. comm. January 2002).

Appendix D2 provides a summary of those species recorded on the Arcoona Tableland and in the region.

Field assessment recorded 12 species at Site 40a and 13 species at each of Sites 45a and 52a. These totals probably underestimate the species diversity and abundance of reptiles, especially at Sites 40a and 45a where the habitat diversity is greater than at Site 52a.

Agamidae

Ctenophorus fordi is a species of sand dunes and is only associated with areas of *Gunniopsis quadrifida* and *Salsola kali* (Read and Owens 1999b). Consequently, it is unlikely that this species will be recorded at the project area, even though it has been recorded on the Arcoona Tableland.

Similarly, *C. pictus* generally inhabits sandy habitats, although it may be found in low shrublands over heavier soils.

Studies by Read and Owens (1999b) suggests that *C. gibba* is a nomadic species and does not burrow as much as other members of the genus. This species inhabits cracking soils and replaces *C. nuchalis* in such areas. The latter species inhabits sandy or loamy soil habitats. The northern areas of gibber, not the Arcoona Tableland, provide critical habitat for *C. gibba* (Brandle 1998).

Of the *Tympanocryptis* species previously recorded on the Arcoona Tableland, *T. tetraporophora* (Eyrean earless dragon) is the most abundant agamid of the gibber plains (Appendix D2). *T. intima* is also widespread on gibber plains, while *T. lineata* occasionally occurs.

Geckonidae

Nine species of gecko have been recorded on the Arcoona Tableland, with a further five species recorded for the region. *Diplodactylus tessellatus* is typically found on rocky, cracking soils; *D. damaeus* and *D. stenodactylus* are located on sandier soils and consequently are unlikely to be present in the project area.

Species of *Gehyra* are unlikely to be found at the proposed sites even through they are known to occur on the Arcoona Tableland. *Gehyra purpurascens* appears to be a tree specialist, while *G. variegata* is associated with woodland and rocky habitats (Brandle 1998) and will colonise infrastructure, such as buildings (J Read, Ecological Horizons, pers. comm. November 2001). Such habitat requirements are not provided within the sites but would be met if the proposal goes ahead.

Heteronotia binoei is a generalist species occupying a large range of habitats but favouring loose surface rock and drainage lines. The species is also commonly found in built structures.

The *Nephrurus* species, *N. levis* and *N. milii* (knob-tailed geckos), have been recorded on the Arcoona Tableland. However, *N. levis* is associated with sandy habitats and is unlikely to occur in gibber areas. *N. milii* is present in rocky habitats and occurs at all three sites.

N. deleanei (Pernatty knob-tailed gecko) is a vulnerable species restricted to dunes along the margin of the Arcoona Tableland. Suitable habitat for the species does not occur at any of the sites.

Pygopodidae

Three species have been recorded both in the region and also on the Arcoona Tableland. The legless lizards of the region appear to be widespread but uncommon. SA Museum records list *Pygopus nigriceps* (black-headed scaly-foot) within the vicinity of all three sites.

Scincidae

Half of the 23 species of skinks recorded on the Arcoona Tableland were probably associated with gibber plains and gilgai soils. *Ctenotus olympicus* and *C. strauchii* are species of such habitats; *Tiliqua rugosa* and *Menetia greyii* are widespread species also occurring in a number of other habitat types. Brandle (1998) also recorded *Eremiascincus richardsonii* as potentially being present.

Lerista dorsalis populations of the southern and central sections of the Arcoona Tableland are distinctively coloured, having bright red tails (Brandle 1998). Similar colouration also occurs in *Lerista bougainvillii*.

Varanidae

Varanus gilleni (pygmy mulga goanna) and *V. gouldii* (sand goanna) are residents of the Arcoona Tableland. Both occur across the project area but the former is uncommon.

Typhlopidae

The blind snakes, *Ramphotyphlops* species, are widespread in the arid zone of South Australia. Two species, *R. bituberculatus* and *R. endoterus*, have been recorded on the Arcoona Tablelands and may be present at the proposed sites.

