Part B

Environmental impact statement

7 Existing environment

7.1 Geology of the project area

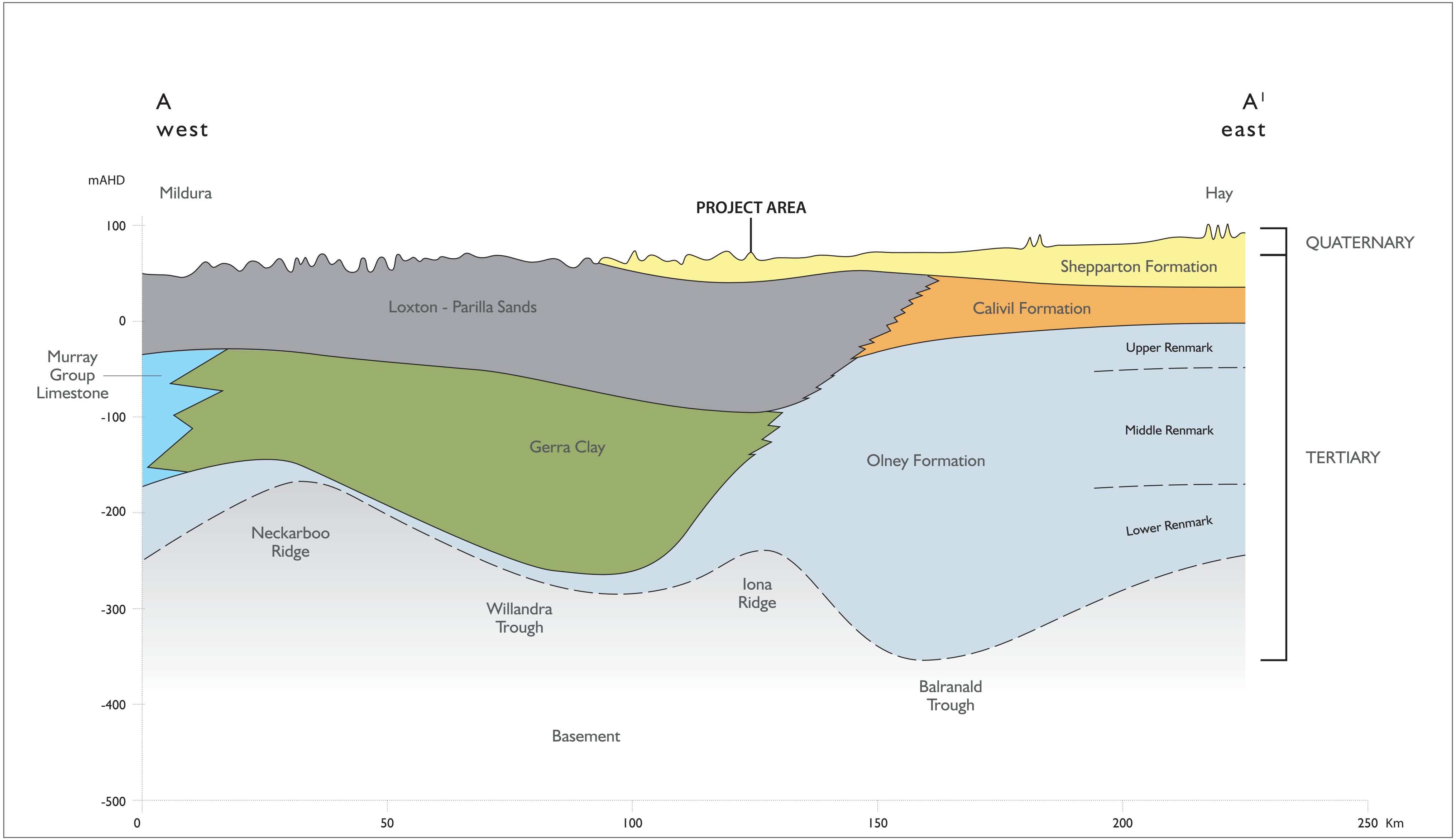
The project area is located in the centre of alluvial sediments in the Murray Basin. Subregions of this Basin are defined by surface geomorphology, and the presence of the Ivanhoe Block and associated structures. Within the project area the basal unit, which directly overlies the basement rocks (comprising Proterozoic and Palaeozoic rocks) is the Olney Formation. The Olney Formation sediments are predominantly continental, but the marginal marine Geera Clay interfingers through the middle sequence at the project area. A conceptual regional geological cross section is shown in Figure 7.1.

At the project area the Olney Formation is overlain by the Loxton-Parilla Sands Formation which is in turn overlain by the Shepparton Formation. The Loxton-Parilla Sands is a thick sequence of marine sands that contains the target mineral deposits, while the Shepparton Formation comprises fluvio-lacustrine unconsolidated clays and silts.

7.1.1 West Balranald deposit

At the West Balranald deposit, the Shepparton Formation consists of a thick layer of unconsolidated to poorly consolidated clays and silty clays with inter-bedded sand lenses. This unit is highly variable across the West Balranald deposit and drilling has defined two dense clay layers (locally up to 4 to 6 m thick). Moderately to strongly indurated iron cemented rock layers are also present within the sand-dominant lenses between the clay layers. The thickness of the unit varies from approximately 19 m at the northern end to more than 36 m through central and southern areas of the deposit. The unit strikes in a north-west – south-east direction.

The upper Loxton-Parilla Sands marine sequence varies in thickness along the strike of the deposit from 16 to 20 m in the north to more than 60 m at the southern end. The sequence typically consists of three upper beach facies; foreshore, surf zone and lower shore. The different facies have varying horizontal hydraulic conductivities. A marine transgression marks the boundary between the LPS1 and the lower (older) marine sequence LPS2. The lower marine sequence (LPS2) is host to the West Balranald deposit and consists of three facies (foreshore, surf zone and lower shore), with the mineral sands deposit lying within the foreshore facies of LPS2. Explorative drilling along the length of the West Balranald deposit confirmed the presence of confining Geera Clay along the strike of the West Balranald mine below the LPS2.



Regional geological cross section

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 7.1

7.1.2 Nepean deposit

The Nepean deposit has the same stratigraphic units and strike as the West Balranald deposit (Loxton-Parilla Sands and Shepparton Formation) with differing local features. The Shepparton Formation across the extent of the Nepean deposit consists of an upper layer which contains the consistently high clay contents of the typical Shepparton Formation. Underlying this at the northern and southern ends of the deposit are additional fluvio-lacustrine sediments of the Shepparton Formation, these have more variable clay contents than is typically seen in the region. These sediments are interpreted to be derived from material eroded from the uplifted Iona Ridge and a broad paleo-channel immediately adjacent to the southern edge of the Iona Ridge. In the south, this unit is 80 m thick including up to 60 m of the highly variable sediments beneath the typical Shepparton Formation sediments.

Within the Loxton-Parilla Sands unit, unlike the West Balranald deposit, the contact between the LPS2 and the overlying LPS1 regressive sequence is impossible to delineate as the LPS1 sequence is incomplete. Similar to the West Balranald deposit, the lower marine sequence (LPS2) is host to the Nepean deposit and is also located within the foreshore facies, often immediately above the poorly sorted coarser surf zone sands. Below the LPS2 at the Nepean deposit is the confining Geera Clay unit.

7.2 Hydrogeology

The Murray Basin is a large closed groundwater basin with regional aquifer systems, confining layers and permeability barriers to groundwater flow. Locally in the vicinity of the project area, there is limited recharge from direct rainfall and some limited recharge from surface water systems, with most recharge to the area occurring via through flow from the east.

Consistent with topographic gradients, hydraulic gradients are very gentle in the central and western Murray Basin, and the broad flow direction in all aquifers is from east to west. However, the basement structure influences the groundwater flow direction in the project area causing a slightly north northwest trend in flow. This is most pronounced in the deeper Olney Formation[1]. The horizontal hydraulic conductivity in both the Shepparton Formation and Loxton-Parilla Sands is variable, due to the depositional environments and volume of clay; continual lateral flow through formations is not common.

There is an upwards hydraulic gradient from the Olney Formation and Geera Clay to the Loxton-Parilla Sands and Shepparton Formation based on pressure head differences observed on-site and reported in the literature (Kellet 1989). Heads in the Shepparton Formation and Loxton-Parilla Sands are mostly similar, although results of hydrogeological pumping and injection trials indicate that the two units are poorly connected (Iluka 2015) and therefore vertical flow is limited.

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[1] An aquifer is defined as a rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water. The groundwater underlying the project area is not considered to be sufficiently permeable to transmit economic quantities of water, nor does it have a widespread suitable quality. Other technical studies refer to the groundwater in the Shepparton Formation, Loxton-Parilla Sands and Olney Formation as being aquifers, this terminology has not been adopted in this EIS.

Groundwater quality within the Murray Basin is variable, with fresher water near the basin margins to the east. Quality becomes poorer in a westerly direction (down gradient), and within the project area is typically highly saline. Salts originate from the marine depositional environment and are enhanced by low precipitation and high evaporation rates as well as long groundwater residence times. The water quality of the Shepparton Formation and Loxton-Parilla Sands is comparable, and is characterised by high salinity, neutral pH, low dissolved metals and Na-Cl type dominance.

Site groundwater salinity, represented by electrical conductivity (EC) is variable, and a decreasing trend with depth is observed. The salinity of the Shepparton Formation and Loxton-Parilla Sands are similar, and these formations have the highest EC measurements (averaging 48 and 56 milllisiemens per centimetre (mS/cm), respectively) which is equivalent to the EC of sea water (53 to 60 mS/cm). The EC is lower in the Olney Formation with an average EC of 9.3 mS/cm.

Dissolved metal measurements are typically low amongst the formations, although the following dissolved metals results are elevated at the shallower formations (Shepparton and Loxton-Parilla Sands): aluminium, strontium and iron, while manganese was high in the Shepparton Formation only. Aluminium, iron and manganese measurements were an order of magnitude lower in the Olney Formation than the Shepparton Formation.

Further details on the hydrogeology of the project area can be found in the water assessment contained in Appendix G.

7.3 Geomorphology

The stratigraphic sequences in the Murray Basin are dominated by consolidated sand, silt, clay and lime-rich sediments, formed by marine, deltaic, fluvial and aeolian depositional environments. Current landforms in the project area may have formed in either the Pleistocene period (approximately 2.5 million to 12,000 years ago) or the Holocene period (approximately 12,000 years to the present day).

Pleistocene relict landforms are found in the northern half of the West Balranald mine, and are associated with the relict lakes (dry clay pans), including Muckee, Tin Tin and Pitarpunga lakes. The development and history of these lake formations is understood from work undertaken on the geomorphic development of the Willandra Lakes system, located approximately 39 km from the northern extent of the West Balranald mine and 23 km from the northern extend of the Nepean mine.

The most dominant Holocene landforms in the project area are the linear dune field systems and ephemeral creeks such as Box Creek. Dating of buried soils has shown that this dune system was last active approximately 15,000 years ago (Bowler and Polach 1971).

Unlike fluvial deposition in Pleistocene landscapes, Holocene stream deposition and activity is comparatively less well understood; it is likely that flood deposition in Box Creek, a tributary of the Lachlan River, has not been active for quite some time. Its flow regime is dependent on major flood events in the Lachlan River, as it not fed by local run-off because of the area's low gradients, low rainfall and generally permeable soils. Muckee, Tin Tin and Pitarpunga lakes have been dry for at least the last few hundreds to thousands of years. These lakes functioned as overflow lakes being fed through Box Creek.

The development of linear dunes landforms appears to have varied in the Holocene period, with certain dune landforms more active at certain times corresponding to variations in regional climatic conditions.

Although geomorphically stable, parts of the project area have been subject to erosion caused by pastoral activity resulting in eroded pans and scalds where vegetation has been removed and the aeolian sands have deflated. Other areas of exposure and erosion are a result of mechanical disturbance from rural infrastructure such as water storage dams, ground tanks, access tracks and cut lines for fences. This erosion, over time has led to soils on lunette features to be dispersed upon wetting and move down slope. On the back plain landforms sheet erosion has led to the topsoil being stripped and the formation of hard surfaced scalds. Some of these scalds also contain patchy vegetation mounds around their margins. These mounds may preserve an original soil profile beneath a cap of windblown sediment.

In the southern section of the West Balranald mine are longitudinal dune formations, approximately 2 to 6 m above the swales, which, in some places cover parts of old lake beds. Some of these dunes have also been extensively eroded and now form a series of sand sheets. Sand that has been cemented by calcium carbonate (ie calcrete) can also be found in the dunes.

7.4 Soils and topography

The West Balranald mine is generally flat ranging from 62 to 70 m Australian Height Datum (AHD), while the terrain of the Nepean mine is slightly more undulating with elevations ranging from 64 to 100 m AHD.

The project area contains a variety of soil landscapes resulting in varying depositional sequences and characteristics. Based on land system mapping taken from *Land Systems of Western New South Wales* (NSWSCS 1991), 10 local land systems have been identified within the project area (Table 7.1). Of these, the Arumpo and Rata land systems cover the majority of the project area.

Table 7.1 Land systems of the project area

Land system	Geomorphology	Soils, vegetation and erosion
Arumpo	Long linear, east-west trending dunes of reworked Quaternary aeolian material with narrow swales and flats merging to level sandplains; dune relief to 7 m.	Dunes of deep brownish sands and calcareous sands; swales of highly calcareous solonized brown soils and texture-contrast soils; sandplains of solonized brown soils and calcareous red earths; dunes with dense mallee and variable porcupine grass; swales with belah, rosewood and inedible shrubs; variable speargrass, cannon-ball and forbs. Minor to moderate windsheeting.
Bulgamurra	Slightly undulating sandplain of Quaternary Aeolian material and areas of east-west trending dunes and rises; relief to 6 m; open calcareous flats and scattered swamps and depressions to 500 m diameter.	Sandplain of solonized brown soils with clumps of belah, rosewood, scattered wilga and nelia; dunes of deep brownish sands with white cypress pine or mallee and porcupine grass; areas of edible and inedible shrubs, variable speargrass, copperburrs and forbs; depressions of grey cracking clays with fringing black box. Minor to moderate windsheeting and drift.
Condoulpe	Sandplain of Quaternary aeolian material with large areas of east-west trending dunes; relief to 5 m; open flats, terminal drainage basins, locally depressed to 2 m.	Plain and flats of predominantly solonized brown soils and areas of red earths; dunes of deep brownish sands; drainage basins of grey cracking clays; generally dense to scattered belah and mallee; areas of dense edible chenopods; drainage basins of dense black box, nitre goosefoot and dillon bush; variable speargrass, annual saltbushes and forbs. Minor to moderate windsheeting and scalding.

Table 7.1 Land systems of the project area

Land system	Geomorphology	Soils, vegetation and erosion
Gulthul	This land system is characterised as an extensive plain between the Darling and Murrumbidgee Rivers. It consists of an extensive calcareous quaternary sand plain with scattered low dunes with relief of up to 7 m, flats and sinks.	The plains comprise highly calcareous solonized brown soils often with exposed kunkar, travertine or limestone while the dunes comprise dunes of red calcareous sands and brownish sands. Moderately dense mallee, scattered to clumped belah; dense edible saltbushes and bluebushes occur on the plain with areas of dense inedible shrubs and porcupine grass occurring on the dunes. Flats and sinks in the land system comprise red texture contrast soils and grey cracking clays, often fringed by mallee and belah, scattered dillion bush and variable speargrass and forbs. Minor windsheeting erosion occurs on the plain.
Hatfield	Undulating sandplain of Quaternary aeolian material, east-west trending dunes, relief to 5 m; depressions of fine-textured alluvium to 500 m wide and depressed to 5 m.	Plains of solonized brown soils, red and brown texture-contrast soils and red earths with scattered clumps of rosewood and belah; moderately dense bluebushes and bladder saltbush; dunes of deep brownish sands with clumped white cypress pine, prickly wattle and bluebushes; depressions of grey clays with nitre goosefoot, dillon bush and canegrass. Moderate scalding on plain; slight drift on sandy rises.
Marma	Severely scalded levees, with associated swamps, pans and lunettes; relief to 5 m; associated floodplain of fine-textured Quaternary alluvium and aeolian sandplains.	Levees of red and yellow texture-contrast soils and grey cracking clays; sandplains and lunettes of solonized brown soils and red texture-contrast soils; floodplains of grey cracking clays; scattered to dense bluebushes, bladder saltbush and old man saltbush; canegrass in swamps; abundant forbs, copperburrs and annual saltbushes. Severe scalding and watersheeting.
Rata	Relict floodplain of grey, fine-textured Quaternary alluvium with small, shallow sub-circular depressions to 500 m wide; relief to 2 m; isolated low rises of coarse-textured aeolian material.	Plains of grey cracking clays and compact clays with dense stands of bladder saltbush; canegrass and nitre goosefoot in depressions; black bluebush, scattered belah and rosewood on sandy rises; abundant annual saltbushes, copperburrs, annual forbs and grasses. Minor scalding on plains; minor windsheeting on rises.
Riverland	This land system consists of a floodplain of fine textured Quaternary alluvium.	Land units within the system include perennial channels and back channels, billabongs, levees and river side lunettes (source bordering dunes). Vegetation in the Riverland system includes river red gum, black box, river cooba, lignum and abundant grasses and forbs. Scalding levees and lunettes and gullying of riverside banks are the major forms of erosion.
Wilkurra	Sandplain of Quaternary aeolian material with isolated dunes and rises trending east-west, relief to 5 m; small level swales and flats.	Plains and flats with highly calcareous solonized brown soils; dunes with deep brownish sands; uniformly dense stands of belah and rosewood, scattered mulga, wilga and inedible shrubs; white cypress pine on sandy rises; variable speargrass, copperburrs and forbs. Minor windsheeting and drift.
Youhl	Reniform to sub-circular depressions of fine textured Quaternary alluvium to 10 km in diameter; remnant lunettes on eastern margins; relief to 5 m; associated sandy rises.	Lakebeds of grey cracking clays and red texture-contrast soils; lunettes of saline or compact clays, or calcareous red earths; sandy rises of earthy sands and red earths; lakebeds treeless with dense bladder saltbush and bluebushes, scattered Dillon bush, nitre goosefoot and old man saltbush; lunettes of scattered bluebush; perennial grasses, copperburrs and annual saltbushes. Moderate to severe scalding on lakebeds; gullying and rilling of lunettes.

Source: NSW SCS 1991.

7.5 Climate

The project area is characterised by hot dry summers and cold winters. Climatic data from the BoM weather station at Balranald town indicates that monthly mean minimum temperature ranges from 3.5°C to 16.4°C and the monthly mean maximum temperature ranges from 15.7°C to 33°C.

The median annual rainfall is 324.8 mm. Rainfall generally occurs throughout the year with the highest median rainfall over spring and the lowest median rainfall over summer.

7.6 Surface water resources

The Lachlan, Murrumbidgee and Murray rivers are the major permanent surface water features in the vicinity of the project area, shown in Figure 3.2. The Lachlan River flows south-west terminating at Great Cumbung Swamp, a 16,000 ha swamp dependent on flows from the Lachlan River, approximately 42 km east of the project area. The Great Cumbung Swamp joins the Murrumbidgee River to the south and becomes part of the Low bidgee Floodplain (CSIRO 2008).

Flows within these rivers are regulated by major dams in their headwaters, and by local regulating structures such as Balranald Weir and the Paika levee, which divert water for irrigation purposes.

Permanent surface water flows are confined to the major rivers and their associated backwaters and billabongs which are outside of the project area. The catchments within the project area do not contribute to flows of the major permanent surface water features in the vicinity of the project area, except under extreme flood conditions (WRM 2015).

Dry relic lake beds (Pitarpunga, Muckee and Tin Tin lakes) (see Figure 7.2) generally occur to the north east and east of the West Balranald mine and are subject to agricultural activities including grazing and cropping.

Local drainage is poorly defined with the exception of Muckee, Pitarpunga and Tin Tin lakes, and Box Creek downstream of the confluence with Arumpo Creek. Identifying local drainage catchments and flowpaths is complicated due to the dunal landforms, which result in numerous small depression storages and small dry lakes. Under existing conditions it is likely that any runoff from the project area would drain via shallow overland sheet flow, before being captured by the dry lakes or depressions evident in the topography (WRM, 2015).

Further details on the surface water resources in and surrounding the project area can be found in the surface water management report in Appendix J.

7.7 Biodiversity

The northern part of the project area (where the Nepean mine is located) is dominated by Saltbush, Chenopod and Black Box communities, with some woodland. Some dry lakes and claypans also occur. The West Balranald mine contains mostly agricultural land used for grazing and cropping, with remnant native vegetation consisting of patches of mallee and saltbush plains.

Eleven native vegetation types were identified within the project area:

- Spinifex Dune Mallee Woodland;
- Chenopod Sandplain/Swale Mallee Woodland;
- Black Bluebush Low Open Shrubland;
- Pearl Bluebush Low Open Shrubland;
- Bladder Saltbush Low Open Shrubland;
- Old Man Saltbush Shrubland;
- Belah – Pearl Bluebush Woodland;
- Belah – Chenopod Woodland;
- Black Box Grassy Chenopod Open Woodland;
- River Red Gum Woodland; and
- Flat Open Claypan/Derived Sparse Shrubland/Grassland.

An additional vegetation community was identified; consisting of bare soil, cultivated and developed areas.

Much of the project area is grazed by livestock (as well as feral animals, particularly goats) which has resulted in degradation of the shrub and ground vegetation layers within mallee vegetation across the project area and surrounds.

A total of 198 flora species and 171 vertebrate fauna species were recorded in the project area during field surveys for the Balranald Project.

No threatened flora species were recorded during the surveys within the project area. Five species of Commonwealth-listed fauna were detected during field-survey.

7.8 Land ownership

Land ownership in and near the project area includes Western Lands Lease (WLL), freehold, Crown and other land tenures. Outside Balranald town, properties are typically large rural land holdings, and homesteads and dwellings are sparsely located. Land holdings within the project area are shown in Figure 6.3. Land details within the project area are listed in Table 7.2.

Homesteads, dwellings and other built structures (eg sheds and other outbuildings) in the vicinity of the project area have been identified based on aerial photography interpretation, with ground-truthing of built structures closer to the project area, as required. For the purposes of the EIS, built structures are identified as assessment locations, shown in Figure 7.3.

Table 7.2 Land details in the project area

Lot number	Deposited plan number	Lot number	Deposited plan number
4727	767893	6654	769427
1229	762714	99	751245
1226	762711	1184	762595
1	751182	5501	768410
4808	762298	5332	768243
1224	762709	128	760747
1225	762710	6615	769405
4	751182	5331	768242
1175	762586	5326	768237
5	751182	1174	762585
1227	762712	43	751217
1223	762708	40	751217
88	760470	1	751232
103	751245	31	751217
98	751245	39	751217
73	751245	4812	769046
4864	769099	20	751232
100	751245	4809	762298
104	751214	5325	768236
102	751214	41	751217

7.9 Surrounding land uses

7.9.1 Agriculture

The project area and surrounding land is zoned for primary production under the Balranald LEP. Land uses in and surrounding the project area are primarily agricultural, and include grazing and cropping. Charcoal farming and gypsum mining is also undertaken on nearby properties.

7.9.2 Natural resources

Natural resources and features in the region are shown in Figure 7.2. The Yanga National Park and Murrumbidgee River are approximately 13 km south-east of the West Balranald mine. The project area adjoins the Murrumbidgee River approximately 10 km north-east of Balranald town.

Mungo National Park and Willandra Lakes Region World Heritage Area are approximately 39 km from the northern extent of the West Balranald mine and 23 km north-west of the northern extent of the Nepean mine.

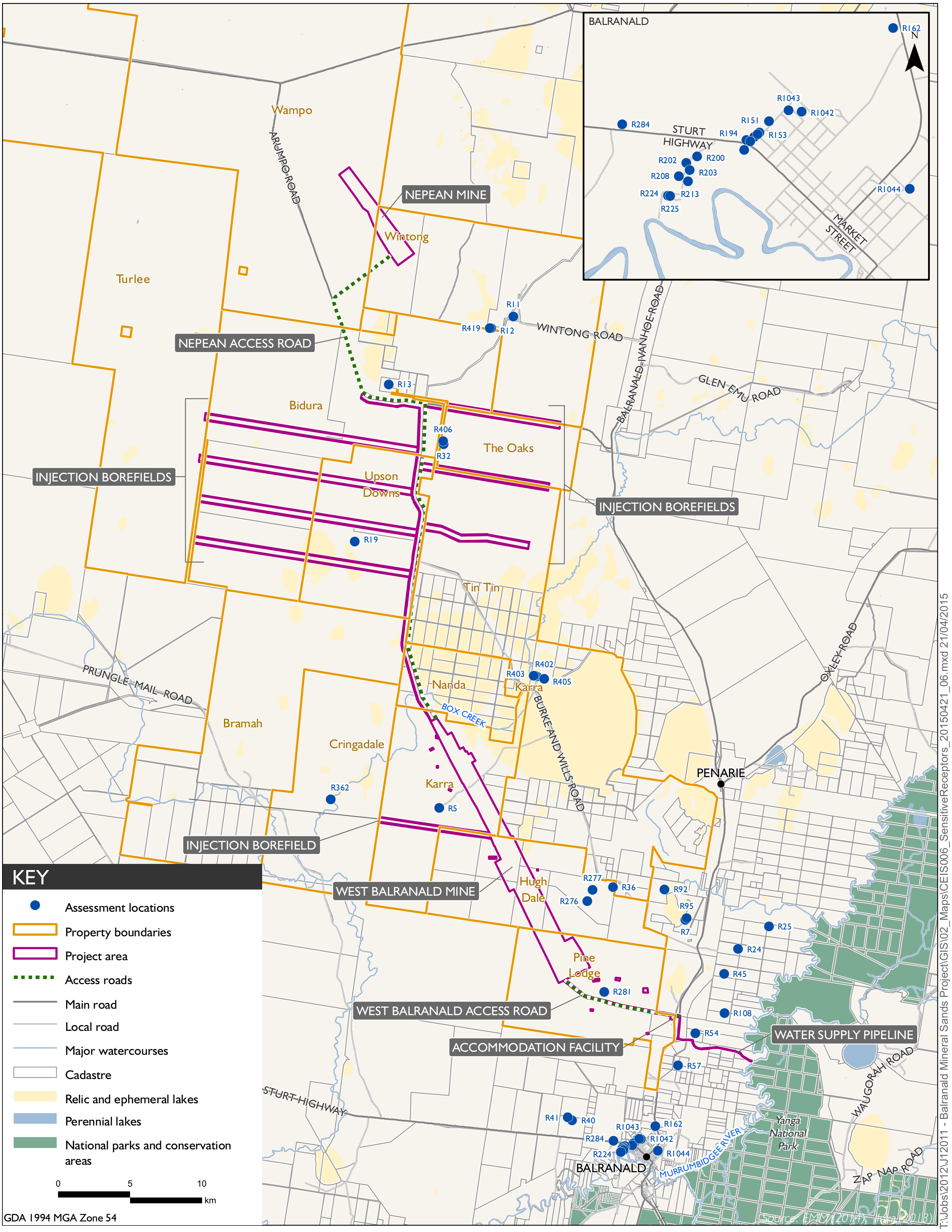
7.9.3 Conservation areas

There are several areas of mallee vegetation in and adjoining the project area which are managed in accordance with WLL conditions under the WL Act. These conditions relate to management of certain areas of mallee vegetation, known as 'southern mallee', referred to herein as SMCAs. SMCAs are managed by lease holders in such a way that conserves vegetation. SMCAs in the project area are shown in Figure 7.3. SMCAs are subject to special conditions under WLLs that were originally established to protect habitat loss associated with agricultural land uses including clearing and grazing.

As with much of the project area, SMCAs have been grazed by feral animals, resulting in degradation of the shrub and ground vegetation layers within mallee vegetation.

7.9.4 Mining

Mining and exploration land uses are shown in Figure 7.4. No substantial mining land uses currently exist in the Balranald LGA, although there are a number of mineral titles. A small gypsum mining operation is located to the east of the project area. Approval for a mineral sands mine, known as the Atlas-Campaspe Mineral Sands Project, located approximately 20 km north of the project area, was granted in 2014.



EMM ILUKA

Assessment locations and land ownership

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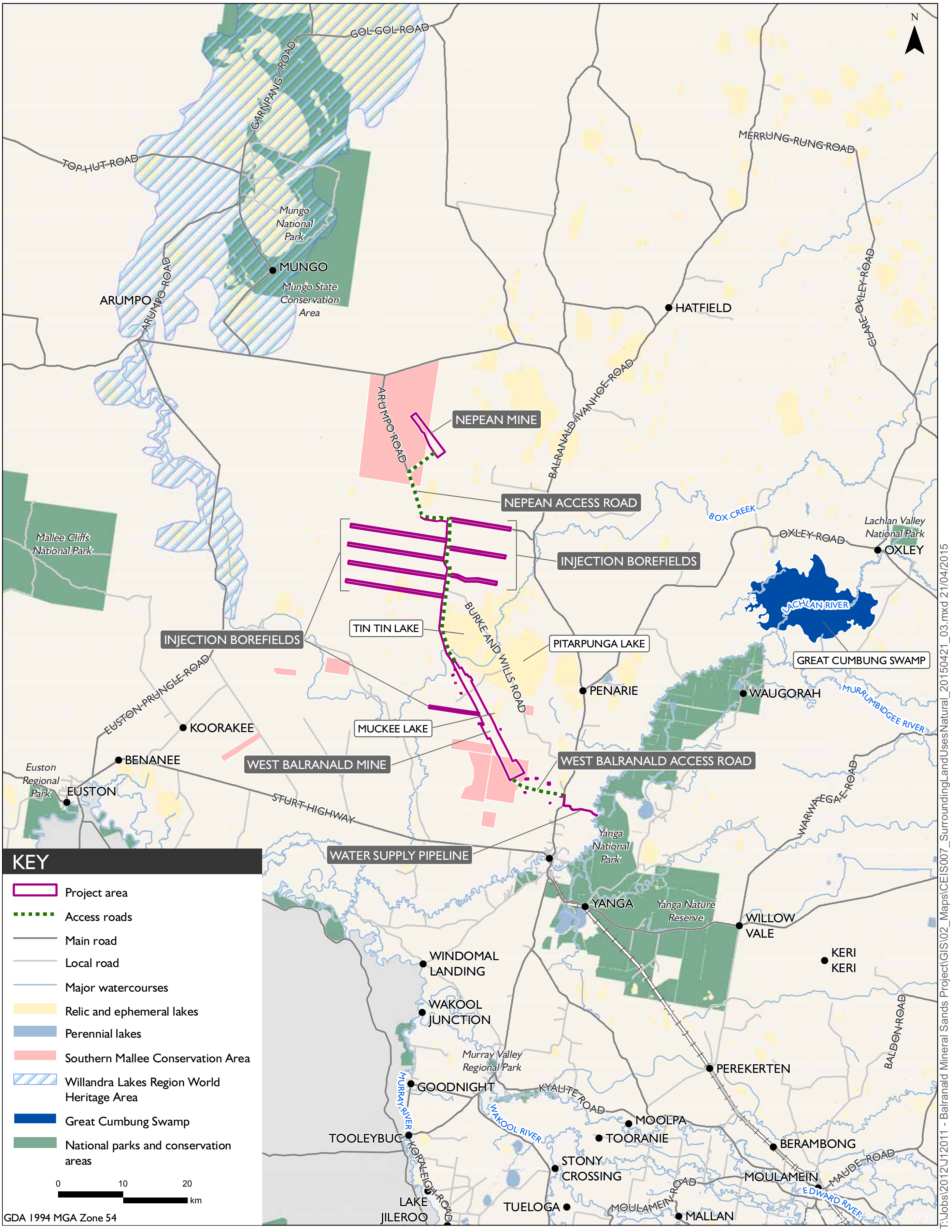
Figure 7.2



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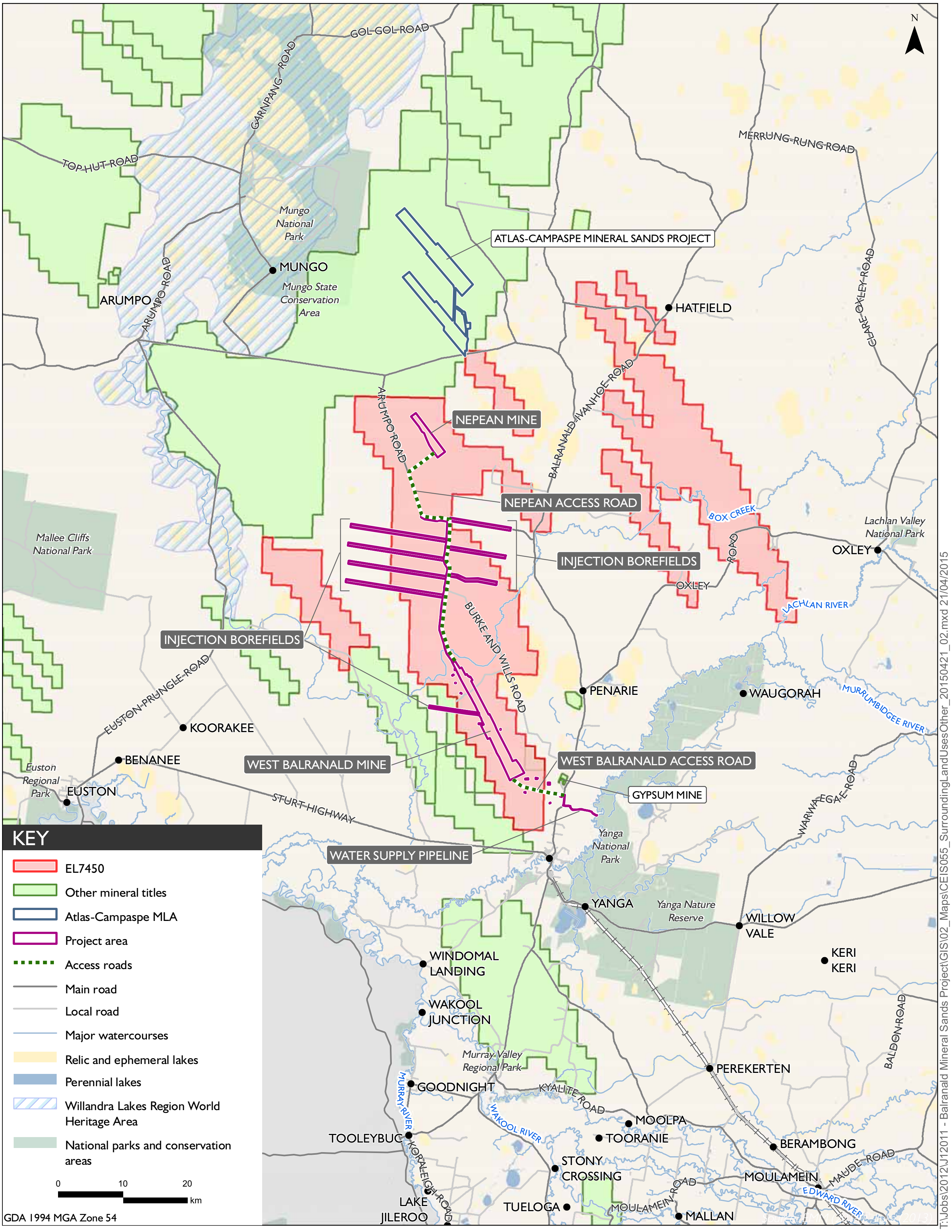
Surrounding land uses - natural features

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 7.3



Surrounding land uses - other features

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Figure 7.4

8 Impact assessment approach

8.1 Assessment approach

As with any resource project, the economic viability of mining is inherently sensitive to market conditions and commodity prices. Furthermore, with the scale of mining proposed for the Balranald Project, including both material handling and groundwater management, associated capital and operating costs also affect economic viability. Such sensitivities and costs can affect critical aspects of the Balranald Project; an example of this is overall pit design, with pit dimensions (including width and length) varying depending on product pricing and market conditions. Accordingly, there is a need for ongoing design optimisation depending on market conditions in the lead up to, and over the life of the Balranald Project.

The ongoing process of mine optimisation may result in changes during detailed design, including:

- overall extent (width and length) of the pit within the mining area;
- location and volume of overburden and soil stockpiles within the direct disturbance area;
- location and layout of infrastructure within the processing area;
- location of groundwater dewatering and injection infrastructure;
- location of other infrastructure such as internal haul roads and services infrastructure; and
- avoidance of environmental constraints (eg Aboriginal heritage items, significant vegetation).

As a result, there is a need to provide flexibility in the design of the Balranald Project in any planning approvals. Accordingly, to allow for this flexibility, the adopted environmental impact assessment approach for each technical study is conservative (ie assumed worst case scenarios), providing the ability for some project elements and infrastructure to be relocated within the project area during detailed design.

The approach for the environmental impact assessments considered the principles of avoid, manage, mitigate and offset. That is:

- where attributes with high significance were identified that could be avoided, Iluka revised the project design to avoid impacts to these area by relocating infrastructure (such as internal roads, injection borefields, soil and overburden stockpiles and ancillary infrastructure); and
- where features could not be avoided and would be directly impacted, it was assumed that these would be impacted, and the EIS prepared on this basis with identification of measures to manage, mitigate and offset the impact.

The following chapters provide a summary of the existing environment, assessment methods, potential impacts and management and mitigation measures associated with each environmental aspect relevant to MNES identified in the EIS Guidelines for the Balranald Project, including:

- biodiversity;
- Aboriginal cultural heritage;
- non-Aboriginal (or historic) heritage;
- water resources;
- geochemical;
- radiation;
- social;
- economics; and
- rehabilitation.

These chapters are summaries of technical assessments prepared for each of these aspects. Copies of the technical assessments can be found in Appendices C to N. Each technical assessment addresses the above requirements where relevant. In particular, the chapters in this EIS summarising the technical assessments have been structured to provide a description of the existing environment, an assessment of the potential impacts of the Balranald Project and a description of the management and mitigation measures that would be implemented by Iluka to ensure residual impacts are addressed. Guidelines, policies and plans relevant to each technical assessment are also addressed.

In addition, the chapters prepared to address the EIS Guidelines include details on:

- the existing environment of the proposal site and surrounding areas that may be directly or indirectly affected by the action;
- an assessment of relevant impacts of the action; and
- proposed avoidance, mitigation and offset measures to deal with the relevant impacts of the action.

Specific requirements in Sections 4, 5 and 6 of the EIS Guidelines are referenced where relevant in each of the chapters.

It should be noted that technical assessments were also completed for a range of other environmental aspects to support the SSD application under the EP&A Act which are contained in the NSW EIS, including:

- noise and vibration;
- air quality;
- greenhouse gas;
- soil resources;

- land use;
- traffic;
- bushfire; and
- visual.

Summaries of these technical assessments have not been included in this EIS as they are not considered relevant to the MNES assessed.

9 Biodiversity

9.1 Introduction

A biodiversity assessment was undertaken by Niche Environment and Heritage (Niche) for the Balranald Project and is provided in Appendix C. The assessment was undertaken to address the requirements of Sections 4, 5 and 6 of the EIS Guidelines (see below) and in accordance with the following regulations, methods and guidance documents:

- *Draft NSW Biodiversity Offset Policy for Major Projects* (OEH 2014);
- *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna – Amphibians* (DECCW 2009);
- *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft* (DECC 2004);
- *Threatened Species Assessment Guidelines: the Assessment of Significance* (DECC 2007);
- *Guidelines for Threatened Species Assessment* (DoP 2005);
- *BioBanking Assessment Methodology* (BBAM) (OEH 2104);
- *Framework for Biodiversity Assessment* (FBA) (OEH 2014);
- *Environmental Offsets Policy* (Commonwealth DoE 2012);
- *Survey guidelines for Australia's threatened bats Guidelines for detecting bats listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999* (DEWHA 2010)*;*
- *Survey guidelines for Australia's threatened birds Guidelines for detecting birds listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999* (DEWHA 2010)*;*
- *Survey guidelines for Australia's threatened frogs: Guidelines for detecting frogs listed as threatened under the EPBC Act* (DEWHA 2010);
- *Survey guidelines for Australia's threatened mammals: Guidelines for detecting mammals listed as threatened under the EPBC Act* (DEWHA 2011);
- *NSW State Groundwater Dependent Ecosystem Policy*(DLWC 2002);
- *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NOW 2012);
- *Policy & Guidelines - Fish Friendly Waterway Crossings* (NSW Fisheries 2003);
- *Policy & Guidelines - Aquatic Habitat Management and Fish Conservation* (NSW Fisheries 2013); and
- *State Environmental Planning Policy No. 44 – Koala Habitat Protection*.

9.2 EIS Guidelines

As previously stated, the EIS Guidelines state that two key assessment requirements are in relation to:

- impacts on threatened species and ecological communities listed under sections 18 and 18A of the EPBC Act; and
- impacts on migratory species listed under sections 20 and 20A of the EPBC Act.

The EIS Guidelines require details on the existing environment, relevant impacts and proposed avoidance, mitigation and offset measures to deal with the relevant impacts of the Balranald Project in relation to threatened species and ecological communities, and migratory species.

They state:

> **4. DESCRIPTION OF THE ENVIRONMENT**
>
> a) quantification and description of, and maps showing, the location, nature, extent and where relevant, the condition, of all vegetation types occurring on and adjacent to the vegetation on site;
>
> b) quantification and description of, and maps showing, the distribution and abundance of EPBC Act listed threatened species and ecological communities within the site and in surrounding areas that may be impacted by the proposal. This should include, *but not be limited to,* up-to-date survey results for the Malleefowl, South eastern Long-eared Bat, Regent Parrot, Winged Peppercress, Cobar Greenhood Orchid, Yellow Swainson-pea, Murray Swainson-pea, Mossgiel Daisy, *Austrostipa metatoris*, *Austrostipa wakoolica*, Western Water-starwort, Striated Spike-sedge, Chariot Wheels, River Swamp Wallaby-grass and Menindee Nightshade (and any other relevant listed species and ecological communities);
>
> c) quantification and description of, and maps showing, the nature, location and extent of habitat for EPBC Act listed threatened species and ecological communities within the site and in surrounding areas that may be impacted by the proposal;
>
> d) a detailed description of the scope, methodology, timing, effort and results of all targeted surveys undertaken for all relevant EPBC Act matters and associated habitat, how the methodologies compare with any relevant guidelines or policies and a description of any limitations and constraints of the surveys undertaken and a justification of their adequacy;
>
> ...
>
> **5. RELEVANT IMPACTS**
>
> a) a detailed description and assessment of the nature and extent of all relevant impacts, including direct, indirect, facilitated and cumulative impacts at all stages of the action that the action will have or is likely to have in the short-term and long-term on:
>
> i. threatened species and ecological communities listed under sections 18 and18A of the EPBC Act;
>
> ii. migratory species listed under sections 20 and 20A of the EPBC Act;
>
> ...

c) any cumulative impacts, where potential project impacts are in addition to existing impacts of other activities (including known potential future expansions or developments by the proponent and other proponents in the region and vicinity), and the potential cumulative impact of the proposal on ecosystem resilience. The cumulative effects of climate change impacts on the environment must also be considered in the assessment of ecosystem resilience. Where relevant to the potential impact, a risk assessment should be conducted and documented.

...