Boidae

Antaresia stimsoni (Stimson's python) is present on the Arcoona Tableland and has been recorded at Woomera (SA Museum database) and on Andamooka Station (J Read, Ecological Horizons, pers. comm. November 2001). *Aspidites ramsayi* (woma python), although recorded in the region at Olympic Dam, has not been recorded on the Arcoona Tableland.

Elapidae

Six species of Elapidae have been recorded for the Arcoona Tableland, all of which appeared to have been widespread throughout the arid region. Most, if not all, would be expected to occur at each of the three sites.

Leptodactylidae

Amphibian diversity is low for much of the stony desert area (Brandle 1998), including the project area. *Neobatrachus centralis* (trilling frog) is the only species to have been recorded in the region, for the Arcoona Tableland and at all three sites. The species spends a large portion of its life underground (Read and Tyler 1994) with spasmodic breeding events following rain.

Invertebrates

The diversity of invertebrates in the region and Arcoona Tableland is relatively unknown, as most of the previous faunal studies have focused on vertebrates. Specimens collected from past studies are, in general, yet to be identified or studied in detail. Species richness depends on seasonal conditions (Kinhill Engineers 1997) and consequently is in a state of flux. Read and Andersen (2000) provided a useful summary of some of the ant species in the Olympic Dam area and their potential use as bio-indicators

Ants

Shattuck and Barnett (2001) indicated that the Australian arid zone has about 25 ant genera — considered to be a low diversity. None of these genera are endemic to the arid zone, and generally also occur in more coastal areas. The diversity of species is similar to that of the coastal areas, while the semi-arid transition zone appears to have a greater diversity.

Field studies identified nine genera within the project area, representing seven different functional groups (Andersen 1990): dominant Dolichoderinae, associated subordinate Camponotinae, hot climate specialists, cold climate specialists, cryptic species, opportunists, and generalised Myrmicines (Table 9.6).

TABLE 9.6 Ant functional groups in the project area

Functional group	Genera	Relevant features
Dominant Dolichoderinae	*Iridomyrmex*	Abundant, active and aggressive; able to monopolise resources
Generalist Myrmicines	*Monomorium* *Pheidole*	Unspecialised behaviour but successful competitors owing to rapid recruitment and effective defences
Opportunists	*Rhytidoponera* *Odontomachus*	Unspecialised behaviour; poor competitors
Other groups	*Melophorus* *Camponotus* *Prolasius* *Hypoponera*	Variety of subordinate or highly specialised ants, usually with features that reduce interactions with other ants

Functional group distribution for the three sites is comparable to a site with little disturbance (Andersen 1993). Dominant Dolichoderinae (*Iridomyrmex* spp.) are the most abundant species, proportionally followed by opportunistic species (*Rhytidoponera* spp. and *Odontomachus* spp.). Cold climate species (*Prolasius* spp.) were only recorded at Site 52a, and are a group that is generally more abundant in habitat with reduced *Iridomyrmex* (Andersen 1990). Similarly, *Hypoponera* (a cryptic species) was only recorded at Site 52a.

No sub-cryptic or solitary foragers were recorded at any site. Future monitoring will probably increase the number of genera, species and functional group diversity.

Spiders

The arid zone of Australia, and the region, has a large and poorly studied spider fauna. Very few surveys have been undertaken on the Arcoona Tableland and invertebrate specimens collected from the region are yet to be assessed in detail. Table D2.12 provides a summary of the specimens recorded.

Thirteen families of ground-dwelling spiders, with 30 subordinate taxa, have been recorded. Miturgidae (lined spiders) were the most abundant, followed by Lycosidae (wolf spiders). Amaurobiidae and Dictynidae were the least observed, each with only one specimen captured, both at Site 52a. Site 52a was the only site to record at least one specimen for all families represented.

Zodariidae (spotted ground spiders) were the most diverse group with six taxa, followed by Lycosidae, with five taxa. Site 52a supported the greatest spider diversity; Sites 40a and 45a supported lower and similar diversities.

A greater diversity of species is expected at all sites with more extensive sampling. For example, only five species of Lycosidae were collected but more species are expected to be present in the region (D Hirst, South Australian Museum, pers. comm. November 2001). Such spiders have specific habitat requirements and consequently may occupy a range of microhabitats in the region.