6. PROPOSED AVOIDANCE, MITIGATION AND OFFSET MEASURES

(a) a description of how the action has been designed to avoid impacts to migratory species, threatened species and ecological communities, World Heritage values and National Heritage values;

(b) a consolidated list of mitigation measures proposed to be undertaken to prevent or minimise the relevant impacts of the action, before, during and after construction, during operation, decommissioning and rehabilitation;

(c) the cost of the proposed mitigation measures;

...

(i) in the event that impacts cannot be avoided or mitigated, a description of any offsets to compensate for any predicted or potential residual impacts on matters of NES. This should be in accordance with the EPBC Act Environmental Offsets Policy and include:

a. an assessment of how any proposed offset compensates for the residual impacts on matters of NES likely to remain following avoidance and mitigation measures to be implemented;

b. the location of any proposed offset;

c. the timing of the delivery of any offset; and

d. how the offset will be secured and managed in perpetuity.

With the exception of the cost of proposed mitigation measures, the above requirements are addressed in this chapter and the biodiversity assessment contained in Appendix C. In relation to costs of proposed mitigation measures, estimated costs of all mitigation measures have been incorporated into the economic assessment of the Balranald Project discussed in Chapter 16 and contained in Appendix N. Preparation of cost estimates for likely management actions for offset packages will be done in consultation with NSW OEH, NSW LLS and NSW NPWS (as applicable).

9.3 Methods

9.3.1 Database and literature review

To characterise ecological features of the project area a detailed review of relevant literature and vegetation mapping was undertaken as well as searches of relevant databases. This background information was used to design the ecological field surveys that were commensurate with the species and the extent of potentially suitable habitat identified within and adjoining the project area.

Threatened species databases and previous documents relevant to the Balranald Project reviewed to identify threatened species, populations and communities that may occur in the project area included:

- NSW Atlas of Wildlife Database for six 1:100 000 map sheets: Weimby (7528), Bidura (7529), Turlee (7530), Balranald (7628), Paika (7629), Hatfield (7630) (October 2014);
- Threatened Species Profile Search from the OEH website for the Lower Murray Darling CMA and Murrumbidgee catchment management areas (CMAs) (November 2014);
- national rare or threatened Australian plants (ROTAP) database (Briggs and Leigh 1996); and
- Protected Matters Search of a 50 km radius around the project area.

9.3.2 Field survey

Field survey work was completed over four years by Ecotone Ecological Consultants (Ecotone) and Niche within and surrounding the project area. This included survey of:

- the Balranald and Nepean mines and access roads by Ecotone from 2011 to 2013; and
- additional ancillary infrastructure, including injection borefields and water supply pipeline by Niche from 2013 to 2014.

Given the project areas size and accessibility the survey methods used aimed to provide representative and stratified sampling of:

- vegetation and fauna habitat; and
- targeted threatened species.

Where cryptic species were not identified but considered likely to occur and given the scale of the project, these were assumed to occur where suitable habitat was available.

Flora surveys were completed using the methods prescribed in the BBAM (OEH 2014) and FBA (OEH 2014). A total of 207 quadrats, or plots, were completed, of which 94 were within the project area and an additional 113 in surrounding areas (within 1,000 m from the project boundary). Plots outside of the final project area were a result of changes in the mine plan, the area and extent of which modified and minimised to reduce impacts on habitat for threatened fauna.

The number of quadrats completed exceeded the recommendations within OEH's *Threatened Biodiversity Survey and Assessment – Guidelines for Developments and Activities* (DEC 2004), except for vegetation type 11 Flat Open Claypan/Derived Sparse Shrubland. No quadrats were completed given the extremely sparse nature and highly disturbed element within this vegetation type, and benchmark values were used in the offset calculations.

Driving transects were completed throughout all vehicle-accessible parts of the project area, with walking meanders supplementing these where vehicle access was not possible. Transects were used to record vegetation boundaries, the general condition of vegetation in different parts of the project area and any opportunistic flora species not detected in the quadrats. The walking meanders were also used to survey for threatened flora species across the project area.

The combination of floristic quadrats and walking meanders, supported by driving transects were ideal for detecting the range of threatened flora with potential to occur within the project area; walking meanders and transects along with driven transects allowed for significant coverage of the project area while floristic quadrats provided detection advantages for less conspicuous threatened plants. The mixture of survey techniques for threatened plants is consistent with recommended approaches by regulatory authorities.

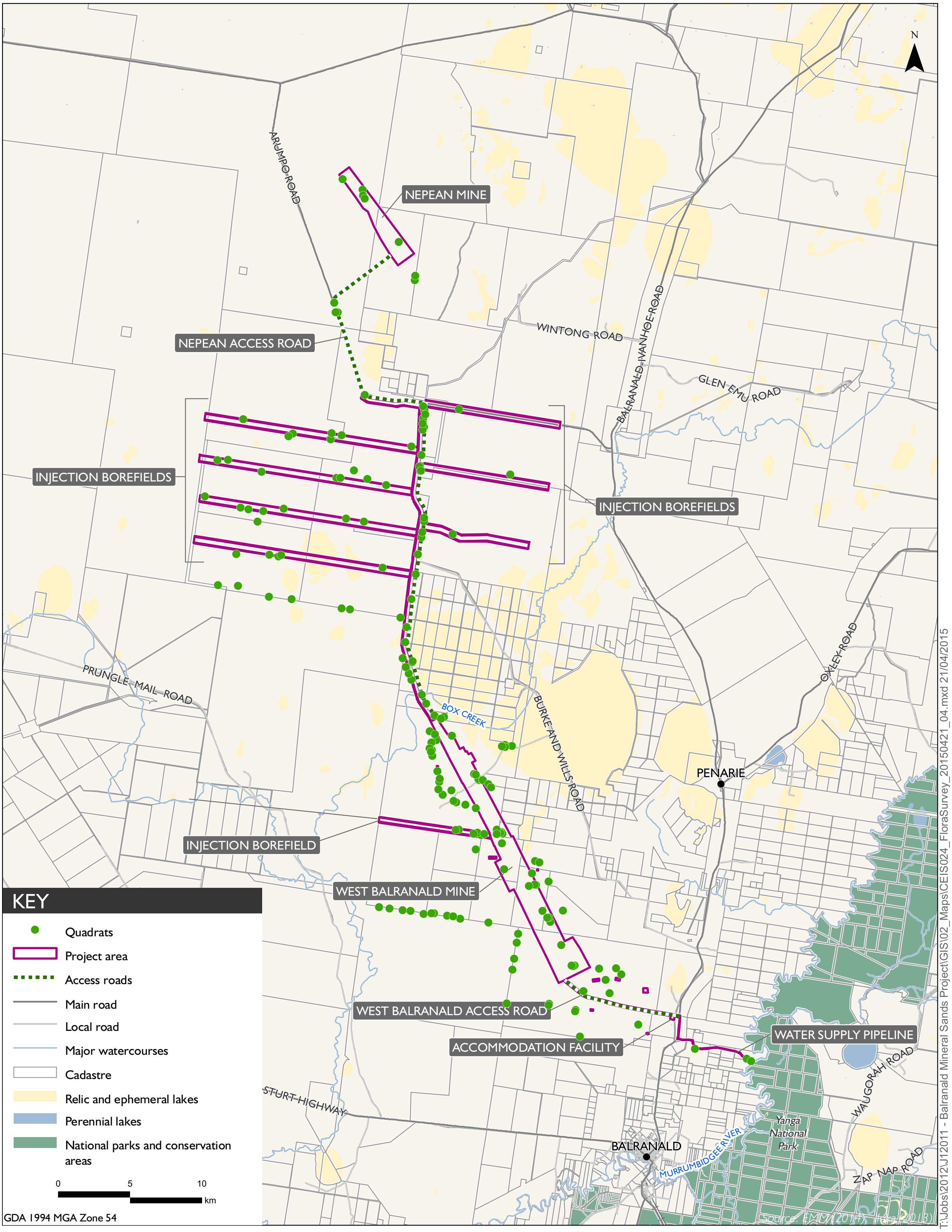
Flora quadrat locations can be seen in Figure 9.1.

Fauna surveys were completed across the project area and surrounds. Primary fauna survey sites were established in 2011 by Ecotone, mainly within the mine disturbance areas to sample all broad fauna habitats available. The following survey methods were conducted at each primary survey site:

- habitat assessment;
- pitfall trapping, reptile funnel traps and Elliott traps;
- micro-bat survey;
- diurnal reptile census;
- nocturnal survey for mammals, reptiles and frogs;
- remote cameras;
- call playback; and
- sand pads targeting introduced species (Nepean mine only).

Additional fauna surveys were undertaken by Ecotone in the project area in 2012 and 2013 including:

- habitat assessment;
- Malleefowl mound search transects;
- nocturnal and diurnal reptile searches (January 2013 only);
- nocturnal and diurnal call playback specifically targeting the Bush Stone Curlew, Red throat, Rufous Fieldwren, Shy Heathwren, Striated Grasswren and Southern Scrub-Robin (January 2013 only); and
- driven spotlight transects targeting the Plains Wanderer and nocturnal reptiles (2011 and 2013).



Flora quadrat locations

Balranald Mineral Sands Project
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Figure 9.1

Additional surveys to cover the injection borefields, Murrumbidgee River locality and water supply pipeline area, and West Balranald and Nepean mine areas were sampled by Niche between late 2013 and 2014 including:

- bat and bird surveys;
- full flora and fauna survey (2013 and 2014);
- targeted Regent Parrot survey; and

targeted survey for Malleefowl. During all surveys, opportunistic observations of fauna or flora habitat and species were recorded.

All fauna survey was completed in accordance with OEH's *Threatened Biodiversity Survey and assessment – Guidelines for Developments and Activities* (DEC 2004) and *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna – Amphibians* (DECCW 2009).

The survey effort for threatened fauna took into considered a number of EPBC Act guidelines including:

- DEWHA (2010) *Survey guidelines for Australia's threatened bats Guidelines for detecting bats listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999;*
- DEWHA (2010) *Survey guidelines for Australia's threatened birds Guidelines for detecting birds listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999;*
- DEWHA (2010) *Survey guidelines for Australia's threatened frogs: Guidelines for detecting frogs listed as threatened under the EPBC Act*; and
- DEWHA (2011) *Survey guidelines for Australia's threatened mammals: Guidelines for detecting mammals listed as threatened under the EPBC Act*.

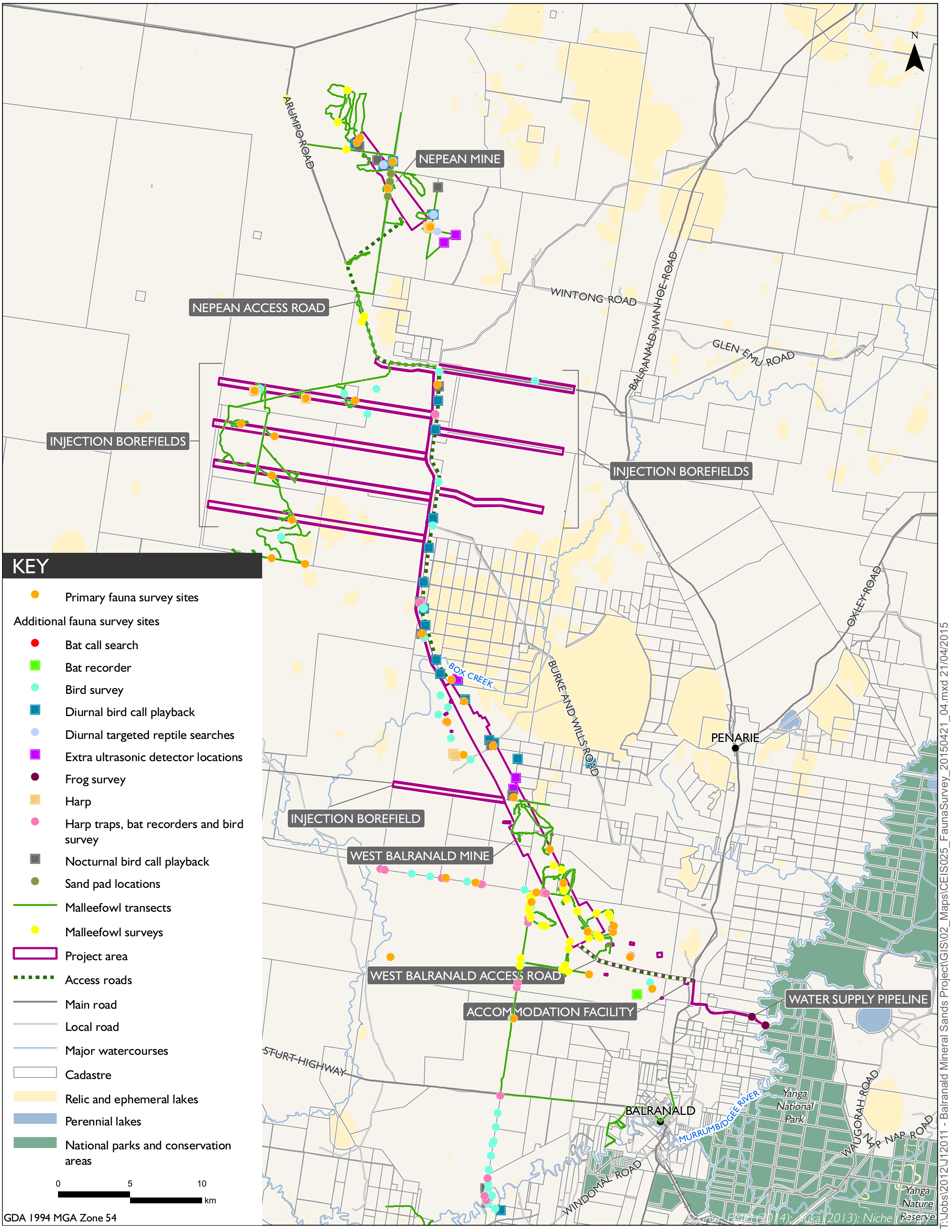
The total survey effort for each method is detailed in Table 9.1. Fauna survey locations can be seen in Figure 9.2.

Table 9.1 Summary of fauna survey effort

Survey method	Inside project area(or < 1 km distant)					Outside project area	Total
	Nepean mine	West Balranald mine	Nepean access road	Injection borefield	Water supply pipeline		
Camera traps (nights)	63	94	38	154		393	742
Elliot traps (nights)	214	304	100	1,040		1,110	2,768
Pitfall traps (nights)	166	196	20	98		126	606
Reptile Funnels (nights)	214	304				0	518
Nest Boxes (nights)			240	32		1,952	2,224
Diurnal bird survey (20 min surveys)	6	7	22	20	2	95	152

Table 9.1 Summary of fauna survey effort

Survey method	Inside project area(or < 1 km distant)					Outside project area	Total
	Nepean mine	West Balranald mine	Nepean access road	Injection borefield	Water supply pipeline		
Nocturnal call playback (15 min surveys)	2	8	3	1		1	15
Diurnal call playback (15 min surveys)	4	6		16		9	35
Diurnal reptile searches (hours)	8	9	7	9		14.5	47.5
Bat call detectors (stationary - nights)	12	20	14	10		54	110
Bat call detectors (handheld - hours)	5	8				0	13
Harp traps (nights)	10	16	10	2		40	78
Sand plots (nights)	9					0	9
Frog census and active search (hours)	1	2 *			3	3	9
Predator Scats	22	8				0	30
Nocturnal spotlight (driven/walked – hours)	9	12	1	10		22.5	54.5
Malleefowl Transects (hours)	38	23	7			19	97
Malleefowl Mound Checks		4				5	9
Regent Parrot – point surveys (hours)		4				30	34
Regent Parrot – transect surveys walked (hours)						62	62
Regent Parrot – transect surveys (driven)		6				14	20



Fauna survey locations

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 9.2

9.4 Results

9.4.1 Database and literature review

The project area occurs in the Murray Darling Depression and Riverina Bioregion and the South Far Western Plains botanical subregion, and occurs over two CMAs, the Lower Murray Darling CMA and Murrumbidgee CMA.

The project area traverses the Lachlan Lakes, Swamps and Lunettes, Lachlan Depression Plains, Mallee Cliffs Sandplains, and Lachlan Channels and Floodplains Mitchell Landscapes. The northern third of the west Balranald mine consists of flat alluvial and lacustrine deposits of gravel, sand, silt and clay. The southern two-thirds consists of Aeolian flats to gently undulating plains and dunes of red and red-brown clayey sands and loams. The Nepean mine consists of tertiary marine and non-marine sediments overlain with Quaternary aeolian fluvial and lacustrine deposits of sand, silt and clay (Soil Conservation Service of NSW 1990).

The Murrumbidgee River occurs to the east and south of the project area. The West Balranald mining area is part of the catchment for Paika Creek (central) and Box Creek (northern part). Dry lake beds (Muckee and Tin Tin) occur in the northern half and are currently being cropped. The Nepean mining area is part of the catchment for Box Creek and dry lake beds occur to the east and south.

The West Balranald mine passes through an area of SMCA which is fenced and set aside as an offset for clearing mallee remnants for agriculture. The Nepean mining area occurs within a large area of Linear Dune Mallee with approximately 60% of the area being within the Wampo SMCA. This conservation area contains known habitat for the listed threatened species.

The searches and literature review identified 14 Commonwealth-listed flora species that are known or could occur in the project area, including:

- five species listed as endangered under the EPBC Act: *Austrostipa wakoolica, Caladenia tensa, Calotismoorei, Lepidium monoplocoides* and *Leucochrysum albicans* vartricolor; and

- nine species listed as vulnerable under the EPBC Act: *Acacia carneorum, Atriplex infrequens, Austrostipa metatoris, Brachyscome papillose, Callitriche cyclocarpa, Maireana cheelii, Solanum karsense, Swainsona murrayana* and *Swainsona pyrophila.*

Three Commonwealth-listed threatened ecological communities (TECs) listed under the EPBC Act are known or could occur in the project area:

- Buloke Woodlands of the Riverina and Murray- Darling Depression Bioregions;

- Grey Box Grassy Woodlands and Derived Native Grasslands of South-eastern Australia; and

- Weeping Myall Woodlands.

The searches and literature review also identified 25 Commonwealth-listed fauna species that are known or could occur in the project area, comprising:

- six species listed as endangered, comprising:
  - Australasian Bittern (*Botaurus poiciloptilus*);

- Red-tailed Black-Cockatoo (inland subspecies) (*Calyptorhynchus banksii samueli*);
- Swift Parrot (*Lathamus discolour*);
- Black-eared Miner (*Manorina melanotis*);
- Australian Painted Snipe (*Rostratula australis*); and
- Spotted-tailed Quoll (*Dasyurus maculatus*).

- 10 species listed as vulnerable, comprising:
  - Southern Bell Frog (*Litoria raniformis*);
  - Thick-billed Grasswren (*Amytornis textilis modestus*);
  - Malleefowl (*Leipoa ocellata*);
  - Red-lored Whistler (*Pachycephala rufogularis*);
  - Plains-wanderer (*Pedionomus torquatus*);
  - Regent Parrot (eastern subspecies) (*Polytelis anthopeplus monarchoides*);
  - Koala (*Phascolarctos cinereus*);
  - Corben’s Long-eared Bat (*Nyctophilus corbeni*);
  - Greater Long-eared Bat (south eastern form) (*Nyctophilus timoriensis*); and
  - Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris)*.
- nine species listed as migratory, comprising:
  - Fork-tailed Swift (*Apus pacificus*);
  - Great Egret (*Ardea alba*);
  - Cattle Egret (*Ardea ibis*);
  - Latham’s Snipe (*Gallinago hardwickii*);
  - White-bellied Sea-Eagle (*Haliaeetus leucogaster*);
  - Malleefowl (*Leipo aocellata*);
  - Black-tailed Godwit (*Limosa limosa*);
  - Rainbow Bee-eater (*Merops ornatus*); and
  - Satin Flycatcher (*Myiagra cyanoleuca*).

Note that the Malleefowl is listed as both vulnerable and migratory under the EPBC Act, and as such has been counted twice in the 23 species at are known or could occur in the project area.

No critical habitat was identified for threatened flora or fauna.

9.4.2 Vegetation

The project area contains three broad areas and types of vegetation.

The northern part of the project area (where the Nepean mine is located) is dominated by Saltbush, Chenopod and Black Box communities, with some woodland. Some dry lakes and claypans also occur. The northern part of the Nepean mine is part of a SMCA. Areas outside the SMCA are used for agricultural purposes, particularly sheep grazing.

The southern area part of the project area is dominated by Mallee communities, consisting of Spinifex Mallee interspersed with Chenopod Mallee and pure Chenopod Mallee closer to the centre of the West Balranald mine. The far southern end of the West Balranald mine area has been mostly cleared for crops with remnant patches or strips of native Mallee vegetation. The West Balranald mine contains mostly agricultural land used for grazing and cropping, with remnant native vegetation consisting of patches of mallee and saltbush plains.

All project areas are grazed by feral goats, which have reduced the shrub and ground layer within the Mallee communities.

The Murrumbidgee River locality and water supply pipeline area contains floodplain communities.

During the field survey, 198 flora species were recorded, including a total of 46 introduced species. Eleven BioMetric Vegetation Types were identified in the project area (shown in Figure 9.3) include:

- Vegetation type 1 - Spinifex Dune Mallee Woodland;
- Vegetation type 2 - Chenopod Sandplain/Swale Mallee Woodland;
- Vegetation type 3 - Black Bluebush Low Open Shrubland;
- Vegetation type 4 - Pearl Bluebush Low Open Shrubland;
- Vegetation type 5 - Bladder Saltbush Low Open Shrubland;
- Vegetation type 6 - Old Man Saltbush Shrubland;
- Vegetation type 7 - Belah – Pearl Bluebush Woodland;
- Vegetation type 8 - Belah – Chenopod Woodland;
- Vegetation type 9 - Black Box Grassy Chenopod Open Woodland;
- Vegetation type 10 - River Red Gum Woodland; and
- Vegetation type 11 - Flat Open Claypan/Derived Sparse Shrubland/Grassland.

An additional vegetation community was identified; Vegetation type 12- Cultivated Grain Crops/Cleared Weedy Fallow/Developed. This community is highly modified and consists of mostly bare soil, cultivated and developed areas.

Vegetation types mapped in the project area (see Table 9.2) are shown in only small areas of vegetation types 9 - Black Box Grassy Chenopod Open Woodland and 10 - River Red Gum Woodland occur in the disturbance area. Black Box Grassy Chenopod Open Woodland occurs in the central-northern part of the West Balranald mine and outer part of the Murrumbidgee River Floodplain, while River Red Gum Woodland only occurs along the banks and floodplain of the Murrumbidgee River along the proposed water supply pipeline. Both communities are in a modified condition from past and ongoing tree thinning, logging and cattle grazing.

A total of 5,160.5 ha of native vegetation was mapped across the disturbance area, with an additional 186.1 ha of non-native vegetation cover or disturbed areas (Table 9.2). Vegetation type 2 - Chenopod Sandplain/Swale Mallee Woodland is the most abundant community in the disturbance area. This community occupies flat plains, gently sloping rises and lower-lying swale areas between the crests of the east-west linear dunes in Nepean mine, northern end of the Nepean access road and southern end of West Balranald mine. Vegetation type 4 - Pearl Bluebush Low Open Shrubland also has a high abundance over the project area, though mainly in the northern section of the West Balranald mine adjacent to the large dry lakebeds and claypan areas. Both vegetation types are in fair to good condition despite grazing by stock and feral animals.

Noxious weeds were generally absent across the project area with the exception of disturbed areas where at least four declared noxious species occurred in larger amounts. Declared weeds under the NSW *Noxious Weeds Act* 1993 include Onion Weed *(Asphodelus fistulosus)* African Boxthorn *(Lycium ferocissimum)* Noogoora Burr *(Xanthium occidentale)* Bathurst Burr *(Xanthium spinosum).*

Most of the remnant woodland within the project area is mapped as unburnt since at least 1972.

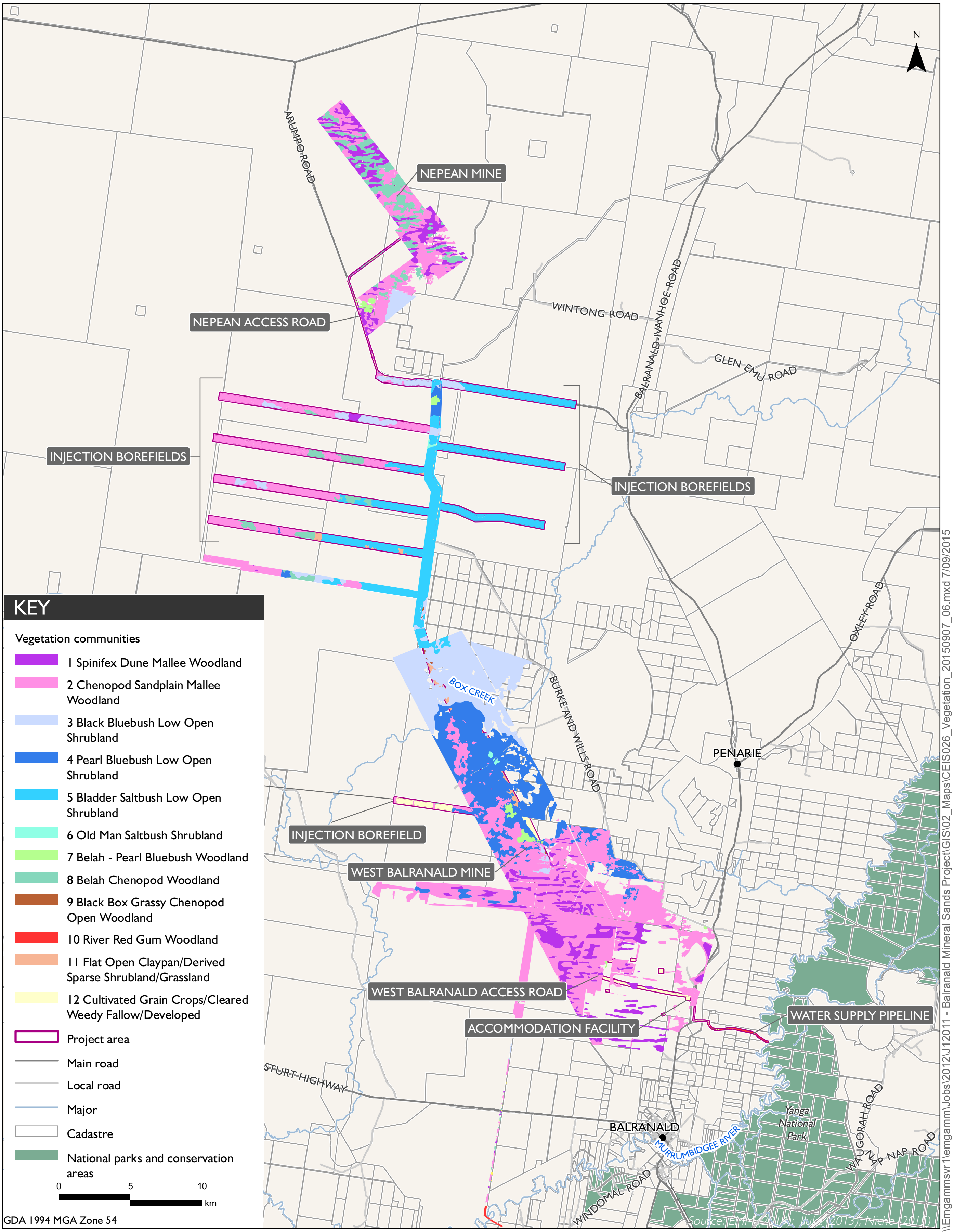
Table 9.2 Vegetation types recorded in the disturbance area

Vegetation formation	Vegetation class	BioMetric vegetation type	Recorded vegetation type	Extent within disturbance area (ha)[1]								
				Nepean mine	Nepean access road	West Balranald mine	West Balranald access road	Borefield	Water supply pipeline	Accommodation facility	Gravel extraction area	Total
Semi-arid woodlands (shrubby sub-formation)	Dune Mallee Woodlands	LM130 - Linear Dune Mallee mainly of the Murray-Darling Basin Bioregion	1. Spinifex Dune Mallee Woodland	187.2	8.6	311.6	7	8.1	0	0	13.9	536.4
	Sand Plain Mallee Woodlands	LM116 - Chenopod sandplain mallee woodland/shrubland of the arid and semi-arid (warm) zones	2.Chenopod Sandplain/Swale Mallee Woodland	248.4	28	1,392.20	14.4	366.2	2.3	0	0	2,051.5
	Semi-arid Sand Plain Woodlands	LM107 – Black Oak – Pearl Bluebush open woodland of the sandplains of the semi-arid warm and arid climate zones	7.Belah – Pearl Bluebush Woodland	0	5.3	105.8	0	3.7	0	0	0	114.8
		LM108 – Black Oak – Western Rosewood open woodland on deep sandy loams of Murray-Darling Depression and Riverina Bioregions	8.Belah – Chenopod Woodland	368.3	8	0	0	62.4	0	0	0	438.7
Semi-arid woodlands (grassy sub-formation)	Inland Floodplain Woodlands	LM105 – Black Box open woodland with chenopod understorey mainly on the outer floodplains of the Riverina and Murray-Darling Depression Bioregions	9.Black Box Grassy Chenopod Open Woodland	0	0.2	1.4	0	4.3	1	0	0	6.9
Forested wetlands	Inland Riverine Forests	LM143 – River Red Gum – Lignum very tall open forest or woodland on floodplains of semi-arid (warm) climate zone	10.River Red Gum Woodland	0	0	0	0	0	3.8	0	0	3.8

Table 9.2 Vegetation types recorded in the disturbance area

Vegetation formation	Vegetation class	BioMetric vegetation type	Recorded vegetation type	Extent within disturbance area (ha)[1]								
				Nepean mine	Nepean access road	West Balranald mine	West Balranald access road	Borefield	Water supply pipeline	Accommodation facility	Gravel extraction area	Total
Arid shrublands (Chenopod sub-formation)	Aeolian Chenopod Shrublands	LM102 – Black Bluebush low open shrubland of the alluvial plains and sandplains of the arid and semi-arid zones	3.Black Bluebush Low Open Shrubland	0	30	85.6	0	169.3	0	0	0	284.9
		LM138 – Pearl Bluebush low open shrubland of the arid and semi-arid plains	4.Pearl Bluebush Low Open Shrubland	0	8	1,032.5	0	23.9	0	0	7.7	1,072.1
	Riverine Chenopod Shrublands	LM110 – Bladder Saltbush shrubland on alluvial plains in the semi-arid (warm) zone	5.Bladder Saltbush Low Open Shrubland	0	40	0	0	518	0	0	0	558
		LM137 – Old Man Saltbush shrubland mainly of the semi-arid (warm) climate zone (south western NSW)	6.Old Man Saltbush Shrubland	0	0	19.3	0	0.5	0	0	0	19.8
Saline wetlands	Inland Saline Lakes	LM124 - Disturbed annual saltbush forbland on clay plains and inundation zones of the arid and semi-arid climate zones	11.Flat Open Claypan/Derived Sparse Shrubland/ Grassland	0	1.7	50.9	0	21	0	0	0	73.6
Not classified	12. Cultivated Grain Crops/Cleared Weedy Fallow/Developed			1.2	27.5	59.4	30.5	36.3	3.8	7.1	20.3	186.1
Total				**805.1**	**157.3**	**3,058.7**	**51.9**	**1213.7**	**10.9**	**7.1**	**41.9**	**5,346.6**

Note: 1. Areas in Niche (2015) were calculated to the nearest 0.1 ha.



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Mapped vegetation types

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Figure 9.3

9.4.3 Flora

During the field survey, 198 flora species were recorded. No threatened flora listed on either the TSC Act or EPBC Act were recorded within the project area. A list of all flora species identified from within the project area including the BioBanking attribute data is included as Appendix 4 of the biodiversity assessment contained in Appendix C of this EIS.

Of the 198 flora species, 34 subject threatened flora species have been previously recorded within the area bounded by the six map sheets, or have potential habitat within 50 km of the centre of the West Balranald mine or centre of the Nepean mine. This includes seven Commonwealth-listed species, including *Brachyscome papillosa*, *Lepidium monoplocoides*, *Maireana cheelii*, *Pterostylis cobarensis*, *Santalum murrayanum*, *Swainsona murrayana* and *Swainsona pyrophila*.

9.4.4 Fauna

Most of the project area is subject to grazing by livestock (sheep or cattle), with the exception of the SMCAs, where livestock grazing is not permitted, but grazing by feral herbivores is common. This has resulted in the general absence or reduced diversity of palatable herb and shrub species. The limited ground cover, understorey cover and floral diversity has led to a lower than expected passerine bird diversity in the project area. The surveys also indicated that foxes, feral cats, rabbits, brown hares, pigs, house mice and goats are common, which negatively impacts on vegetation cover, regeneration and consequently native fauna diversity.

Despite this, an array of fauna species was recorded during the surveys including:

- 171 vertebrate species consisting of two frog, 111 bird, 36 reptile and 25 mammal species were recorded in the proposed West Balranald mine;
- 143 vertebrate species consisting of two frog, 82 bird, 33 reptile and 26 mammal species in the proposed Nepean mine;
- 107 vertebrate species consisting of 62 bird, 21 reptile and 24 mammal species in the injection borefield area;
- 15 species in the proposed water supply pipeline route where only nocturnal frog searches were completed; and
- an additional 101 species were recorded from survey outside of the project area but within the locality.

Further, several habitat features that are important for both common and threatened fauna species were recorded throughout the project area. This included:

- spinifex clumps: within vegetation type 1 - Spinifex Dune Mallee Woodlands, in the southern part of the West Balranald mine and the Nepean mine;
- hollow bearing trees and stags: within vegetation types 2 - Chenopod Sandplain/Swale Mallee Woodland, 7 -Belah – Pearl Bluebush Woodland and 8 - Belah – Chenopod Open Woodland;
- hollow logs and fallen timber: moderately common in vegetation type 1 - Spinifex Dune Mallee Woodlands;

- permanent water features: restricted to occasional farm dams in the project area; and
- ephemeral water features: in the eastern end of the proposed water supply pipeline.

Species richness was greater in areas of woodland, and decreased within shrubland habitats particularly those distant from woodland areas. A large number of species, mainly birds, were recorded as opportunistic observations only.

Five Commonwealth-listed fauna species were detected during field-survey, including Corben's Long-eared Bat, Malleefowl, Plains-wanderer, Regent Parrot, and Rainbow Bee-eater. Notwithstanding this, while the Plains-wanderer was recorded as being detected, the record could not be accurately confirmed.

9.4.5 Commonwealth-listed species, populations and communities

No threatened flora species were recorded during the surveys within the project area. However six Commonwealth-listed flora species are considered to have a low to moderate likelihood of occurrence within the project area, based on the field surveys and literature review (see Table 9.3) and therefore potentially impacted by the Balranald Project. For the purposes of impact assessment, species with a low to moderate likelihood of occurrence, and moderate chance of being impacted, were assumed to be present in the disturbance area potentially impacted by the proposal.

Five Commonwealth-listed fauna species were detected during field-survey, including Corben's Long-eared Bat, Malleefowl, Plains-wanderer, Regent Parrot and Rainbow Bee-eater. Notwithstanding this, while the Plains-wanderer was recorded as being detected, the record could not be accurately confirmed. Six Commonwealth-listed fauna species are considered to be potentially affected by the Balranald Project. These include the species detected during survey and the Southern Bell Frog (*Litoria raniformis*) which has potential to occur with the project area.

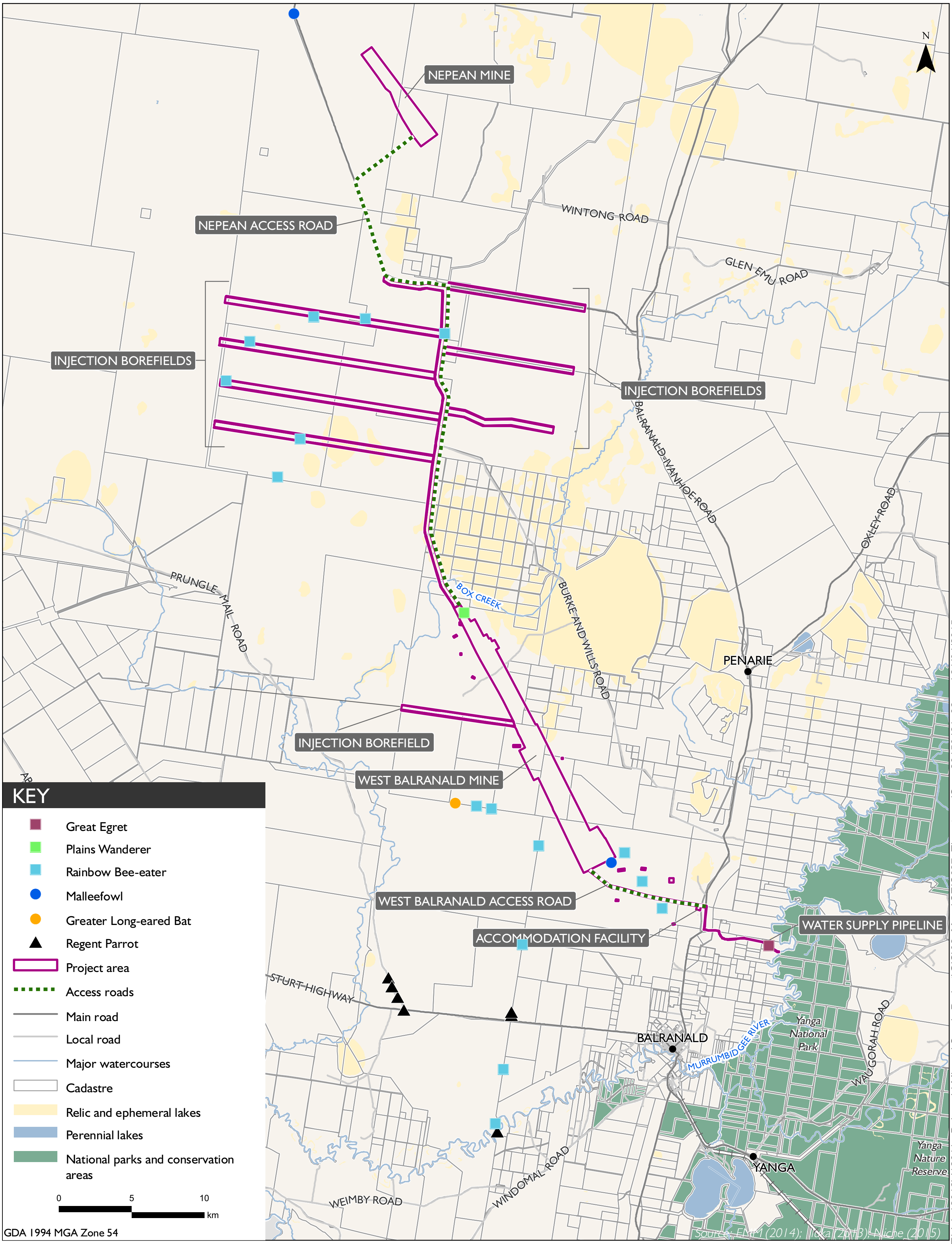
The locations of recorded Commonwealth-listed species can be seen in Figure 9.4.

No Commonwealth-listed populations were identified within the project area and none are considered likely to occur. None of the identified vegetation types in the project area meet the description of any TECs listed under the EPBC Act.

A total of 39 Malleefowl related observations were made during the course of field surveys (see Figure 9.5). The majority of observations (17) made were of old mounds that had no evidence of recent use, followed by footprints (12) indicating the presence of Malleefowl, recently used mounds (6) then observations of actual birds (2) and active mounds (3).

Active mounds and recently used mounds identified were all located within the West Balranald mine areas along with several bird and footprint observations. There were no active mounds recorded in the Nepean mine area, however a single bird was recorded within 250 m of the proposed mine area, and footprints were recorded on several occasions approximately 10 km south-west of the mine.

Malleefowl habitat potential has been mapped based on the density of records and known habitat preferences (see Figure 9.5). Mapping revealed that preferred habitat areas were those situated within the dunal mallee systems containing Vegetation type 1 - Spinifex Dune Mallee Woodland and Vegetation type 2 - Chenopod Sandplain/Swale Mallee Woodland.



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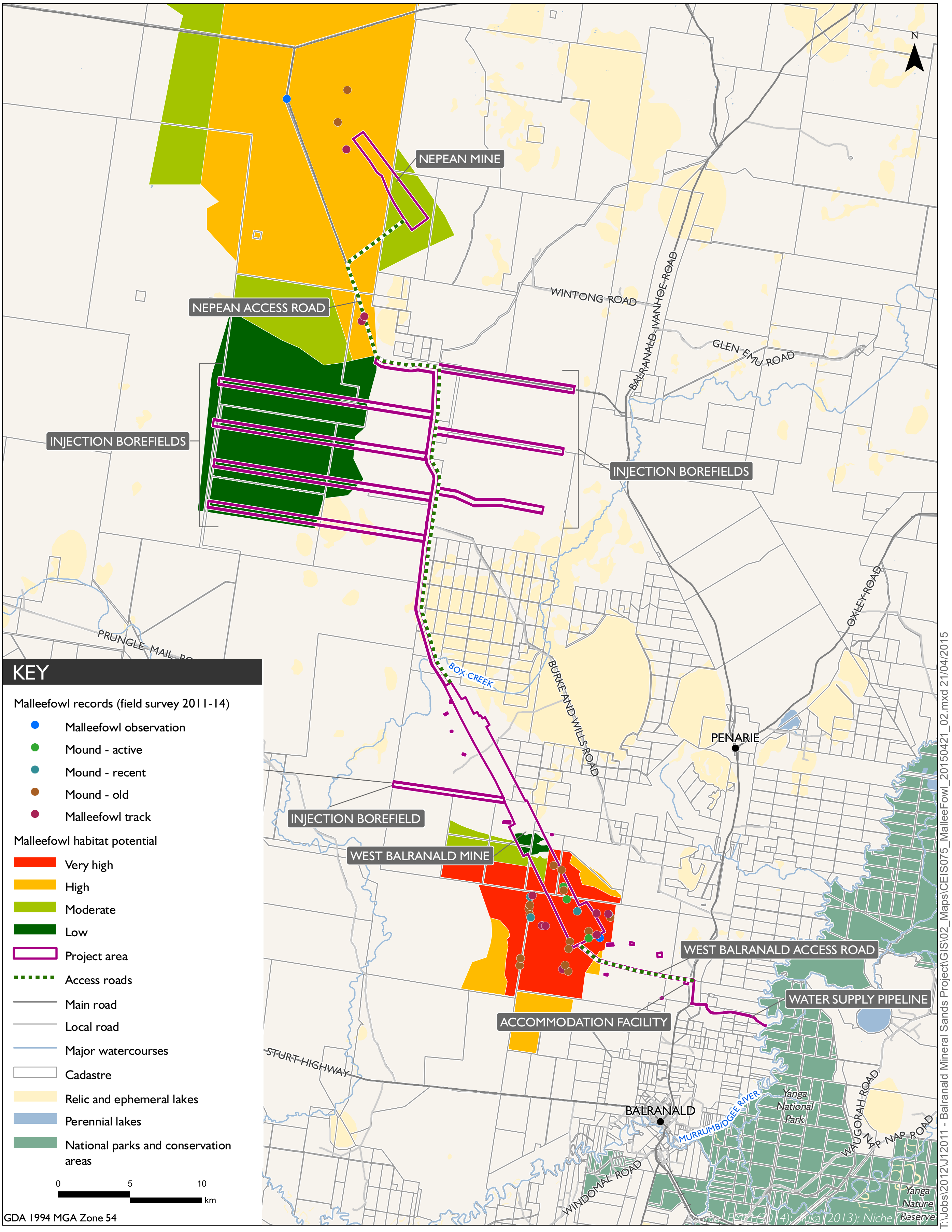
Commonwealth-listed species locations

Balranald Mineral Sands Project
Environmental Impact Statement

Figure 9.4



Malleefowl records and habitat

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 9.5

9.5 Impact assessment

9.5.1 Direct impacts

The Balranald Project would result in the disturbance to approximately 5,160.5 ha of native vegetation. A further 186.1 ha of exotic pasture and existing cleared land would be developed as a result of the Balranald Project. The total of the disturbance is approximately 5,346.6 ha. The area of each vegetation community to be impacted in each part of the project area is shown in Table 9.4.

As no TECs occur, the significance of remnant native vegetation to be impacted was assessed based on the distribution of vegetation types within the locality (20 km radius of the project area) (Table 9.4). Vegetation type 1 - Spinifex Dune Mallee Woodland was the least extensive (9,486 ha) community within the locality, with the project impacting 5.6% of its local extent. Impacts to chenopod communities (Vegetation types 3 - Black Bluebush Low Open Shrubland and 4 - Pearl Bluebush Low Open Shrubland) would be approximately 2.5%, while the project would impact less than 1% of the remainder of vegetation communities within the locality.

Table 9.3 Conservation significance of remnant native vegetation in the disturbance area

Vegetation type	Area cleared in CMA (%)	Disturbance area (ha)	Approximate extent in locality (ha)	Area of project disturbance in locality (ha)
1. Spinifex Dune Mallee Woodland (LM130)	5	536.4	36,137	1.5
2.Chenopod Sandplain/Swale Mallee Woodland (LM116)	30	2,051.5	127,317	1.6
3.Black Bluebush Low Open Shrubland (LM102)	10	284.9	37,177	0.8
4.Pearl Bluebush Low Open Shrubland (LM138)	10	1,072.1	10,325	10.4
5.Bladder Saltbush Low Open Shrubland (LM110)	40	558.0	131,416	0.4
6.Old Man Saltbush Shrubland (LM137)	90	19.8	2,646.4	0.7
7.Belah – Pearl Bluebush Woodland (LM107)	20	114.8	42,601	0.3
8.Belah – Chenopod Woodland (LM108)	20	438.7		
9.Black Box Grassy Chenopod Open Woodland (LM105)	15	6.9	11,913	0.1
10.River Red Gum Woodland (LM143)	35	3.8	30,147	0.0
11.Flat Open Claypan / Derived Sparse Shrubland / Grassland (LM124)	50	73.6	15,759	0.5
12.Cultivated Grain Crops / Cleared Weedy Fallow / Developed	-	186.1	73,150	0.3
Total		**5346.6**	**518,588**	**1.0**

The only identified highly cleared vegetation type (90% cleared) in the disturbance area is 6 - Old Man Saltbush Shrubland, according to CMA clearing estimates in the OEH *BioMetric Vegetation Type Database*. Only a small proportion of the disturbance area (19.8 ha) contains this community and overall, the community has limited conservation significance within the project area in its present form and condition due to past and ongoing disturbance.

The disturbance area includes SMCAs that have been set aside as a form of environmental conservation reserve for the clearing of vegetation in the development of farming land for the purposes of cultivation. Approximately 1,179 ha of a total of 22,574 ha (or 5%) of the SMCAs would be impacted by the project.

9.5.2 Indirect impacts

Indirect impacts may be experienced on areas outside of or adjacent to the project area as a result of mine construction and operation. Such impacts would largely operate on a short to medium timeframe (ie the life of the mine), and would be minimised where possible through management procedures. A range of indirect impacts are likely to, or could occur as a result of the Balranald Project:

- increased noise, dust and light from mine construction and operational activities;
- loss of connectivity and fragmentation of habitats at a regional scale through clearing of intact areas of native vegetation within the project area;
- erosion or sedimentation in areas adjoining construction and operational activities;
- increased spreading of weed propagules;
- increased edge-effects for surrounding vegetated areas; and
- changes in vegetation composition and structure as well as available fauna habitats due to altered fire regimes (more or less frequent fire).

The indirect impacts are variable in terms of the extent they may occur from the disturbance area. In developing the disturbance area, a series of informal buffers were applied to account for a range of geotechnical and logistical constraints, and to provide some flexibility to account for minor changes during design. The following general buffer distances were adopted when developing the disturbance areas for the West Balranald and Nepean mines:

- West Balranald mine: the disturbance area was based on an approximate 200 m wide buffer from the location of infrastructure, with reduced buffers of 100 m and 50 m adopted in areas of high risk for heritage significance and identified Aboriginal cultural heritage sites, respectively.
- Nepean mine: the disturbance area was based on an approximate 200 m wide buffer from the location of infrastructure.

Based on these buffers, approximately 33% of the project area at the West Balranald mine (ie 1,000 ha), and 43% of the project area at the Nepean mine (ie 350 ha) have been incorporated into the disturbance area, and are considered to cover indirect impacts, although these are conservatively assessed as direct impacts in this report. Mitigation measures proposed in Section 13.4 would further reduce any potential indirect impacts. It is anticipated that most of which would remain undisturbed to but would allow for flexibility during detailed design.

For other project elements, the disturbance area was calculated as follows:

- West Balranald access road: a corridor of approximately 150 m wide was surveyed which comprises the project area. Within this corridor, a disturbance area of 60 m wide has been adopted, although the actual area of disturbance is likely to be less in some areas.

- Nepean access road: a corridor of 50 m wide was surveyed which comprises the project area. Within this corridor, a disturbance area of 40 m wide has been adopted. Of the total 39 km length of the Nepean access road, approximately 22 km is existing public roads (Burke and Wills Road and Arumpo Road) which would generally not result in disturbance outside the existing road corridor.

- Injection borefield: a total of eight injection borefields are included in the project area. Each borefield is approximately 400 to 500 m wide and contains two 50 m wide corridors containing linear groundwater infrastructure. Therefore a 100 m wide corridor (ie 2 x 50 m corridors) for each borefield was adopted that would be directly impacted.

- Accommodation facility: a disturbance area of 7 ha was adopted that would be directly impacted.

- Water supply pipeline: a corridor of 40 m wide was surveyed which comprises the project area, and a disturbance area of 15 m wide was adopted that would be directly impacted.

- Gravel extraction areas: a total disturbance area of 42 ha was adopted that would be directly impacted.

9.5.3 Impacts to threatened biodiversity

i Threatened and aquatic ecological communities

No TECs listed under the EPBC Act occur within the project area, or would be impacted by the Balranald Project. As such, assessments of significance are not required or completed.

ii Threatened flora

No threatened flora species were recorded in the disturbance area. However, six Commonwealth-listed species may occur and be impacted by the Balranald Project. Commonwealth assessments of significance were completed for these species. The assessments concluded that significant impacts were unlikely for any of the flora species:

- approximately 1,630 ha of potential habitat for the Mossgiel Daisy (*Brachyscome papillosa*) would be impacted by the Balranald Project, which is approximately 0.8% of available habitat in the locality;

- approximately 295.6 ha of potential habitat for the Winged Peppercress (*Lepidium monoplocoides*) would be impacted by the Balranald Project, which is approximately 0.2% of available habitat in the locality;

- approximately 1,934.7 ha of potential habitat for the Chariot wheels (*Maireana cheelii*) would be impacted by the Balranald Project, which is approximately 0.7% of available habitat in the locality;

- approximately 2,587.9 ha of potential habitat for the Cobar Greenhood Orchid (*Pterostylis cobarensis*) would be impacted by the Balranald Project, which is about which is approximately 1.2% of available habitat in the locality

- approximately 2,499 ha of potential habitat for the Slender Darling Pea (*Swainsona murrayana*) would be impacted by the Balranald Project, which is approximately 1.5% of available habitat in the locality; and

- approximately 2,588 ha of potential habitat for the Yellow Swainson-pea (*Swainsona pyrophila*) would be impacted by the Balranald Project, which is approximately 1.2% of available habitat in the locality.

iii Threatened fauna

Six Commonwealth-listed fauna species are likely to be affected by the Balranald Project. Commonwealth assessments of significance were completed for these species. The assessments concluded that a significant impact was likely for the Malleefowl (refer to Table 9.4).

Table 9.4 Significance of impacts to Commonwealth-listed fauna recorded or likely to occur

Common name	EPBC Act status	Likelihood of occurrence	Significance of impacts
Southern Bell Frog (*Litoria raniformis*)	V	Not recorded Moderate potential	Known - will be impacted. A significant impact is not likely.
Malleefowl (*Leipoa ocellata*)	V	Recorded	Known - will be impacted. A significant impact is likely.
Plains-wanderer (*Pedionomus torquatus*)	V	Possible record Moderate potential	Moderate - chance of impact. A significant impact is not likely.
Rainbow Bee-eater (*Merops ornata*)	M	Recorded	Known - will be impacted. A significant impact is not likely.
Regent Parrot (*Polytelis anthopeplus monarchoides*)	V	Recorded	Known - will be impacted. A significant impact is not likely.
Corben's Long-eared Bat (*Nyctophilus corbeni*)	V	Recorded	Known - will be impacted. A significant impact is not likely.

Note: V-vulnerable, E-endangered, M-migratory.

One of the affected threatened species (Malleefowl) could potentially be significantly impacted by the Balranald Project. A biodiversity offset strategy has been developed to compensate for the unavoidable and significant impacts on threatened fauna and their habitat (Section 9.6.3).

No critical habitat listed under the EPBC Act would be impacted by the Balranald Project.

The Balranald Project will remove up to 2,543 ha of potential Malleefowl habitat (most of which is preferred habitat) (Table 9.5). This includes removal of at least three active and six recently used Malleefowl mounds (Figure 9.5). Section 5.13 of the biodiversity assessment (Appendix C) provides detailed consideration of potential impacts to Malleefowl.

Table 9.5 Malleefowl habitat quality across the disturbance area

Habitat quality category	Area of habitat (ha)
Very high	1,168
High	403
Moderate	596
Low	377
Total	**2,543**

The West Balranald access road and the Nepean access road occur within known Malleefowl habitat. The increase in vehicle movements in these areas has the potential to result in an increase in bird/vehicle interactions and death or significant injury to individual birds. Due primarily to the removal of a large area of current known and potential breeding habitat, it is likely that the local population could be placed at risk of extinction.

9.5.4 Key threatening processes

i General

A list of key threatening processes (KTPs) is maintained under the EPBC Act. KTPs relevant to the Balranald Project are listed in Table 9.7 and detailed further below. Unless otherwise stated, the information regarding the KTPs has been derived from the final determinations or profile of the KTP.

Table 9.6 KTPs relevant to the Balranald Project

KTP	Operating presently or historically	Increased by Balranald Project
Land clearance	Yes	Yes
Competition and land degradation by rabbits	Yes	Yes
Competition and land degradation by unmanaged goats	Yes	Yes
Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases	Yes	Potential
Infection of amphibians with chytrid fungus resulting in chytridiomycosis	Yes	No
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	No	Very low potential
Predation by European red fox	Yes	Yes
Predation by feral cats	Yes	Yes

ii Land clearance

Clearing of native vegetation has been recognised as causing destruction of habitat, fragmentation of populations, riparian zone degradation, disturbed habitat which may permit the establishment and spread of exotic species and loss of leaf litter.

The Balranald Project would lead to the clearing of a total of 5,160.4 ha of native vegetation. This is discussed in detail in Section 9.5.1.

iii Competition by rabbits and goats

Grazing and burrowing rabbits have the potential to cause erosion problems, reduce recruitment and survival rate of native plants and alter landscapes. Feral goats will browse shrubs and trees, graze forbs and grass, and eat fallen fruit capsules, bark and other dead plant material.

Rabbits and goats are known to occur in the project area and the locality. The creation new corridors and disturbing vegetation canopy and ground would provide an environment that would allow rabbits and goats to increase in numbers. Rehabilitation areas would also provide young plants palatable to rabbits and goats.

iv Predation by foxes and feral cats

Feral cats are known to occur within the project area. Feral cats were observed during the field survey within the disturbance area of the injection borefields. The vegetation within the project area is fragmented and therefore is unlikely to substantially increase the movement of feral cats. Without management there is some potential for the Balranald Project to increase the fragmentation of fauna habitat in the project area which may provide increased foraging opportunities for the exotic predators.

9.5.5 Cumulative impacts

Cumulative impacts can arise from the compounding activities of a single operation when considering past, current and future activities in an area. In relation to the Balranald Project, the cumulative impacts are considered to be the total impact on the environment that would result from incremental impacts (including both direct and indirect impacts) from the development added to other existing impacts and proposed developments in the locality and region.

The primary cumulative impacts of the Balranald Project are associated with the Balranald Project's direct and indirect impacts. Impacts which are likely to be cumulative within the Balranald project areas include the clearing of vegetation, loss of individuals, potential increases in feral animal populations and weed invasion. It is likely that the accumulating impacts would increase linearly and proportionally with the area of disturbance. The cumulative impacts listed may not be fully expressed until well after completion of mining due to the characteristics of semi-arid woodland (dependent on sporadic rainfall for completion of reproductive processes, seedlings and young plants significantly prone to grazing by goats and rabbits) and the time-delay of flow-on effects on fauna.

The Balranald Project would add to the impacts that will result from the Atlas-Campaspe Mineral Sands Project which will be located to north of the Balranald Project. The Atlas-Campaspe Mineral Sands Project requires the clearance of approximately 4,158 ha of mostly native vegetation, progressively over approximately 20 years. Vegetation to be impacted mainly comprises Belah-Rosewood Woodland (2,035 ha) and Linear Dune Mallee (1,040 ha). These are different communities to the project area, which will require clearing of mainly vegetation type 2 - Chenopod Sandplain/Swale Mallee Woodland (2,051.5 ha) and 4 - Pearl Bluebush Low Open Shrubland (1,072.1 ha). The Balranald Project and Atlas-Campaspe Mine considered together would result in cumulative impacts from native vegetation and habitat clearing totalling approximately 9,318 ha.

Similarly, the Atlas-Campaspe Mine will result in impacts to the following threatened fauna and their habitats, which were recorded within the disturbance area and are also subject to impacts from the Balranald Project: Malleefowl, Freckled Duck, Spotted Harrier, Little Eagle, Bush Stone-curlew, Australian Painted Snipe, Major Mitchell's Cockatoo, Regent Parrot, Redthroat, Pied Honeyeater, White-fronted Chat, Hooded Robin, Chestnut-backed Quail-thrush, Varied Sittella, Gilbert's Whistler, Southern Ningaui, Western Pygmy-possum, Yellow-bellied Sheathtail-bat, Corben's Long-eared Bat, Little Pied Bat, Inland Forest Bat, Bardick, Jewelled Gecko, Mallee Worm-lizard and Spinifex Slender Blue-tongue.

Beyond these major projects, the main industries and land uses in the surrounding locality are cattle, sheep and goat grazing on native semi-arid pasture along with cropping. The majority of land within the bioregion is used for agriculture (84%), with most of this being used for grazing native or modified pastures (ABS 2009).The Balranald Project will result in the disturbance of approximately 145.7ha of cropping land. A further 5,160.4 ha consists of native vegetation, most of which is used for grazing.

The majority of the project area still retains native vegetation although clearing for agriculture, timber harvesting and the impacts of grazing have altered the structure and composition of the vegetation.

The proposed impact avoidance and mitigation measures are likely to assist with mitigating these cumulative impacts in the Balranald project area. The indirect impacts will be managed and monitored through mitigation strategies as detailed in Section 9.6.

Whilst the Balranald Project will result in an increase in degradation to natural ecosystems within the Murray Darling Depression Bioregion, it should be noted that the Balranald Project will involve an offset that will contribute to managed conservation areas within the Bioregion. On balance, the Balranald Project will add significantly to the conservation of native vegetation and threatened species habitat in the locality and region, through the proposed BOP.

9.5.6 Willandra Lakes Region World Heritage Area

The WLRWHA is located approximately 39 km from the northern extent of West Balranald mine and 23 km north-west of the northern extent of Nepean mine. The WLRWHA covers 240,000 ha of semi-arid landscape mosaic comprising dried saline lake bed plains vegetated with saltbush communities, fringing sand dunes and woodlands with grassy understoreys (SEWPAC 2008).

No impacts to the threatened biodiversity of the WLRWHA are likely as a result of the Balranald Project. The same conclusion was reached for the Atlas-Campaspe Mine (AMBS 2013) which is located 10 km to the east of the WLRWHA.

9.5.7 Certainty of impacts on MNES

All impacts on MNES are considered to be known and largely predictable, including both direct and indirect impacts. With the implementation of proposed management and mitigation measures, and offsets (see below), impacts are not considered to be irreversible.

9.6 Management and mitigation

9.6.1 Avoidance

Impacts to biodiversity have been considered throughout the site selection and design process. Where possible, impacts to species and habitat of conservation significance have been avoided.

Site selection for the Balranald Project has been largely dictated by the presence of the resource within Iluka's EL. However, the location of plant, roads, stockpiles and ancillary infrastructure (eg injection borefields) have all been tailored to avoid impacts wherever possible, particularly areas with higher environmental values.

Avoidance during project design has included:

- significant re-design of the West Balranald and Nepean mine plans to maximise direct placement of overburden materials within the mine void, resulting in significantly less surface disturbance and broad-scale clearing required;
- a significant reduction of the total clearing footprint of the Nepean Mine, approximately 50% of the original mine footprint;
- reducing the footprint of the Balranald Mine (at its southern end) reducing clearing of mallee vegetation and the retention of a large east-west running vegetation corridor (at least 400 m wide) south of the disturbance area, which contains known Malleefowl habitat and also forms part of a SMCA;

- the alignment of the Nepean access road was changed to avoid vegetated areas, conservation areas and Malleefowl habitat;
- incorporation of local deviations to the Nepean and West Balranald access roads to avoid features eg avoidance of known Malleefowl mounds;
- utilisation of public roads such as Arumpo Road and Burke and Wills Road as far as possible reducing clearing; and
- utilisation of existing fence lines and/or property boundaries (which include existing fire break clearing lines) to minimise clearing where possible.

Affected threatened species will benefit from the above avoidance measures, as follows:

- A reduction in overall clearing (compared with the initial project area) has reduced possible clearing of Malleefowl habitat by approximately 3,000 ha and potential Corben's Long-eared Bat habitat by approximately 2,000 ha. The reduced area of clearing will also mean a larger area of high and very high potential Malleefowl habitat is retained east of the West Balranald mine totalling approximately 1,000 ha, which will assist the ability of Malleefowl to continue to inhabit this area.
- A reduction in the southern extent of clearing for the West Balranald mine area by approximately 1,900 m has resulted in the potential to include a 600 m wide corridor area within the Mallee vegetation, which is very high potential habitat for Malleefowl. This will serve to allow continued connectivity between east and west parts of known Malleefowl habitat which will be fragmented by the mine. It is noted that the West Balranald access road will interrupt the proposed corridor, however this interruption is unlikely to represent a barrier to occasional movement of Malleefowl between the eastern and western side of the West Balranald mine.
- Reduction in overall clearing and retention of a significant 600 m wide corridor of mallee woodland at the southern end of the West Balranald mine would aid in the retention of marginal foraging habitat for the Regent Parrot (however it is noted that the species was not recorded further north than the Sturt Highway despite extensive survey).
- Reductions in the extent of clearing for the West Balranald mine and reduction in its eastern extent around Burke and Wills Road has resulted in a larger buffer between the disturbance area and potential Plains Wanderer habitat within Pitarpunga Lake. The project area has increased the buffer area between proposed disturbance and potential habitat areas by 500 m to 1,000 m.

9.6.2 Management and mitigation measures

Management and mitigation measures would be implemented to minimise impacts on biodiversity during the construction, operation and rehabilitation stages of the Balranald Project.

A biodiversity management plan (BMP) would be prepared for the Balranald Project. It would manage various activities throughout the life of the project to protect important biodiversity values in the project area. Key commitments to be covered by the BMP include threatened species management (including specific provisions for Malleefowl), pest and weed management, fire management and site hygiene practices. The BMP will identify potential risks to the successful implementation of the plan, and include a description of the contingency measures that would be implemented to mitigate against these risks. The BMP will include details of who would be responsible for monitoring, reviewing and implementing the plan.

The BMP will include specific protocols dealing with any potential interaction between the project activities and threatened flora or fauna species during the life of the Balranald Project. The plan will include directions for survey, monitoring and management of key threatened species known or considered to be potentially impacted by the Balranald Project (in particular Malleefowl) and protocols for reporting and managing any unforeseen threatened species occurrences within the project area. Measures designed to mitigate impacts on threatened species would be monitored for success.

A specific Malleefowl management and monitoring plan will be developed, consistent with the '*National Manual for the Malleefowl Monitoring System*' and the '*National Recovery Plan for Malleefowl*'. The Malleefowl plan will form a significant component of the BMP for the project area, and Management Plans for the offset site(s). Active management of Malleefowl within the project area will occur during construction, operations and rehabilitation phases. The BMP would include specific information for this threatened species including:

- land clearance:
    - pre clearance surveys or remote sensing in very high - moderate potential habitat to detect active mounds;
    - 200 m buffer established around active mounds until hatching occurs which will be determined through monitoring protocol;
- fragmentation:
    - maintenance of a corridor at the southern end of West Balranald mine area;
    - identified corridors to be specifically targeted in predator control programs;
    - management of vegetation and development of BMP and fire management plans for impact and offset areas to reduce the risk of high intensity/frequency fire;
    - consolidation of vegetation and removal of tracks where appropriate within offset areas as per offset management plans to be established;
- predation (foxes and cats):
    - develop and implement BMP focussing on feral management. Inclusion of predator control programs within the Balranald project area including fox and cat baiting;
    - trapping, shooting or poisoning programs depending on the most effective identified methods or combination of methods;
- competition and land degradation by rabbits and goats:
    - develop and implement BMP focussing on feral management;
    - rabbit control including burrow ripping within offset areas and Iluka managed areas;
    - removal of watering points, fencing and collecting of goats (eg via one way gate systems) will be features of offset management plans;
    - ongoing monitoring of response of vegetation to goat exclusion in offset areas;

- road strike:
  - communications protocols to inform staff and contractors of the presence and importance of Malleefowl and controls in place for impact minimisation;
  - planning to minimise road-strike for Malleefowl by limiting truck speeds and provision of appropriately sized signage along access roads, particularly areas close to active or recently active mounds, or where Malleefowl prints are observed;
  - development of methods and communication tools to monitor road-strike and mortality of Malleefowl and disseminate such information to the public and appropriate state and local authorities/interest groups;
- edge effects - management protocols for the identification of noxious or important environmental weeds within areas to be cleared (in order to avoid transporting the weeds to the rehabilitation area) and also within the rehabilitation area;
- weeds - management protocols for the identification of noxious or important environmental weeds within areas to be cleared (in order to avoid transporting the weeds to the rehabilitation area) and also within the rehabilitation area;
- dust and noise:
  - establishment of dust control procedures and monitoring;
  - special measures to be taken (eg increased frequency of road wetting) where active mounds occur within 200 m of roads or other dust sources and outside of clearing areas;
  - once the position of active Malleefowl mounds is established measures can be investigated to lower machinery and vehicle noise in areas adjacent to Malleefowl nesting;
- fire - establishment of fire management planning and exclusion measures within construction and offset areas; and
- light - special measures to be taken (eg blocking or diminishing of night light) where mounds occur within 200 m of roads or other dust sources and outside of clearing areas.

Monitoring of Malleefowl will occur using a combination of LiDAR survey, drone survey, real time monitoring cameras, walked transects, site visits, and opportunistic observations depending on what methods are established as being the most effective and efficient throughout the process of BMP formulation. A preliminary proposed monitoring program has been included in the biodiversity assessment in Appendix C. This programme will be finalised and incorporated into the BMP and offset site management plan(s) as relevant. Results of the Malleefowl monitoring in and around the project area will be collated on an annual basis and reported as required.

Other key mitigation and management measures that would be included in the BMP are:

- protocols for clearing restrictions, informed by important lifecycle events of the threatened species known or likely to occur within the project area which are likely to be significantly impacted by the Balranald Project;
- clearing protocols in line with the Rehabilitation and Closure Strategy (EMM 2015);

- protocols for cleared vegetation to be used immediately elsewhere in Balranald Project for progressive rehabilitation; and
- the use of trittering or mulching for temporary access during construction where possible.

The BMP will outline monitoring programs to be set up to measure the success of biodiversity management protocols and activities across the Balranald Project such as management actions for threatened species, pest management activities, and rehabilitation and revegetation activities. Monitoring programs will include goals and performance indicators to measure the success of proposed mitigation measures.

9.6.3 Biodiversity offset strategy

i General

A Biodiversity Offset Strategy for the Balranald Project was provided in the draft biodiversity assessment (Niche 2015), which outlined the approach to offsetting. The strategy primarily relied upon securing suitable lands using offset mechanisms which are then managed for conservation in-perpetuity. The strategy also outlined initial investigations into numerous candidate offset properties. A BOP has now been developed, which presents further detailed investigations into one specific property (referred to as the subject offset site) to satisfy the Commonwealth offset requirements for significant impacts to Malleefowl and Corben's Long-eared Bat.

The BOP has been prepared to meet the requirements of the Commonwealth's *Environmental Offsets Policy*. The subject offset site will also contribute significantly towards the NSW offset requirement but additional offset measures will be needed to fulfil this requirement.

ii Draft NSW Biodiversity Offset Policy for Major Projects

The *Draft NSW Biodiversity Offset Policy for Major Projects* applies to the Balranald Project. The policy:

- establishes a set of offsetting principles for major projects;
- defines key thresholds for when offsetting is required;
- adopts an assessment methodology to quantify and describe the offset required;
- defines mechanisms required to establish offset sites; and
- provides a range of flexible options that can be used in lieu of providing offsets, including rehabilitation actions and supplementary measures.

Advice was provided to the Director of Planning, Land and Community - NSW Mining by the Chief Executive of OEH in December 2014 relating to the mechanisms available to major project proponents in NSW to secure an offset site. The mechanisms available to major project proponents are listed below, however the advice only applies to projects which will receive project approval within the transitional period, which applies to the Balranald Project. According to the advice supplied, interim mechanisms for securing offsets include:

- BioBanking agreement (preferred);
- dedication of land under the NPW Act;

- a trust agreement under the NSW *Nature Conservation Trust Act 2001*; and
- a property vegetation plan registered on title under the NV Act.

Notwithstanding the information presented above, the *Draft NSW Biodiversity Offset Policy for Major Projects* contains within it provision for the establishment of an offset fund into which proponents may contribute financially an amount which otherwise would be equal to the cost of establishing independent offset sites. The fund is not yet available and the timing for the development of the fund has not been confirmed. However, if the fund is established within a timeframe that may make it available to Iluka as an option for securing biodiversity offsets for the project (ie for Stage 2 - see below).Contributing to the fund will be considered as an option for securing offsets for the Balranald Project.

The *Draft NSW Biodiversity Offset Policy for Major Projects* requires the quantification of offsets by applying a reliable transparent assessment methodology and the policy identifies the FBA as the appropriate mechanism to do this. The FBA identifies the BioBanking Credit Calculator (BBCC) as the appropriate tool for quantifying the precise nature of the offsets required in both Ecosystem Credit and Species Credit terms. The 'major project' function of the BBCC is used under the FBA.

iii Commonwealth Environmental Offsets Policy

Environmental offsets are provided as measures that compensate for the residual adverse impacts of an action under the *Environmental Offsets Policy*. Offsets should counterbalance the impacts that remain after avoidance and mitigation measures have been implemented. For assessments under the EPBC Act, offsets are only required if residual impacts are significant on MNES.

An offsets package is defined in the *Environmental Offsets Policy* as a suite of actions that a proponent undertakes in order to compensate for the residual significant impacts of a project. An offsets package can comprise of a combination of direct offsets and other compensatory measures. Direct offsets are actions that deliver a measurable conservation gain for an impacted protected matter. Conservation gains may be achieved by:

- improving existing habitat for the protected matter;
- creating new habitat for the protected matter;
- reducing threats to the protected matter;
- increasing values of a heritage place; and
- averting the loss of a protected matter or its habitat that are under threat.

Under the *Environmental Offsets Policy*, biodiversity offsets may be secured through a number of mechanisms including:

- developing offsets of public lands;
- developing offsets on private lands;
- developing offsets on Indigenous owned lands;
- developing offsets in the marine environment (not applicable to the Balranald Project); and
- providing indirect measures to supplement a direct offsets site(s).

Indirect measures or other compensatory measures that are not directly related to securing land based, otherwise unprotected, habitat for those MNES which will be significantly impacted by a proposal, may include measures that are anticipated to lead to benefits for the impacted protected matter. Other compensatory measures may include funding for suitable research or education programs. Under the *Environmental Offsets Policy*, a minimum of 90% of the offset requirements for any given impact must be met through direct offsets.

The *Environmental Offsets Policy* is guided by ten overarching principles to be applied when determining the suitability of offsets.

iv Staging of offsets

Iluka will secure the BOP in two main stages with different timing requirements relating to each stage depending on the requirements of the NSW TSC Act, the Commonwealth EPBC Act and development consent conditions for the project.

The first stage of the offset will cater for all offsetting requirements for development of the West Balranald mine and associated infrastructure while the second stage will address offset requirements associated with development of the Nepean mine. EPBC Act offsets for stage one will be in place prior to development of the West Balranald mine. Similarly, the offsets for stage two will be in place prior to development of the Nepean mine.

The timeline for securing the NSW based offsets has been agreed to with the NSW DoP in response to the evolving offset mechanisms in NSW. Offset credits for the West Balranald mine must be retired within three years of the commencement of construction of the West Balranald mine, while for the Nepean mine the credits must be retired prior to the commencement of construction of the Nepean mine.

v NSW offsets

A calculation of the nature and extent of offset credits required due to the biodiversity impacts associated with the Balranald Project has been undertaken using Version 4.0 of the BBCC. The values generated within the BBCC have been presented to NSW OEH and revised after consultation. Additional offsetting requirements were also added to the generated credit values to further compensate for impacts to SMCA areas, with the total agreed offset requirement in terms of credits and hectares documented within the NSW development consent conditions.

The calculation resulted in a requirement to provide a total of 263,563 ecosystem credits to compensate for impacts to 5,160.5 ha of native vegetation which contains threatened species habitat.

In addition, the Balranald Project will result in impacts to SMCAs. Negotiation and agreement between NSW DoP, NSW OEH and the Commonwealth DoE in regard to additional offsets for clearing of SMCA areas has been reached. Iluka will add a stated amount of hectares corresponding to the vegetation communities impacted (within the SMCAs) to its overall offset credit liability.

vi Commonwealth offsets

Only one Commonwealth-listed species, the Malleefowl, is likely to be significantly impacted by the project. The conclusion of a significant impact for this MNES means that offsetting is required under the EPBC Act.

Since submission of the draft biodiversity assessment (Niche 2015) as part of the draft EIS, the DoE has confirmed its determination in relation to significantly impacted MNES. Consequently, biodiversity offsets will be required to compensate for significant impacts on two MNES - both threatened species listed as vulnerable. Those species are:

- Malleefowl (*Leipoa ocellata*), as identified in the biodiversity assessment; and
- Corben's Long-eared Bat (*Nyctophilus corbeni*), which although not identified as significantly impacted within the biodiversity assessment, was added by DoE as a significantly impacted species after consideration of impacts to the species outlined within the draft biodiversity assessment (Niche 2015).

vii Proposed biodiversity offset package

Initial investigations into numerous candidate offset properties has occurred with one specific offset site developed to satisfy all of the Commonwealth offset requirement for significant impacts to Malleefowl and Corben's Long-eared Bat (the subject offset site). Aspects of the subject offset site are described below and in further detail within the addendum to this report titled *Balranald Mineral Sands Project EPBC Act Biodiversity Offset Package* (Niche 2016) in Appendix C. The offset site will be secured via a BioBanking agreement.

Presently, specific details of the location of the subject offset site have not been given publically due to privacy limitations, however its characteristics in regard to biodiversity values (particularly in relation to Malleefowl and Corben's Long-eared Bat) along with its capacity to meet EPBC offset requirements are presented in Appendix C. Specific details (i.e. location, habitat information, spatial results of field surveys and vegetation mapping) of the subject offset site have been provided to DoE in-confidence to allow for a full consideration of the adequacy and appropriateness of the site.

Initial investigation into numerous other candidate offset properties has occurred and works undertaken to date have identified that suitable offsets exist, both in quantum and type, within the vicinity of the Balranald Project to satisfactorily cover the remaining offset requirement after securing of the subject offset site.

Both the NSW and Commonwealth offset requirements acknowledge the staging of the Balranald Project and allowance is made to enact the required offset measures coincidently with the two mining stages (West Balranald and Nepean mines) to reflect the timing of impacts on biodiversity. In addition, the NSW offset requirement for the West Balranald mine (stage one) is deferrable until three years after the commencement of any clearing associated with mining activities. This acknowledges impending changes to offset policy in NSW. Conversely, Commonwealth offset measures (offsets for impacts to Malleefowl and Corben's Long-eared Bat) must be in place prior to the commencement of any mining activities for the West Balranald mine.

Iluka is committed to providing and securing a suitable offset package for the Balranald Project that would satisfy the Commonwealth offset requirements. The approach taken by Iluka to develop a suitable biodiversity offset is in accordance with the key offsetting policy principles at both the NSW and Commonwealth levels. The offset requirements under the EPBC Act have been agreed to with DoE after extensive consultation and the provision of reporting with a detailed explanation of the offsetting process and characteristics of the offset site within the *Balranald Mineral Sands EPBC Act Biodiversity Offset Package* (Niche 2016) (Appendix C).

Iluka is committed to developing a suitable and appropriate biodiversity offset for the Balranald Project. Ongoing consultation with OEH and DoE will continue to take place to finalise the overall BOP.

Details of the subject offset site are presented in Table 9.7.

Table 9.7 Values/characteristics of the subject offset site

Criteria	Values/characteristics
Size	A maximum of 10,900 hectares of the property is available for offsetting and therefore the property is a good prospective site representing a large consolidated offset with extensive patch size.
Vegetation types and condition	Vegetation is predominantly Chenopod Sandplain/Swale Mallee Woodland with significant areas of Spinifex Dune Mallee Woodland interspersed between the Chenopod Mallee. These are key vegetation types for Malleefowl and the prevailing habitat of impact for Malleefowl within the development area. Smaller areas of Belah – Chenopod Woodland and *Acacia melvillei* Woodland (listed as an EEC under the State TSC Act) also occur. Prevailing vegetation condition within the property is similar to better quality parts of the project area. The property is largely ungrazed by domestic livestock, however goats are common. There is significant room for improvement in regard to vegetation condition via management of goats and other feral animals.
Malleefowl habitat	The property has confirmed records of Malleefowl with numerous mounds having been identified within the property over the last two decades. Confirmation of recently active mounds and current Malleefowl activity (via footprints) occurred during field survey of the property between November 2015 and March 2016 as detailed within Niche 2016. Mound density within the subject site is similar or higher to mound densities within the West Balranald mine area. Mound density is much higher than the Nepean mine area.
Corben's Long-eared Bat habitat	Recent survey has confirmed the presence of Corben's Long-eared Bat within the offset site which is expected to occur within all woodland vegetation types throughout the site. A similar survey effort undertaken within the subject offset site in regard to harp trapping for the species yielded seven individuals of the species captured from three sites (Niche 2016).
Proximity to development area	The subject offset site is within 100 km from the Balranald Project site. Malleefowl and Corben's Long-eared Bat habitat within the subject offset site has connectivity with a large proportion of the habitat to be impacted from the Balranald Project, with habitat between the two areas being predominantly native vegetation. Vegetated corridors are restricted in some areas to approximately 800m (Malleefowl are known to use even narrow corridors including linear roadside strips of vegetation from time to time). Overall there is expected to be some migration of Malleefowl individuals (albeit potentially infrequent) and Corben's Long-eared Bat between the development and subject offset site.
Proposed offsetting mechanism	A NSW Biobanking agreement is currently the preferred mechanism for offsetting.

Table 9.7 Values/characteristics of the subject offset site

Criteria	Values/characteristics
Other threatened biodiversity values	The following threatened species have been recorded at the property: • Chestnut Quail-thrush (TSC Act – confirmed during recent field survey) • Corbens Long-eared Bat (TSC Act and EPBC Act – confirmed during recent field survey) • Gilbert's Whistler (TSC Act – confirmed during recent field survey) • Hooded Robin (south-eastern form) • Inland Forest Bat (TSC Act – confirmed during recent field survey) • Little Pied Bat (TSC Act) • Major Mitchell's Cockatoo (TSC Act) • Mallee Worm-lizard (TSC Act) • Regent Parrot - eastern subspecies (TSC Act and EPBC Act – note foraging habitat only) • Varied Sittella (TSC Act) • Western Pygmy Possum (TSC Act) • Acacia melvillei shrubland (TSC Act)

In order to quantify the offset requirement for the Malleefowl and Corben's Long-eared Bat, the EPBC Act Offset Assessment Guide (hereafter referred to as the EPBC offset calculator) was applied by both Niche (on behalf of Iluka) within the draft of this Biodiversity Assessment and subsequently by DoE. Scoring used within the EPBC Act calculator by both parties and the justification behind initial offset is presented in Appendix C.

The final offset requirement as calculated by DoE is presented in Table 9.8. The requirement is separated into two stages to reflect the stages of the proposed development as discussed above. Habitat within the offset area as presented to DoE has been given a quality score of 7 out of 10 for both Malleefowl and Corben's Long-eared Bat. Other scoring parameters used by DoE can be found in Appendix C.

Table 9.8 Staged offset requirement calculated by DoE for the Balranald Project using the offsets assessment guide

Species/Habitat Class	Development area total (ha)	Balranald mine (stage 1) area (ha)	Nepean mine (stage 2) area (ha)	Total (100%) DoE Offset Requirement (ha)	Stage 1 offset requirement (ha)	Stage 2 offset requirement (ha)
Malleefowl High/Very High	1,571	1,218	353	5,250	4,070	1,180
Malleefowl Low/Moderate	973	521	452	1,850	991	859
Combined Malleefowl	**2,544**	**1,739**	**805**	**7,100**	**5,061**	**2,039**
Corben's Long-eared Bat	3,143	2,338	805	10,430	6,052	2,898

It has been communicated to Iluka that (consistent with DoE policy) the offset requirement can be satisfied through either a 100% direct offset arrangement or a 90% direct offset and 10% indirect offset arrangement. Iluka opts to satisfy 100% of the offset requirement through the establishment of a direct offset (the subject offset site).

9.7 Conclusion

Flora and fauna databases and previous reports were reviewed to identify threatened species and TECs that could potentially occur within the project area. This information aided in the development of multiple targeted field surveys conducted between October 2011 and December 2014.

Eleven BioMetric Vegetation Types were identified within the project area with two additional vegetation types created to recognise highly modified vegetation communities. None of the vegetation types within the disturbance area are listed as TECs under the TSC Act or EPBC Act. As such, no significant impact to any TEC will occur as a result of the proposed development.

No Commonwealth-listed flora were recorded within the project area. However, it is considered that five have the potential to occur and may be impacted by the Balranald Project. Five species of Commonwealth-listed fauna were detected during field-survey. Given the presence of suitable habitat or known records, a total of seven Commonwealth-listed species have the potential to be impacted by the Balranald Project.

The Balranald Project has evolved during the course of the biodiversity investigations and a suite of measures have been designed to avoid, minimise and mitigate adverse impacts on biodiversity. However, residual impacts remain, with the project progressively clearing 5,160.5 ha of native vegetation. Of the species recorded or with the potential to occur, significant impacts were only identified for the Malleefowl.

The significant impact criteria under the EPBC Act, were addressed for each of the five affected threatened species listed under the EPBC Act, and highlighted that one threatened species (the Malleefowl) would be significantly impacted. No migratory species would be significantly impacted. No critical habitat listed under the EPBC Act will be impacted by the Balranald Project.

The Balranald project also has the potential for indirect impacts from erosion and sedimentation in adjacent bushland and weed invasion. However, the impact assessment has used a conservative approach and incorporated buffers into the disturbance area, which would remain largely unaffected over the life of the project, to quantify and assess such impacts.

Impacts would be compensated through a BOP. A Biodiversity Offset Strategy for the overall Balranald Project has been included in this assessment and detailed investigation of a nominated offset site for the EPBC Act offset requirement detailed within an addendum to Appendix C. Further work on the BOP is currently being undertaken in consultation with OEH, DoE and other relevant stakeholders to offset the disturbance to vegetation and threatened biodiversity habitat.

Through the implementation of avoidance measures, mitigation measures and the biodiversity offset strategy, biodiversity values in the surrounding region and the viability of threatened species and communities that are impacted by the Balranald Project will be maintained or improved over the medium to long term.

10 Aboriginal cultural heritage

10.1 Introduction

An Aboriginal cultural heritage assessment was prepared by Niche for the Balranald Project to address the requirements of Section 4, 5 and 6 of the EIS Guidelines (see below) and the following guidelines:

- *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011);
- *Draft Guidelines for Aboriginal Cultural Heritage Assessment and Community Consultation* (DEC, 2005);
- *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (DECCW 2010b) (the ACHCRs);
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010a (the Code); and
- *Burra Charter* (Australia International Council on Monuments and Sites 2013).

A separate assessment was prepared to assess the potential impacts of the Balranald Project on non-Aboriginal (or historic) heritage. The results of this assessment are described in Chapter 11.

The main objectives of the Aboriginal cultural heritage assessment were to:

- identify Aboriginal heritage within the project area with a focus on sites in the areas of proposed impact including;
  - Aboriginal objects and sites;
  - Aboriginal socio-cultural sites, which may be intangible (ie not associated with Aboriginal objects);
  - areas of archaeological sensitivity (referred to as “risk layers” in the technical report);
- assess the archaeological significance of objects and sites within the areas of impact;
- assess the cultural significance of objects, sites and the landscape through consultation with the registered Aboriginal parties;
- assess the impact of the project on the identified archaeological and cultural values; and
- formulate a management strategy that is appropriate to the significance and the level of predicted impact to those sites.

10.2 EIS Guidelines

As previously stated, the EIS Guidelines state that two key assessment requirements are in relation to:

- impacts on the world heritage values of a declared World Heritage place listed under sections 12 and 15A of the EPBC Act; and
- impacts on the national heritage values of a National Heritage place listed under sections 15B and 15C of the EPBC Act.

The EIS Guidelines require details on the existing environment, relevant impacts and proposed avoidance, mitigation and offset measures to deal with potential impacts of the Balranald Project on world and national heritage places.