A number of specimens collected in the project area are of scientific interest. The Amaurobiidae representative collected at Site 52a has not, apparently, previously been collected. This species is of particular taxonomic interest and may represent a new species. The collection of *Durodamus yeni* at Sites 40a and 52a extends the known distribution of this species from Etadunna Station, 300 km northeast of Woomera.

Species of Zoridae and Prodidomidae are widespread in the northeast of South Australia but are rarely collected. Their collection on the Arcoona Tableland is of biological interest.

Introduced Animals

Eight species of introduced mammal and three species of introduced bird are present in the region and Arcoona Tableland. All are contributing to the decline in many native species.

Of particular concern are *Oryctolagus cuniculus* (European rabbit), *Vulpes vulpes* (red fox) and *Felis catus* (feral cat). The impact of these species on the plant and animal diversity and abundance has been significant. The introduction of rabbit calicivirus disease to the area in 1996 has generated a significant reduction in the arid zone rabbit population, and provided positive flow-on effects for populations of plants (cover and abundance) and small mammals (WMC (Olympic Dam Operations Ltd) 1997).

Red fox is regarded as being evenly distributed over all habitats, while feral cat (and European rabbit) appear to favour dune swale habitat over gibber plains (Read 1994; Read and Bowen 2001).

The predation and competition generated by the presence of red fox and feral cat is a major contributor to the reduction in abundance and distribution of many small mammals and reptiles (Read and Bowen 2001).

The impact of European rabbit is listed under the EPBC Act as a threatening process due to the competition it provides for native herbivores and its contribution to land degradation. Predation by red fox and feral cat on native species has resulted in these two species also being listed as threatening processes under the EPBC Act.

All three species are present or likely to occur at each of the three sites.

Rattus rattus (black rat) and *Mus musculus* (house mouse) have been recorded in the region, and house mouse on the Arcoona Tableland. During good seasons, the numbers of these species can quickly build up and place pressure on the resources available for native species.

Passer domesticus (house sparrow), *Sturnus vulgaris* (common starling) and *Streptopelia chinensis* (spotted turtle-dove) have been recorded for the region and Arcoona Tableland. The former two species were recorded at Koolymilka, the latter was present at Woomera, but none was recorded at any of the three sites.

No introduced invertebrates were recorded at any of the three sites.

9.4 Impacts and Risks — Construction

The principal impacts of the project on the biological environment would be associated with construction activities for the repository. It is anticipated that these activities would include:

- road design and construction, including potential upgrading or realignment of existing roads (depending upon the site chosen), potentially including widening and surface upgrade, and accession of material from borrow pits
- clearing and levelling of part of the final site within the buffer zone for infrastructure and trench development (most of the site would be left as undisturbed buffer)
- construction of perimeter fencing, plus security patrol tracks.

Any potential adverse environmental impacts and risks can be managed and minimised by careful planning before any ground-disturbing work is begun.

9.4.1 Vegetation and Flora

The principal impacts associated with construction activities are the direct and indirect loss of vegetation (as fauna habitat) through clearance and the increased risk of weed introduction and dispersal from construction vehicles and equipment. Vegetation clearance is listed as a key threatening process under the EPBC Act due to its ability to cause a species to become threatened or its threatened status to be upgraded to a higher level of threatened classification. Some minor vegetation clearance would be necessary for road realignment and construction if Sites 40a or 45a were determined to be the preferred site. Furthermore, vegetation clearance within the central 500 x 500 m zone (100 x 100 m of which would be occupied by trenches) would be undertaken for infrastructure and disposal trench/borehole development.

Initial site clearance is expected to only involve the vegetation that must be removed to carry out construction activities. Maintaining native vegetation would minimise dust and erosion problems, as well as the introduction of weeds. Once the repository is established, all future activities would be kept to existing infrastructure areas, such as roads, tracks and hardstand areas.

The extent of vegetation clearance likely to take place at the repository site is a very small area in relation to the distribution of the vegetation communities across the Arcoona Tableland and the existing impacts associated with use of each of the potential sites. Consequently, the impacts of vegetation clearance on the vegetation communities and habitats would be strictly limited.