They state:

> **4. DESCRIPTION OF THE ENVIRONMENT**
>
> ...
>
> f) a description of the World Heritage values and National Heritage values of any relevant World Heritage properties or National Heritage places which may be directly or indirectly impacted by the action, including but not limited to the Willandra Lakes Region World Heritage property (National Heritage place);
>
> g) a description of the research methodology used to assess impacts to World Heritage and National Heritage values and, if fieldwork was undertaken, details including: the dates the fieldwork was undertaken, the area covered, who undertook the fieldwork and the methods employed;
>
> h) identification of the relevant Indigenous people with rights or interests in the Willandra Lakes Region, and how these people were determined as the relevant Indigenous people; and
>
> i) a description of the consultation process undertaken to seek active involvement from the relevant Indigenous people with rights or interests. The department strongly encourages the use of the Ask First principles and the principle of free prior informed consent when engaging with Indigenous communities.
>
> ...
>
> **5. RELEVANT IMPACTS**
>
> a) a detailed description and assessment of the nature and extent of all relevant impacts, including direct, indirect, facilitated and cumulative impacts at all stages of the action that the action will have or is likely to have in the short-term and long-term on:
>
> ...
>
> iii. the World Heritage values of a declared World Heritage property listed under Sections 12 and 15A of the EPBC Act; and
>
> iv. the National Heritage values of a National Heritage place listed under section15B and 15C of the EPBC Act;
>
> ...

e) a description of the research methodology used to assess impacts on World Heritage and National Heritage values, including full details of any fieldwork undertaken;

f) results and conclusions of research undertaken to assess the impacts of the action on the World Heritage and National Heritage values of the Willandra Lakes Region, including details of consultation with the relevant Indigenous people with rights or interests in the Willandra Lakes Region;

g) a letter from any relevant Indigenous people who have been involved in a particular study, have asserted a particular view or have provided information that has influenced the findings of the assessment, confirming that they understand what has been written in the relevant parts of the EIS and agree that this is an accurate reflection of their view and/or involvement; and

h) evidence that any advice from relevant Indigenous people has been taken into consideration. If you decide not to follow advice given in the interests of the protection of Indigenous heritage values, a robust justification must be provided.

...

6. PROPOSED AVOIDANCE, MITIGATION AND OFFSET MEASURES

(a) a description of how the action has been designed to avoid impacts to migratory species, threatened species and ecological communities, World Heritage values and National Heritage values;

(b) a consolidated list of mitigation measures proposed to be undertaken to prevent or minimise the relevant impacts of the action, before, during and after construction, during operation, decommissioning and rehabilitation;

(c) the cost of the proposed mitigation measures; and

With the exception of the cost of proposed mitigation measures, the above requirements are addressed in this chapter, the non-Aboriginal heritage chapter (Chapter 11), the Aboriginal cultural heritage assessment contained in Appendix D and the non-Aboriginal heritage assessment contained in Appendix E. As previously stated, the costs of all mitigation measures have been incorporated into the economic assessment of the Balranald Project discussed in Chapter 16 and contained in Appendix N.

10.3 Methods

10.3.1 Aboriginal stakeholder consultation

Aboriginal stakeholders were identified in accordance with OEH's *Aboriginal cultural heritage consultation requirements for proponents* (DECCW, 2010) and the *Draft Guidelines for Aboriginal cultural heritage impact assessment and community consultation* (DEC, 2005c). Consultation included the "Ask First" principles (Australian Heritage Commission 2002) which are included in OEH's requirements and guidelines.

OEH's guidelines outline a four stage consultation process that was completed, as follows:

- Stage 1 – notification of the project and registration of interest;
- Stage 2 – presentation of information about the project;
- Stage 3 – gathering information about cultural significance; and
- Stage 4 – review draft cultural heritage assessment report.

10.3.2 Database searches

Databases that hold relevant records for the project area were accessed, the purpose of which was to determine if recorded sites were located within the project area prior to field survey. The databases accessed are:

- Aboriginal Heritage Information Management System (AHIMS);
- heritage schedule of the Balranald LEP;
- State Heritage Register (SHR);
- State Heritage Inventory (SHI) for government agency listings (section 170 register);
- Commonwealth Heritage List (CHL);
- National Heritage List (NHL); and
- World Heritage List (WHL).

10.3.3 Literature review

The environmental and archaeological background of the project area and surrounding landscape was undertaken by review of existing consultant archaeology reports, soil mapping, land system mapping and geomorphic advice. These documents provided information to achieve an understanding of the environmental background, the existing landscape and archaeological potential.

10.3.4 Field survey

A basic landscape analysis was undertaken prior to the field survey to divide the area into transects for pedestrian survey. The analysis included constraints such as access to land, potential rainfall impacts and surface visibility. The focus of the survey was on areas of greatest exposure such as scalds, eroded surfaces, openings in vegetation and cuttings.

Survey participants were spaced 10 to 20 m apart and moved slowly forward in a line scanning the ground, flagging any cultural materials identified as they passed over them. Sites were recorded using a hand-held GPS with an average accuracy of ± 7 m and using data sheets. Discrete sites were distinguished by a separation of 40 m or more. The AHIMS site recording form guided the site and artefact attribute recording process for up to 300 artefacts per site. Where site size exceeded 300 artefacts, an estimate was made. The senior archaeologist made all final decisions in respect to environmental description of the transect and the content of cultural materials flagged by the survey team.

Survey was conducted in over four separate field trips in 2012, 2013 and 2014, as follows:

- October 2012 - 25 field days with three archaeologists and five Aboriginal sites officers provided by the RAPs. About 628 ha of a 10,137 ha investigation area was surveyed;
- October to November 2013 - 12 field days with four archaeologists and six Aboriginal sites officers provided by the RAPs. About 963 ha of a 4,000 ha investigation area was surveyed;
- October 2014 - 11 field days with four archaeologists and six Aboriginal sites officers provided by the RAPs. About 841 ha of a 2,600 ha investigation area was surveyed; and
- December 2014 - 12 field days with eight archaeologists and eight Aboriginal sites officers provided by the RAPs. About 1,125 ha of a 3,300 ha investigation area was surveyed.

10.3.5 Assessment of significance

i Assessment criteria

An assessment of significance was completed for each of the Aboriginal sites. The significance assessment was guided by the principles of the *Burra Charter* (Australia International Council on Monuments and Sites 2013) and the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011). The following scientific significance assessment criteria were used:

- research potential - which considers the contribution of a site to the understanding of Australia's cultural history or human occupation;
- rarity - which is determined based on the degree a site demonstrates common aspects of the archaeological record; the fewer site or artefact types, the rarer they are;
- representativeness - which considers how well a site represents, or is an example of other sites in the same class or category;
- aesthetic - which relates to the sensory responses people have to a place and which may be associated with the setting of a site; and
- educational potential - which considers the ability of a site to portray easily recognisable archaeological features and therefore be used to inform people of the past.

ii Site condition

The condition of each site was also assessed to inform the assessment of significance. Four categories were used:

- excellent - pristine condition, unaffected by natural erosion or impacts of human agency in the preservation of its contents and structure;
- good - slightly affected by erosion or impacts of human agency and its contents and structure are probably more than 70% intact;
- fair - affected by erosion or impacts of human agency and its contents and structure are probably less than 50% intact; and

- poor- severely affected by erosion or impacts of human agency and its contents and structure are probably less than 25% intact.

The bulk of the sites fell within the poor to fair site condition categories and is reflective of the impacts of grazing and historic land use within the project area.

iii Significance grading

Using the criteria above, sites were graded in terms of level of significance from low to high. This grading would directly inform the management measures for the archaeological sites within the project area. Grading was determined by using the sites at Lake Mungo as examples of high value.

Each recorded site was assigned a significance level of high, medium or low, defined as follows:

- Low - the site or object contains only a single or limited number of features, and has no potential to meaningfully inform our understanding of the past beyond what it contributes through its current recording (ie no or low research potential). The site or object is a representative but unexceptional example of the most common class of sites or objects in the region. Many more similar examples can be confidently predicted to occur within the project area, and in the region.

- Moderate - the site or object derives value because it contains features, both archaeological and contextual, which through further investigation may contribute to our understanding of the local past. These features include, but are not limited to: the relationship with landscape features or other Aboriginal archaeological sites or areas of identified heritage importance; diagnostic archaeological or landscape features that inform a chronology; and a relatively large assemblage of stone artefacts. The presence of a diverse artefact and feature assemblage, and connectedness with landscape features and other notable sites provide relatively higher representative and rarity values than sites of low significance.

- High - the site or object has value because it contains archaeological and/or contextual features which through further investigation may significantly contribute to our understanding of the past, both locally and on a regional scale. These features include, but are not limited to: Aboriginal ancestral remains; the site's relationship with landscape features or other Aboriginal archaeological sites or areas of identified heritage importance; diagnostic archaeological or landscape features that inform a chronology; and a very large assemblage of stone artefacts associated with other features such as oven remains or shell midden. Such sites would be relatively rare, and would be representative of a limited number of similar sites that make up this class; hence they derive high representative and rarity values.

10.4 Results

10.4.1 Aboriginal stakeholder consultation

i Stage 1 - Notification

The consultation log for the project is attached as Appendix 1 in the Aboriginal cultural heritage assessment (Appendix D). Stage 1 of the consultation requirements was to identify potential cultural knowledge holders for the Balranald Project. Notifications were sent on 19 December 2011 to the following groups of interest:

- Queanbeyan OEH Environmental Protection and Regulation Group Office, Landscape and Aboriginal Heritage Protection (South);
- Balranald Local Aboriginal Land Council (LALC);
- Office of the Registrar (under the NSW *Aboriginal Land Rights Act 1983*);
- National Native Title Tribunal (NNTT) South-East and Central Registry;
- Native Title Services Corporation Limited (NTSCORP);
- BSC; and
- Lower Murray Darling CMA (Lower Murray Darling CMA now the NSW Government Local Land Service Western).

Written responses were received from Balranald LALC, Lower Murray Darling CMA, NTSCORP, NNTT and OEH and a list of potential cultural knowledge holders was compiled from the information provided.

Advertisements were published in the *Riverine Grazier* and *The Guardian* on 7 March 2012, and the *Mildura Weekly* on 9 March 2012 inviting any additional Aboriginal parties to register an interest in the Balranald Project.

As a result of the above consultation, the following six organisations and persons became registered Aboriginal parties (RAPs) to the Balranald Project:

- Balranald LALC;
- Kay Dowdy (nee Murray);
- Daniel Kelly Snr on behalf of the Balranald Aboriginal Health Service (BAHS) representing Mutthi-Mutthi people;
- Yarkuma Aboriginal Support Service;
- Ali Maher - National Koorie Site Management; and
- Paul Charles - Kullila Site Consultants.

Yarkuma Aboriginal Support Service was registered but subsequently removed as a RAP on 14 November 2012 at the organisation's request.

ii Stage 2 - Presentation of project information

Information about the Balranald Project was presented to the RAPs on a number of occasions via information sessions and letters.

Following registration, invitations were extended to the RAPs to attend a project information session held in Balranald town on 14 June 2012. The purpose of the information session was to provide information on the project and methodology of the Aboriginal cultural heritage assessment. In addition, the RAPs were informed of their roles and responsibilities during this information seminar.

After this information session held 14 June 2012, the RAPs were provided with a letter (letter dated 30 May 2012) inviting feedback on the project information provided and the proposed methodology for the assessment. Twenty-eight days were allowed for RAPs to suggest protocols to be adopted into the information gathering process, to provide feedback on the assessment and survey methodology and highlight any other matters such as issues or areas of cultural significance that might affect, inform or refine the methodology.

iii Stage 3 - gathering information about cultural significance

Requests for information on pre-existing cultural values within the project area were made to the RAPs in the letter of invitation (14 June 2012) and during the information session held 14 June 2014 as well as via an additional letter dated 6 August 2012.Twenty-eight days were provided to the RAPs to respond.

A written response to the request for feedback on the proposed survey methods were received from Daniel Kelly Snr (on behalf of the BAHS representing Mutthi Mutthi people). Mr Kelly's comments included identification of previous sites such as deposits, middens, culturally modified trees, burial and stone tool use found in the area, the importance of mining to the local economy and need for full participation of Mutthi Mutthi people in all aspects of the cultural heritage assessment.

iv Stage 4 - review draft cultural heritage assessment report

At the completion of the first field survey and subsequent assessment a workshop was hosted on 16 October 2012 in Balranald by Iluka in association with Niche. A summary of the results, the assessment process, field results and impacts were presented with the intention of receiving feedback from the RAPs. Some verbal feedback was received from a number of RAPs present at the meeting, with the main themes of discussion being:

- site avoidance where possible;
- appropriate management of any objects collected; and
- the strong desire of the RAPs to remain informed and involved in the decision making processes with regard to Aboriginal cultural heritage matters.

A project update and invitation to attend a consultation meeting was sent to the RAP on 27 January 2015. The consultation meeting was held on 26 February 2015. In attendance were representatives of Balranald LALC (Nanette Smith, David Edwards, Maxine Kelly), National Koori Site Management (Kyle Denazzi) and Kullila Site Consultants (Geoffery Maher). Apologies were received from BAHS representing Mutthi Mutthi people (Daniel Kelly Snr). Niche Environment and Heritage presented the results of the draft Aboriginal cultural heritage assessment and provided a hard copy and digital copy of the draft report to all RAPs with a 28 day timeframe for written responses. The meeting included discussions on the draft management and mitigation measures.

As a result of the above consultation process, written and verbal feedback on the draft report was provided by:

- Balranald LALC;
- BAHS representing Mutthi Mutthi people;
- National Koori Site Management; and
- Kullila Site Consultants.

To date, no RAPs or submissions from RAPs have identified any existing use or access to the project area for cultural purposes. The land is currently privately held. The Balranald Project has resulted in increased access to the project area for Indigenous people through the Aboriginal cultural heritage assessment and management process.

Full copies of written responses are provided in Appendix 1 of the Aboriginal cultural heritage assessment contained in Appendix D of this EIS. Responses to each submission received on the draft Aboriginal cultural heritage assessment and as a result of the consultation meeting are provided in the table below (see Table 10.1).

Table 10.1 Submissions from RAPS and responses to submissions

Submission No.	RAP	Date	Consultation detail	Key issues discussed	Responses and applied changes
1	Balranald LALC, Kullila Site Consultants, National Koori Site Management	26 February 2015	Presentation of draft Aboriginal cultural heritage assessment at consultation meeting 2015	Aboriginal objects must stay on country and there needs to be the respectful treatment of human remains if they are found.	An Aboriginal Cultural Heritage Management Plan (AHCMP) will be developed in consultation with the RAPs that includes: • a protocol for the collection, storage and management (short and long term) of any salvaged material; • a protocol for the return of salvaged materials following the completion of mining; • a protocol for the discovery and management of human remains within the project area, including stop work provisions and notification protocols; and • procedures for the management and reporting of previously unknown Aboriginal heritage sites that may be identified during the life of the Balranald Project.
2	Balranald LALC	26 February 2015	Presentation of draft Aboriginal cultural heritage assessment at consultation meeting 2015	Involvement of elders and using the archaeology as educational tools to teach.	As detailed above, an AHCMP will be developed in consultation with the RAPs. The plan will include a protocol for the collection, storage and management (short and long term) of any salvaged material.
3	Balranald LALC	26 February 2015	Presentation of draft Aboriginal cultural heritage assessment at consultation meeting 2015	Thanking the ancestors/welcome to country for contractors.	An AHCMP will be developed in consultation with the RAPs including protocol for heritage awareness. Iluka will also review opportunities to include welcome to country introductions across project activities.

Table 10.1 Submissions from RAPS and responses to submissions

Submission No.	RAP	Date	Consultation detail	Key issues discussed	Responses and applied changes
4	Balranald LALC	27 March 2015	Written responses to draft Aboriginal cultural heritage assessment	The report indicates consultation with the Mutthi Mutthi clan and as there are descendants from other clans such as the Nari Nari and Yitti Yitti clans living in the Balranald area, representatives of these clans should have been involved in the initial consultation process. However, having said that, is it possible that consultation with the Nari Nari and Yitti Yitti clans was not required as the archaeological site work undertaken was not located within these clan areas?	Iluka has undertaken the required consultation as per relevant guidelines. Balranald LALC registered and became a RAP and has been a primary stakeholder for the duration of the project. Part of their role was to communicate the project to their members, provide information regarding any cultural significance or issues of cultural concern for the project area, nominate and select sites officers to participate in the archaeological fieldwork and have involvement in the development of the management of any Aboriginal heritage values. It is valuable that individuals who identify as Mutthi Mutthi, Ytta Yitta and Nari Nari and who have connection to the project area have now been included by the LALC in the project and have been provided with the opportunity to comment on cultural significance and management of Aboriginal heritage values within the area. The ACHMP will detail management of Aboriginal heritage within the project area. As one of the RAPs, Balranald LALC will be involved in the development and consultation for that document and it would be valuable of the LALC were to continue to facilitate the involvement of the different clan groups with a connection to the project area in this process.
5	Balranald LALC	27 March 2015	Written responses to draft Aboriginal cultural heritage assessment	Timing of meeting with RAPs after comments due on the draft Aboriginal cultural heritage assessment and the display of the NSW EIS.	After public exhibition of the NSW EIS, Iluka undertook consultation activities within Balranald and the wider area to present the information in the EIS and answer any questions the community had regarding the environmental impacts of the project.
6	Balranald LALC (David Edwards)	27 March 2015	Telephone response to draft Aboriginal cultural heritage assessment	What will happen to the ground once the ore has been removed? The ground surface and vegetation should be returned to its natural state.	Iluka have prepared a Rehabilitation and Closure Strategy (EMM 2015) which details the proposed final landform and land use upon closure of the mine. This was made available in the NSW EIS. The proposed final landform will be safe, stable and compatible with surrounding topography.

Table 10.1 Submissions from RAPS and responses to submissions

Submission No.	RAP	Date	Consultation detail	Key issues discussed	Responses and applied changes
7	Balranald LALC (David Edwards)	27 March 2015	Telephone response to draft Aboriginal cultural heritage assessment	What are the plants in the project area? Who will look after the land management? There are members of the local Aboriginal community that are working towards land management certification.	A biodiversity assessment has been prepared which details the flora and vegetation communities in and surrounding the project area. This document, which is contained in this EIS, was also made available in the NSW EIS. At this point in time, Iluka has not finalised the workforce requirements for the Balranald Project. Once these requirements are identified and understood, appropriately qualified persons will be considered for all positions.
8	BAHS, Daniel Kelly	27 March 2015	Written responses to draft Aboriginal cultural heritage assessment	That all cultural tools be stored in a safe place and returned to location once the mine ground is closed.	An ACHMP will be developed in consultation with the RAPs that includes: • a protocol for the collection, storage and management (short and long term) of any salvaged material; and • a protocol for the return of salvaged materials following the completion of mining.
9	BAHS, Daniel Kelly	27 March 2015	Written responses to draft Aboriginal cultural heritage assessment	Mutthi Mutthi field workers who assisted with cultural assessment be employed on site as care takers to look after all cultural tools and artefacts that are kept in storage until such time that the cultural tools and artefacts are return to the ground that they was taken from.	At this point in time, Iluka has not finalised the workforce requirements for the Balranald Project. Once these requirements are identified and understood, appropriately qualified persons will be considered for all positions.
10	BAHS, Daniel Kelly	27 March 2015	Written responses to draft Aboriginal cultural heritage assessment	I recommend that care is taken at all time and that the environment and its habitat will remain a priority during the operation of the mine by Iluka	A biodiversity assessment and a Rehabilitation and Closure Strategy have been prepared and were made available in the NSW EIS. An ACHMP will be developed to ensure that cultural heritage aspects of the project are managed in consultation with the RAPs.

Table 10.1 Submissions from RAPS and responses to submissions

Submission No.	RAP	Date	Consultation detail	Key issues discussed	Responses and applied changes
11	National Koori Site Management and Kullila Site Consultants	30 March 2015	Written responses to draft Aboriginal cultural heritage assessment	We accept your final draft as a true and correct report, but would like to see site officers employed throughout the life of the mine, to oversee that any burials sites be protected.	An ACHMP will be developed in consultation with the RAPs that includes: • a protocol for the protection, storage, management and access arrangements for (short and long-term) salvaged Aboriginal objects informed by the wishes of the RAPs; • a protocol for the discovery and management of human remains within the Project area, including stop work provisions and notification protocols; and • procedures for the management and reporting of previously unknown Aboriginal heritage sites that may be identified during the life of the Balranald Project. At this point in time, Iluka has not finalised the workforce requirements for the Balranald Project. Once these requirements are identified and understood, appropriately qualified persons will be considered for all positions.
12	National Koori Site Management and Kullila Site Consultants	30 March 2015	Written responses to draft Aboriginal cultural heritage assessment	Even though there were a lot of surface artefacts, scarred trees, ovens etc, protecting our Cultural must have high importance.	An ACHMP will be developed to ensure that cultural heritage aspects of the project are managed in consultation with the RAPs.
13	National Koori Site Management and Kullila Site Consultants	30 March 2015	Written responses to draft Aboriginal cultural heritage assessment	We would at some stage still like to do a small Dig, just to see what is below the ground.	An ACHMP will be developed in consultation with the RAPs and provide detail regarding the proposed collection and salvage activities within the disturbance areas. Further details on the proposed collection and salvage activities proposed are contained in the Aboriginal cultural heritage assessment contained in Appendix D.
14	National Koori Site Management and Kullila Site Consultant	October 2014	Fieldwork notes	The silcrete core at UD 77 was important and should be collected.	An ACHMP will be developed in consultation with the RAPs and provide detail regarding the proposed collection and salvage activities within the disturbance areas. Further details on the proposed collection and salvage activities proposed are contained in the Aboriginal cultural heritage assessment contained in Appendix D.

Table 10.1 Submissions from RAPS and responses to submissions

Submission No.	RAP	Date	Consultation detail	Key issues discussed	Responses and applied changes
15	BAHS, Mr. Daniel Kelly.	October 2012	Written response to presentation of 2012 survey	The review requests that Iluka should take on the Mutthi Mutthi people views and recommendations relating to the care of cultural value and artefacts maybe stored in a Mutthi Mutthi Cultural Resource centre to be named after a Muthi Muthi elder Mrs Alice Kelly – Alice background she was one of the first women to sit of the world Willandra heritage advisory committee and Mungo Joint Management for many years before entering the dreaming. With sites of heritage value be respected and left in tack.	Subsequent revisions to the project footprint excised a large percentage of Aboriginal site WB 40, associated with Muckee Lake, from the disturbance area. A number of other Aboriginal sites identified during the 2012 field season were subsequently excised from the disturbance footprint. An ACHMP will be developed in consultation with the RAPs that includes: • a protocol for the protection, storage, management and access arrangements for (short and long-term) salvaged Aboriginal objects informed by the wishes of the RAPs; • a protocol for the discovery and management of human remains within the Project area, including stop work provisions and notification protocols; and • procedures for the management and reporting of previously unknown Aboriginal heritage sites that may be identified during the life of the Balranald Project, consistent with the management measures described in Appendix D.
16	National Koori Site Management and Kullila Site Consultant	August 2012	Written response to 2012 fieldwork	During the current survey for West Balranald that they had found hundreds of artefacts and that the Landskape due diligence assessment completed for Balranald did not locate anyway. Requested on behalf of NKSM and Kullila that further investigation occur within the West Balranald areas, Turkey nest and Muckey creek. Noted that these areas were of significance and were near Lake Mungo and that perhaps test pits would be of value to the Mutthi Mutthi.	Additional survey was undertaken in the West Balranald mine footprint and in the project area between 2013 and 2015. Subsequent revisions to the project footprint excised a large percentage of Aboriginal site WB 40, associated with Muckee Lake, from the disturbance area. A number of other Aboriginal sites identified during the 2012 field season were subsequently excised from the disturbance footprint. An ACHMP will be developed in consultation with the RAPs and provide detail regarding the proposed collection and salvage activities within the disturbance areas. Further details on the proposed collection and salvage activities proposed are contained in Appendix D.

10.4.2 Database searches

i Aboriginal Heritage Information Management System

An AHIMS search was conducted within 10 km of the project area.

The distribution of recorded sites supports the model that water sources are an important indicator of habitation with archaeological sites being abundant within the Riverland land system. Nevertheless, the absence of recorded sites can be a reflection of the lack of survey in some areas, rather than the absence of artefacts.

The majority of site features recorded in the AHIMS are stone artefacts and hearths, some mounds, shell middens, culturally modified trees, grinding grooves, fish traps and conflict sites.

Table 10.2 shows AHIMS recorded site distribution by land system.

Table 10.2 AHIMS search results by land system

Land System	Number of sites	% of sites
Riverland	102	40.80
Youhl	104	41.60
Marma	24	9.60
Condoulpe	16	6.40
Arumpo	1	0.40
Mungo	1	0.40
Rata	1	0.40
Victoria	1	0.40
Total	**250**	**100.00**

ii Other registers

A search was undertaken of other heritage registers to determine if there were any registered Aboriginal heritage items within, or surrounding, the project area, including the:

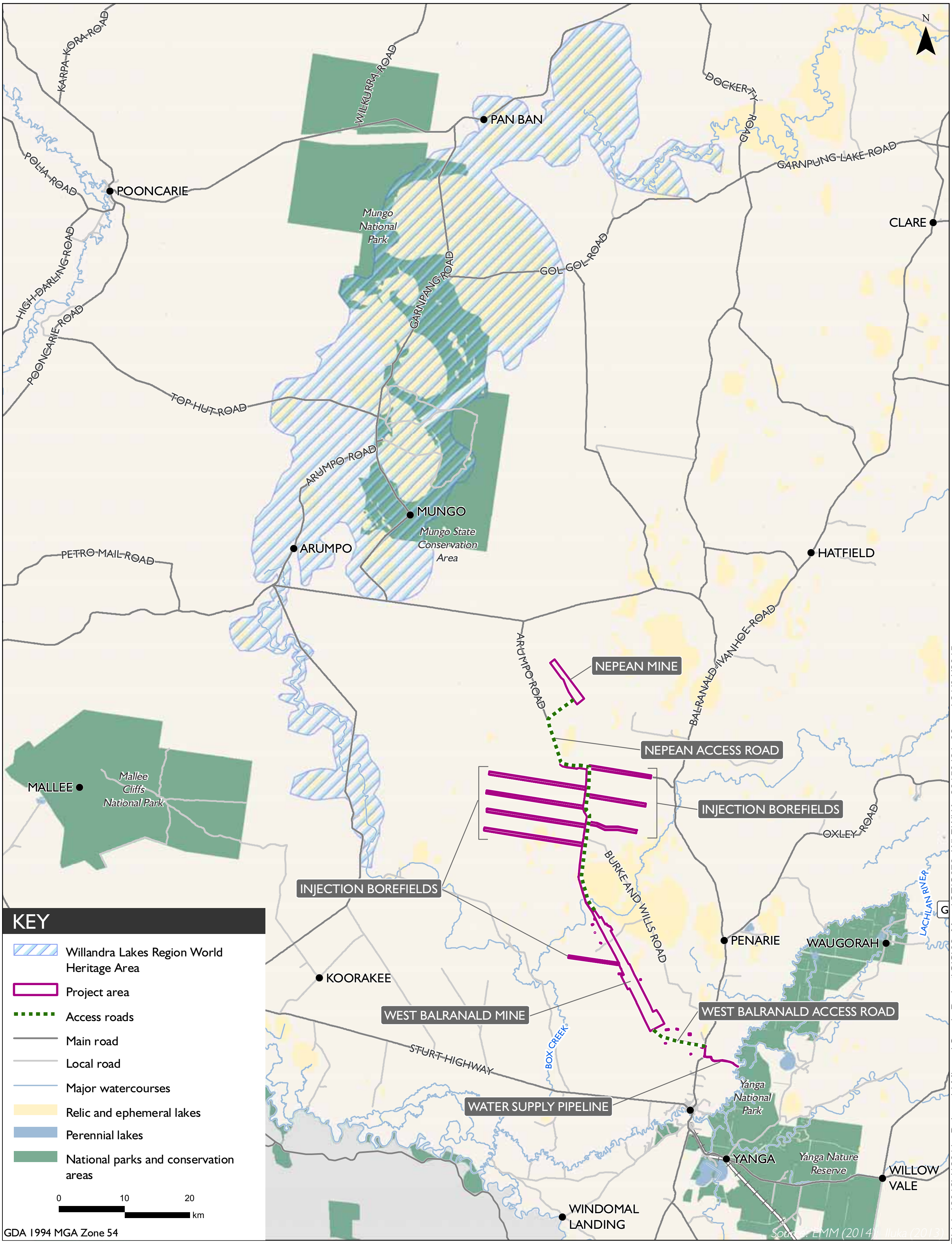
- heritage schedule of the Balranald LEP;
- SHR;
- SHI for government agency listings (section 170 register);
- CHL;
- NHL; and
- WHL.

No Aboriginal heritage items are listed within the project area in the above registers. The nearest registered item is the Willandra Lakes Region World Heritage Area (WLWHA) listed on both the NHL and WHL and at its closest is approximately 15 km from the Balranald project area (Figure 10.1). The WLRWHA was inscribed on the WHL in 1981 and further refined and endorsed by the World Heritage Committee in 1995. The WLRWHA was one of the first Australian sites to achieve World Heritage status, with the Great Barrier Reef and Kakadu also being nominated and accessioned to the WHL in 1981. The WLWHA has been den

- Natural:
  - as an outstanding example representing the major stages in the earth's evolutionary history; and
  - as an outstanding example representing significant ongoing geological processes.
- cultural:
  - bearing an exceptional testimony to a past civilisation.

Further cultural heritage values and criteria for the inscription of the WLRWHA into the NHL are also listed by the Commonwealth government and are summarised below. Broadly these criteria can be described as landforms and locations which greatly extend our understanding of Australia's environmental and Aboriginal cultural history, including:

- exposures of sedimentary sequences which reveal Pleistocene sedimentary profiles and associated archaeological and paleontological materials;
- extensive intact lakeshore landforms that may contain extensive archaeological and paleontological materials;
- the remains of hearths, including those with considerable antiquity, which have provided an ideal source for palaeomagnetism measurements;
- archaeological sites which occur within stratified sedimentary sequences and provide evidence for the antiquity and continuing presence of human occupation;
- archaeological sites which contain evidence of utilisation of lacustrine resources during lake full phases, and rangeland resources during arid phases;
- archaeological sites which demonstrate continuity of human occupation for the region through fluctuations in lake levels drying of the system about 15,000 years ago through the Holocene period and up to historic times;
- archaeological sites which provide outstanding examples of hunting and gathering, a way of life that has dominated the Australian continent up to modern times, including:
  - evidence of human occupation of, and interaction with, the landscape of lakes, lunettes and sand dunes over time in the form of campsites, middens, fireplaces, quarries, knapping floors and burials; and
  - campsites and fireplaces that reflect people's hunting, gathering and fishing diet;



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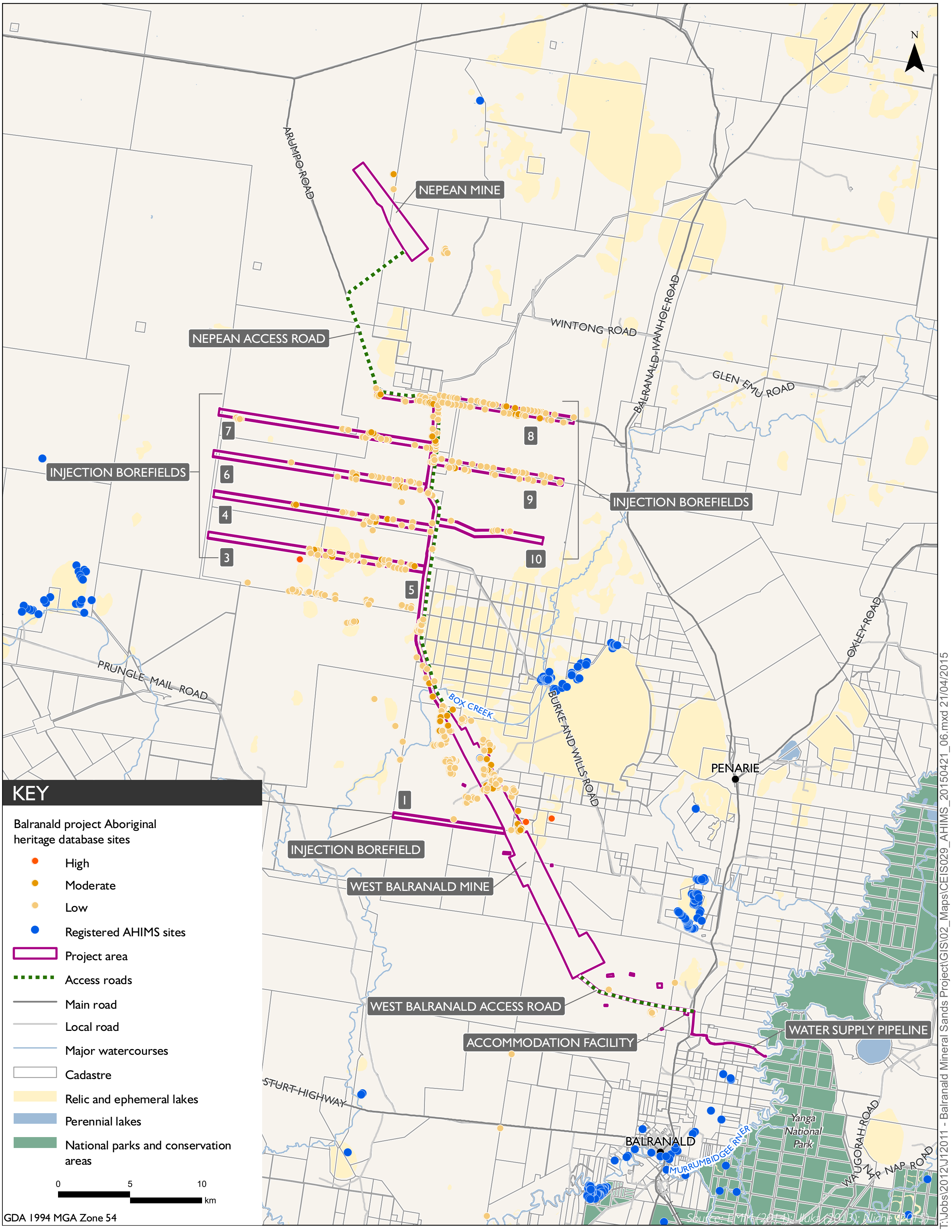
Location of the Willandra Lakes Region World Heritage Area

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 10.1



Aboriginal sites in and around the project area

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 10.2

- burial sites which are of global significance for the antiquity of burial practices represented and also for the information they provide on the development of human societies, including Pleistocene and Holocene burial sites; and

- burial sites with associated mortuary goods and evidence of ritual burials which demonstrate the antiquity of particular burial practices and the development of religious beliefs and systems over time.

10.4.3 Literature review

i Existing environment

The project area is located within the semi-arid zone of NSW. The climate is characterised by hot summers, cold winters and low annual rainfall. It consists of a series of dune fields and sand plains vegetated by mallee communities, and also contains brown soil undulating plains usually vegetated by saltbush, bluebush, belah and rosewood communities. Depressions and ephemeral lakes occur across the region. These lakes can fill with water periodically during local heavy rains and regional flood events. In some cases the lakes can hold water for several months.

Straddling two subregions; the Lachlan and Murrumbidgee Alluvial Fans, and the Scotia dune fields, the project area is characterised by dune fields, and sand plains and vegetated by mallee communities with undulating plains of brown solonised soils usually vegetated by saltbush, bluebush, belah and rosewood communities. On the margin of this system is a series of large relict lakes, remnants of an earlier landscape, fringed by lunette formations. These lunette formations are crescent-shaped, fixed dunes along the edges of relict lakes, playas and river valleys in arid and semi-arid lands.

The project area is derived from Tertiary and Quaternary sediments about 60 million years old. It is covered by ten local land systems; Arumpo, Bulgamurra, Condoulpe, Guthul, Hatfield, Marma, Rata, Riverland, Wilkurra and Youhl (Soil Conservation Service of NSW 1991).

The West Balranald mine area has three dominant land systems. The Marma land system is characterised by its vaguely defined scalded drainage tracks. The Rata land system has extensive covering of saltbush and small sub-circular depressions and the Condoulpe land system is characterised by its sand plain between dune fields and Riverine Plain. The Arumpo land system is dominant in the Nepean mining area and is characterised by its parallel dunes and sand plain with narrow chalky swales.

The hydrology of the project area is poorly defined with the exception of Muckee, Pitarpunga and Tin Tin lakes, and Box Creek downstream of its confluence with Arumpo Creek. Upstream of this confluence, Box Creek is a distributary of the Lachlan River, and lacks a deeply incised channel or deep waterholes. However, when filled with water, low points in the landscape would have provided a resource-rich environment that would have been exploited by the Aboriginal people in the region.

Also present in the project area are swamp depressions and ephemeral small lakes, and a system of large relict lakes and fringing lunette formations. While there are no perennial watercourses, Box Creek, an ephemeral tributary of the Lachlan River which is active only during major flood events, flows through the project area to the north of the West Balranald mine. Changes in the availability of water have been demonstrated in the archaeological record of Aboriginal use of the Willandra Lakes landscape. The changes in the climate and hydrology that may have effected how and where Aboriginal people used the landscape in the past would have included changes in precipitation and also channel switching of the Lachlan River further upstream. In the southern part of the project area there are extensive gently undulating riverine plains (associated with the Murrumbidgee River), and vegetation dominated by saltbush shrub lands, ephemeral grasslands and Black Box fringing cane grass depressions.

Landscapes that demonstrate geological forces from two epochs and resulting archaeological landscapes are represented within the project area; the Pleistocene, approximately 2.5 million to 12,000 years ago, and the Holocene, which started to form 12,000 years ago to the present. Pleistocene relict landforms are found in the vicinity of the northern half of the West Balranald mine area near Muckee Lake, Tin Tin Lake and Pitarpunga Lake, while it is highly likely that Pleistocene relict landforms may also be present in some parts of the injection borefields.

The Holocene is generally characterised by a warmer, wetter environment until 5,000 years ago when the environment became dryer. The change in climate is reflected in the change in landforms and the archaeological landscape.

The dominant Holocene landforms in the vicinity of the project area are the linear dune fields and ephemeral creeks and channels. Dates returned from the analysis of buried soils demonstrates that the dune system as last active about 15,000 years ago (Bowler and Polach 1971).

The Pleistocene landscape preserves evidence of ancient Aboriginal occupation, as demonstrated by archaeology within the WLRWHA about 23 km from the Nepean mine (Figure 10.1) and 15 km west of the westernmost boundary of the injection borefields. Lake Mungo, which is part of the WLRWHA, has been extensively studied with respect to geomorphology, ancient environment and archaeological context, amongst other topics, the results of which have been used as a basis for the study of the project area.

ii Archaeological context

Research specific to the project area is sparse and has, by necessity, drawn from the extensive body of information on Lake Mungo within the WLRWHA.

The WLRWHA in particular, has a long history of occupation dating back at least 40, 000 years. Studies of lakes within the Willandra lakes and creek system to the north and west of the project area demonstrate a correlation between the changing climate from the Pleistocene to the Holocene, with aridity increasing to the mid-Holocene (approximately 5,000 years ago), at which point the system reaches its current semi-arid status, the climate becoming essentially what it is like today.

Early archaeological work in the region has recorded human remains in Lake Mungo (Mungo I) dated to approximately 30,000 years ago during the Pleistocene period (Bowler 1998). Due to this being the earliest known Australian Aboriginal archaeological site it could not be substantiated until a further two remains were found and dated to a similar period (Johnson and Clarke 1998). Numerous human remains have since been found in the sand dunes of the Willandra Lakes area.

Regional archaeological surveys and predictive modelling has shown that riverine landforms and lunette lake systems within the Murray Basin are particularly rich in evidence of Aboriginal occupation. Several Aboriginal heritage investigations have been conducted close to the project area. An area 5 km to the east of the project area, a section of Paika Creek and Paika Lake on Paika Station, and Box Creek and Geraki Creek on Tin Tin Station, was surveyed by Martin (2010). During this survey over 300 Aboriginal sites were recorded. Of these, special significance was placed on a historic camp on Tin Tin Station where several Aboriginal families lived during the 1950s. Other sites in abundant quantities included stone artefact scatters and hearths. Some mounds, shell middens, culturally modified trees, grinding grooves, fish traps and conflict sites were also recorded. In additional, large mounds containing baked clay and a termite mound heat retainer, ashy deposit, and rare fragments of shell were recorded.

Recent archaeological work conducted by Niche (2012) in the sand plain and relict lake land systems near Hatfield and Ivanhoe, reported 100 Aboriginal sites including hearths, artefact scatters and isolated finds across three land systems shared with the project area (Marma, Hatfield and Youhl).

The pre-contact environment was modified by the settlement and practices of the incoming European population. Pastoral practices such as sheep and cattle grazing resulted in tree clearances along the water courses, erosion of soils and the subsequent changes to the water system. This has resulted in significant impact to the soils on lunettes dispersing and moving down slope on wetting. Extensive areas of mallee have been cleared, resulting in increasing erosion, which in turn can have a significant effect on archaeological site visibility and integrity.

iii Site prediction modelling

Site prediction modelling was undertaken to identify the likelihood of Aboriginal occupation based on environmental factors, land systems and previous archaeological assessments from western NSW. The following factors were considered when predicting sites of Aboriginal occupation:

- access to water;
- climatic conditions, landscapes which are well protected from both extremes of the elements;
- access to raw material for the production of stone tools;
- level ground with good drainage;
- elevation above cold air currents and lingering front prone valley systems often with good views of the river flats and water courses; and
- adequate fuel supply.

Quarries for stone tool manufacture are unlikely to occur within the project area as there are no known quarries of stone suitable for artefact manufacture located in or near the project area. Calcrete and carbonate nodule deposits have been recorded but would have primarily used as heat retainers and were unlikely to have been used to fashion tools.

Holocene sites are predicted to occur along the Box Creek floodplain and have been estimated to be no older than 500 to 3,000 years old. It is possible that buried archaeological deposits are also preserved within the alluvial deposit of the Box Creek catchment and burials may be present in the areas of deep soil accumulation such as lunettes and alluvium.

Evidence of much older occupation may also be possible within the project area, as indicated by the presence of a burnt emu egg shell recovered and dated as 17,000 year old date to the east of the project area from site WB66 on the eastern Muckee Lake lunette.

The project area has the potential to contain very ancient Aboriginal cultural sites as a result of the landforms having formed either in the Pleistocene or Holocene period. In some cases, landforms such as lakeside lunettes and source bordering dunes deposited during the Pleistocene may be present in the project area and may contain ancient Aboriginal sites, potentially with ages similar to those found in the WLRWHA. Portions of the lunette on the western shoreline outside the project area have gullying and sheet wash erosion. Pelletal clay is evident in these locations and may be indicative of a Pleistocene landscape.

10.4.4 Field survey

The locations of the Aboriginal sites identified during the survey in and around the project area are presented in Figure 10.2.

Approximately 2,119.9 ha of the 9,964 ha project area was surveyed. This coverage equates to a representative sample of 21.3% of the project area. Survey coverage of land systems within the project area such as Gulthul, Hatfield, Marma, Rata, Riverland, and Youhl was between 32% and 64%.

The survey coverage is represented in Table 10.3.

Table 10.3 Survey coverage of the land systems

Land system	Land system area in project area (ha)	Area surveyed in project area (ha)	Average visibility (%)	Average exposure (%)	Effective coverage area (ha)	Effective coverage (%)
Arumpo	773	9.9	66.0	34.0	2.2	22.4
Bulgamurra	2.0	0	60.0	40.0	0.0	0.0
Condoulpe	2,058.4	26.5	55.7	35.4	5.2	19.7
Gulthul	1,965.3	526.2	60.7	30.0	95.8	18.2
Hatfield	976.1	331.3	61.9	41.8	85.7	25.9
Marma	1,262.2	347.8	60.8	39.6	83.7	24.1
Rata	2,560.4	722.0	53.8	34.9	135.4	18.8
Riverland	17.8	10.8	60.0	40.0	2.6	24.0
Wilkurra	75.2	7.6	60.0	40.0	1.8	24.0
Youhl	274.2	137.8	61.0	29.5	24.8	18.0
Total	**9,964.5**	**2,119.9**	**57.9**	**35.8**	**439.4**	**20.7**

*Note: * PAD = Potential archaeological deposit; a location considered to have a potential for subsurface archaeological material.*

Analysis by land systems within the project area (see Table 10.4) indicates the highest artefact density per hectare was recorded on the Marma land system (7.1), followed by the Hatfield (4.7) and Youhl (4.5), Rata (2.7) and Perekertin (2.3), Wilkurra (2.0), Gulthul (1.0), Bulgamurra (0.5), Arumpo (0.1), Condoulpe (0.1) and Riverland (0.1). The sample size for the remaining land systems was relatively low. In the cases of the Wilkurra, Bulgamurra and Arumpo land systems, the results reflect overall trends reported in local and regional archaeological assessments.

Table 10.4 Artefact density per ha of surveyed land system in the Balranald Project Aboriginal Heritage Database

Land system	All recorded/estimated artefacts in the Balranald Project Aboriginal Heritage Database	Surveyed land system (ha)	Artefacts per hectare of land systems surveyed
Arumpo	2	16.7	0.1
Bulgamurra	4	7.9	0.5
Condoulpe	31	606.0	0.1
Gulthul	661	667.6	1.0
Hatfield	1619	347.5	4.7
Marma	4299	605.6	7.1
Perekertin*	82	36.2	2.3
Rata	2777	1037.6	2.7
Riverland	1	19.3	0.1
Wilkurra	28	13.8	2.0
Youhl	884	198.4	4.5
Total	10388	3556.2	

Note: ** The Perekertin land system was surveyed but subsequently the project area was revised and it was excluded.*

The number of Aboriginal sites was broken down by project element to illustrate the areas of highest heritage impact in terms of numbers. The highest level of impact to sites is predicted to occur in the West Balranald Mine where 70 sites were recorded, all of which will be removed by the proposed activity.

The number of sites within each project element is presented in Table 10.5.

Table 10.5 Summary of Aboriginal sites within the Balranald Project Aboriginal Heritage Database by project element

Project element	No. sites in project area	No. sites in disturbance area
Injection borefield 3	50	15
Injection borefield 4	23	7
Injection borefield 5	88	34
Injection borefield 5 and Nepean access road	7	7
Injection borefield 6	23	20
Injection borefield 7	22	11
Injection borefield 8	59	55
Injection borefield 9	31	29
Injection borefield 10	7	5
Gravel extraction area C	1	1
Injection borefield 8 and Nepean access road	1	1
Nepean access road	1	1
West Balranald mine	70	70
Sub-total	***3***	***256***
	No. sites outside project area	-
Outside project area but within 100 m	314	-
Outside project area	134	-
Sub-total	***168***	**-**
Total	**548**	**256**

In total, 548 Aboriginal sites were identified during the survey although not all sites are within the project area. Three-hundred and eighty-three (383) are located in the project area with an addition 34 within 100 m outside the project boundary. Two-hundred and fifty-six (256) sites are located in the disturbance area. Sites outside the project area number 134 and were recorded prior to the final project boundaries being determined.

The Balranald Project Aboriginal Heritage Database relates to all sites identified during the survey, within and outside the project area.

Table 10.6 Summary of Aboriginal sites in the Balranald Project Aboriginal Heritage Database by site type

Site type	Sites in Balranald Project Aboriginal Heritage Database**		Sites in project area		Sites in disturbance area	
	No.	%	No.	%	No.	%
Artefacts	230	41.97	162	42.30	114	44.53
Isolated artefact	246	44.89	166	43.34	94	26.72
Artefacts and hearth	42	7.66	34	8.88	30	11.72
Hearth	22	4.01	16	4.18	14	5.47
Hearth and isolated artefact	5	0.91	4	1.04	3	1.17
Artefacts, hearth, culturally modified tree and PAD*	1	0.18	1	0.26	1	0.26
Artefacts, mound, mound scatter, hearth, hearth scatter and PAD	1	0.18	0	0	0	0
Culturally modified tree	1	0.18	0	0	0	0
Total	**548**	**100.00**	**383**	**100.00**	**256**	**100.00**

Note: ** PAD = Potential archaeological deposit; a location considered to have a potential for subsurface archaeological material.*

***The Balranald Project Aboriginal Heritage Database includes sites recorded in areas that were excised from the project area after the survey effort.*

10.4.5 Summary of survey results

Three hundred and eighty (383) sites were recorded in the project area with 256 occurring in the proposed disturbance area. Archaeological survey was also conducted in areas that were formerly part of the project area but have since been excised, bringing the total recorded number of sites to 548.

Of all the sites identified, 89.8% contained a single site feature (ie only stone artefacts or only hearths) and 10.2% of the sites contained two or more site features (ie hearths and artefacts or hearths, artefacts, culturally modified tree and PAD).The majority of sites contained between one and ten stone artefacts. The largest sites are made up of a number of types occurring singly or as combinations and include artefact scatters, hearths with charcoal, termite heat retainers and burnt emu shell.

Stone artefacts, both as isolated occurrences and open artefact scatters, were the most common site type and the most frequent site feature. Artefacts were represented in silcrete, quartzite, sandstone, chert and rhyolite materials. Artefact classes included grinding stone fragments, retouched flakes, flakes, cores, anvils and hammerstones. The presence of residual soils and rills suggest the presence of PADs.

Hearths, both as isolated occurrences and clusters of hearths, were the second most frequent site type and site feature. They are in various forms that included intact, disturbed (retain a central concentration of heat retainers), partially buried, exposed or buried, scattered (central concentration is lost and does not have a clear focal point) and remnant (doughnut shaped without a central focus).

Three culturally modified trees were identified. One culturally modified tree was identified as part of the much larger site of West Balranald 40 (WB40). This site, WB40, is a high density archaeological complex containing a high frequency and diversity of stone artefacts (1,030), hearths, a culturally modified tree and PAD. It has been assessed as one of the most significant sites in the project area for its complexity and diversity with Pleistocene and Holocene deposits and its research value. This site is partially located within the disturbance area of the West Balranald mine.

Hearths are a common feature across the landscape. One hundred individual hearths were recorded in 63 sites. Seventy were assessed to have fair to excellent dating potential (these are recorded on the Balranald Project aboriginal heritage database thus includes hearths in areas that are now excluded from the project boundary). The hearths that remain intact or partially buried offer excellent dating potential.

Stone artefacts, both as isolated occurrences and open artefact scatters, were the most common site type and the most frequent site feature. Hearths, both as isolated occurrences and clusters of hearths, were the second most frequent site type and site feature. One culturally modified tree was identified as part of the much larger site of WB40. This site, WB40, is a high density archaeological complex containing a high frequency and diversity of stone artefacts (1,030), hearths, a culturally modified tree and PAD. It has been assessed as one of the most significant sites in the project area for its research and scientific value and for the potential for Pleistocene and Holocene deposits to exist. This site is partially located within the disturbance area of the West Balranald mine.

The majority of sites contained between one and ten stone artefacts. Fewer than 10% of sites contained between 11 and 50 Aboriginal stone artefacts (118 sites). Eleven sites contained between 50 and 100 artefacts. Thirteen sites contained between 100 and 200 artefacts. Eight sites contained more than 200 artefacts. The eight largest sites include one that is not in the project area (UD26). The largest sites are made up of a number of types occurring singly or as combinations and include artefact scatters, hearths with charcoal, termite heat retainers and burnt emu shell.

The density of these larger sites, and the type of artefacts they comprise, provide the opportunity for detailed site and artefact analysis. Some of these sites, through their high artefact counts and range of site features like hearths, grinding dishes and culturally modified trees represent extensive occupation. A small number of these larger sites contained densities of artefacts and artefact types that represented one or more knapping floors or events. Some of the sites have not had their boundaries determined as the surveys were restricted to the project area that was current at the time.

Artefacts were represented in silcrete, quartzite, sandstone, chert and rhyolite materials. Artefact classes included grinding stone fragments, retouched flakes, flakes, cores, anvils and hammerstones. The presence of artefacts eroding from residual soils and rills suggest the presence of PADs.

Hearths are a common feature across the landscape. One hundred individual hearths were recorded in 63 sites. Seventy were assessed to have fair to excellent dating potential (these are recorded on the Balranald Project aboriginal heritage database thus includes hearths in areas that are now excluded from the project boundary). They are in various forms that included intact, disturbed (retain a central concentration of heat retainers), partially buried, exposed or buried, scattered (central concentration is lost and does not have a clear focal point) and remnant (doughnut shaped without a central focus). The hearths that remain intact or partially buried offer excellent dating potential.

Culturally modified trees also occur across the landscape in the region. One culturally modified tree was recorded in the project area but outside of the disturbance area at site WB40. At least another two are located outside the project area in site B15.

10.4.6 Significance assessment

Of the total 383 sites (comprised of one or more elements) one is of high significance (WB40), 61 are of moderate significance and 321 are of low significance. As previously discussed, WB40 is partially located within the disturbance area of the West Balranald mine.

Based on current archaeological and geomorphic evidence, including extensive field survey during this assessment, there are no identified outstanding examples of landscapes or geomorphic features located in the project area that have similar values to the WLRWHA (ie World Heritage Values criteria iii and iiiv). According to current evidence and known Aboriginal cultural knowledge, there are no places or sites located within the project area that represents exceptional testimony to a cultural tradition or to a civilisation which is living or which has disappeared. To date no raw material sources have been identified within the project area but it is possible that material sourced from silcrete quarries in the WLRWHA were discarded in the project area. However there has been little dedicated research to inform such knowledge in the local area.

Similarly, comparing the cultural heritage resource recorded within the project area to the National Heritage Values (a), (b), (c) and (g) listed by the Commonwealth, there are no recorded Aboriginal sites or places of cultural significance that have outstanding heritage values significant to the nation identified within the project area. There are some sites recorded within or just outside the project area that do contain important archaeological evidence of comparatively ancient Aboriginal occupation, but none are considered to have the same scientific significance of sites or places recorded in the WLRWHA.

Table 10.7 provides a summary of the scientific significance ratings for each project element.

Table 10.7 Summary of scientific significance ratings by project element

Disturbance Area	Site	Sites
West Balranald mine	**70**	
Low	56	Karra 1, WB 100, WB 101, WB 113, WB 114, WB 115, WB 117, WB 11,
		WB 2, WB 3, WB 30, WB 31, WB 33, WB 34, B 35, WB 36, WB 37, WB 38, WB 39, WB 4, WB 45, WB 48, WB 49, WB 50, WB 52, WB 53, WB 56, WB 67, WB 68, WB 69, WB 72, WB 73, WB 75, WB 76, WB 77, WB 78, WB 79, WB 80, WB 81, WB 82, WB 83, WB 84, WB 85, WB 86, WB 87, WB 88, WB 89, WB 90, WB 91, WB 92, WB 93, WB 94, WB 95, WB 96, WB 97, WB 99
Moderate	13	WB 1, WB 27, WB 29, WB 32, WB 41, WB 42, WB 46, WB 51, WB 63, WB 65, WB 70, WB 71, WB 74
High	1	WB 40
Injection borefield 3	**50**	
Low	45	UD 139 , UD 140, UD 143, UD 145, UD 141, UD 144, UD 43, UD 44, UD 47, UD 50, UD 52, UD 78, UD 142, UD 28, UD 29, UD 30, UD 31, UD 32, UD 33, UD 34, UD 35, UD 36, UD 37, UD 38, UD 39, UD 40, UD 41, UD 42, UD 45, UD 46 / UD 48 / UD 49, UD 53, UD 54, UD 60, UD 61, UD 63, UD 66, UD 67, UD 68, UD 69, UD 71, UD 72, UD 74, UD 76, UD 79, UD 80
Moderate	5	UD 62 / UD 64 / UD 65 / UD 70 / UD 75, UD 51, UD 55, UD 77, UD 73

Table 10.7 Summary of scientific significance ratings by project element

Disturbance Area	Site	Sites
Injection borefield 4	**23**	
Low	17	UD 96, UD 97, UD 99, UD 105, UD 106, UD 107, UD 108, UD 109, UD 110, UD 111, UD 88, UD 90, UD 91, UD 94, UD 95, UD 98, UD 121
Moderate	6	UD 92 / UD 93 / UD 100 / UD 101 / UD 102, UD81 / UD82 / UD83 / UD84 / UD85 / UD86 / UD87, B 11, B 12, UD 103, UD 104
Injection borefield 5	**88**	
Low	72	B 18, B 23, B 25, B 69, B 70, B 78, B 79, B 80, B 81, B 82, B 88, Karra31, Karra40, B 20, B 21, B 52, B 53, B 54, B 55, B 74, B 98, BWR IF 2, Karra37, B 72, B 51, B 24, B 29, B 46, B 47 / B 48, B 85, BWR10, BWR11, BWR13, BWR14, BWR15, BWR16, BWR17, BWR18, BWR19, BWR20, BWR21, BWR22, BWR23, BWR24, BWR26, BWR29, BWR3, BWR30, BWR31, BWR39, BWR4, BWR40, BWR5, BWR6, BWR7, BWR8, BWR9, BWR 41, BWR 42, Karra30, Karra34, Karra35, Karra36, Karra38, Karra39, Karra 70, UD 131, UD 132, WB 108, WB 109, WB 110
Moderate	16	B 17 /B 19 / B 26 / B 27 / B 28, B 71, B 83, B 84, B 86, Karra33, Karra 61 WB 107, BWR28, BWR 32, BWR 33, BWR 34 / BWR 35WB 43, BWR12, BWR25, BWR27
Injection borefield 5 and Nepean access road	**7**	
Low	3	B 22, Karra13, TT 16
Moderate	4	BWR32, BWR33, BWR34, BWR35
Injection borefield 6	**23**	
Low	19	UD 124, UD 125, UD 129, UD 137, B 77, UD 112, UD 113, UD 114, UD 115 / UD 119, UD 117, UD 118, UD 127, UD 133, UD 134, UD 135, UD 136, UD 126, UD 128, UD 138
Moderate	4	UD 120, UD 122, UD 123, UD 116
Injection borefield 7	**22**	
Low	18	B 38, B 39, B 50, B 97, B 45, B 49, B 73, B 75, B 31, B 32, B 34, B 35, B 36, B 37, B 40, B 41, B 42, B 76
Moderate	4	B 43, B 44, B 30, B 33
Injection borefield 8	**59**	
Low	52	B 57, B 63, B 64, B 65, B 66, B 67, B 68, B 87, B 89, B 90, B 91, B 92, B 93, B 94, W 10, W 11, W 12, W 3, W 4, W 5, W 6, W 7, W 8, W 9, B 56, B 58 / B 62, B 59, B 60, B 61, B 95, B 96, TO 1, TO 11, TO 13, TO 18, TO 19, TO 21, TO 22 / 23, TO 24, TO 25, TO 26, TO 27, TO 28, TO 29, TO 30 / TO 31, TO 46, TO 47, TO 48, TO 49, TT 24, BWR38, W 1
Moderate	7	W 2, TO 12, TO 14, TO 15, TO 17, TO 2 / TO 20, TO 16
Injection borefield 9	**31**	
Low	30	TO 32, TO 33, TO 34, TO 35, TO 36, TO 37, TO 38, TO 39, TO 40, TO 41, TO 42, TO 43, TO 44, TO 45, UD 130, TT 25, TT 26, TT 27, TT 28, TT 29, TT 30, TT 31, TT 32, TT 33, TT 35, TT 37, TT 38 / TT 39, TT 9, TT 36,
Moderate	1	TT 34
Injection borefield 10	**7**	
Low	7	TT 10, TT 12, TT 13, TT 14, TT 15, TT 11
Injection Borefield 8 and Nepean access road	**1**	
Moderate	1	BWR37

Table 10.7 Summary of scientific significance ratings by project element

Disturbance Area	Site	Sites
Nepean access road	**1**	
Low	1	BWR IF 1
Gravel Extraction Area C	**1**	
Low	1	WB 105
Total	**383**	

10.5 Impact assessment

10.5.1 Introduction

The impact assessment was based on ascertaining consequences of harm on the value of the Aboriginal sites based on the type and degree of harm predicted. Three consequences of harm were predicted:

- total loss of value – no heritage values would remain subsequent to the harm;
- partial loss of value – some heritage values would remain subsequent to the harm; and
- no loss of value – there would be no harm, and no loss of value.

Impacts have been defined as direct and indirect, as follows:

- direct harm - harm associated with surface disturbance activities is anticipated to cause either a total or partial loss of heritage value at affected sites, and would have a cumulative or landscape impact of partial loss of values for the area as a whole, including:
  - disturbance of the ground surface or soil units (eg vegetation clearance and topsoil stripping, soil removal and excavations) in areas with Aboriginal objects on the surface or within the soil profile; and
  - changes to a site or place's context that has secondary impacts to the site or place, resulting in the loss of cultural values;
- indirect harm - potential indirect harm that the proposed activities include but are not limited to:
  - increased visitor traffic;
  - erosion; and
  - changes to the groundwater levels which may affect the longevity of specific Aboriginal site types that are groundwater dependent (eg culturally modified trees).

Direct harm would only occur within the disturbance area.

For the purposes of the impact assessment, where a portion of a site falls within the disturbance area, that portion of the site is considered to be directly impacted while the remaining portion of the site is considered to be indirectly impacted. Any direct impact to a site is considered to result in a loss of value. Any site that is directly impacted would therefore be considered to have resulted in, at minimum, a partial loss of value. Where 50% or less of a site would be directly impacted, the loss of value to the site is considered partial. Where more than 50% of a site would be directly impacted, the loss of value is considered to be total.

The Balranald Project would result in the loss of heritage values to one site of high significance, 57 sites moderate significance and 316 sites of low archaeological significance. Table 10.8 summarises the expected loss of value (impact) as total, partial or none for sites in the project area based on their archaeological significance.

One site of high archaeological significance would suffer a partial loss of value from the proposed project activities. Sites of low archaeological significance would suffer the greatest relative total loss of values, while sites of moderate significance would suffer proportionally higher partial loss of value than the sites of low significance. This is because the sites of low significance are generally smaller in area than the sites of moderate significance, and because efforts have been made to avoid the sites of moderate and high significance as far as possible, hence resulting in partial, rather than total, loss of value.

Table 10.8 Summary of archaeological significance and corresponding loss of value

Archaeological significance	Total loss of value	Partial loss of value	No loss of value	Total number of sites
High	0	1	0	1
Moderate	18	32	7	57
Low	188	35	93	316
Total	206	68	100	374

10.5.2 Aboriginal archaeological risk layers

The archaeological sensitivity of the project area was investigated through extensive background research and survey. An archaeological model was created to assess the likelihood of Aboriginal sites and artefacts being present in the project area by analysing the number and density of recorded sites and their relationship with environmental proxies. A computer model, which utilised digital datasets including the Western NSW land system mapping, NSW hydrology and drainage mapping, aerial imagery and vegetation mapping, was prepared with the results overlain on the project area. The definition of the risk layers is provided in Table 10.9.

The results are the Aboriginal heritage risk layers, created for the purposes of informing management and mitigation measures for the project (Figure 10.3). Appropriate responses to identified impacts in the project area are guided by the existence of landscapes and the expectation of the nature and value of the archaeology that may be present.

Table 10.9 Archaeological risk layer definitions

Risk layer rating	Character of risk layer rating
High	Landscape features associated with sites of moderate to high significance and frequent low density sites of low significance. These landscape features may be lunettes, dunes, scalds and pans associated with depressions, relict lakes, relict creeks and vegetation suggesting shallow water tables. Land systems such as Marma, Hatfield, Youhl, Rata and Peretkin frequently contain these features.
Moderate	Landscape features associated with frequent isolated and low density sites, often of low significance. The landscape features may be dunes, scalds or pans and differ from the high risk rating due to their increasing distance from water or resource and/or the limited nature of that resource. Land systems such as Marma, Hatfield, Youhl, Rata and Peretkin frequently contain these features.
Low	Landscape features associated with low archaeological potential or infrequent, isolated Aboriginal objects of low significance. These landscape features are typically characterised by disturbed land or limited temporary or permanent water sources, mallee dunefields, calcareous rises or saltbush plains with few pan, scalds, soaks and depressions. Land systems such as Arumpo, Bulgamarra, Condoulpe and Gulthul often contain these landscape features.

10.5.3 West Balranald mine

The West Balranald mine has 70 recorded sites within its boundary, all of which have the potential for impacts. One site, WB40, is of high significance and will have approximately 2% (1 ha) of its total surface area directly impacted by mining activities.

A little over 40% of the land within the West Balranald mine has been assessed to be within the moderate to high archaeological risk layers. The identification of moderate to high archaeological risk must also consider that avoiding known sites is likely to result in the identification of additional sites of equal or greater value.

10.5.4 Nepean mine

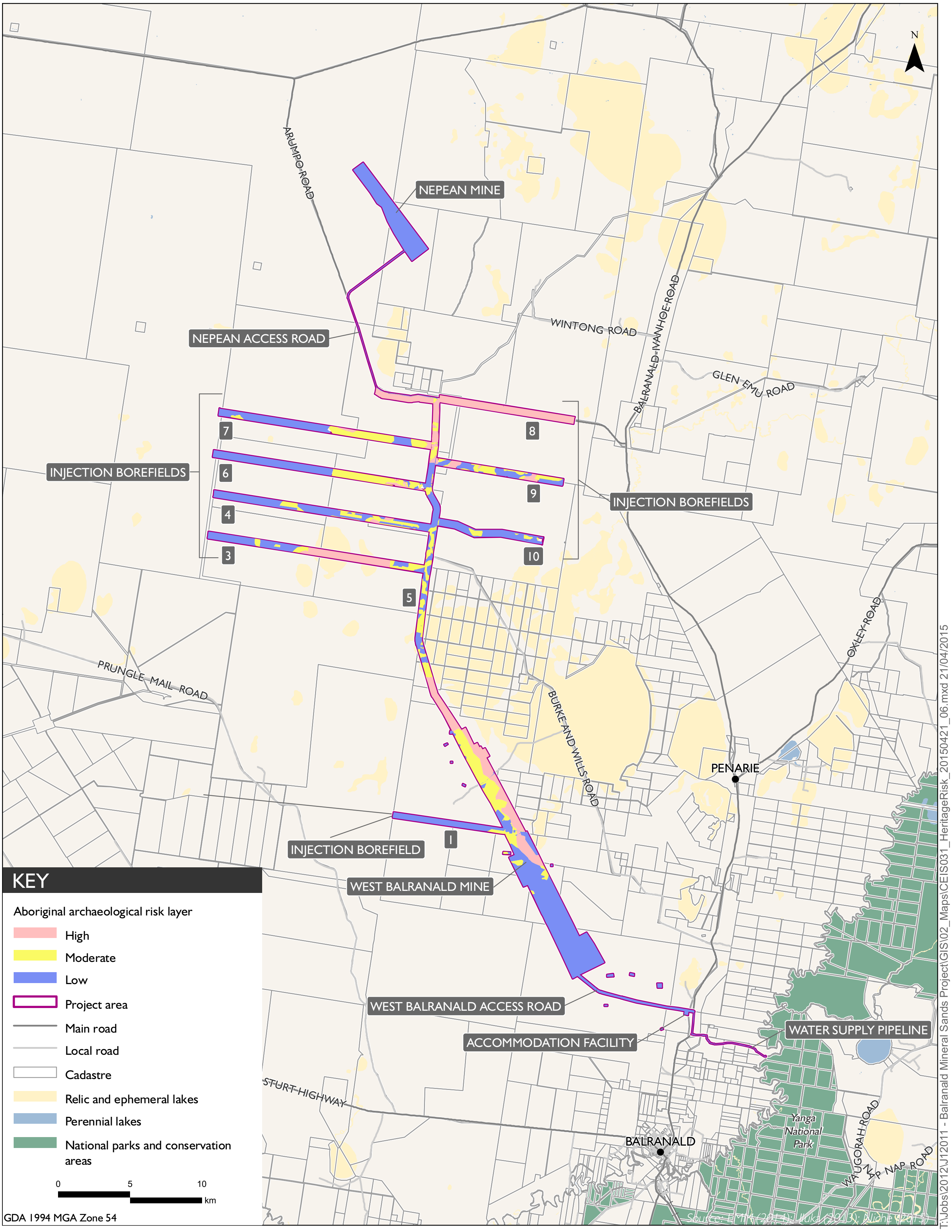
All of the land contained with the Nepean mine is categorised as having low archaeological risk. No known Aboriginal sites have been identified in the Nepean mine. Aboriginal sites may occur in this area but they will most likely be infrequent, small, fall within the low significance category and represent occasional discard rather than frequent or long term occupation of the area.

10.5.5 Injection borefields

Three-hundred and three (303) Aboriginal sites were recorded in the injection borefields, with the proposed activities potentially harming 182 of those sites. Indirect impacts are predicted for 36 sites and 85 Aboriginal sites will not be impacted by the proposed activities.

A total of 44 of the 303 sites have been assessed to be of moderate significance.

Optimisation of the injection borefields through the placement of pipelines, access tracks, turkey's nests and pumps etc should consider that approximately 48% of the borefields area is considered to be of moderate to high archaeological risk. The identification of moderate to high archaeological risk must also consider that avoiding known sites is likely to result in the identification of additional sites of equal or greater value.



Aboriginal archaeological risk layers in the project area

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 10.3

10.5.6 Cumulative impacts

Cumulative impacts are the successive, incremental and combined impacts of one or more activities on the environment, including cultural heritage values. Taken in context with pre-existing development and conservation in the region, the Balranald Project would have some effect on the cumulative impact on the Aboriginal cultural heritage of the local area and region. Pre-existing impacts in the region include land clearing and agricultural activities, and the recently approved Atlas-Campaspe Mineral Sands Project. Existing conservation areas in the regional area include the WLRWHA, Mungo National Park, Yanga National Park and the SMCAs.

The pre-existing disturbance to the landscape within the project area and local area represent significant ground surface modification. Given that the majority of the archaeological record is found on deflated surface in the project area and surrounds, it is considered that there have been high levels of pre-existing harm to the archaeological record, and to the cultural heritage of the region. In conservation areas this harm has been arrested, and in the WLRWHA, managed to conserve heritage values.

The dominant character of the archaeological record of the local area was previously not well known. The results of the Aboriginal cultural heritage assessment indicate that the project area generally contains surface stone artefact sites with low numbers of artefacts. For the most part, these sites are interpreted to be Holocene in age. In some places, the project area has the potential to contain both larger and/or older sites, although these are very unlikely to be as significant as the sites in the WLRWHA.

Despite the survey coverage achieved, the project differs from the WLRWHA in that:

- there have been no burials or quarries identified to date;
- there have been no mound sites indicating extensive occupation identified within the disturbance area to date;
- there are very few sites that contain visible shell identified to date;
- there have been no faunal remains identified of exceptional value;
- the majority of burnt features and hearths had no visible artefactual or bone material in them;
- there are a limited number of intact knapping events in which a core is associated with its flaking debitage;
- there are a limited number of sites with multiple features, the bulk of sites contain less than 0.2 artefacts per square metre and less than 10 artefacts; and
- there have been no ceremonial or stories regarding the project area identified by the RAPs to date.

The relict lake systems and drainage lines within the project area are, on average, shallower and less well defined than those within the Willandra Lakes system and smaller in their overall dimensions.

For the most part, potential impacts of the Balranald Project involve the harm of relatively high numbers of low value archaeological sites. This is not considered a significant cumulative impact because the results of the Aboriginal cultural heritage assessment indicate that similar archaeological sites, of similar value, would be present in commensurate environmental contexts immediately adjacent to the project area, and throughout the local area and region. Some areas of high and moderate archaeological sensitivity would be impacted by the Balranald Project, however such areas would also occur adjacent in the local area such upstream and downstream in the Box Creek catchment and larger lunette features associated with Pitarpunga, Tin Tin and Paika lakes, and throughout the region.

When considered in context of the large areas of land that have been subject to agricultural activities in the region, areas of conservation that are already present within the region, and the relatively confined nature and flexibility of some parts of the Balranald Project, the cumulative impact of the project on Aboriginal cultural heritage is considered to be low and within acceptable limits.

10.5.7 Impacts on Willandra Lakes Region World Heritage Area

The Aboriginal cultural heritage assessment considered impacts of the Balranald Project on the WLRWHA.

There are no proposed development activities associated with the Balranald Project that would directly or indirectly impact on the cultural heritage values of the WLRWHA. The closest point of the project area to the WLRWHA is the western boundary of the injection borefields which lie between 15 km and 16 km from the eastern boundary of the WLRWHA. At its closest point the Nepean mine area is approximately 23 km south east of the boundary of the WLRWHA, while the West Balranald mine is located approximately 34 km away. The results of other technical assessments undertaken as part of the EIS, such as noise, air quality, visual, groundwater and biodiversity, indicate that there would be no direct or indirect impacts on the WLRWHA.

Consultation with the RAPs did not identify any contemporary or recent past use of the project area by the local Aboriginal community. The project area has been, in the recent past, under private ownership and not accessible to the public.

A review of the WLRWHA management plan and newsletters indicate that the WLRWHA is used for but not limited to ceremonial purposes, education, family gatherings, food and resource gathering and hunting. These documents do not indicate any cultural activities with a physical connection to the project area.

It is not typical to undertake population studies of common abundant species as part of the EIS process however, it is considered unlikely that the Balranald Project would impact on any floral or faunal species likely to be hunted by Aboriginal people, such as common abundant species like kangaroo or emu, given the consolidated Mallee habitat between the Balranald Project and the WLRWHA. As noted above, individual technical studies there are no anticipated direct or indirect impacts on the WLRWHA.

While the Balranald Project will result in an increase in traffic along two access routes to the WLRWHA – Burke and Wills and Arumpo roads, it will not restrict or diminish access to the WLRWHA.

In summary, the location of the project area is distant enough from the WLRWHA for there to be no foreseeable direct or indirect physical impacts on the WLRWHA from the proposed Balranald Project.

In addition to the above, based on current archaeological and geomorphic evidence, including extensive field survey during the Aboriginal cultural heritage assessment, there are no identified outstanding examples of landscapes or geomorphic features located in the project area that have similar values to the WLRWHA.

According to current evidence and known Aboriginal cultural knowledge, there are no places or sites located within the project area that represent exceptional testimony to a cultural tradition or to a civilisation which is living or which has disappeared.

Finally, assessment of the Aboriginal archaeological and cultural landscape of the Project area with national heritage criteria did not identify any archaeological or cultural sites of national significance and none that are considered to have the same scientific significance of sites or places in the WLRWHA.

10.6 Management and mitigation measures

10.6.1 Aboriginal cultural heritage management plan

An Aboriginal cultural heritage management plan (ACHMP) has been prepared for the Balranald Project in consultation with RAPs, OEH and DoP. It sets a framework for the management of Aboriginal heritage values throughout the life of the project.

The ACHMP has been structured around activities that will be implemented on the Balranald Project to manage Aboriginal heritage. The overall approach involves:

- Mitigation of impact through the Aboriginal heritage research program: completed prior to land disturbance in high and moderate risk areas and areas identified in the archaeological subsurface excavation program. It includes the following elements:
  - geomorphic assessment;
  - archaeological surface collection;
  - archaeological subsurface investigation (areas of archaeological research interest only;
  - analysis and dating;
  - reporting; and
  - storage of recovered Aboriginal heritage evidence and care and control agreements.
- Ongoing management requirements implemented for the duration of the project in high, moderate and low risk areas, and includes the following elements:
  - communication and involvement of RAPs;
  - communication with Aboriginal stakeholders through the Aboriginal Cultural Heritage Working Group;
  - management of land disturbance;
  - management of Aboriginal sites where disturbance can be avoided;
  - management of new finds in the high and moderate archaeological risk layers;
  - management of human remains in the high, moderate and low risk areas;
  - raising cultural heritage awareness (inductions, toolboxes, training);

- storage of recovered Aboriginal heritage evidence; and
- ACHMP review and reporting.

10.6.2 Archaeological research and salvage excavation program

In order to manage and mitigate the impacts of the Balranald Project on the scientific and cultural values of the identified Aboriginal heritage evidence, Iluka has committed to an Aboriginal heritage research program in specifically identified areas where impact cannot be avoided within the moderate and high archaeological risk layers prior to disturbance of the areas. The aim being that a representative sample of artefacts and evidence can be collected before disturbance of the area. The Aboriginal heritage research program consists of:

- geomorphic assessment;
- surface collection program of a sample of Aboriginal objects;
- an archaeological subsurface excavation program in select locations;
- the dating of selected samples recovered from the surface collection and subsurface excavation programs;
- analysis of a selected samples of Aboriginal objects recovered from the surface collection and subsurface excavation programs;
- updated significance assessments of identified sites; and
- reporting on the results of the surface collection and subsurface excavation programs.

For high and moderate risk areas, the following management measures would be implemented:

- avoidance where possible;
- where not possible, archaeological surface collection of Aboriginal objects in accordance with the ACHMP, which would include:
- collection undertaken by appropriately qualified and experienced archaeologists and representatives of the Registered Aboriginal Parties, where available;
- collection undertaken prior to any activities or impact occurring in that area;
- defined collection areas based on the ACHMP, depending on whether or not the areas has been previously surveyed;
- systematic collection of a representative sample of surface Aboriginal heritage evidence with respect to the nature and extent of heritage evidence and that delineates collection areas, takes site and site feature photographs and records the provenance of each Aboriginal object or site feature;
- recovered archaeological material stored in accordance with the Temporary Storage Protocol; and
- a representative sample of Aboriginal objects may be selected for further lithics analysis and attribute recording.

Details of the research and salvage program are contained in the ACHMP. A summary of the research program activities in each risk area is outlined in Table 10.10.

Table 10.10 Summary of the research program activities by the archaeological risk layer and archaeological subsurface excavation program locations

Risk layer	Unsurveyed areas and K sites identified in the ACHA	Area of research interest
High	• Aboriginal heritage research program (surface collection of artefacts)	• Aboriginal heritage research program (surface collection and archaeological subsurface excavation commitments)
Moderate	• Aboriginal heritage research program (surface collection of artefacts)	• Aboriginal heritage research program (surface collection and archaeological subsurface excavation commitments)
Low	No management and mitigation measures.	-

10.7 Conclusion

The Aboriginal cultural heritage assessment examined predicted impacts to Aboriginal sites and objects from the Balranald Project. The results were obtained through an investigation of the existing environment, previous archaeological assessment, field survey and Aboriginal stakeholder consultation.

The cultural heritage survey was conducted over three field programs between 2012 and 2014. The field programs involved a total of 535 person days of survey. A total of 548 Aboriginal sites were identified across all archaeological investigations for the Balranald Project. These sites were added to the BPAHD. Approximately 76% of the identified Aboriginal sites (417) are located in or within 100 m of the project area. Three hundred and eighty three Aboriginal sites are located within the project area and 256 Aboriginal sites are located within the disturbance area.

The project area has social significance to the Aboriginal community because it contains archaeological sites and traditional resources that establish a link between the past and present Aboriginal use of the land. The project area contains landscapes which have high and moderate archaeological value, but for the most part contains landscapes that are of low archaeological value. The high and moderate value areas include the Box Creek distributary stream at the northern end of the West Balranald mine and areas of relict lake fringes and depressions at the northern injection borefields and Muckee Lake. These parts of the project area are significant because they may reveal important details about how and when Aboriginal people lived in this area, and how Aboriginal settlement of the area relates to, and informs what is known of Aboriginal history in adjoining areas, including the WLRWHA. In particular the areas of high and moderate significance within the project area may provide a story of how people have utilised the area and how this relates to the active and inactive phases of Box Creek's history, and the episodic filling history of the lakes as the availability of water changed from the terminal Pleistocene to the present. As well as providing information about the chronology and nature of Aboriginal settlement of the region, the project area may also provide additional information on the local and regional use and distribution of resources, such as raw materials for making stone tools.

An impact assessment was completed for the sites to be impacted by the Balranald Project and management and mitigation measures considered. As a result of the archaeological investigation the following recommendations were made:

- preparation of an ACHMP, which has subsequently been prepared;
- surface salvage collection and management of areas based on risk rating for sites directly disturbed as a result of the Project; and
- development of an archaeological research and salvage excavation program.

The ACHMP provides detailed procedures for the management of Aboriginal sites and for the unexpected discovery of Aboriginal objects and human remains. Aboriginal objects or sites subject to impacts from the project will be recorded and collected, and through agreement with all stakeholders, a keeping place will be established to ensure the care and control of the collection.

11 Non-Aboriginal heritage

11.1 Introduction

A non-Aboriginal, or historic, heritage assessment was undertaken by Landskape for the Balranald Project in accordance with the EIS Guidelines as discussed in Chapter 10. The historic heritage assessment is provided in Appendix E and summarised in this chapter.

The assessment was guided by the following best practice heritage publications:

- the *Australian International Council on Monuments and Sites Charter for Places of Cultural Significance* (also known as the *Burra Charter*, Australian ICOMOS 2013); and
- the *NSW Heritage Manual* (Heritage Office 2006).

11.2 Method

A general predictive model examining possible heritage sites was formulated from relevant historical data along with topographical and geological maps to identify landscapes with the potential to contain archaeological sites. The predictive model for historic heritage in the region indicates that sites of significance would relate to early pastoral activities of the late nineteenth century or the first half of the twentieth century. Site types that have the potential to occur included dwellings and outbuildings, discarded farm machinery and blazed survey marks.

A field inspection of the majority of the project area was undertaken on 19 to 20 April 2011 and 13 February 2012 to complement the predictive model.

Searches of the following databases were completed:

- the NHL;
- the SHR; and
- the Balranald LEP.

11.3 Results

11.3.1 European settlement history

Captain Charles Sturt was the first European to visit the Lower Murrumbidgee River in 1830 and passed the site where Balranald town is now situated. Six years later, the Surveyor-General of NSW, Major Thomas Livingstone Mitchell, camped at what is now Balranald town during his 1836 survey expedition of south-eastern Australia. Mitchell was accompanied by an Aboriginal guide, Yuranigh, who preferred to be called John Piper. Two streets in Balranald town, Yuranigh and Piperstreets, have been named in his honour.

In the following years, routes along the Murrumbidgee and Murray rivers were used to drive cattle overland from the colony of NSW to Adelaide. In the mid nineteenth century, pastoralists brought sheep to the region which led to reports of land being suitable for grazing. In March 1845, George Hobler established Paika Station, to the east of the project area, after claiming the northern reach of the Murrumbidgee River. It was the earliest and largest land holding within the region and covered the majority of the project area (see Figure 11.1).

Balranald town came into existence when peddlers, shepherds and itinerants crossed the Murrumbidgee River and established a settlement of simple, rough shelters. The first store and the Balranald Inn appeared in 1848. The town was named Balranald that year by George James MacDonald, the first commissioner for crown lands on the Lower Darling District after Balranald House, his birthplace on North Uist in the Outer Hebrides. At the time it was hoped that the town would become an important river port. In 1850 a post office opened and the first district constable was appointed. The town was laid out and gazetted in 1851.

The Darling Pastoral District was established in 1847. William Charles Wentworth took up the Paika lease, encompassing most of the project area. By 1851, Paika carried 11,000 sheep. The Victorian Exploring Expedition, led by Robert O'Hara Burke, with third in command William John Wills, passed through Balranald town in 1860 (Feldtmann 1976). Burke and Wills camped at Balranald town on 15 and 16 September 1860 before heading north to Paika station.

With land reforms, including the passing of the *Crown Lands Act 1881,* most of the old pastoral holdings including Paika were reallocated as Western Lands Leases in 1886 in an attempt to break the domination of land tenure by a few wealthy individuals. However this failed to stop the establishment of pastoral agglomerations including Peter McPherson's sons who took up some 194,884 acres over the project area, now Tin Tin, Karra and Paika stations. The remainder of the project area was covered by WLLs held by multiple title holders.

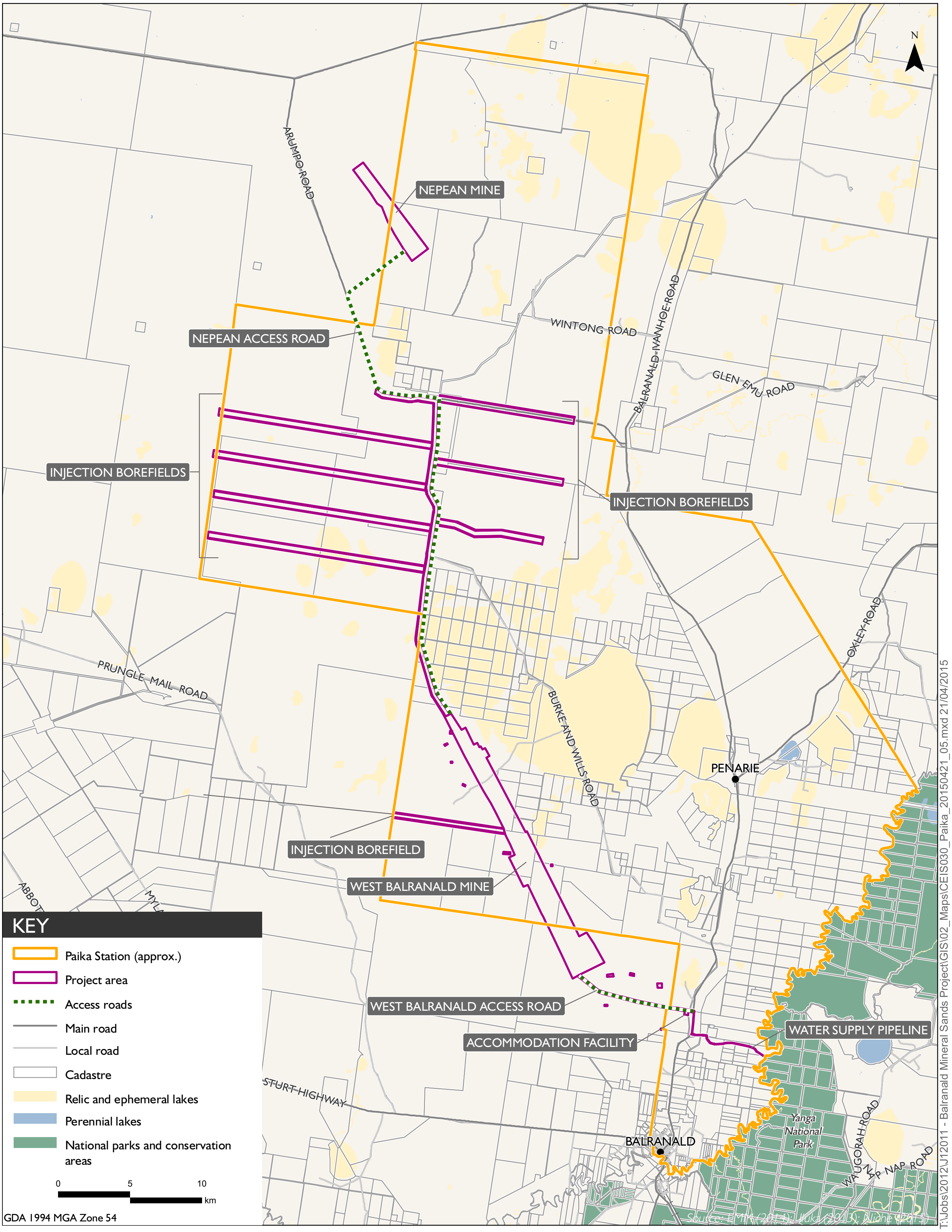
After World War One, sections of Paika Station near Pitarpunga Lake were subdivided into small allotments as part of a soldier settlement scheme, and now form part of Tin Tin Station.