Introduction of Weeds

Any form of ground disturbance provides an opportunity for the establishment of weed species. However, this can be minimised by good management practices including:

- minimising the area that is disturbed
- preventing the introduction of seeds, particularly of species that are not already present in the area by appropriate cleaning of any plant, machinery or vehicles that are brought on to site during construction.

There are few introduced plant species present at the three potential repository sites but ground disturbance for the construction phase of the project might provide opportunities for weed establishment, which in turn could lead to loss of space and resources for native species, and an increased risk of exotic populations of spreading into surrounding areas. It is planned to minimise such impacts by:

- promoting the establishment of perennial native grasses
- promptly removing weeds, particularly perennial species, before they become established.

Erosion

The potential for accelerated erosion of soils on gibber tablelands is greatest when the protective gibber mantle is removed or disturbed. This is most likely to occur during construction. Any gibbers that are removed from the central repository area would be stockpiled separately from topsoil, subsoil and other material so that they can be replaced following construction or as part of decommissioning. Care would be taken not to alter flows in any drainage channel, either by blocking it or by excavating across or within the channel (this is likely to be a greater problem at Sites 40a and 52a than at 45a).

Soil erosion may be caused by construction activities, through accelerated wind and water erosion, for example by surface deflation, rilling and gullying following removal of the gibber strew from the surface of the stony desert soils. In addition, some of the subsoil at the sites would be dispersive if saturated by water. The removal of the surface strew from gibber plains combined with a heavy rainfall event can result in significant and major accelerated erosion, so this would be avoided.

Topsoil Management

Any topsoil that is removed during construction can be stockpiled for future use, with any cleared vegetation placed on top of the topsoil stockpile in order to provide additional protection of the topsoil from wind and water erosion and also provide a vegetated stockpile that would be an ongoing seed bank. It is anticipated that such topsoil stockpiles could be placed on flat ground wherever possible and if necessary protected from water erosion by the construction of suitable banks and drains.

Dust generated by increased frequency of traffic on tracks and exposure of the soil surface may be sufficient to defoliate perennial shrubs (Kinhill Engineers 1997). Traffic would be largely confined to the time of initial construction and first burial campaign. After that, campaigns are expected to be significantly smaller and only occur once every 2–5 years.

Any amenity plantings of vegetation around the repository would be confined to species indigenous to the Arcoona Tableland.

9.4.2 Fauna

Construction activities and traffic movement pose a hazard to wildlife, either directly or indirectly, through:

- loss of habitat by vegetation clearance or ground disturbance
- increased competition with other animals through displacement from their home ranges
- increased predation due to lack of shelter and displacement stress.

The more sedentary nature of some mammal and retile species, as opposed to bird species, places them at greater risk of impact. The impacts may not be significantly detrimental to species but would negatively impact on local populations.

Five threatened animal species have been recorded within the project area. Of these the most significant is plains rat, which is listed as Vulnerable under the EPBC Act. It is present at Sites 40a and 45a. The population of this species appears to be larger at the former site where it was present at two of the three trapping sites. The distribution of the species outside of the boundaries of Sites 40a and 45a is unknown but suitable, good quality habitat of rocky gilgai is present. Therefore, it is likely that the species would occur elsewhere in the vicinity. Any activity within the buffer zones of Sites 40a and 45a should avoid, as much as is practicable, all key habitat areas actually or potentially occupied and used by this species. Monitoring of the population of the species can address this.

Key threatening processes (predation by foxes and cats, and competition and land degradation by rabbits) may be increased as a result of construction, although this is unlikely if suitable management procedures were established and implemented. This could be accomplished by establishing a perimeter fence and then removing all pest animals.

In order to exclude large fauna from the site, a fence of equal construction to the dog fence would be required, that is one that excludes all medium and large mammals. (Normal station type cattle and sheep fences do not exclude kangaroos, which are able to jump over a fence of this height.) Rabbit netting can exclude rabbits. It is anticipated that the outer fencing would be of such a standard that the area becomes a wildlife refuge similar to, but much smaller than, the Arid Zone Recovery Project at Olympic Dam, which provides a suitable model for this project area.