11.3.2 Survey results

Examination of historic pastoral maps did not reveal any previous pastoral homesteads in the project area. No historic heritage sites were observed in the project area during the field surveys. The current landholder of Tin Tin Station identified the inferred path of the 1860 Burke and Wills expedition and an earthen water supply channel built by Alan and Walter McPherson in the 1890s, as features of historic interest; however, both are located outside the project area. There are no registered historic heritage sites in the project area.

The closest historical feature on the NHL and SHR is the WLRWHA which is located approximately 23 km north-west of the Nepean mine. Willandra Lakes' historical values are identified on the SHR as owing to being part of early European inland exploration (the Burke and Wills expedition) and development of the pastoral industry in south western NSW. Willandra Lakes also has significance for continuous human occupation of the area for the past 40,000 years, and has Pleistocene archaeological value for its contribution to the significant understanding of early cultural development in the region.

The closest registered historic site on the Balranald LEP is the Balranald Fire Station in Market Street, Balranald, approximately 13 km south of the project area.



EMM ILUKA

The boundary of Paika Station

Balranald Mineral Sands Project

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Figure 11.1

11.4 Impact assessment

Predictive modelling derived from desktop review, complemented by field surveys of the project area suggests that there is a low potential for significant historic heritage to occur in the project area. Therefore, no impacts to historical heritage are expected for the Balranald Project.

Potential impacts to the WLRWHA are addressed in Section 10.5.7. No impacts to the WLRWHA are predicted as a result of the Balranald Project.

11.5 Management and mitigation

As there are no historic heritage sites or values predicted to be impacted by the Balranald Project, no management or mitigation measures are proposed.

However, if historic heritage object(s) are uncovered during the construction and operational phases, all works would halt in the immediate area to prevent any further impact in accordance with state legislation. A suitably qualified archaeologist would be contacted to determine the significance of the object(s). Any new object(s) would be registered with OEH and BSC including details of their proposed management.

11.6 Conclusion

The historic heritage assessment conducted by Landskape did not identify any historic heritage sites or values with potential to be impacted by the Balranald Project, including the WLRWHA which is the closest historical feature on the NHL and SHR. Accordingly, no management or monitoring measures are required in respect of historic heritage. Notwithstanding contingency measures would be in place for the unlikely event that any historic heritage object(s) is identified during construction and operation of the Balranald Project.

12 Water resources

12.1 Introduction

The water assessment for the Balranald Project was prepared by EMM (Appendix G) in accordance with the EIS Guidelines (see below) and following regulations, methods and guidance documents:

- *Australian Groundwater Modelling Guidelines* (NWC 2012);
- *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC/ARMCANZ 2000);
- *The Basin Plan for the Murray-Darling* (MDBA 2012);
- Groundwater monitoring and modelling plans - Information for prospective mining and petroleum exploration activities (NOW 2014);
- *Guidelines for the assessment and management of groundwater contamination* (DEC 2007);
- *National water quality management strategy guidelines for groundwater protection in Australia* (ANZECC/ARMCANZ 2000);
- the AIP (NOW 2012);
- *NSW State Government policy framework document* (DLWC 1997); and
- *Murray Darling Basin groundwater quality sampling guidelines, technical report no. 3* (MDBC 1997).

The water assessment was prepared using a number of technical assessments which have been appended to the water assessment, including:

- *Groundwater dependent ecosystems impact assessment report* (CDM Smith 2015; Appendix H);
- *Balranald Project DFS1 groundwater modelling* (Jacobs 2015; Appendix I);
- Regional groundwater monitoring information, commenced in 2011 on a quarterly basis;
- Summary of landholder discussions as part of the beneficial use assessment (Land and Water Consulting 2014);
- *Balranald Mineral Sands Project surface water management report* (WRM 2015; Appendix J);
- *Acid and metalliferous drainage risk and management implications for mining and closure of the West Balranald Mineral Sands deposit* (Earth Systems 2015; Appendix K); and
- *Iluka 2015 Balranald Mineral Sands Project, Radiation risk assessment April 2015* (Appendix L).

Groundwater modelling undertaken by Jacobs, as presented in the groundwater modelling report, was independently peer reviewed by Hugh Middlemis.

12.2 EIS Guidelines

The EIS Guidelines require specific details on the existing environment, relevant impacts and proposed avoidance, mitigation and offset measures to deal with potential impacts of the Balranald Project on water resources.

They state:

4. DESCRIPTION OF THE ENVIRONMENT

...

e) a description of the quality, quantity, location and connectivity and/or hydrological flow regimes of surface and groundwater - including seasonal dynamics (e.g. volume, timing, duration and frequency of flows) within and adjacent to areas likely to be directly or indirectly impacted by the action;

...

5. RELEVANT IMPACTS

...

d) any technical data arid other information used to assess impacts including:

i any modelling undertaken on changes to surface and groundwater hydrology; and

...

6. PROPOSED AVOIDANCE, MITIGATION AND OFFSET MEASURES

(a) a description of how the action has been designed to avoid impacts to migratory species, threatened species and ecological communities, World Heritage values and National Heritage values;

(b) a consolidated list of mitigation measures proposed to be undertaken to prevent or minimise the relevant impacts of the action, before, during and after construction, during operation, decommissioning and rehabilitation;

(c) the cost of the proposed mitigation measures; and

With the exception of the cost of proposed mitigation measures, the above requirements are addressed in this chapter and the water assessment contained in Appendix G. In relation to costs of proposed mitigation measures, the costs of all mitigation measures have been incorporated into the economic assessment of the Balranald Project discussed in Chapter 16 and contained in Appendix N.

12.3 Methods

12.3.1 Hydrogeological numerical model

A regional groundwater model (BAL2.0) was developed by Jacobs (2015) to simulate groundwater behaviour under the proposed mining conditions, including dewatering abstraction and reinjection conditions. This was used to inform the design of the dewatering systems and to quantify impacts to the groundwater regime. Local scale 'sub-models' were calibrated to site production and injection trials and this was extrapolated across the full BAL2.0 model domain to calibrate the regional model.

The numerical model is based on extensive site investigations undertake over a number of years, a compilation of data used to describe the hydrostratigraphy, recharge and discharge features and groundwater flow directions, and a sound conceptual hydrogeological model. The model domain, measuring 90 km east-west and 90 km north-south, includes the West Balranald and Nepean deposits, and part of the Murrumbidgee and Murray rivers.

12.3.2 Assessment approach

This water assessment examines the following project-related activities: construction and use of site infrastructure, dewatering, water reinjection, mining and on-site water storage and the impacts to water quality, water level and pressure, groundwater surface water interaction and the physical disruption of aquifers and water courses. The receptors that have been identified as potentially being sensitive to water impacts in the region include:

- ecosystems that rely on groundwater, including groundwater dependent ecosystems (GDEs);
- Murrumbidgee River and ephemeral water courses; and
- private landholder bores, properties and infrastructure.

12.3.3 Assessment criteria

The minimal impact thresholds outlined in the AIP will be used to assess the potential impacts to groundwater resulting from the Balranald Project. The AIPs 'minimal impact considerations' are employed to assess impacts to water table levels, water pressure levels and water quality across a range of different groundwater system types.

The groundwater within the Western Murray Groundwater Source in the MDB Porous Rock WSP in the vicinity of the Balranald Project is classified as 'less productive', based on the very high salinity levels. The greater water source is then classified as a 'porous rock' water source. The minimal considerations for porous rock units of less productive groundwater systems have therefore been adopted for this assessment.

12.3.4 Site water management

Site water management including the management of water sources and proposed water management infrastructure is described in Section 3.7.

12.4 Results

12.4.1 Surface water

The Murrumbidgee and Murray rivers are the major permanent surface water features in the vicinity of the project area (Figure 7.3). The Lachlan River terminates at the Great Cumbung Swamp, approximately 42 km east of the project area. Further upstream this is a major permanent surface water feature. The Murrumbidgee and Murray rivers provide key water resources for large populations within the Murray Darling Basin including town water, agricultural and environmental supplies. The Murrumbidgee River is about 13 km south-east of the West Balranald mine, and flows in a south-westerly direction, to its confluence with the Murray River about 40 km to the south-west of Balranald town. A small part of the project area (the water supply pipeline) is located on the western flood plain of the Murrumbidgee River.

Due to the climatic conditions (ie low rainfall and high evaporation), flat landscape, and large areas of permeable soils, there is little locally derived runoff in the project area and no permanent surface water sources. Extremely heavy local rainfall events are capable of filling local depressions, including dry relic beds and creating temporary flow in drainage features, such as Box Creek.

Within the project area is Box Creek, an ephemeral watercourse that receives distributary flows from the Lachlan River. Box Creek has no defined beds and flow has only occurred in Box Creek on several occasions in the last 60 years in association with heavy local rainfall or large flooding events. The vast majority of the Box Creek catchment area, which covers most of the project area, drains into dry lakes or depressions; significant and sustained rainfall is needed for Box Creek to flow (WRM 2015).

i Drainage

To the far north-east of the project area, Merrowie and Middle creeks, overflow distributaries of the Lachlan River, drain into Box Creek. However only if the flood levels are high enough and sustained for a long enough period will flood water from Middle and Merrowie Creeks drain into Box Creek. Muckee, Pitarpunga and Tin Tin Lakes are on the eastern side of the project area, and Box Creek drains into these lakes. Run off in the vicinity of West Balranald mine also typically drains north into these Lakes. If these lake become full (they are typically dry) flow will drain into Box Creek downstream of the lakes, to the west of the project area. After merging with Arumpo Creek, Box Creek flows into the Murrumbidgee River, approximately 30 km south-west of the project area.

The vast majority of the Box Creek catchment area drains into dry lakes or depressions; very little to no local runoff enters Box Creek. Under pre mining conditions it is likely that any runoff from the project area would drain via shallow overland sheet flow towards dry lakes or minor depressions (WRM 2015).

The Nepean mine is located on a ridge of slightly elevated ground that forms the western boundary of the Box Creek catchment area. Run off in the vicinity of the Nepean mine flows into a dry lake at the eastern toe of the ridge; overflow flows south through the edge of the injection borefield on the eastern side of the project area towards Tin Tin Lake (WRM 2015).

ii Flow

As Box Creek is an ephemeral stream, there is no available stream flow data. Box Creek flow characteristics have been determined based on observations with landholders and are reported in WRM (2015) as follows:

- there was sufficient flow in Box Creek to cause Pitarpunga and Tin Tin lakes to fill and overflow in 1956 with flow originated from flooding in the Lachlan River;
- flooding was observed several times in the 1970s, although it is unclear if this was as severe as the 1956 flood, or if the lakes filled and overflowed; and
- flooding occurred in the project area and surrounds in 2010/2011, however it is thought this was due to heavy, localised rainfall in the Box Creek catchment area rather than overflow from the Lachlan River (via Merrowie and Middle Creeks). There was not sufficient volume to cause Tin Tin and Pitarpunga lakes to fill and overflow into Box Creek in the vicinity of the project area.

The 2010/2011 flood event recorded an estimated peak discharge in Box Creek downstream of the Balranald-Ivanhoe Road of 150 m^3/s. This was the result of a two day rainfall event that exceeded 1 in 100 annual exceedance probability (AEP) event (WRM 2015). The AEP is the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year (BoM 2014).

Although not mentioned by landholders, a flood also occurred in 1990in the Lachlan River detailed in the *Lachlan River – Hillston Floodplain Management Plan Lake Brewster to Whealbah* (DNR 2005). The1990 flood event in the Lachlan River had an AEP of between 1 in 60 to 1 in 70, and a flow rate of 3,000 ML/day (WRM 2015). This flood did not result in sufficient flows in Box Creek, and Pitarpunga and Tin Tin lakes, despite high flows in Middle and Merrowie creeks. Peak flow rates in the Lachlan River during the 1990 and 1956 flood events were comparable, however the duration of the 1956 event was approximately three months longer (totalling nine months) than the later flood. This suggests that for flooding in the project area to occur, flooding of the Lachlan River in excess of six months is required.

iii Water quality

The Murrumbidgee and Murray rivers in the vicinity of the project area contain fresh water supplies that are frequently used for purposes such as town water supply and irrigation. DPI-Water reports that the recent salinity of the Murrumbidgee River at the Balranald weir is fresh, with an average electrical conductivity (EC) of 0.2 mS/cm (in February 2015). Background water quality data is available for the Lachlan, Murrumbidgee and Murray rivers; however this is not relevant to the Balranald Project as no water will be discharged to these rivers.

12.4.2 Groundwater

The project area is within the alluvial sediments of the Murray Basin, which is a large closed groundwater basin with regional aquifer systems, confining layers and permeability barriers to groundwater flow. The combined thickness of the Murray Basin sediments ranges from 250 to 290 m.

The basal unit overlying the basement rocks (Palaeozoic rocks of the Lachlan Fold Belt) is the Olney Formation, comprising predominantly continental clay, silt and sand sediments (Kellet 1989). A marginal marine unit, the Geera Clay, interfingers through the middle sequence. Overlying the Geera Clay and Olney Formation is the Loxton-Parilla Sands, a thick sequence of marine sands that contains the target mineral deposits. Overlying the Loxton-Parilla Sands is the Shepparton Formation, comprising fluio-lacustrine unconsolidated clays and silts. Each of these formations are described in the following sections.

The geology of the Murray Basin (conceptualised), including the project area, from east to west is shown in Figure 7.1.

i Formations

a. Shepparton Formation

The Shepparton Formation is a composite aquifer-aquitard system comprising unconsolidated clays, sandy clays and fine grained sand. The Shepparton Formation hosts the superficial water table in most of the project area, although the bulk of the Shepparton Formation at the Nepean deposit is unsaturated. Stiff clay lenses 4-6 m in thickness at the base of the Shepparton Formation separates the groundwater within the Shepparton Formation from the groundwater within the Loxton-Parilla Sands at the West Balranald deposit, however Iluka confirmed clay rich layers are not universally continuous.

b. Loxton-Parilla Sands

Jacobs (2015) divides the Loxton-Parilla Sands into repeating cycles of a facies stack moving upwards from offshore, to lower shore, to surf zone and then foreshore facies. These different depositional zones have varying hydraulic conductivities. At the West Balranald deposit the surf zone has the highest hydraulic conductivity and can be several meters thick, while the offshore facies, consisting of finer units, are conceptualised as a lower permeability layers.

c. Geera Clay

The Geera Clay has a very low permeability and is therefore considered an aquitard. This unit acts as a low permeability barrier to groundwater movement between the Loxton-Parilla Sands and Olney Formation, and has a profound effect on pressure distribution and water chemistry of the Olney Formation.

d. Olney Formation

The Olney Formation is confined where overlain by Geera Clay in the west, however further east, the formation is considered semi-confined (Kellett 1989). Above the Ivanhoe Block, the mid Olney Formation is largely replaced by the Geera Clay and the lower Olney Formation is truncated by the basement rocks (the Iona Ridge).

ii Recharge

Regionally, recharge to the Murray Basin sediments within NSW primarily occurs along the basin margins to the east, with groundwater then flowing generally in a westerly direction. Recharge from these easterly areas is largely via a combination of river leakage (particularly during overbank flood events) and direct rainfall recharge. Localised recharge also occurs across the Murray Basin, particularly adjacent to major rivers and during high flow or flood events.

Locally in the project area there is limited recharge from direct rainfall, with most recharge to the area occurring via through flow from the east. While minor direct rainfall recharge may occur locally, the low rainfall and high evaporation means this volume would be minimal and the presence of stratified low permeability clays and silts in the Shepparton Formation often results in this water entering perched systems. The Loxton-Parilla Sands and the Olney Formation is recharged via through flow from the east of the project area.

In the Lower Murrumbidgee, the connectivity between the Murrumbidgee River and the underlying Murray Basin sediments is considered to be seasonably variable (MDBA 2012). Locally, the depth to groundwater near the Murrumbidgee and Murray rivers is lower than the river stage, which indicates the loosing nature of these rivers in this local area.

iii Discharge

The central divide between the Murray and Darling basins, overlying the rising basement associated with the Ivanhoe Block, is the regional groundwater discharge zone for the eastern Murray Basin in NSW. The rising basement causes aquifer thinning, and along with the decrease in permeability associated with the Geera Clay, creates the potential for upward vertical discharge (Kellet 1989).

The ancient and dry lakes in the vicinity of the West Balranald deposit (ie Tin Tin, Pitarpunga and Muckee lakes), with relatively lower topography and apparent surface salinisation, form localised groundwater discharge features experiencing evaporative losses from the watertable.

iv Levels and flow

There is a general decrease in the depth to water moving north and north-west from the Murray and Murrumbidgee rivers. At the northern end of the West Balranald deposit, and at the Nepean deposit, the groundwater table lies within the Shepparton Formation. At the southern end of the West Balranald deposit the water table lies within the Loxton-Parilla Sands.

Groundwater flow at the project area is generally from east to west. In the deeper Olney Formation, groundwater flows to the west-northwest as a result of the basement structure in this area. The Ivanhoe Block impedes westerly through flow in the Riverine Plain as the regional aquifer either thins out over the rising basement block or is truncated by it. The Geera Clay also forms a hydraulic barrier to lateral flow to the lower Loxton-Parilla Sands and the middle Olney Formation, forcing westerly groundwater flow lines in the middle and upper Olney Formation to converge.

Kellett (1991 and 1994) indicates artesian conditions to the east of the project area and URS (2012) reports a measured head at a monitoring bore at the West Balranald deposit (WB3 P1) of 3.1 m above the ground surface. Iluka has identified two artesian Olney Formation pastoral bores (HD1 and T02) in the vicinity of the West Balranald deposit. A strong vertical upward gradient is pronounced at DPI-Water nested monitoring sites GW036866 (40 km north of Balranald town) and GW036674 (68 km north of Balranald town) where there is approximately 9 m and 5 m difference, respectively, in head pressure between the Loxton-Parilla Sands, and the deeper Geera Clay and Olney Formation. Upward vertical head gradients are consistent with the monitoring sites at the discharge end of the Balranald Tough and near where the basement rises, causing upward groundwater flow.

Comparison of heads in the Shepparton Formation and Loxton-Parilla Sands at DPI-Water nested monitoring site GW036866 demonstrates the potential for a small upward gradient from the Loxton-Parilla Sands to the Shepparton Formation. This would tend to suggest that, away from the rivers, groundwater has the potential to move upwards. If this is the case, rainfall recharge cannot be significant, otherwise a downward gradient would be observed, and it is likely evapotranspiration may be intercepting seepage of rainfall that does penetrate to the water table.

v Hydraulic conductivity

Hydraulic conductivity in the Shepparton Formation is highly variable, due to the heterogeneous nature of this formation with sand and clay lenses throughout. Continual lateral flow through formations is not common. A range of bulk hydraulic conductivity is observed in the Loxton-Parilla Sands and this is due to the differences in the hydraulic conductivities of the different surf and offshore zones. The stratification in this unit is likely to cause considerable vertical anisotropy in hydraulic conductivity measurements.

12.4.3 Hydrogeochemistry

Groundwater quality within the Murray Basin is variable, and Evans and Kellet (1989) report that one-third of the resource is highly saline with salts originating from the marine depositional environment. The cycle of low precipitation and high evaporation is also likely to enhance the salinity within the shallow geological formations. The high occurrence of groundwater abstraction and irrigation in the eastern areas of the Murray Basin has enhanced shallow and mid groundwater interaction, contributed to the mixing of saline waters and has remobilised salts from previously unsaturated zones. Ancient and dry lakes in the western areas are indicative of groundwater discharge zones and the formations are likely associated with saline conditions in the upper aquifers (Kellet 1989).

There is a general trend of salinity concentrations in all water bearing units to increase linearly from east to west, in line with groundwater flow direction. The salinity trend is proportional to distance along a flow line and this indicates mixing between groundwater and additional water inputs via stream leakage and rainfall infiltration. Groundwater mixing influences the water quality and reduces the degree of difference between the water quality of different formations.

Water quality in the Shepparton Formation is highly variable and related to permeability, depth to water table and anthropogenic influences. There are local areas in the Shepparton Formation where pockets of fresher groundwater lenses are identified to be floating on regional saline groundwater. Water quality sampling indicates that the salinity of the Shepparton Formation and Loxton-Parilla Sands is similar, and these formations had the highest EC and total dissolved solids (TDS) measurements (average EC of 48 millisiemens per centimetre (mS/cm) in the Shepparton Formation and average EC of 56 mS/cm in the Loxton-Parilla Sands). The TDS and EC is lower in the Olney Formation, with an average EC of 9.3 mS/cm, and this is comparable to the EC in the Geera Clay.

The EC of sea water is 53-60 mS/cm. An EC between 0 and 0.5 mS/cm is considered to be good drinking water for humans. Beef cattle and adult sheep can tolerate water with an EC up to 6 and 7 mS/cm. Water below 3 mS/cm is generally suitable for irrigation. Water with an EC up to between 5 to 12 mS/cm can be used for irrigation, however this requires consideration of the crop and plant salt tolerance (ANZECC/NRMHC 2011).

As such, water within the Loxton-Parilla Sands (which is similar to sea water) cannot be used for human or stock consumption, or irrigation. Water within the Olney Formation generally can only be used for irrigation.

12.4.4 High priority groundwater dependent ecosystems

NSW WSPs include schedules with lists of high priority GDEs which are required to be assessed using the minimal impact criteria outlined in the AIP. The applicable groundwater WSPs listed in Chapter 5 were reviewed for reference to GDEs. Only the Lower Murrumbidgee Groundwater WSP identified high potential GDEs. Two high priority GDEs were identified in the area:

- terrestrial vegetation along the floodplains and prior streams, which occur to the south and west of the Murrumbidgee River; and
- the Great Cumbung Swamp, which, as previously discussed, is a known ecological asset, which is about 42 km to the east of the West Balranald mine (see Figure 7.3).

There are no high priority GDEs contained within the Western Murray Porous Rock Groundwater Source within the MDB Porous Rock WSP, in which the project area is located.

i Ecosystems that potentially rely on groundwater

Baseline investigations (SKM 2011) undertaken as part of the PFS identified the occurrence of ecosystems that potentially rely on groundwater in the vicinity of the project area. These investigations mapped and characterised ecosystems that potentially rely on groundwater into two broad categories:

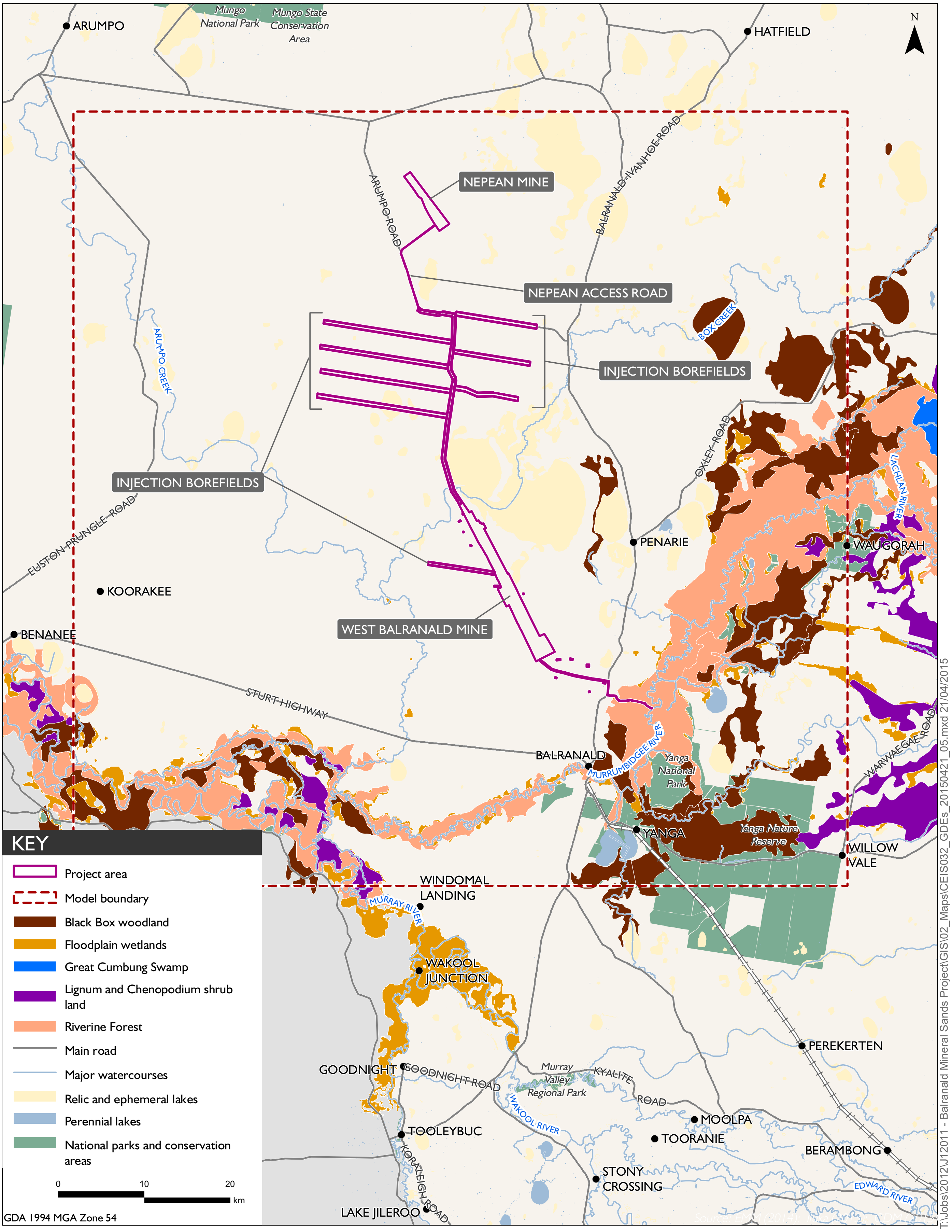
- wetlands and vegetation associated with the Murrumbidgee, Lachlan and Murray river floodplain environments, as per the Lower Murrumbidgee Groundwater WSP for the vegetation to the south and west of the Murrumbidgee River; and
- vegetation (primarily Black Box woodland) outside the floodplain and permanent streams, in topographic depressions where the water table may be shallow enough and not too saline.

The distribution and type of ecosystems that potentially rely on groundwater are shown in Figure 12.1.

Potential groundwater reliance associated with both of these environments is likely to be only partial, if at all. Groundwater use by vegetation in the region is influenced by two main factors: the depth of the water table and salinity. The ecosystems that potentially rely on groundwater associated with the floodplain environments include the high value River Red Gum forests and the Great Cumbung Swamp (which, as discussed previously, has already been identified as a high priority GDE by DPI-Water). While Black Box woodland is generally less significant in terms of its ecological value, it provides locally valuable fauna habitat (as well as shade and shelter for stock) in a landscape sparsely populated by trees.

Rainfall and periodic flooding of the Murrumbidgee River are more likely sources of water for vegetation (URS 2012). Thus floodplain environments are considered to have a low susceptibility to altered groundwater conditions due to the close presence of the Murrumbidgee River, a regular water source. Further from floodplains, vegetation may have a greater reliance on groundwater as there are no permanent water sources in these environments.

An investigation was undertaken to establish where the Black Box vegetation was accessing water from (Appendix H). This study found that rainfall and episodic surface water (irregular flooding and/or pooling from heavy rainfall) provided the dominant water source for Black Box, although there was some potential for these trees to use groundwater opportunistically to supplement their water needs. Previous studies have shown Black Box to be a hardy, resilient species capable of sustaining droughts and quite saline conditions (up to 60 mS/cm).



Ecosystems that rely on groundwater

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 12.1

12.4.5 Water users

Based on data from DPI-Water, there are 95 privately owned registered bores within a 65 km radius of the project area. Sixty are screened in the Shepparton Formation and 35 are screened within the Olney Formation. They are predominantly registered for stock and/or domestic use.

Land and Water Consulting (2014) undertook a groundwater use study within the project area. This comprised interviewing 16 available landholders on the status and use of any bores on their property. The majority of the registered landholder bores in the project area rely on groundwater for predominantly stock use, and bore water is the only source of stock water with the exception of intermittent surface water runoff.

Artesian conditions were observed in four bores screened in the Olney Formation. Salinity conditions were variable (ranging between 350 mg/L to 5,300 mg/L TDS) and the bores were mostly low yielding, typically around 0.4 L/s.

i Water demand

Construction phase water supply will be sourced from the Olney Formation. The volume of abstracted water is 75 ML/yr for the first 1.5 years before mining commences, this volume increases to 150 ML/yr for a further 1 year, when two bores are operational. For the final half year of pre-mining construction the volume reduces back to 75 ML/yr. The total volume taken is 300 ML over three years.

Demands for water during the operation phase would be primarily generated by the processing plant, dust suppression and potable requirements for amenities. The ISP also requires potable water which would be sourced from the water supply pipeline and filtered. The water demands for the Balranald Project are summarised in Table 12.1.

Water balance modelling indicates that the Balranald Project would source the majority of the required water from dewatered groundwater with make-up water supplied via on-site sources (ie rainfall runoff, and groundwater inflow to the pit). Mine affected water will be reused to supply the MUP, processing plant and saline water dust suppression demands. The dewatering borefield production rates are predicted to exceed the net makeup water demands at all stages of mine life.

Table 12.1 Operation phase water demands

Demand	Water type	Average volume (ML/year)	Source
Dust suppression			
Overburden/ore removal	Saline	380	Saline groundwater
Saline overburden rehabilitation			
Mine access road, haul roads, service roads			
Topsoil/subsoil and non-saline overburden removal	Non-saline	310	Water supply pipeline
Soil and non-saline rehabilitation			
Light vehicle roads			
Process water			
Process plant demand (PCP, WCP, WHIMS)	Saline	15,075	Mine affected water Saline groundwater
MUP demand	Saline	4,160	Mine affected water Saline groundwater

Table 12.1 Operation phase water demands

Demand	Water type	Average volume (ML/year)	Source
ISP demand	Non-saline	100	Water supply pipeline
Wash down bays	Non-saline	10	Water supply pipeline
Workforce consumption			
Personnel – potable	Potable	5	Truck
Personnel – toilet and non-drinking	Non-saline	10	Water supply pipeline
Total demand	*Saline*	*19,615*	Mine affected water Saline groundwater
	Non-saline	*450*	Water supply pipeline
	Potable	*5*	Truck

12.4.6 Site water balance

A water balance combining the mine affected water management system, saline groundwater and reinjection volumes has been prepared for pre-mining, and Years 1, 4 and 8 of the conceptual mine plan. This is presented in Table 12.2 and indicates marginal net change in total site water inventory during operation. A representative water schematic is also shown in Figure 12.2.

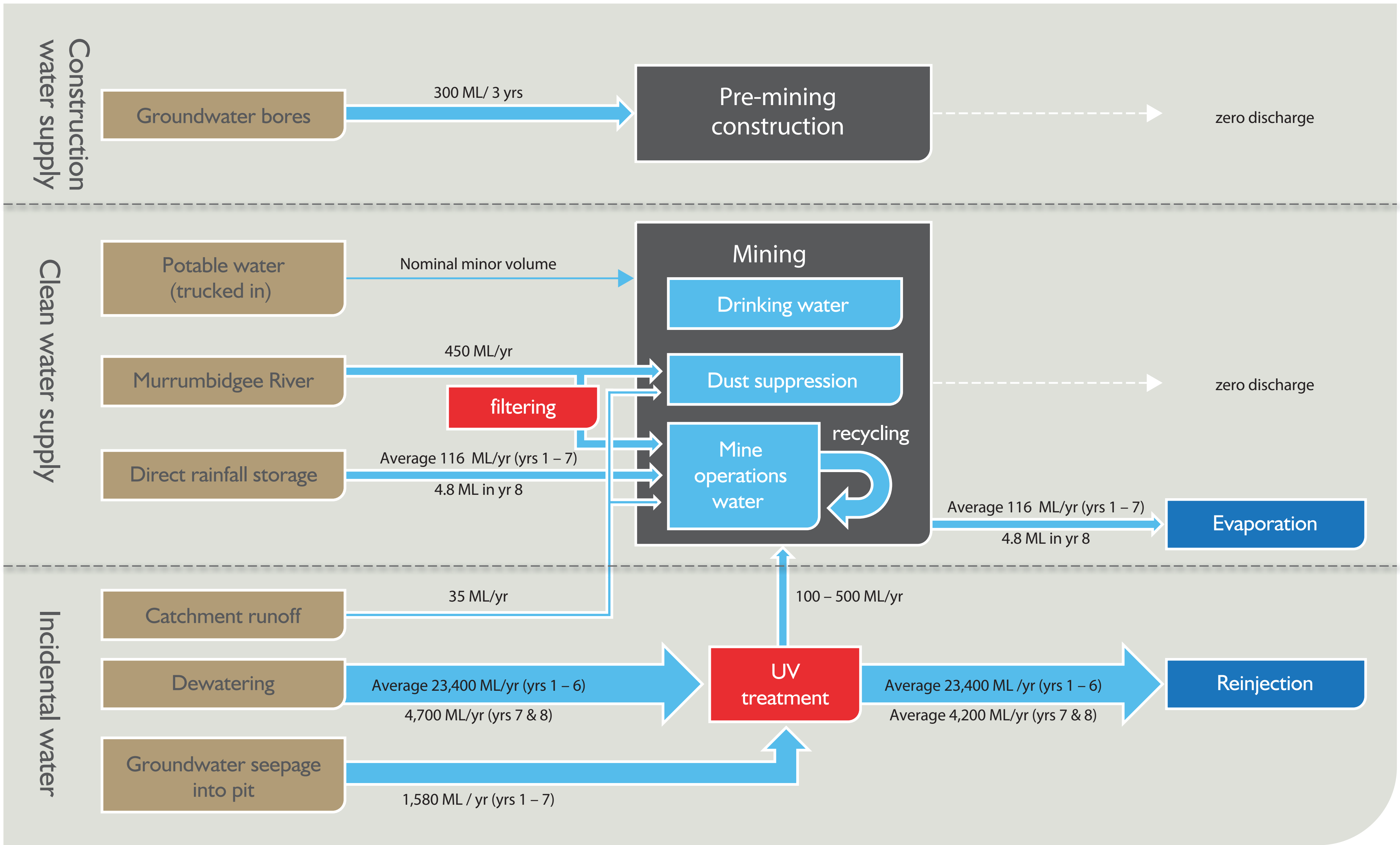
Table 12.2 Water balance (average rainfall year)

Parameter	Construction (total*)	Year 1 ML/ yr (operational)	Year 4 ML/yr (operational)	Year 8 ML/yr (operational)
Inflows to water management system				
Groundwater inflow to pit	-	1,577	1,577	0
Catchment runoff	-	34.9	32.5	37.7
Direct rainfall on water storages	-	11.2	12.1	4.8
Dewatering borefield	-	19,532	22,421	1,239
Saline water supply to processing plant	-	-	-	841
Water supply bores – Olney Formation	300			
Total inflows	**300**	**21,155**	**24,043**	**2,123**
Outflows from water management system				
Net site water management system	-	1,558	1,553	27.3
Uncontrolled releases	-	0	0	0
Evaporation	-	68	71	27.7
Reinjection	-	19,532	22,418	2,065
Total outflows	**-**	**21,158**	**24,042**	**2,120**
Net change in total site water inventory	**-300**	**-3**	**1**	**3**

Notes: Taken from Jacobs 2015 and WRM 2015.

** Total water usage has been provided for 2.5 years as the rate of abstraction is variable during this period.*

The water management system maximises the capture and reuse of mine affected water. The volumes of required makeup water are significantly less than the volumes of saline water that are predicted to be produced by dewatering.



EMM

Water balance schematic

Balranald Mineral Sands Project
Environmental impact statement

Figure 12.2

12.5 Impact assessment

12.5.1 Surface water assessment

With the exception of the water supply pipeline from the Murrumbidgee River, there is an absence of permanent surface water sources within the project area. There are no surface water users, and no surface water related infrastructure. Although the Balranald Project is located in the Murray Basin and proximate to the Murrumbidgee, Murray and Lachlan rivers, there are no direct surface water impacts to these rivers.

The potential impacts to the surface water environment resulting from the Balranald Project include:

- loss of catchment area that drains into Box Creek, Pitarpunga and Tin Tin lakes due to capture of runoff within on-site storages and the pit;
- potential for runoff from the project area to become contaminated with elevated salinity, low pH, heavy metals, and fuels, oils and grease due to interaction with either:
  - saline groundwater (at West Balranald mine in particular);
  - stockpiles, overburden or acid forming materials;
  - MUP area and processing areas;
  - mine voids;
- overflow of the mine water management system during large rainfall events resulting in the release of sediment laden water or saline groundwater;
- interference with flood flows along Box Creek, Pitarpunga and Tin Tin lakes and their tributaries; and
- depletion of regional water availability associated with abstraction of water from the Murrumbidgee River and potential use from other external sources.

Each of these potential impacts is addressed below.

i Loss of catchment area

During the operational phase of the Balranald Project, the maximum catchment area draining to the mine water management system would be 194.3 ha. This is less than 1% of the total Box Creek catchment area (WRM 2015). The loss of 1% of the catchment area is considered insignificant, especially considering the ephemeral nature of Box Creek and the lack of reliance by environmental and human users on this system.

ii Impacts to receiving environments from potentially contaminated runoff

There is the potential for runoff water quality to be affected by chemicals, natural elements or undergo physiochemical changes (ie increased EC or lowered pH), and cause contamination to possible receptors, including groundwater, soils and vegetation. However for this to occur surface water needs to be present and in contact with a contaminating agent, and the surface water then needs come into contact with a receptor. This is considered a highly unlikely scenario due to the lack of surface water in the Balranald Project area and the implementation of a water management plan which will control all project water.

Surface water runoff from undisturbed areas will be diverted, where possible, around areas disturbed by mining and released from the site before it has the potential to become contaminated. Surface water runoff from disturbed areas has the potential to be contaminated, and this water will be captured, stored and treated as part of the mine water management program. No run off from disturbed areas will be released from the site.

In the event of a heavy rainfall event sulfuric acid has the potential to become mobilised, causing acidification of soils, groundwater or process water. In addition acidic seepage from stockpiles could also cause acidified ponding. Appropriate management of stockpiles will greatly reduce the volume of potential acidity generated from stockpiles.

There will be no surface releases of saline groundwater abstracted from dewatering. The majority of the water abstracted will be injected back into the Loxton-Parilla Sands.

If run off is contaminated with chemicals (ie fuels, oils, lubricants) from a spill event it will be treated in accordance with the water management plan.

iii Mine water overflow

The project area has a dynamic flooding history and historic flooding has resulted in the inundation of the entire Box Creek floodplain. Flooding in Box Creek can be the result of heavy rain fall events in the local catchment area, floodwater overflowing from the Lachlan River and draining into Box Creek via Merrowie and Middle Creek or a combination of the two scenarios.

WRM (2015) simulated flood flow behaviour in Box Creek and its floodplain, including Muckee, Pitarpunga and Tin Tin lakes using TUFLOW hydrodynamic modelling software to investigate the possibility of the West Balranald mine and subsequent final void becoming inundated by floodwater overflowing from Box Creek or the nearby lakes (shown in Figure 12.3). A constant discharge of 300 m^3/s was applied to Box Creek, this discharge was applied to represent a conservative flood event greater than 1 in 100 AEP, and was twice the estimated February 2011 peak discharge in Box Creek prior to entering Pitarpunga and Tin Tin lakes. The Nepean deposit is located outside of the predicted Box Creek and Tin Tin Lake flood extent, although parts of the Nepean access road and injection borefields are located within the flood extent.

Modelling indicates that the West Balranald mine and subsequent void are not predicted to be completely inundated by flooding from Box Creek, while parts of the Nepean access roads and the reinjection borefields may be subject to inundation. Parts of the West Balranald mine could be potentially inundated by floodwater that backs up into the Muckee Lake from Pitarpunga Lake. The greatest inundation (6.5 m) is expected at Muckee Lake adjacent to West Balranald mine, although at Pitarpunga Lake, also adjacent to West Balranald mine, the height of the maximum possible inundation is only 0.36 m. The flooded area coincides with the limits of the alluvium located in low lying areas.

WRM (2015) concludes there is a less than a 1% chance of uncontrolled release of mine affected water during Year 1 and 4. All predicted uncontrolled releases of water from mine affected water storages simulated in the modelling were associated with the same rainfall event (February 2011), which had some 72-hour rainfall intensities that were 34% greater than estimated 1 in 100 AEP rainfalls. If a rainfall event of this nature occurred, the predicted volume of uncontrolled releases would be small and diluted with large amounts of clean runoff. No uncontrolled releases of mine affected water are predicted for Year 8, due to the volume and configuration of the mine water.

iv Interference with flooding

The majority of the mine infrastructure for both the West Balranald and Nepean mines is located outside the predicted Box Creek and associated lakes flood extent area. Mine infrastructure located in areas subject to flooding, including a small part of the West Balranald mine, and parts of the Nepean access road and injection borefield, are not expected to impact on flooding. The access road will be constructed at the existing ground level and is not expected to impact predicted flood levels, velocities or flow distributions. The injection bores have a small diameter and likely present an insignificant obstruction to any flood flows, and these bores would not be damaged by flood flows. A small bund wall would be sufficient to protect the West Balranald mine from flooding, if required.

v Regional surface water availability

The use of external water will be minimised by sourcing all processing water from the mine water management system and saline water extracted from the dewatering borefield. No external water will be required to supply these demands, and hence these demands will have no impact on regional water availability.

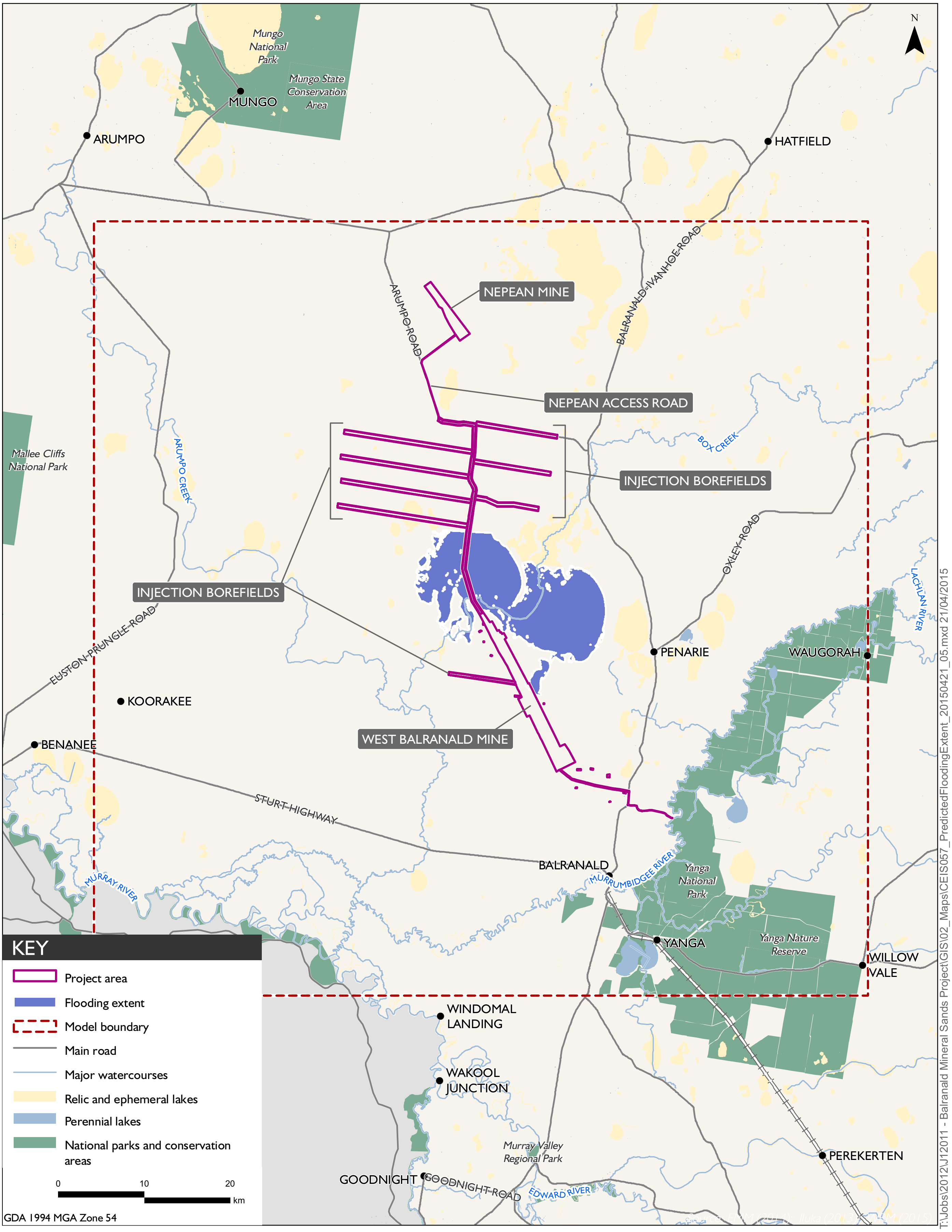
The required water access license to take water from the Murrumbidgee River will be purchased from the registered water license market under the Murrumbidgee River WSP. The only source of external water will be potable drinking water trucked into the project area.

12.5.2 Groundwater assessment

A groundwater assessment was prepared which considered changes to groundwater levels, groundwater chemistry and hydrogeology in respect of private landholder bores, GDEs, hydrostratigraphy and geochemistry.

i Groundwater levels

The abstraction and injection of groundwater will result in changes to the pre mining groundwater levels and potentiometric pressures. A numerical model was prepared which predicted changes in groundwater levels as a result of the Balranald Project generally across the project area and locally at identified sensitive receptors.



EMM ILUKA

Predicted flooding extent

Balranald Mineral Sands Project
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Figure 12.3

a. Construction phase abstraction

The numerical model concluded that abstraction from the Olney Formation for construction purposes resulted in localised drawdown, with the 0.2 m drawdown contour constrained to a small area (ie less than 10 m) at the Plant Well. Residual drawdown from the two other wells modelled (Wellfield 3 and Wellfield 7), was less than 0.2 m.

The relatively minor drawdown associated with construction abstraction over this short three year period will not cause any impacts of concern and is not explored further as a potential impact.

b. Mine dewatering and reinjection

Dewatering from the Loxton-Parilla Sands will result in a decrease in the potentiometric pressure in this formation, and to a lesser degree the overlying Shepparton Formation. The numerical model predicts an average dewatering rate at the West Balranald mine of 746 L/s for the six years of mining and an average of 95 L/s during the two years of backfilling, totalling 145,109 ML over 8 years. The model predicted average dewatering rate at the Nepean mine is 100 L/s for the 1.5 years of mining, comprising a total of 4,671 ML (Jacobs 2015; Appendix I). Dewatering aims to maintain the potentiometric surface of the Loxton-Parilla Sands at a depth 5 m below the pit floor.

Drawdown cones, representing reductions in potentiometric pressures, at the West Balranald mine extend in the Loxton-Parilla Sands and Shepparton Formation for the length of the deposit during mining. The extent of the 2 m drawdown cone extends approximately 5 km in the Loxton-Parilla Sands from the mining area at its maximum extent. The 0.2 m drawdown cones continue to spread laterally (by up to 15 km in the Loxton-Parilla Sands and 10 km in the Shepparton Formation) during the 100 year duration when post mining conditions are modelled. Drawdown in the Loxton-Parilla Sands as a result of dewatering will increase the vertical hydraulic gradient with the Shepparton Formation, but actual flow between these units is governed by the presence, thickness and continuity of clay layers within the Shepparton Formation.

The model predicted 0.2 m drawdown in the Shepparton Formation and Loxton-Parilla Sands at the end of mining the Nepean deposit (mining Year 7.5) is localised, extending no more than 2 km from the deposit in both units. No residual impact of dewatering (ie drawdown) is evident at the Nepean deposit 100 year after mining has commenced.

Iluka will inject water produced from dewatering operations back into the Loxton-Parilla Sands. Injection rates peak at around 1,300 L/s during mining and the total modelled injected volume (148,820 ML) is comparable to the volume of abstracted groundwater.

Modelled predicted mounding (ie increase in potentiometric pressures) is observed in the target Loxton-Parilla Sands and overlying Shepparton Formation at the injection borefield. Pressure heads in the Loxton Parilla Sands increase by more than 5 m above the pre-mining pressures, while heads in the Shepparton increase by 2 m. During the 100 years of post mining numerical modelling in both the Loxton-Parilla Sands and Shepparton Formation indicates that the 0.2 m mounding contours continue to expand (to approximately 12 km from the edge of the injection borefields) and a 1 m mounding contour remains at the centre of the borefields. Injection into the Loxton-Parilla Sands will increase the vertical hydraulic gradient with the Shepparton Formation, but upward flow is governed by the presence, thickness and continuity of clay layers within the Shepparton Formation.

During injection, injection will be managed so that the pressure in the Loxton-Parilla Sands is less than 3 m below either natural the surface or the surface of the pit floor at all times. The threshold is a compromise between the unsaturated zone thickness (which is minimal at some locations), the off-path injection bore field footprint and the risk of preferential flow through the more permeable part of the Shepparton Formation. This is a conservative approach and even where clay lens that act as aquitards were absent across the project area, the water table rise is within 3 m of the site surface.

c. Impacts to private landholder bores

Groundwater level fluctuations at private bore locations were predicted using the numerical model (Jacobs 2015). The predictions were made for the entire modelling period, ie during mining and for 100 years of recovery. Table 12.3 provides a summary of the predicted levels of change.

Table 12.3 Overview of predicted groundwater level changes in private landholder bores

Formation	Number of private bores	Maximum pressure mounding (m)	Maximum pressure drawdown (m)
Shepparton	57	0.55	1.63
Loxton-Parilla Sands 1 (upper)	2	0	0.0
Loxton-Parilla Sands 2 (lower)	8	0.02	0.06
Geera Clay	9	0.40	0.39
Olney	35	0.04	0.07

The greatest change in groundwater level is observed as mounding in the Shepparton Formation (1.63 m), which is observed at GW034082, ~6 km east of the West Balranald deposit. There is one location, GW600300, where the observed drawdown is approximately 59.5 m, however this bore is located within the West Balranald deposit and will be decommissioned as part of the mining works. GW600300 has subsequently not been included in Table 12.3, the overview of predicted groundwater level change.

This assessment indicates that there are no instances where the maximum change in pre mining groundwater level exceeds 2 m. Therefore there is no requirement for 'make good' provisions in accordance with the AIP.

d. Groundwater dependent ecosystems

The Lower Murrumbidgee Groundwater WSP identified two high potential GDEs, the Great Cumbung Swamp and terrestrial vegetation along the Lower Murrumbidgee floodplains and prior streams. Neither of these GDE are vulnerable to project-related impacts due to the distance of these ecosystems from the project area, and the zones of drawdown and mounding. The Great Cumbung Swamp is also hydraulically upgradient from the project area.

Supporting documentation for the Lower Murrumbidgee Groundwater WSP speculates that the groundwater dependence of the terrestrial vegetation along the floodplains and prior streams is minimal, noting they are dependent mainly on surface water flows (CDM Smith 2015). Thus these ecosystems are considered to be ecosystems that rely on groundwater. Potential impacts to ecosystems that rely on groundwater are discussed in the following section.

e. Ecosystems that rely on groundwater

An assessment of the ecosystems that rely on groundwater was undertaken by CDM Smith (2015). This assessment concluded the predicted drawdown impacts are constrained to areas of Black Box vegetation near the West Balranald mine, but the extent of drawdown is such that predicted impacts are rated as low (ie there will be no significant change in distribution). Predicted mounding impacts are constrained to areas of Black Box vegetation near the dedicated injection borefield. A moderate rating was assigned to some areas of Black Box vegetation in this area and there could be some evidence of changing distribution of species and disturbance.

ii Groundwater quality

Modelling undertaken by Jacobs (2015) indicates drawdown and mounding in both the Loxton-Parilla Sands and the Shepparton Formation. Groundwater abstraction and injection will therefore enhance both vertical and horizontal hydraulic gradients. There is potential for localised groundwater mixing and exchange between the Loxton-Parilla Sands and the Shepparton Formation. Vertical groundwater flow however, is dependent on the nature of clay aquitards within the Shepparton Formation and is likely to be localised.

The abstracted groundwater will be predominantly Loxton-Parilla Sands but will also contain groundwater from the Shepparton Formation. The receiving environment is primarily the Loxton-Parilla Sands, but where vertical flow occurs this will also include the Shepparton Formation (but this will be to a much lesser degree).

Assessment of the pre mining groundwater quality data for both the Loxton-Parilla Sands and the Shepparton Formation indicates similar conditions. Specifically, the Loxton-Parilla Sands is of slightly poorer water quality with a higher EC (average of 56 mS/cm in the Loxton-Parilla Sands and average of 48 mS/cm in the Shepparton Formation). The major cations and anions are the same (Na-Cl) in the Shepparton Formation and Loxton-Parilla Sands, although magnesium is also dominant in the Shepparton Formation.

Preliminary assessment of the project site water quality suggests there will be no negative change in the water quality receiving environments. Ultra violet treatment of injected water will reduce the possibility of introducing bacteria.

The beneficial use of the groundwater systems is governed by the very high salinity of the Shepparton Formation and Loxton-Parilla Sands, and this water is unsuitable for the following beneficial uses: human drinking water, livestock drinking water and irrigation (ANZECC/ARMCAZ 2000 and NHMRC 2011). The only beneficial use of this water is therefore considered to be for emergency supply for stock, and for industrial and mining purposes where use of poor quality water is not a constraint.

In accordance with the AIP, there will not be any change to the water quality that would change the beneficial use category of the water in either the Loxton Parilla Sands or the Shepparton Formation as a direct result of the Balranald Project.

iii Mine void

Iluka has identified that the final elevation of the West Balranald pit void (at the northern end of the deposit) will be 52 m AHD based on backfilling. The pre mining measured water level in the Shepparton Formation at the void is ~48.5 m AHD, and the potentiometric surface of the Loxton-Parilla Sands is ~49 m AHD.

Backfilling will provide a fill cover of at least 3 m above the pre-mining potentiometric surface and 3.5 m above the pre-mining water table elevation. The pre mining potentiometric surfaces are also likely to be conservative (ie higher) compared to the expected water levels post mining due to the sediment pile stratigraphy being replaced with more homogeneous backfill, with potentially larger porosity.

The modelled groundwater level drawdown at the mine void is between 1.2 m lower than the pre-mining water level after 100 years of recovery (ie post mining). Therefore the depth to water at the final West Balranald void will more likely be 4.7 m below ground level 100 years after mining. Recovery to pre-mining water level is expected at approximately 110 years after mining.

Given the planned final backfill level is approximately 13 m below the initial and surrounding ground surface elevation of approximately 65 m AHD, any rainfall runoff is likely to collect within the remaining depression. This is likely to lead to increased recharge to the water table below the remaining depression and, therefore, slight mounding of the water table at this point. Given the void will overlie an area of reduced groundwater levels this enhanced recharge will assist with the overall predicted timeframe for recovery of groundwater levels in the area.

The maximum volume of water predicated to accumulate in the West Balranald final void is 34 ML (WRM 2015). The final void is predicted to behave in a similar hydrologic manner to the nearby dry lakes and surface depressions. The small volume of runoff expected to collect in the void will either evaporate or will infiltrate through the floor of the void into the Loxton Parilla Sands. WRM note that between a 1 in 50 and 1 in 100 rainfall event (with ongoing rainfall) the final void would take approximately 5.5 weeks to completely dry out. Under average rainfall conditions the final void would take approximately 2 weeks to dry out.

Although the daily evaporation exceeds the adopted infiltration rate the height of capillary rise in unconsolidated units occurs at depths of less than 0.75 m (which is the most conservative measurement for unconsolidated sediments) (Fetter 1994). Therefore there is enough cover to avoid the creation of an artificial salina, ie an accumulation of salts via evaporation. The maximum EC of water in the final void is not expected to exceed the existing average EC conditions for the Loxton-Parilla Sands (56 mS/cm).

iv Geochemistry

Earth Systems undertook a geochemistry assessment for the Balranald Project in 2015 (Appendix K). The dewatering and excavation of the deposits will expose sulfidic materials within the ore, overburden, pit wall sediments and process water streams to atmospheric oxygen. This can result in sulfide oxidation and the subsequent generation of acid and metalliferous drainage. The oxidation of sulfide mineral within mine materials is governed by the availability and flux of oxygen, a requirement of oxidation. Grain size, compaction, moisture content and the surface area to volume ratio will affect the degree of oxygen diffusion. Therefore, the overall oxidation of the dewatered sulfide minerals within the pit walls and the ore stockpiles is limited by the diffusion of oxygen into the pit walls and stockpiles via the exposed face (Earth Systems 2015).

The Nepean deposit does not contain significant quantities of sulfidic minerals and is classified as non acid forming. In addition the Nepean deposit is closer to the surface and considerably smaller than the West Balranald deposit and therefore, the extent of disturbance and duration of mining at Nepean will be less than at West Balranald. The Nepean deposit is therefore likely to represent a lower acid and metalliferous drainage risk than the West Balranald deposit.

The West Balranald non saline overburden and saline overburden is also classified as non-acid forming (Earth Systems 2015), while the majority of the organic overburden and ore samples analysed had a low to moderate potentially acid forming classification. There is a pronounced increase in the risk profile of the acid and metalliferous drainage risk classification, with the top of the organic overburden materials defining the upper boundary of the potentially acid forming materials.

Dewatering of the West Balranald deposit will result in the desaturation of large volumes of in-situ organic overburden within the pit walls. This will expose susceptible sulfides, mainly in the ore and organic overburden, to oxidation with the subsequent risk of acid and metalliferous drainage generation. Should heavy rainfall occur, acid and metalliferous drainage could be transported below the pit floor to the natural groundwater level, causing acidification of groundwater. The organic overburden within mining and backfill lags, and the pit walls represents with largest acid and metalliferous drainage risk area (Earth Systems 2015).

Lime dosing may be undertaken to neutralise acid and metalliferous drainage generation, this will raise the pH of the overburden and pit walls. It is expected that the overburden and pit walls will remain predominantly dry during mining, however there is the potential for enhanced alkaline conditions to be mobilised via groundwater flow once the pits are backfilled if there is a low groundwater buffering capacity. Modelling indicates that drawdown curves continue to expand during the 100 years post mining indicating that groundwater will flow towards the centre of the pit voids, and will not contribute to the wide scale mobilisation of alkaline conditions.

v Hydrostratigraphy

The mining and backfilling process will result in localised alteration to the physical structure and distribution (ie stratigraphy) of the Loxton-Parilla Sands and Shepparton Formation. On a regional scale the current hydrostratigraphy and associated aquifer properties are not expected to change. While backfill will be compacted to some degree this will not be undertaken with the specific aim of replicating pre-mining porosity and specific yield properties. The resulting localised porosity and associated specific yield of backfill material is expected to be elevated from current levels.

Along the mine paths, where the degree of stratification is reduced by the mining and backfilling process, it is expected that post-mining hydraulic conductivity will differ from current conditions. Generally, it is expected that, due to the reduction in stratification, vertical hydraulic conductivity will increase while the mixing of higher and lower conductivity material could potentially reduce localised horizontal hydraulic conductivity. Under such conditions localised perched water tables are less likely to occur with recharge more readily percolating down to the regional water table.

12.5.3 Cumulative impacts

There are a number of mining tenements for mineral sand deposits in the Murray Basin in NSW. One of these is the Cristal Mining Atlas-Campaspe Project, which received development consent under the EP&A Act in 2014. The Atlas-Campaspe Project is approximately 20 km to the north of the Nepean deposit and will comprise the extraction of mineral sands from the Loxton-Parilla Sands. Groundwater abstraction would be undertaken to supply mine water and for localised dewatering; this water falls under the Western Murray Porous Rock Groundwater Source in the MDB Porous Rock WSP.

The predicted 1 m drawdown cone extends a maximum 2 km from the southernmost part of the Atlas-Campaspe deposit (which is closest to the Nepean deposit), which does not overlap with the drawdown from the Nepean deposit (Resource Strategies 2013). There is approximately 17 km between the predicted 1 m drawdown cones of the two mines. Cristal Mining currently holds a combined total of 21,442 share components (units or million litres) in the Western Murray Porous Rock Groundwater Source for the Ginkgo and Snapper Mines.

The very poor quality of the groundwater in the Western Murray Porous Rock Groundwater Source limits the beneficial use of the water in the system, and this is represented by the dominant purpose of water being for mining and industrial purposes, and for stock supplies. There is no significant demand for water from this source in the region.

There are also a few operational gypsum projects to the north of the Murray River, including a mine located immediately to the east of the West Balranald deposit; these projects comprise shallow works that do not comprise groundwater abstraction. Therefore gypsum operations are unlikely to contribute to cumulative hydrogeological impacts.

12.5.4 Impacts to Willandra Lakes Region World Heritage Area

The results of the surface water and groundwater assessments indicate that there will be no impacts to existing water resources in and surrounding the WLRWHA.

12.6 Management and mitigation

12.6.1 Water management system

Water management for the Balranald Project combines surface water management and the management of abstracted and injected groundwater. The operation of the water management system will be documented in a water management plan which will also contain details on monitoring. A key to successful water management for this project will be the separation and control of water from different sources, and of different water qualities. The water management system will be designed to:

- segregate different water sources and different water qualities (ie mine affected water, and raw water from the Murrumbidgee River, sediment-laden water);
- capture and contain mine affected water and prevent discharge to receiving water environments;
- ensure unused abstracted, saline groundwater is contained and injected rather than discharged to the surface;
- capture and segregate runoff from the following locations:
  - MUP area, processing area, and the saline overburden stockpiles;
  - the non-saline overburden, topsoil and subsoil stockpiles;
  - other disturbed areas;
- divert clean runoff away from areas disturbed by mining activities to minimise the volume of mine affected water;

- manage sediment laden water in accordance with an erosion and sediment control plan that would be part of the water management plan, which will include the capture and treatment of sediment laden water in sediment dams;
- reuse and recycle water in mining operations;
- include contingency measures to accommodate either a surplus or deficit of site water; and
- communicate with key stakeholders (ie DPI-Water, landholders, other users).

The risk of acid and metalliferous drainage requires the management of stockpiles, and exposed (desaturated) organic overburden and ore material. While some residual acid and metalliferous drainage from the in-situ and backfilled organic overburden is likely to be unavoidable, alkaline amendments and specific materials handling practices can lower the overall acid volume generated.

12.6.2 Surface water

The water management plan would include the following surface water mitigation and management measures:

- surface water quality sampling from key storages within the mine affect water management system would be completed, with monitoring parameters based on the expected water quality, and frequency of monitoring based on climatic conditions;
- regular inspection of surface drainage and dam infrastructure; and
- metering and quality monitoring of all water volumes pumped from in pit sumps.

12.6.3 Groundwater

Groundwater quality and groundwater level monitoring has been carried out on the existing network of monitoring bores on an intermittent basis since their installation and quarterly since 2013 for the purpose of baseline data collection. The established monitoring network will be used for ongoing monitoring during construction and operation to assess groundwater level and quality trends; this data will be used to verify the model predictions and assess the degree of inter-aquifer mixing. Groundwater quality monitoring will enable early detection of any change in groundwater quality or possible groundwater contamination.

Field based physiochemical water quality monitoring of the dewatered groundwater prior to reinjection will occur on a daily basis. Real time metering of all dewatering and reinjection volumes will be recorded using telemetry systems. This monitoring data will also be used to record take and injection volumes.

The water management plan will contain all of the details for the groundwater monitoring program and will also include the establishment of groundwater level and quality triggers, actions and contingencies that will be implemented in the event that monitoring indicates an impact. Triggers specific to groundwater reliant ecosystems will also be developed, these will be designed to indicate substantial deviation from expected or predicted impacts or to provide an early warning of an impact that has not been predicted.

12.7 Conclusion

A water assessment was undertaken to understand potential impacts of the Balranald Project on water resources, including surface water and groundwater resources. Water investigations, focusing on the hydrogeological regime, have spanned three years and comprise the collection of site data and the development of a numerical model. Both the conceptual and numerical models were constructed using available hydrogeological data including borehole logs, water level and quality monitoring data, regional hydrogeological maps, topography data and published literature, and in accordance with the Australian Groundwater Modelling Guidelines.

The receptors identified as potentially being sensitive to water impacts in the region included:

- ecosystems that rely on groundwater, including GDEs;
- Murrumbidgee River and ephemeral water courses; and
- private landholder bores, properties and infrastructure.

Based on the assessment criteria contained in the AIP impacts from groundwater abstraction and reinjection are likely to be minimal. Overall there are few water related impacts as a result of the Balranald Project due to:

- groundwater quality of the target units for abstraction and injection (Loxton-Parilla Sands and Shepparton Formation) already being highly saline, and not suitable for beneficial uses (human drinking water, livestock drinking water and irrigation) without treatment;
- the absence of landholder bores in areas where 2 m or greater drawdown or mounding is predicted;
- the absence of GDEs; and
- compliance with the Water Act and WM Act, and the rules within the relevant WSPs.

In regards to criteria not included in the AIP the following impacts are possible:

- Predicted mounding impacts which are constrained to areas of Black Box vegetation near the dedicated injection borefield. There could be some evidence of changing distribution of species and disturbance.
- Localised alteration to the physical structure and distribution (ie stratigraphy) of the Loxton-Parilla Sands and Shepparton Formation. Along the mine paths it is expected that post-mining hydraulic conductivity will differ from current conditions.
- Generation of acid and metalliferous mine drainage associated with the desaturation of mine pit walls and overburden, and oxidation of sulfides.

Preliminary assessment of the project site water quality suggests there will be no negative change in the water quality receiving environments. In addition the proposed mine site water management strategy and infrastructure will be designed to ensure that the Balranald Project has a negligible impact on the quality of surface runoff.

The results of the water assessment indicates that the Balranald Project will not have an impact on the controlling provisions for the Balranald Project, including:

- world heritage properties;
- places listed on the National Heritage Register;
- listed threatened species and ecological communities; and
- listed migratory species.

13 Geochemical

13.1 Introduction

The EIS Guidelines state:

> **5. RELEVANT IMPACTS**
>
> ...
>
> d) any technical data and other information used to assess impacts including:
>
> ...
>
> ii. details of any by-products that may be disposed of (including in the mine void), including the chemical composition of the materials, radio-activity levels, proposed method of disposal (including the final depth of disposed materials), the potential for materials or their constituents to become remobilised, and the potential for the materials to cause short-term or long-term harm to the environment, including to matters of NES;

To address this requirement, a geochemical and radiation assessments of the Balranald Project were prepared. The results of the geochemical assessment are summarised in this chapter, while the results of the radiation assessment are summarised in Chapter 14.

The geochemical assessment was prepared by Earth Systems (Appendix K) and the results are summarised in this chapter. The geochemical assessment was also required to inform a number of other assessments to address matters including water management and impacts to water resources.

The geochemical assessment was undertaken in accordance with the following regulations, methods and guidelines:

- *Leading Practice Sustainable Development Program for the Mining Industry: Managing Acid and Metalliferous Drainage* (Department of Industry, Tourism and Resources 2007);
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000a);
- *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC/ARMCANZ 2000b);
- *Guidelines for Groundwater Protection in Australia* (ANZECC/ARMCANZ 1995);
- *Using the ANZECC Guidelines and Water Quality Objectives in NSW* (DEC 2006);
- *NSW Water Quality and River Flow Objectives* (DECCW 2006);
- *The NSW State Groundwater Policy Framework Document* (Department of Land and Water Conservation 1997);
- *The NSW State Groundwater Quality Protection Policy* (Department of Land and Water Conservation 1998);

- *Guidelines for the Assessment and Management of Groundwater Contamination* (DEC 2007);
- *NSW Waste Classification Guidelines* (DECCW 2009);
- *The NSW Acid Sulfate Soils Assessment Guidelines* (Acid Sulfate Soils Management Advisory Committee 1998);
- *Prediction & Kinetic Control of Acid Mine Drainage* (AMIRA 2002); and
- *Global Acid Rock Drainage Guide* (International Network for Acid Prevention 2010).

13.2 Method

Geochemical test work programs were completed for the Balranald Project. A preliminary geochemical characterisation program was conducted by KCB in 2012 (KCB 2013) and a supplementary geochemical characterisation program and assessment was conducted by Earth Systems in 2014 (Appendix K).

The supplementary geochemical characterisation program increased the sampling density for geochemical characterisation of the overburden materials and included a detailed assessment of the acid mine drainage (AMD) potential of the dewatered and sulfidic pit walls and benches (in particular, the OOB).

13.2.1 Sampling

A total of 101 samples (73 from the West Balranald deposit and 28 from the Nepean deposit) were analysed for static geochemical test work as part of the preliminary geochemical program to characterise the overburden and ore from 14 locations. Samples from a further three locations were part of the supplementary geochemical characterisation program.

The geochemical test work was conducted on the following samples:

- overburden (including NSOB, SOB and OOB) which allowed for the assessment of AMD risk associated with overburden stockpiles, backfill material and de-saturated pit wall/bench/floor material;
- ore which allowed for the assessment of AMD risk associated with key domains on-site including ore stockpiles and oversize material screened at the MUP; and
- product and mining by-product streams which allowed for the assessment of AMD risk associated with key domains on-site including product and mining by-product stockpiles, ModCoD and backfill material.

Mining by-products and product samples were prepared and supplied by Iluka for classification and included:

- sand tails;
- ModCoD;
- thickener underflow; and
- WHIMS process streams (ilmenite, magnetic rejects and HMC).

Samples of the following mining-by products that would be generated at the Hamilton MSP and potentially transported back to the project area for placement in the mine void were classified in accordance with the *NSW Waste Classification Guidelines*:

- PDC ilmenite;
- combined monazite rejects;
- Hyti (Leucoxene);
- combined zircon wet tails;
- rutile wet concentrate circuit tails;
- PDC conductors oversize (+410 µm); and
- float circuit tails.

13.2.2 Test work

Laboratory test work conducted in the geochemical characterisation programs included:

- mineralogical test work to clarify the distribution of primary sulfides, secondary acid sulfate generating mineral species and carbonate minerals within the ore and overburden;
- static geochemical test work to understand the potential magnitude of AMD risk associated with key materials;
- kinetic geochemical test work to characterise the potential rate of AMD generation associated with key materials; and
- test work to characterise the physical properties and potential reactivity of the key materials and characterise against the EPA guidelines.

The characterisation of the sampling and testing are detailed in Section 13.3.2.

13.3 Existing environment

13.3.1 Hydrogeology

The two key geological formations within the project area are the Shepparton Formation and the Loxton-Parilla Sands, with the ore body hosted in the Loxton-Parilla Sands. The ore body at the West Balranald mine is below the water table, while at the Nepean mine the ore body is either above or straddling the water table. The geology and hydrogeology of the project area are described in Chapters 7 and 12.

13.3.2 Geochemical characterisation

Following sampling and testing, the AMD risk of the materials was assessed. The samples were classified into the following categories outlined in Table 13.1:

- potentially acid forming (PAF):
  - high potential for acid generation;
  - moderate/high potential for acid generation;
  - moderate potential for acid generation;
  - low potential for acid generation;
- non acid forming (NAF):
  - unlikely to be acid generating; and
  - likely to be acid consuming.

Table 13.1 AMD risk classification

General AMD risk classification	Detailed AMD risk classification	Overburden samples				Ore	
		West Balranald			Nepean	West Balranald	Nepean
		NSOB	SOB	OOB	NSOB		
PAF	High potential for acid generation	-	-	6	-	1	-
	Moderate/high potential for acid generation	-	-	-	-	-	-
	Moderate potential for acid generation	-	-	12	-	7	-
	Low potential for acid generation	-	-	34	1	8	-
Total PAF samples		**-**	**-**	**52**	**1**	**16**	**-**
NAF	Unlikely to be acid generating	13	50	1	22	-	5
	Likely to be acid consuming	-	-	-	-	-	-
Total NAF samples		**13**	**50**	**1**	**22**	**-**	**5**

From the results shown in Table 13.1, it can be seen that:

- NSOB and SOB at the West Balranald deposit is generally NAF;
- both the ore and OOB at the West Balranald deposit is PAF; and
- the ore and NSOB overburden at the Nepean deposit is NAF.

13.4 Impact assessment

13.4.1 Methodology

The geochemical characterisation results were used in combination with the Balranald Project's water balance (Section 12.4.4) and groundwater modelling (Section 12.4.6) to assess the potential geochemical impacts of the Balranald Project during construction, operation and post closure.

For each potential impact that could occur from PAF material, the likelihood, consequence and resulting impact rating was assessed with reference to a standard impact assessment matrix developed by Iluka specifically for the Balranald Project (Table 13.2). Residual impact ratings were then determined, taking into account proposed AMD management and mitigation approaches and with consideration of the environmental setting of the project area, which is expected to limit the spatial extent of the Balranald Project's impacts associated with local water quality changes.

The definitions of likelihood and consequence for the risk assessment are detailed in Tables 13.3 and 13.4 while Table 13.5 outlines the matrix used to assign impact rating for each potential impact.

Table 13.2 Likelihood definitions

Rating	Description	Likelihood of occurrence	Frequency
A	Almost certain	Recurring event during the life of the mine	Likely to occur more than twice a year
B	Likely	Event that may occur frequently during the life of the mine	Likely to occur once or twice a year
C	Possible	Event that may occur during the life of the mine	Might occur once a decade
D	Unlikely	Event that is unlikely to occur during the life of the mine but may occur following mine closure	Possibility to occur once a century
E	Very unlikely	Event that is very unlikely to occur during the life of the mine and is unlikely to occur following mine closure	Unlikely to occur within a century

Table 13.3 Consequence definition

Rating	Description	Health and safety	Environment	Community	Project interruption	Reputation and image
1	Insignificant	Local treatment with short recovery-minor short term health effects	Onsite release, containable with minimal damage	No damage to external property, infrastructure or water assets	Negligible Critical systems unavailable for less than one hour	Negligible impact
2	Minor	Medical treatment required for short term acute health effects	Major onsite release with some damage, no offsite damage Remediation in terms of days	Minor damage to external property, infrastructure or water assets	Inconvenient Critical systems unavailable for several hours	Adverse local media coverage only
3	Moderate	Lost Time Injury (off work recovery required) or short/medium term health issues	Offsite release, no significant environmental damage Remediation in terms of weeks	Moderate damage to external property, infrastructure or water assets	Critical systems unavailable for less than one day	Adverse capital city media coverage
4	Major	Extensive injuries or chronic health issues	Major offsite release, short to medium term environmental damage to nationally significant ecosystem Remediation in terms of months	Major damage to external property, infrastructure or water assets	Critical systems unavailable for one day or a series of prolonged outages	Adverse and extended national media coverage
5	Catastrophic	Single fatality or permanent disability	Major offsite release, long term environmental damage to nationally or internationally significant ecosystem Remediation in terms of years	Irreparable damage to external property, infrastructure or water assets	Critical systems unavailable for more than a day (at a crucial time)	Demand for government inquiry

Table 13.4 Impact rating matrix

	Consequence				
Likelihood	**1. Insignificant**	**2. Minor**	**3. Moderate**	**4. Major**	**5. Catastrophic**
A. Almost certain	Medium	Medium	High	High	High
B. Probable	Low	Medium	Medium	High	High
C. Possible	Low	Medium	Medium	Medium	High
D. Unlikely	Low	Low	Medium	Medium	High
E. Very unlikely	Low	Low	Low	Medium	Medium

13.4.2 Results

A summary of the potential impacts, management measures and residual impacts of the Balranald Project on groundwater and surface water, relating to the potential for sulfide oxidation and associated AMD generation from mine materials, during the construction, operation and post-closure phases of the development is presented in Table 13.5 to 13.9. Table 13.5 provides a summary of the geochemical overburden impacts, Table 13.6 provides a summary of the geochemical ore impacts, Table 13.7 provides a summary of geochemical mining by-product impacts, Table 13.8 provides a summary of geochemical pit walls, benches and floor impacts, and Table 13.9 provides a summary of geochemical products impacts of the Balranald Project.

The impact ratings are based on estimated AMD generation rates, where available, and the subsequent implications for the receiving environment including water resource use, aquatic ecosystems or riparian land.

Table 13.5 Summary of geochemical overburden impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	Impact	Phase	Conseq.	L'hood	Impact		Conseq.	L'hood	Impact
Overburden material stockpiled above ground level – West Balranald	Runoff or seepage of AMD from temporary OOB stockpile into surface water/ groundwater	Construction	Major	Probable	High	Confirm field-based method for identification of PAF versus NAF overburden. Routine monitoring and segregation of OOB. Low permeability liner, incorporating limestone, beneath OOB stockpile. Surface water drainage control around OOB stockpile. Minimise surface area of OOB stockpile (relocate to pit as soon as possible). Incorporate sufficient quantity of limestone in OOB stockpile, allowing for three times the theoretical neutralisation requirement. Collect, treat and/or reuse any acidic runoff or seepage from OOB stockpile. Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at MUP dam and OOB stockpile.	Major	Unlikely	Medium
		Operation	n/a	n/a	-	Not required.	n/a	n/a	-
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
Overburden material stockpiled above ground level – Nepean	Runoff or seepage of AMD from temporary overburden stockpiles into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Unlikely	Medium	More extensive geochemical assessment of overburden materials for the Nepean deposit.	Minor	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 13.5 Summary of geochemical overburden impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	Impact	Phase	Conseq.	L'hood	Impact		Conseq.	L'hood	Impact
Overburden material used for site construction works	Runoff or seepage of AMD from overburden materials used for site construction works into surface water/ groundwater	Construction	Major	Very unlikely	Medium	Avoid use of OOB for site construction works. If any overburden is to be used as a construction material then characterise and classify the material to ensure that it is both NAF and non-saline.	Moderate	Very unlikely	Low
		Operation	Major	Very unlikely	Medium	As above.	Moderate	Very unlikely	Low
		Post-closure	Minor	Very unlikely	Low	As above.	Minor	Very unlikely	Low
Overburden material backfilled in pit - West Balranald	Release of AMD from backfilled overburden into void/groundwater or surface water as a result of sulfide oxidation between the time of OOB dewatering and final inundation below groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Possible	Medium	Continue routine monitoring and segregation of OOB. Return OOB directly to its final storage location as low as possible in the backfill profile. Rapidly cap (within 1-2 days) backfilled OOB with at least 5 m of SOB or inert clay-rich material. To address any residual acidity, incorporate sufficient quantity of limestone into backfilled OOB, allowing for three times the theoretical neutralisation requirement. Traffic compact backfilled limestone-blended OOB, and cover as soon as practicable. Collect, treat and/or reuse any acidic runoff or seepage from backfilled OOB. Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at pit sump and MUP dam. Regular groundwater monitoring from dewatering bores.	Minor	Unlikely	Low

Table 13.5 Summary of geochemical overburden impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
		Post-closure	Major	Probable	High	As per operations phase management approach. Monitor the rate of groundwater rebound and bore water chemistry in backfilled OOB until the final groundwater level has been achieved, to confirm that sufficient neutralising capacity has been added to prevent residual acid salts from contaminating the groundwater system. Use dewatering bores to facilitate post-closure monitoring of groundwater rebound, prior to full decommissioning.	Moderate	Unlikely	Medium
Overburden material backfilled in pit - Nepean	As above	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Unlikely	Medium	More extensive geochemical assessment of overburden materials for the Nepean deposit.	Minor	Very unlikely	Low
		Post-closure	Major	Unlikely	Medium	More extensive geochemical assessment of overburden materials for the Nepean deposit.	Minor	Very unlikely	Low

Table 13.6 Summary of geochemical ore impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Ore material stockpile from West Balranald	Runoff or seepage of AMD from stockpiled ore into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Major	Probable	High	Backfill oversize material directly to West Balranald pit. Backfill oversize material to the pit in the same manner as backfilled OOB. Low permeability liner, incorporating limestone, beneath stockpiled ore. Surface water drainage control around stockpiled ore. Minimise surface area of ore stockpile. Incorporate sufficient quantity of limestone in stockpiled ore, allowing for three times the theoretical neutralisation requirement. Collect, treat and/or reuse any acidic runoff or seepage from stockpiled ore, as an alternative or in combination with limestone blending (see above). Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at MUP dam and ore stockpile/s.	Major	Unlikely	Medium
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
Ore material stockpile from Nepean deposit	As above	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Unlikely	Medium	More extensive geochemical assessment of ore materials for the Nepean deposit.	Minor	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 13.6 Summary of geochemical ore impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Process plant water	Uncontrolled release of process plant water affected by AMD from ore material	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Unlikely	Medium	Incorporate bunding around the process plant area and develop an emergency response plan to address the risk of uncontrolled overflow of process water that may be affected by AMD from the ore material.	Moderate	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
Pipeline failure while pumping ore slurry from MUP to PCP	Runoff or seepage of AMD from ore slurry into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Possible	Medium	Install bunding and ore slurry collection sump(s) along the pipeline alignment. Clear vegetation along pipeline alignment and ensure fire control systems are in place before commencing pipeline operation. Install isolation valves along pipeline. Shut-down ore transfer during any bushfire event in the vicinity of the slurry pipeline. Install a pipeline leak detection system. Regular pipeline maintenance and inspection. Recover any spilled material as soon as practicable. Incorporate AMD considerations into emergency response procedures for potential pipeline failure.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 13.6 Summary of geochemical ore impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Transport accident on haul road between Nepean and West Balranald deposits leading to spill of Nepean ore	Runoff or seepage of AMD from Nepean ore into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Minor	Unlikely	Low	Recover any spilled ore as soon as practicable. Incorporate AMD considerations into emergency response procedures for potential transport accident involving a spill of ore material. More extensive geochemical assessment of ore materials for the Nepean deposit. Construct internal roads within the project area to minimise interaction between mining equipment and haul trucks, and general light vehicle traffic on site.	Minor	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 13.7 Summary of geochemical mining by-product impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Mining by-products stored above ground level	Release of AMD via supernatant water overflow from TSF to Box Creek	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Major	Possible	Medium	Develop TSF operating protocols to maintain/create sufficient storage to contain the design rainfall event. Incorporate sufficient quantity of limestone in ModCod, allowing for three times the theoretical neutralisation requirement. Routine monitoring and characterisation of ModCod to inform neutralisation requirements. Regular surface water monitoring at TSF. Field-based kinetic geochemical test work (oxygen diffusion profiles) to refine acidity load estimates / neutralisation requirements. Incorporate AMD considerations into TSF emergency response procedures.	Major	Unlikely	Medium
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
	Seepage of AMD from TSF into groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Minor	Possible	Medium	Install clay liner across TSF embankment and floor. Ensure that any seepage is collected and pumped back to the TSF or treated and reused on site. Regular seepage water monitoring at TSF.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 13.7 Summary of geochemical mining by-product impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
	TSF embankment failure leading to release of sulfidicmining by-products/AMD to surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Major	Unlikely	Medium	TSF design to withstand extreme rainfall/ earthquake events in accordance with ANCOLD guidelines. Develop TSF operating protocols to maintain/create sufficient storage to contain the design rainfall event. Regular surface water monitoring at TSF. Incorporate AMD considerations into TSF emergency response procedures.	Moderate	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
	Runoff or seepage of AMD from temporary MBPs stockpiles into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Probable	Medium	Transport the Hamilton by-products back to the mine site as frequently as possible to minimise AMD generation at the processing plant and associated neutralisation requirements. Return sand tails, magnetic rejects and Hamilton by-products directly, if possible, to the West Balranald pit. Low permeability liner, incorporating limestone, beneath by-product stockpiles. Consider temporary stockpiling below ground level so drainage reports to the pit sump. Surface water drainage control around stockpiled by-products. Minimise surface area of by-product stockpiles. Incorporate sufficient quantity of limestone in stockpiled by-products, allowing for three times the theoretical neutralisation requirement. Routine monitoring and characterisation of each by-product stream to inform neutralisation requirements. Collect, treat and/or reuse any acidic runoff or seepage from stockpiled by-products.	Moderate	Very unlikely	Low

Table 13.7 Summary of geochemical mining by-product impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	Impact	Phase	Conseq.	L'hood	Impact		Conseq.	L'hood	Impact
						Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at MUP dam and by-product stockpile/s.			
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
Mining by-products placed below ground in West Balranald pit	Release of AMD from backfilled MBPs below final groundwater level, into void/ groundwater or surface water.	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Possible	Medium	Routine monitoring and characterisation of mining by-products to inform neutralisation requirements. No disposal of mining by-products in the Nepean pit. Co-dispose Balranald thickener underflow and sand tails as ModCod material, to facilitate handling and trafficability of backfilled material. Backfill mining by-products directly if possible, in particular float plant tails, to their final storage location above the backfilled OOB but below NAF materials in the backfill profile. Incorporate sufficient quantity of limestone into backfilled mining by-products, allowing for three times the theoretical neutralisation requirement. Traffic compact backfilled limestone-blended mining by-products and cover with SOB as soon as practicable. Collect, treat and/or reuse any acidic runoff or seepage from backfilled mining by-products. Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at pit sump and MUP dam.	Minor	Unlikely	Low