A rabbit, fox, cat, stock and kangaroo proof fence around the perimeter of the preferred site would establish an exclosure facility for monitoring the recovery of native species without the threats imposed by exotic species and larger native grazing species. Such an exclosure facility may, in future, provide valuable opportunities for management of threatened species and as a reference site for the Pastoral Board. Animals protected by this exclosure would be small enough to get through the fence should their range require it.

The area cleared for fence construction would be the minimum necessary for safe construction and maintenance of the fence.

Animals that enter or fall into the trench during construction would be able to exit up the access ramp. Animals that fall into the boreholes would be removed before daily work began. Construction periods would be quite short (weeks for trenches, days for boreholes) and thus, even if rain fell during construction, there would not be time for a drought refuge for wildlife to form.

9.5 Impacts and Risks — Operation

The activities associated with the operation of the repository would generate fewer impacts on biodiversity. The infrequent operational activities would include:

- transportation of materials to and within the site for burial
- maintenance of facilities and infrastructure, including fire breaks and surface water runoff management
- sewage management and wastewater management, including washdown water
- burial and monitoring of the low-level radioactive waste

- coordination of repository operational and land management activities with Pastoral Board, the adjacent landholder(s) and other stakeholders, particularly in the case of Site 52a, with the Department of Defence and other users of the WPA (e.g. government agencies).

9.5.1 Vegetation and Fauna Habitats

Waste would be transported to the site during the first disposal campaign and then infrequently, possibly every 2–5 years. Activity at the site between the disposal campaigns would only involve monitoring. Times of increased traffic in the area of the preferred site have the potential to increase weed introduction and establishment, along the route and at the site.

Fire is generally not a problem on the chenopod shrublands of the Arcoona Tableland. However, fire may occur in this habitat following exceptional seasons if a substantial fuel load of mainly grasses has built up in the understorey (Kingoonya Soil Conservation Board 1996). However it is anticipated that in between waste burial campaigns there would be no or little infrastructure that can be affected by fire left at the site. For other times of activity, a cleared track two grader blades (8 m) wide around both fences could provide adequate protection from bushfires, which also, under extreme conditions, could be used as a base for back-burning operations to protect the site.

Operational activities are unlikely to cause further disturbances to the lifecycle of plants following construction.

9.5.2 Fauna

It is anticipated that the installation of a vermin-proof fence would continue to restrict the movement of larger species during operation of the waste repository. The resultant benefits provided for small mammals and reptiles would outweigh the restriction of larger animal movements.

The development of a more structurally diverse area may provide habitat for those species that use built structures, particularly some birds, lizards and bats. There is potential to introduce pest vertebrates and invertebrates to the site on vehicles accessing the region from other parts of Australia. This could be managed by appropriate monitoring measures such as vehicle and load hygiene management controls, and appropriate monitoring at the site.

Movement of Radionuclides Baseline Studies

The baseline data for radionuclides have been analysed and are discussed in Section 12.2.1. It is proposed that vegetation and fauna monitoring for the uptake of nuclides be undertaken five yearly.

9.6 Impacts and Risks — Surveillance

It is anticipated that surveillance of the repository site between disposal campaigns may include:

- periodic monitoring of the site between campaigns
- maintenance of access restrictions
- maintenance of infrastructure
- management of repository contents.

9.6.1 Vegetation and Flora

Potential impacts associated with the above activities might include:

- disturbance of vegetation along the edge of the perimeter track
- possible development of some channelled water flows, with the potential for accelerated erosion and weed establishment.

9.6.2 Fauna

Management practices would aim to reduce or minimise and, where possible, avoid impacts of operational activities on fauna associated with any:

- disturbance from human activities
- accidental introduction of pest plants and animals, especially invertebrates.

9.7 Impacts and Risks — Decommissioning and Institutional Control

The recommended end-use of the repository site is as a biological reference area for the Arcoona Tableland. The minimalist approach to vegetation removal and impacts suggested above can help achieve this goal. Depending on the amount of monitoring required for the repository site itself, most hardstand areas might be suitable for rehabilitation. This would require standard rehabilitation techniques including the removal of hardstand, ripping and seeding with locally collected seed.

Associated activities and impacts include:

- closure of trenches/opening of trenches
- removal of infrastructure
- site restoration, including gibber replacement and revegetation with a saltbush community.

9.8 Environmental Safeguards to Minimise Impacts

A number of the impacts generated by the development can be reduced or minimised by developing procedures and safeguards. Table 9.7 summarises the general impacts associated with the proposal and Table 9.8 summarises the environmental safeguards for the impacts and risks considered in the previous section. These requirements would be formalised in an EMP for construction and operation of the repository.

9.9 Monitoring Program and Procedures

9.9.1 Vegetation and Flora

Vegetation monitoring has been established to ensure that four of the monitoring sites at each of the three potential waste repository sites would be outside the outer fence when it is constructed. These monitoring sites would act as control sites to detect any changes in

vegetation that may occur inside the fenced area as a result of the construction works and operation of the repository.

TABLE 9.7 Likely and potential general impact areas and risk during construction, operation, surveillance, decommissioning and institutional control

Potential impact	Construction	Operation–surveillance	Decommissioning–institutional control
Disturbance to vegetation	H	L	L
Loss of topsoil	H	L	M
Interception and concentration of surface water flows	M	L	L
Altered drainage patterns to swamps and drainage channels	M	L	L
Accelerated erosion from excavations in drainage channels	L	L	L
Erosion of dispersive soils	M	L	M
Rutting of surface by construction traffic	M	L	M
Dust from trafficked areas	M	L	M
Introduction of weeds	H	M	M
Fire	L	L	L

H = high risk, M = medium risk, L = low risk

TABLE 9.8 Environmental safeguards to minimise the impacts of the proposed repository

Repository phase	Impact or risk	Environmental safeguard
Construction	**Vegetation**	
	Vegetation clearance	Before construction establish detailed photopoints and baseline plans of existing conditions; minimise disturbance by restricting vegetation clearance to only that necessary for building siting and trench development; place cleared vegetation over areas of disturbance following construction
	Weed introduction and dispersal	Keep vehicle hygiene to a high standard i.e. only clean machinery allowed on site
		Eradicate existing weeds
		Identify and remove newly established populations of weeds
	Threatened species	Survey access routes for threatened species; maintain a watching brief for presence of rare species within the fenced exclosure; where appropriate clearly mark and avoid all populations (or individuals); implement approved conservation measures for each species
	Accelerated soil erosion	Restrict surface disturbance to that necessary to complete construction; stockpile surface strew and topsoil and replace in appropriate areas or use elsewhere on the site; establish water management techniques as part of construction
	Off-road driving	Prohibit vehicle movement off existing or proposed road alignments and within the buffer zone; restrict vehicle movement within the operational zone to those areas of construction

Repository phase	Impact or risk	Environmental safeguard
	Fauna	
	Direct loss of individuals	Stage the construction to allow fauna adequate time to vacate burrows, roosting and nesting sites; where trenches are constructed, conduct daily checks for trapped animals; capture trapped animals and release nearby; undertake construction activities outside of the main breeding season for sedentary species (particularly threatened species)
	Loss of habitat	Habitat loss is associated with vegetation clearance and surface disturbance: confine disturbance activities to those areas essential for construction
	Increased competition for resources and predation	If practicable, undertake construction outside of dry conditions to reduce the stress on available resources and animals
	Threatened species	Define and avoid habitat critical for threatened species e.g. deep cracking soils and canegrass areas
	Pest species	Undertake control of pest species, particularly red fox, feral cat and European rabbit after fencing; maintain a clean construction site to prevent attracting pest species
		Monitor invertebrate species for the presence of introduced pests
	Fencing	Establish predator and stock proof fencing; maintain its integrity
Operation	**Vegetation**	
	Weed introduction and dispersal	Keep vehicle hygiene to a high standard, i.e. only clean vehicles allowed on site, and provide facilities for washdown
		Remove newly established weed populations
	Movement of radionuclides	Establish baseline monitoring in flora
	Wastewater and sewage management	Control wastewater in a closed environment and dispose of it appropriately to discourage weed establishment and vermin
	Fauna	
	Habitat creation from built structures	Monitor incidence of native and pest species, especially vermin and invertebrates in the latter category
	Movement of radionuclides	Establish a suite of monitoring species
	Non-radioactive waste management	Contain all waste and dispose of it off site; separate recyclable waste and transport it to a recycling depot or other appropriate establishment
Surveillance	Vegetation disturbance	Maintain all programs established above
	Fauna disturbances	Maintain all programs established above
Decommissioning and institutional control	General	Restore the site to as natural a state as practicable; use baseline photographs and plans established at the start of the project

The central vegetation monitoring point of the chosen storage site would probably be destroyed during construction of the storage facility. This would leave eight sites inside the perimeter fence, including four sites midway between the inner and outer fences and four sites near the outer corners, some or all of which can be used for ongoing vegetation monitoring.

There would be little advantage in carrying out annual or more frequent monitoring beyond the first few years after the repository is established (unless there are obvious changes to vegetation inside the fenced area). Monitoring is envisaged after the first few years at intervals in the order of five years. Vegetation monitoring can be staged so as to take

advantage of good seasons, especially following summer rainfall. This would allow the compilation of a more complete database on the local vegetation, including the summer-growing grasses that were absent at the time of the August 2001 survey.

Subtle changes in the vegetation that cover a large area would not be detected by these methods but changes can be identified by comparing the baseline data and photos for perennial species at each monitoring site. If such changes are suspected to be occurring and the control sites outside the fence are also in similar condition and thought to be affected, this can be assessed by comparison with the vegetation of several new sites further away from the repository site.

The repository site could form an important reference area for vegetation monitoring programs on the Arcoona Tableland. It could have importance for Commonwealth and State government agencies and for local communities, such as the Council for Sustainable Vegetation Management, Department of Defence, South Australian Rangelands Program and local soil conservation boards.

Elements of the flora monitoring program could include:

- photopoint monitoring and quantitative surveys at the sites established in the field during August
- biodiversity indicator monitoring — based on the quantitative survey data
- pest plant species
- fire fuel loads
- radionuclide monitoring in target species.

After the repository was closed, these programs could be continued annually for five years and then conducted every five years.

9.9.2 Fauna

Elements of faunal monitoring programs may include:

- presence of burrowing animals in repository trenches and other animal species in and around infrastructure
- fauna surveys of invertebrates and vertebrates to be based on the current permanent trapping sites (as detailed in Appendix D2)
- establishment of existing incidence of mutations in trilling frog populations
- maintenance of zero introduced large and medium pest vertebrates, stock and kangaroos within fenced area
- radionuclide monitoring in target species, especially ants.

After the repository was closed, these programs could be continued annually for five years and then conducted every five years.

Chapter 10
Land Use and Activity

10.1 Overview

The land use and activity assessment in this chapter considers the three site options located in the central–north South Australia.

The assessment considers the existing situation of human activity since European settlement, identifies the potential for this situation to change and evaluates possible impacts during the various stages of the national repository's life. The assessment is taken from a primarily non-Aboriginal cultural perspective; issues of indigenous culture, activity and values are addressed in Chapter 11.

The assessment of existing and potential future land use and activity is required in order to establish the extent to which:

- the proposed development might be incompatible with existing activities
- future developments might be incompatible with the proposal.

10.2 Site Planning

10.2.1 State Development Approvals

In most circumstances the *Development Act 1993* controls development and changes of land use throughout South Australia. However, in the case of the national repository, Planning SA, after obtaining Crown legal advice, has advised that no Development Application is required at the State level, as the facility would be constructed on Commonwealth land.

Environmental impact assessment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Section 1.2 of this document) and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) licensing requirements (Section 3.3) satisfy the required land use assessment and approvals requirements for 'controlled activities' such as the waste repository.

Nevertheless, it is noted that the relevant Development Plan and zoning policy for this area present few limitations to the development of this type of facility, provided that environmental and conservation principles are addressed. On the other hand, the zoning does not limit the nature of activities and land uses that might be established in the region in the future.

10.2.2 Nature of the Operation and Facilities

The proposed national repository would have the following features (Sections 6.2 and 6.3):

- an appropriate access road
- security and feral animal-proof fencing
- disposal trenches and/or boreholes that would be filled and capped at the conclusion of each disposal campaign