Table 13.7 Summary of geochemical mining by-product impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
		Post-closure	Major	Probable	High	As per operations phase management approach (most of these measures listed above are intended to not only address operational phase risks but also to pre-emptively manage the potential post-closure impacts. Monitor the rate of groundwater rebound and pore water chemistry in backfilled mining by-products until the final groundwater level has been achieved, to confirm that sufficient neutralising capacity has been added to prevent residual acid salts from contaminating the groundwater system. Use dewatering bores to facilitate post-closure monitoring of groundwater rebound, prior to full decommissioning.	Moderate	Unlikely	Medium
mining by-product pipelines	Failure of mining by-products pipeline	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Possible	Medium	Install bunding and slurry collection sump(s) along the pipeline alignment. Clear vegetation along pipeline alignment and ensure fire control systems are in place before commencing pipeline operation. Install isolation valves along pipeline. Shut-down mining by-product transfer during any bushfire event in the vicinity of the pipelines. Install a pipeline leak detection system. Regular pipeline maintenance and inspection. Recover any spilled material as soon as practicable. Incorporate AMD considerations into emergency response procedures for potential pipeline failure.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 13.7 Summary of geochemical mining by-product impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Return water pipeline	Failure of return water pipeline	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Possible	Medium	Install bunding and return water collection sump(s) along the pipeline alignment. Clear vegetation along pipeline alignment and ensure fire control systems are in place before commencing pipeline operation. Install isolation valves along pipeline. Shut-down return water transfer during any bushfire event in the vicinity of the pipeline. Install a pipeline leak detection system. Regular pipeline maintenance and inspection. Recover any spilled material as soon as practicable. Incorporate AMD considerations into emergency response procedures for potential pipeline failure.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
Hamilton by-product transport to West Balranald mine for final disposal	Transport accident (off site) leading to release into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Unlikely	Medium	Recover any spilled material as soon as practicable. Incorporate AMD considerations into emergency response procedures for transport accident involving a spill of mining by-products.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
Mining by-product transport on site	Transport accident (off site) leading to release into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Minor	Unlikely	Low	Recover any spilled material as soon as practicable. Incorporate AMD considerations into emergency response procedures for transport accident involving a spill of mining by-products.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 13.8 Summary of geochemical pit walls, benches and floor impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
In-situ pit wall, bench and floor material that is unsaturated due to mine dewatering – West Balranald	Release of AMD from dewatered in situ material into void/ groundwater or surface water	Construction	Major	Possible	Medium	Collect, treat and/or reuse any acidic runoff or seepage from box cut wall, bench and floor. Direct any AMD affected groundwater from mine dewatering to treatment plant, if required. Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at box cut sump and MUP dam. Routinely monitor groundwater chemistry during dewatering.	Minor	Unlikely	Low
		Operation	Major	Possible	Medium	Where overburden is exposed in bench lags, maintain a layer of in situ SOB as long as possible (eg minimum 5 m) before disturbing OOB. Incorporate sufficient quantity of limestone into backfilled overburden to address AMD generation from in situ materials (in addition to backfill), allowing for three times the theoretical neutralisation requirement. Collect, treat and/or reuse any acidic runoff or seepage from pit wall, bench and floor. Direct any AMD affected groundwater from mine dewatering to treatment plant, if required. Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at pit sump and MUP dam. Routinely monitor groundwater chemistry during dewatering.	Minor	Unlikely	Low

Table 13.8 Summary of geochemical pit walls, benches and floor impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
		Post-closure	Major	Probable	High	As per operations phase management. Monitor the rate of groundwater rebound and pore water chemistry until the final groundwater level has been achieved, to confirm that sufficient neutralising capacity has been added to prevent residual acid salts from contaminating the groundwater system. Use dewatering bores to facilitate post-closure monitoring of groundwater rebound, prior to full decommissioning.	Moderate	Unlikely	Medium
	Release of AMD from dewatered in situ material into groundwater injection aquifer	Construction	Minor	Unlikely	Low	Routinely monitor groundwater chemistry during dewatering and injection, to confirm that receiving groundwater in the injection aquifer will not be adversely affected.	Minor	Unlikely	Low
		Operation	Minor	Unlikely	Low	As per construction phase management approach.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
	Failure of pipeline between dewatering and injection sites	Construction	Minor	Unlikely	Low	Not required.	Minor	Unlikely	Low
		Operations	Minor	Unlikely	Low	Not required.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
In-situ pit wall, bench and floor material that is unsaturated due to mine dewatering – Nepean	Release of AMD from dewatered in situ material into void/ groundwater/ surface water due	Construction	Moderate	Unlikely	Medium	More extensive geochemical assessment of overburden and ore materials for the Nepean deposit.	Minor	Very unlikely	Low
		Operations	Moderate	Unlikely	Medium	More extensive geochemical assessment of overburden and ore materials for the Nepean deposit.	Minor	Very unlikely	Low
		Post-closure	Moderate	Unlikely	Medium	Not required.	Minor	Very unlikely	Low

Table 13.9 Summary of geochemical product impacts from the Balranald Project

		Potential impacts				Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Mining products – during temporary storage at West Balranald process plant	Runoff or seepage of AMD from stockpiled HMC product into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Minor	Possible	Medium	Low permeability liner, incorporating limestone, beneath HMC product stockpile. Surface water drainage control around HMC product stockpile. Minimise surface area of HMC product stockpiling. Frequent transport of mining products off site. Collect, treat and/or reuse any acidic runoff or seepage from HMC product stockpile. Regular surface and groundwater monitoring at HMC product stockpile.	Minor	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
	Runoff or seepage of AMD from stockpiled ilmenite product into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operations	Minor	Possible	Medium	As per HMC product stockpile during operations phase.	Minor	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 13.9 Summary of geochemical product impacts from the Balranald Project

	Potential impacts					Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Mining products – during off site transport	Transport accident (off site) leading to release of HMC product and subsequent runoff or seepage of AMD from spilled material into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operations	Moderate	Unlikely	Medium	Recover any spilled material as soon as practicable. Incorporate AMD considerations into transport accident emergency response procedures.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
	Transport accident (off site) leading to release of ilmenite product and subsequent runoff or seepage of AMD from spilled material into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operations	Moderate	Unlikely	Medium	Recover any spilled material as soon as practicable. Incorporate AMD considerations into transport accident emergency response procedures.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

13.4.3 Analysis

The highest risk potential and residual impacts during the three phases of the Balranald Project are as follows:

- during the construction phase of the Balranald Project, the highest risk AMD impact, and key residual impact, is runoff or seepage of AMD from temporary OOB stockpile into surface water or groundwater;
- during the operations phase of the Balranald Project, the highest risk AMD impacts, and key residual impacts, are:
    - runoff or seepage of AMD from stockpiled ore at the West Balranald site into surface water or groundwater; and
    - release of AMD from the TSF to Box Creek.
- Post closure and decommissioning of the Balranald Project, the highest risk AMD impacts, and key residual impacts, are:
    - release of AMD from backfilled overburden at West Balranald into the final void or groundwater;
    - release of AMD from backfilled mining by-products at West Balranald below the final groundwater level, into the final void or groundwater; and
    - release of AMD from dewatered insitu material at West Balranald into the final void or groundwater.

13.5 Management and mitigation

A range of measures outlined in Tables 13.5 to 13.9 are proposed to manage and mitigate AMD risks associated with the Balranald Project. The key measures include:

- routine monitoring and segregation of OOB during mining;
- installation of a low permeability/limestone liner beneath OOB stockpiles during excavation of the initial boxcut and stockpiled ore;
- incorporate sufficient quantity of limestone in OOB stockpile liner during excavation of the initial boxcut and stockpiled ore;
- surface water drainage control around the OOB stockpiles during excavation of the initial boxcut and stockpiled ore;
- minimise the amount and surface area of stockpiled OOB (ie relocate to pit as soon as possible) and ore;
- incorporate AMD considerations into MUP dam design, operation and emergency response procedures;

- return OOB directly (via the in-pit haulage routes) to its final storage location as low as possible in the backfill profile below the final (natural) groundwater level in the West Balranald mine;
- rapidly (within 1-2 days) cap backfilled OOB with at least 5 m of SOB or inert clay-rich material sourced from the aquitard separating the Shepparton and Loxton-Parilla Sands Formations;
- incorporate sufficient quantity of limestone into backfilled OOB and mining by-products, allowing for three times the theoretical neutralisation requirement to address AMD from both backfilled and in situ sources, during the operations phase;
- transport compact backfilled limestone-blended overburden and cover as soon as practicable;
- backfill oversize material directly to the West Balranald mine void;
- routine monitoring and characterisation of mining by-products to inform neutralisation requirements;
- no disposal of mining by-products at the Nepean mine;
- co-dispose thickener underflow and sand tails as ModCoD (as described in Section 3.6), to facilitate handling and trafficability of backfilled material;
- return mining by-products from Hamilton MSP directly if possible to their final placement location in the West Balranald mine backfill profile however if this is not possible:
    - stockpile by-products on low permeability pads comprising a limestone liner with surface water drainage control at the MUP site; or
    - alternatively, consider temporary stockpiling of by-products below ground level so that drainage reports to the pit sump;
- transport compacted backfilled limestone-blended mining by-products and cover as soon as practicable;
- regular surface and groundwater monitoring at the pit sump, MUP dam, OOB and ore stockpiles;
- where OOB is exposed in benches in the pit, maintain a layer of in situ SOB as long as possible (eg minimum 5 m) before disturbing OOB; and
- collect, treat and/or reuse any acidic runoff or seepage from OOB stockpiles and stockpiled ore, backfilled OOB, backfilled mining by-products and pit walls/benches/floor.

As demonstrated in Tables 13.5 to 13.9, following implementation of these management and mitigation measures, residual risks were generally found to be low and manageable throughout the three project phases.

13.6 Conclusion

Samples from the West Balranald and Nepean deposits were analysed to characterise the overburden and ore as part of the Balranald Project's geochemical assessment. Mining by-products that would be generated at the Hamilton MSP and product samples were also classified as part of the assessment. The results of the assessment indicate that the NSOB and SOB at the West Balranald deposit is NAF, while the ore and OOB is PAF. At the Nepean deposit, both the ore and NSOB is NAF.

The results were used in conjunction with the water balance estimates and groundwater modelling to assess potential water quality impacts and the quantity of AMD generated from overburden, ore, mining by-products, pit walls, benches and floors and products. As a result of this assessment the highest risk AMD impacts were considered to be:

- during construction phase - runoff or seepage of AMD from temporary OOB stockpile into surface water or groundwater;
- during operations phase - runoff or seepage of AMD from stockpiled ore at the West Balranald mine into surface water or groundwater and release of AMD from the TSF to Box Creek; and
- post closure and decommissioning - release of AMD from backfilled overburden, mining by-products and dewatered in situ material at the West Balranald mine into the final void or groundwater.

A range of measures are proposed to manage and mitigate AMD risks associated with the Balranald Project. Following implementation of these management and mitigation measures, residual risks were generally found to be low and manageable throughout the three project phases.

14 Radiation

14.1 Introduction

The radiation risk assessment was prepared by Iluka to address the EIS Guidelines discussed in Chapter 13 utilising baseline soil and water radiation assessments by Earth Systems and Land & Water Consulting (LWC). The radiation risk assessment can be found in Appendix L.

The key objectives of the radiation risk assessment was to:

- describe and characterise sources of radiation and identify current levels of radiation at the project area;
- determine if any materials (soils, groundwater and by-products) are classified as radioactive; and
- assessing transport activities.

The radiation risk assessment was prepared in accordance with relevant legislation, guidelines and polices, including but not limited to:

- RC Act;
- POEO Act;
- *NSW Waste Classification Guidelines* (EPA 2014);
- *Code of Practice and Safety Guide on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005)* (the Code) (ARPANSA 2005);
- *1990 Recommendations of the International Commission on Radiological Protection* (ICRP), *ICRP Publication 60* (ICRP 1991);
- *Australian Drinking Water Guidelines* (National Health and Medical Research Council 2015); and
- *Guidelines for Drinking-water Quality, 4th edition* (World Health Organisation 2011).

14.2 Existing environment

The main heavy mineral constituents of mineral sands are the titanium-bearing minerals, predominately ilmenite, but also rutile and leucocoxene, zircon, and the rare earth bearing minerals, monazite and xenotime. The relative proportion of these minerals varies from deposit to deposit, but ilmenite contributes by far the largest proportion of the heavy mineral constituents, commonly about 50 to 70%.

As stated in Chapter 2, the combined Measured, Indicated and Inferred Resource of the West Balranald deposit (excluding Nepean) contains 12.0 Mt of heavy mineral with an average assemblage of 10.8% zircon, 11.9% rutile and 64.1% ilmenite. The combined Indicated and Inferred Resource reported for the Nepean deposit contains 2.4 Mt of heavy mineral with an average assemblage of 14.4% zircon, 14.5% rutile and 59.7% ilmenite.

Uranium and thorium are also present in these minerals. The concentrations of uranium and thorium are generally in trace amounts except for monazite, which typically contains 5% to 7% thorium and 0.1% to 0.3% uranium.

Consequently, the mining and processing of heavy mineral ores has the potential to cause elevated radiation exposures of both workers and the public during operations and from the management of waste arising from production. Therefore, depending on the level of potential exposure, certain radiation control measures may be required to provide for an adequate degree of protection for both employees and the public.

In general, radiation hazards to workers arise in the mining and processing of heavy minerals through three principal pathways, namely external irradiation, inhalation and ingestion. The specific potential exposure pathways are:

- external exposure from the ore body during mining of ores or during separation of heavy minerals, or from stockpiled ore or mineral concentrates;
- external exposure during transport of ore or mineral concentrates;
- internal exposure from the inhalation of dust containing elevated levels of radioactivity;
- internal exposure from the inhalation of radon gas released from minerals during mining and processing operations or from stockpiled material; and
- direct ingestion of material during handling of ores and heavy mineral concentrates and products.

Potential exposure pathways to members of the public include off-site releases of dusts or radon gas, contamination of food and water supplies due to the migration of radionuclides from the mine site during mining operations or following the disposal of tailings. Radioactivity associated with the various heavy minerals or tailings may also have the potential to be dispersed in the environment during processing operations.

14.3 Impact assessment

14.3.1 Radiation standards and limits

The risks associated with radiation are mostly known and quantified. The objective of radiation protection is to limit the exposure to radiation by the application of comprehensive programs of measurements of all significant radiation sources to ensure that no employee or member of the public are exposed to levels exceeding those prescribed by legislation.

The premier international body for radiation protection is the ICRP. The radiation limits recommended by the ICRP have generally been adopted around the world, including in Australia in Commonwealth, state and territory legislation. The recommended dose limits have changed over time as more information on the health effects of radiation has become available. However there has been only one major change to the recommended limits to worker in the past 50 years, in the *1990 Recommendations of the International Commission on Radiological Protection*, *ICRP Publication 60* (ICRP 1991).

Radiation standards and limits contained within *1990 Recommendations of the International Commission on Radiological Protection*, *ICRP Publication 60* (ICRP 1991) are shown in Table 14.1.

Table 14.1 Dose limits for occupational exposed persons and members of the public

Application	Dose limit - occupational exposed person	Dose limit - members of the public
Effective dose	20 mSv per year averaged over a period of 5 consecutive calendar years [4,5,6]	1 mSv in a year [7]
Equivalent dose to:		
• lens of the eye	20 mSv per year averaged over a period of 5 consecutive calendar years [4,5,6]	15 mSv in a year
• skin [8]	500 mSv in a year	50 mSv in a year
• the hands and feet	500 mSv in a year	No limit specified

Notes

1. The limit apply to the sum of the relevant doses from external exposure in the specified period and the committed dose from intakes in the same period. In this Note, committed dose means the dose of radiation, arising from the intake of radioactive material accumulated by the body over 50 years following the intake (except in the case if intakes by children, where it is the dose accumulated until the age of 70).

2. Any dose resulting from medical diagnosis should not be taken into account.

3. Any dose attributable to normal naturally occurring background levels of radiation should not be taken into account.

4.With the further provision that the effective dose must not exceed 50mSv in a single year.

5. When a female employee declares a pregnancy, the embryo or foetus should be afforded the same level of protection as a member of the public.

6. When, in exceptional circumstances, a temporary change in the dose limit requirements is approved by the Authority, one of the following conditions applies:

- *The effective dose limit must not exceed 50mSv per year for the period, that must not exceed 5 years, for which the temporary change is approved, and*
- *The period for which the 20mSv per year average applies must not exceed 10 consecutive years and the effective dose must not exceed 50mSv in any single year.*

7. In special circumstances, a higher value of effective dose could be allowed in a single year, provided that the average over 5 years does not exceed 1mSv per year.

8. The equivalent dose limit for the skin applies to the dose averaged over any 1 square centimetre of skin, regardless of the total area exposed.

The doses received may be averaged over five years, but the dose to a worker in any one year must not exceed 50millisieverts (mSv). These limits apply to total dose received from operational sources including external gamma exposure and inhalation of radon decay products and dust (with the doses from natural background being excluded).

There are no exposure limits for the individual dose components. Likewise there are also no specific dose limits set for shorter periods (less than a year). This is because the likely health effects depend only on the total dose accumulated over a long period (possibly decades). In an operational situation, investigation and action levels are set for each pathway at levels that ensure continued exposure will not lead to doses above these long-term limits.

Details on radiation standards and limits can be found in the radiation risk assessment in Appendix L.

14.3.2 Classification of materials

Three 'materials' were considered by Iluka to determine the risk of radiation exposures to both workers and the public as a result of the Balranald Project. This included the risk of exposure to mine materials, groundwater and mining by-products. Mine materials include all soils, including the ore, which will be mined as part of the project.

i Mine materials

Earth Systems undertook a preliminary assessment of the radioactive properties and behaviour of mine materials (overburden, wastes and ore) from the West Balranald deposit. The mine materials were sampled during a sonic drilling and core extraction program of the existing in-situ mine materials from 25 June to 1 July 2014. The sample program was designed to collect information on five distinctive soil lithologies, as follows:

- surface soils (SS);
- NSOB;
- SOB;
- OOB; and
- ore.

The results of this analysis can be seen in Table 14.2.

Table 14.2 Radiation analysis for mine materials

Radionuclide results (Bq/g)	Soil lithologies				
	SS	NSOB	SOB	OOB	Ore
U (ppm)	4.4±0.2	4.8±0.2	1.5±0.1	11.2±0.3	45.0±0.6
U (Bq/g)[#]	0.055	0.060	0.019	0.139	0.56
Th(ppm)	7.8±0.7	15±1	4.5±0.5	5.1±0.4	310±20
Th (Bq/g)[@]	0.032	0.061	0.018	0.021	1.258
Th-232 decay chain					
Th-232	0.031±0.003	0.059±0.005	0.018±0.002	0.021±0.002	1.25±0.09
Ra-228	0.033±0.004	0.058±0.006	0.020±0.002	0.010±0.001	1.3±0.1
Th-228	0.034±0.003	0.057±0.006	0.017±0.002	0.013±0.001	1.3±0.1
U-238 decay chain					
U-238	0.055±0.003	0.060±0.003	0.019±0.002	0.139±0.004	0.538±0.008
Th-230	< 0.11^	< 0.12^	<0.062^	< 0.57^	0.7±0.1
Ra-226	0.022±0.002	0.042±0.004	0.013±0.001	0.015±0.002	0.57±0.06
Pb-210	< 0.017	0.054±0.006	0.022±0.004	< 0.0084	0.46±0.05
Po-210[*]	0.32±0.04	0.064±0.04	0.021±0.04	0.047±0.04	0.22±0.04

Table 14.2 Radiation analysis for mine materials

Radionuclide results (Bq/g)	Soil lithologies				
	SS	NSOB	SOB	OOB	Ore
U-235 decay chain					
U-235&	0.0025&	0.0028&	0.00087&	0.0064&	0.026±0.005
Pa-231	< 0.036	< 0.036	< 0.026	< 0.020	< 0.044
Ac-227	< 0.0067	< 0.0064	< 0.0046	< 0.0041	< 0.031
Th-227	< 0.0067	< 0.0064	< 0.0046	< 0.0041	< 0.031
Potassium-40					
K-40	0.34±0.03	0.61±0.06	0.14±0.01	0.13±0.01	0.14±0.01
Total contained activity‡	**1.5**	**1.9**	**0.57**	**1.0**	**20.9π**

Notes: ** Po-210 concentration on the count date of 19 September 2014.*

^ No gamma peak was detected in the gamma spectrum. Less than values quoted are statistically determined by the gamma analysis software.

&No gamma peak was detected in the gamma spectrum. U-235concentration calculated from the measured U-238 concentration.

ǂ Including K-40. Less than values assume zero concentration for those particular radionuclides in the calculations.

π Assumes the concentration of Po-210 is 0.56Bq/g.

ǂ Includes the contribution from all radionuclides (long- and short-lived) in each of the respective decay chains and K-40. Less than values assume zero concentration for those particular radionuclides in the calculation.

Based on the results of the analysis of the samples, Iluka undertook a classification of all mine materials in accordance with the RC Act and POEO Act. The results of the classification can be seen in Table 14.3.

Table 14.3 Classification of mine materials

Results	SS	NSOB	SOB	OOB	ORE
U (ppm)	4.4	4.8	1.5	11.2	45
Weight % U	0.0004	0.0005	0.0002	0.0011	0.0045
Th (ppm)	7.8	15	4.5	5.1	310
Weight % Th	0.0008	0.0015	0.0005	0.0005	0.0310
Weight% U/0.02	0.022	0.024	0.0075	0.056	0.225
Weight% Th/0.05	0.0156	0.03	0.009	0.0102	0.62
U/0.02 + Th/0.05	0.0376	0.054	0.0165	0.0662	0.845
Radioactive ore?	No	No	No	No	No
Total contained activityǂ	1.5	1.9	0.57	1	20.9
Radioactive substance?	No	No	No	No	No

The results show that none of the mine materials at West Balranald mine, including the ore, exceed the radioactive classifications thresholds for ores or substances under the RC Act and POEO Act. As such, all mine materials are not classified as radioactive.

Further details on the classification of mine materials can be found in the radiation risk assessment in Appendix L.

ii Groundwater

LWC undertook pre-mining radiation groundwater monitoring at the project area, at both the West Balranald and Nepean deposits, between 2 and 5 June 2014. A number of bores were sampled in the Loxton-Parilla Sands, including bores near the ore bodies, bores up and down gradient of the ore bodies and bores within the extent of mining. The results of the analysis for the West Balranald and Nepean deposits can be seen in Tables 14.4 and 14.5, respectively.

Table 14.4 Summary of radiation analysis for West Balranald bores

Analyte	Near the ore body			Up-hydraulic gradient		Mining extent/down hydraulic gradient			
	WB28	WB40	WB41	GW036868(2)	GW036673(2)	WB5	WB17	WB20(1)	WB20(2)
Naturally occurring u-238 series (Bq/L)									
U-238		<0.02	<0.02			<0.02		2.6	2.7
Th-234	<0.17	<0.13	<0.15	<0.14	<0.45	<0.43	0.12	2.2	
Ra-226	0.104	0.091	0.123	0.109	0.06	0.151	1.82	0.5	
Pb-210	<0.16	<0.13	<0.13	<0.15	<0.6	<0.4	<0.17	<0.61	
Po-210	<0.013			0.0124	0.0034		0.0054		
Naturally occurring thorium series (Bq/L)									
Th-232		0.01	0.014			<0.005		<0.005	<0.005
Ra-228	0.325	0.194	0.297	0.206	0.189	0.298	0.683	1.72	
Th-228	<0.039	<0.029	<0.036	<0.037	<0.039	<0.038	<0.030	<0.034	
Naturally occurring uranium radioisotopes (Bq/L)									
U-238	0.053			0.012	0.0099		0.0509		
U-235	0.0113			0.00105	<0.0017		0.0055		
U-234	0.083			0.012	0.0109		0.0569		
Naturally occurring thorium radioisotopes (Bq/L)									
Th-232	<0.013			<0.0034	<0.0019		<0.0045		
Th-230	0.036			0.0261	0.0212		0.0157		
Th-228	0.019			0.0112	0.0128		0.0189		
Th-227	0.022			<0.0071	<0.017		<0.0086		

Table 14.5 Summary of radiation analysis for Nepean bores

Analyte	Near the ore body		Up-hydraulic gradient		Mining extent/down hydraulic gradient	
	N10	GW036790(2)	GW036674(1)	GW036866(2)	N7	N28
Naturally occurring u-238 series (Bq/L)						
U-238				<0.02		<0.02
Th-234	<0.18	<0.13	0.09	<0.14	<0.47	<0.45
Ra-226	0.114	1.87	0.082	<0.053	0.202	1.064
Pb-210	<0.16	<0.14	<0.13	<0.14	<0.61	<0.42
Po-210	<0.0044	0.025	0.0131		0.0081	
Naturally occurring thorium series (Bq/L)						
Th-232				<0.005		<0.005
Ra-228	0.194	0.162	0.097	<0.14	0.185	0.472
Th-228	<0.032	<0.034	<0.017	<0.033	0.036	<0.043
Naturally occurring uranium radioisotopes (Bq/L)						
U-238	0.0568	0.151	0.0136		0.0358	
U-235	0.0046	0.0174	0.0025		0.0027	
U-234	0.066	0.154	0.0134		0.0609	
Naturally occurring thorium radioisotopes (Bq/L)						
Th-232	0.0054	<0.0095	0.0038		<0.0036	
Th-230	0.0172	0.035	0.021		0.00243	
Th-228	0.0099	<0.0098	0.0109		0.0049	
Th-227	<0.008	0.017	<0.006		<0.0076	

Key findings of the groundwater radiation monitoring are as follows:

- With respect to human health screening (ie ingestion of water), only one water sample (sampled from WB20) exceeded the Australian Drinking Water Guidelines (ADWG) dose threshold of 1 mSv per year, largely driven by uranium-238, andradium-228 from the thorium series.

- Radium 228 appears to be generally elevated in all waters sampled, relevant to the World Health Organisation's (WHO) radium-228 screening criterion for drinking waters of 0.1 becquerel per litre (Bq/L).

Notwithstanding the above activity levels, the water sampled (in the Loxton-Parilla Sands) is not suitable for potable use due to salinity levels.

Further details on the classification of groundwater can be found in the radiation risk assessment in Appendix L.

iii Mining by-products

Earth Systems undertook a laboratory test-work program to classify mining by-products that would be produced at the Hamilton MSP in accordance with the EPA's *Waste Classification Guidelines*. Samples of each of the by-product streams were prepared at Iluka’s pilot scale metallurgical test facility based on HMC prepared using West Balranald ore. All samples were submitted for radionuclide and chemical analyses. The by-product streams analysed included:

- primary dry circuit (PDC) ilmenite;

- combined monazite reject;
- HyTi;
- combined zircon wet tails;
- rutile wet circuit concentrate;
- float tails; and
- PDC conductors oversize (+ 410 microns).

Table 14.6 summarises the results of the analysis of the mining by-products.

Table 14.6 Summary of radiation analysis for mining by-products

Radionuclide results(Bq/g)	PDC ilmenite	Combined monazite reject	HyTi	Combined zircon wet tails	Rutile wet circuit concentrate	Float tails sample	PDC conductors
Th-232DecayChain							
Th-232	0.22	77	1.3	0.56	1	0.3	0.89
Ra-228	0.22	68	1.2	0.3	0.91	0.27	0.86
Th-228	0.19	75	1.3	0.3	0.9	0.27	0.86
U-238DecayChain							
U-238	0.11	14	0.42	1.01	0.58	0.48	0.81
Th-230	0.12	17	0.5	0.78	0.51	<0.3	0.9
Ra-226	0.12	13	0.47	0.83	0.58	0.39	0.82
Pb-210	0.14	13	0.42	0.72	0.47	0.33	0.68
Po-210	0.03	8	0.34	0.3	0.16	0.25	0.31
U-235DecayChain							
U-235	0.0051	0.65	0.0194	0.0466	0.0268	0.0222	0.037
Pa-231	<0.026	0.8	<0.069	<0.039	<0.043	<0.064	<0.13
Ac-227	<0.0053	1	0.028	0.046	0.03	0.019	0.047
Th-227	<0.0053	1	0.028	0.045	0.03	0.019	0.047
Potassium-40							
K-40	0.026	<0.32	0.1	<0.024	0.07	<0.044	0.3
Total contained activity‡	**3.7**	**938**	**19.4**	**15.7**	**17.2**	**8.2**	**20.5**
Specific activity - Group 1	1.7	460	9.3	7.0	8.1	3.5	9.5
Specific activity - Group 2	1.6	375	7.9	6.4	7.0	3.5	8.5
Specific activity - Group 3	0.32	89	1.8	1.2	1.5	0.7	1.7
Specific activity - Group 4	0.12	15	0.4	1.1	0.6	0.5	0.8

Notes: ‡IncludingK-40. Lessthanvaluesassumezeroconcentrationforthoseparticularradionuclidesinthecalculations.

Based on the results of the analysis of the samples, Iluka undertook a classification of all by-products in accordance with the *NSW Waste Guidelines* and RC Act. The results of the classification can be seen in Table 14.7.

Table 14.7 Classification of by-products

Radionuclide results(Bq/g)	PDC ilmenite	Combined monazite reject	HyTi	Combined zircon wet tails	Rutile wet circuit concentrate	Float tails sample	PDC conductors
Total contained activity	3.7	938	19.4	15.7	17.2	8.2	20.5
Radioactive Substance	No	Yes	No	No	No	No	No
Specific Activity - Group 1	1.7	460	9.3	7.0	8.1	3.5	9.5
Specific Activity - Group 2	1.6	375	7.9	6.4	7.0	3.5	8.5
Specific Activity - Group 3	0.32	89	1.8	1.2	1.5	0.7	1.7
Specific Activity - Group 4	0.12	15	0.4	1.1	0.6	0.5	0.8
Specific Activity Ratio	1.9	498	10.1	7.7	8.8	3.8	10.3
NSW Waste Guideline Classification	Restricted solid	Hazardous	Restricted solid	Restricted solid	Restricted solid	Restricted solid	Restricted solid
RC Act radioactive substance	No	Yes	No	No	No	No	No

As Table 14.7 shows, with the exception of the combined monazite reject, all of the by-products produced at the Hamilton MSP are likely to be classified as restricted solid waste under the *NSW Waste Guidelines*. The combined monazite reject is likely to be classified as hazardous waste.

Further details on the classification of by-products can be found in the radiation risk assessment in Appendix L.

14.3.3 Radiation dose delivery pathways

Potential radiation dose delivery pathways for employees and members of the public resulting from the Balranald Project would include:

- irradiation by gamma radiation;
- inhalation of dusts containing long lived alpha emitting radionuclides (LLAE);
- inhalation of the decay products of radon (radon-222 and radon-220); and
- ingestion of radionuclides.

These potential dose delivery pathways could occur during the following project activities:

- handling and stockpiling of HMC, mineral concentrates and by-products at Balranald Mine; and
- transporting (via road) of HMC, mineral concentrates and by-products between Balranald Mine and Hamilton MSP.

In addition, there is a risk that an incident or accident resulting in the loss of containment of HMC, mineral concentrates, by-products (eg accident along the transport route) could potentially result in local contamination of land or surface waters.

A discussion of the potential impacts at each of these components is provided below.

i Handling and stockpiling at Balranald Mine

In the absence of management measures, the long-term accrual of radiation dose (via irradiation, inhalation and/or ingestion) of employees and/or members of the public during the handling and stockpiling of HMC, mineral concentrates and by-products at Balranald Mine could cause potential doses in excess of the limits contained within *1990 Recommendations of the International Commission on Radiological Protection*, *ICRP Publication 60* (ICRP 1991) (Table 14.1).

Table 14.8 provides a summary of the potential activities and associated dose delivery pathways that would potentially occur at Balranald Mine. Management of HMC, mineral concentrates and by-products at Balranald Mine would be undertaken in accordance with the management and mitigation measures described in Table 14.8. With the implementation of these measures, the risk of harm to employees, members of the public and the environment from the handling and stockpiling of the HMC, mineral concentrates and by-products would be negligible.

Table 14.8 Potential dose delivery pathways of handling and stockpiling at Balranald Mine

Activity	Potential dose delivery pathway	Management and mitigation measures
Handling and stockpiling HMC, mineral concentrates and by-products	• Inhalation or ingestion of LLAE in dust during handling and stockpiling activities • Doses of gamma radiation through close proximity to the mineral concentrates and by-products	• Radiation monitoring program • Stockpile management standard • Radiation management standard • Dust suppression measures • Radioactive waste management plan
Loading of mineral concentrates onto haulage vehicles	• Inhalation or ingestion of LLAE in dust during loading activities • Doses of gamma radiation through close proximity to the mineral concentrates	• Radiation monitoring program • Stockpile management standard • Radiation management standard • Dust suppression measures • Transport management plan
Unloading of by-products from haulage vehicles	• Inhalation or ingestion of LLAE in dust during unloading activities • Doses of gamma radiation through close proximity to the by-products	• Radiation monitoring programme • Stockpile management standard • Radiation management standard • Dust suppression measures • Radioactive waste management plan • Transport management plan

Table 14.8 Potential dose delivery pathways of handling and stockpiling at Balranald Mine

Activity	Potential dose delivery pathway	Management and mitigation measures
Mixing of by-products with sand residues and coarse rejects.	• Inhalation or ingestion of LLAE in dust through activities associated with loading by-products prior to mixing • Doses of gamma radiation through close proximity to the by-products	• Radiation monitoring program • Dust suppression measures • Radioactive waste management plan
Deposition of blended by-products	• Very little risk of either gamma radiation or dust generation as the blended process waste is wet and material has been blended with non-radioactive material	• Radiation monitoring program • Radioactive waste management plan
Incident or accident resulting in loss of containment of material	• Inhalation of LLAE in dust or doses of gamma radiation • Environmental exposure to radioactive material	• Emergency response plan • Emergency response procedures • Radioactive waste management plan • Transport management plan

ii Transportation

Table 14.9 provides a summary of the potential activities and associated potential dose delivery pathways that would potentially occur during transport of HMC, mineral concentrates and by-products. Management of the transport of HMC, mineral concentrates and by-products for the Balranald Project would be undertaken in accordance with the management and mitigation measures described in Table 14.9. With the implementation of these measures, the risk of harm to employees, members of the public and the environment from the transport of mineral concentrates and MSP process waste would be negligible.

Table 14.9 Potential dose delivery pathways of transportation

Activity	Potential dose delivery pathway	Management and mitigation measures
Transport of HMC, mineral concentrates and MSP process waste	• Doses of gamma radiation through close proximity to the road haulage vehicles and rail wagons containing HMC, mineral concentrates or by-products	• Covering of truck tubs • Haul truck operator training • Contractor management standard • Radiation monitoring program • Radioactive waste management plan • Transport management plan
Wind blown dust during the transport of HMC, mineral concentrates and MSP process waste	• Inhalation or ingestion of LLAE in dust dispersed from haulage vehicles or rail wagons • Doses of gamma radiation through close proximity to the HMC, mineral concentrates or by-products • Environmental exposure to radioactive material	• Covering of truck tub • Haul truck operator training • Contractor management standard • Radiation monitoring program • Emergency response procedures • Radioactive waste management plan • Transport management plan

Table 14.9 Potential dose delivery pathways of transportation

Activity	Potential dose delivery pathway	Management and mitigation measures
Incident or accident resulting in loss of containment of HMC, mineral concentrates or MSP process waste	• Inhalation or ingestion of LLAE in dust or doses of gamma radiation following loss of intended containment of material as a result of collision, failure of containment component, or interference by unauthorised personnel • Environmental exposure to radioactive material	• Emergency response plan • Emergency response procedures • Radioactive waste management plan • Transport management plan

iii Environment

An incident or accident resulting in the loss of containment of HMC, mineral concentrates, by-products or blended process waste (eg accident along the transport route) could potentially result in local contamination of land or surface waters. However, in the event of a loss of containment event, there would be limited radiological consequences, as the heavy nature of the radioactive material (ie monazite) and its insolubility in water, would limit the potential for dispersal and therefore the extent of contamination. The coarse heavy nature of the radioactive material would also limit the potential for the material to become airborne. In addition, the radioactive waste management plan and transport management plan would include a plan for dealing with incidents, accidents and emergencies to respond to these events in order to limit the potential for land and surface water contamination.

It is generally accepted that by achieving adequate protection of human health, an acceptable level of protection will be afforded to the environment. Given that the Balranald Project is expected to achieve human health exposure criteria, it is considered that there would be no significant radiological impact on the environment.

14.4 Management and mitigation

Management and mitigation measures for the management of radioactive materials at the Balranald Project have been detailed in Tables 14.8 and 14.9 and above. These measures include the preparation and implementation of the following:

- handling and stockpiling of HMC, mineral concentrates and by-products at Balranald Mine:
  - radiation monitoring program;
  - stockpile management standard;
  - radiation management standard;
  - dust suppression measures;
  - emergency response plan;
  - emergency response procedures;
  - radioactive waste management plan;
  - transport management plan;

- transport of HMC, mineral concentrates and by-products:
  - covering of truck tubs;
  - haul truck operator training;
  - contractor management standard;
  - radiation monitoring program;
  - emergency response procedures;
  - emergency response plan;
  - radioactive waste management plan;
  - transport management plan;
- environment;
  - all measures described above.

These management and mitigation measures would be detailed in an over-arching radiation management plan (RMP) that would be prepared in accordance with the Code (ARPANSA 2005).The RMP would include details of best practicable technology to minimise potential occupational and member of public doses, and would describe monitoring proposed for the Balranald Project.

Further details on the measures proposed to manage and mitigate potential radiation risks associated with the Balranald Project can be found in the radiation risk assessment in Appendix L.

14.5 Conclusion

Based on the existing environment baseline information collected for the Balranald Project, waste characterisation work and results from the radiological risk assessment, it is considered that with the implementation of the identified mitigation measures, the Project will present a negligible radiological risk to human health and the environment.

15 Social

15.1 Introduction

The EIS Guidelines require an assessment of social and economic matters. They state:

> **10 ECONOMIC AND SOCIAL MATTERS**
>
> The short-term and long-term economic and social impacts of the action, both positive and negative, must be analysed and described. Matters of interest should include, but not be limited to:
>
> a) details of any public consultation activities undertaken, and their outcomes;
>
> b) projected economic costs and benefits of the project, including the basis for their estimation through cost/benefit analysis or similar studies; and
>
> c) employment opportunities expected to be generated by the project (including construction and operational phases).

To address these requirements, social and economic assessments of the Balranald Project were prepared. The results of the social assessment are summarised in this chapter. The results of the economics assessment is summarised in Chapter 16.

The social assessment for the Balranald Project was prepared by EMM (Appendix M). It is based on a substantial body of work undertaken by consultancy Environmental Affairs Pty Ltd for the Balranald Project, which included gathering the majority of the baseline data used in this report, including documenting the relevant policy context, developing a profile of the Balranald community and documenting the results of engagement with relevant stakeholders.

The social assessment considered a number of policies at the Commonwealth, State, regional and local levels. These included:

- *Techniques for Effective Social Impact Assessment: A Practical Guide* (Office of Social Policy, NSW Government Social Policy Directorate 1995);
- *Strengthening Basin Communities* (Commonwealth Government 2009);
- the Basin Plan(MDBA 2012);
- *NSW 2021: A Plan to Make NSW Number One* (NSW Government 2011);
- Mining SEPP;
- *Murray-Lower Darling Regional Action Plan* (NSW Government 2012);
- *Murray Regional Plan NSW 2010-2015* (Regional Development Australia [RDA] Murray 2010);
- *Balranald Shire Community Strategic Plan 'Balranald Shire 2022'* (Balranald Shire Council 2012);
- *Strengthening Basin Communities - Community Development Plans for Balranald and Euston 2012-16*(Balranald Shire Council 2012);

- *Balranald Shire Economic Development Strategy (Western Cluster) 2011-16* (Balranald Shire Council 2011); and

- *Draft Balranald Crime Prevention Plan 2011-15* (Balranald Shire Council 2011).

15.2 Social environment

The Balranald LGA is in the Murray region of south-western NSW, approximately 850 km south-west of Sydney and 450 km north of Melbourne. It is the fifth largest LGA in NSW, covering 21,400 km^2 but represents less than 0.1% of the NSW population (2,283 persons as at the 2011 Census of Population and Housing (the Census)).

The main urban centres in Balranald LGA are Balranald town (1,159 persons), located on the Murrumbidgee River, and Euston (600 persons), located on the Murray River near Robinvale.

The primary assessment area is Balranald town. The boundary of Balranald town aligns with the Australian Bureau of Statistics (ABS) 2011 Census of Population and Housing (2011 Census) Balranald Urban Centres and Localities (UCLs) boundary. This primary area was determined given its proximity to the project area. Notwithstanding this, it should be noted that while Balranald town is the primary assessment area, the Balranald community is generally considered to extend beyond the town of Balranald. The physical extent of the Balranald community varies according to the basis of definition, for example, school catchment areas or source of sporting team participants. As such, a secondary assessment area is the Balranald LGA.

The study area for the social assessment can be seen in Figure 15.1.

The Sturt Highway is the main transport route into and through the Balranald LGA, creating important linkages into Victoria and South Australia. The proximity of the Murrumbidgee River has historically influenced the economy of the Balranald LGA, which is largely based on agriculture, including grains (dryland and irrigated), sheep and cattle. Economic diversification into horticulture, viticulture, organic agriculture, forestry and tourism industries has recently occurred in the area (Sinclair Knight Merz 2010).

15.2.1 Key socio-economic characteristics

Key socio-economic characteristics from the 2011 Census for Balranald town and Balranald LGA, as well as for non-metropolitan NSW and NSW overall, are in Table 20.1 and summarised below.

It should be noted that there were changes to Australian Bureau of Statistics (ABS) collection catchments between the 2006 and 2011 censuses. This resulted in a small increase in the catchment area of Balranald town between 2006 and 2011.

Table 15.1 Key socio-economic characteristics

Characteristic	Balranald town[1]	Balranald LGA	Non-metropolitan NSW	NSW
Population 2011 (persons)	1,159	2,283	2,512,949	6,917,660
Population 2006 (persons)	1,216	2,441	2,419,815	6,549,178
Population growth (2006-2011) (%)	-4.7	-6.5	3.8	5.6
Annual rate of population growth 2006-2011 (%)	-1%	-1.3	0.8	1.1
Forecast population growth[2] 2011-2036 (%)	N/A	-0.7	1.0	1.6
Male population 2011 (persons and %)	589 (50.8)	1,175 (51.5)	-	3,408,878 (49%)
Female population 2011 (persons and %)	570 (49.2)	1,108 (48.5)	-	3,508,780 (50.7)
Indigenous population 2011 (persons and %)	100 (8.6)	155 (6.8)	115,596 (4.6)	172,621 (2.5)
Younger age 0 to 4 years 2011 (%)	6.4	7.3	6.3	6.6
Working age[3] 15 to 64 years 2011 (%)	61.5	63.9	62.5	66.0
People aged 65+ years 2011 (%)	20.3	15.6	18.0	14.7
Median age 2011 (years)	44	41	41	38
Unemployment Sep 2014[4](%)	Not available at the UCL level	5.0	-	5.7
Industry structure 2011 (largest categories)	Health care and social assistance, agriculture/forestry/ fishing, retail trade	Agriculture/forestry/fishing, health care and social assistance, accommodation and food services	Health care/social assistance, retail trade, education and training and manufacturing	Health care/social assistance, retail trade, manufacturing, and professional scientific and technical services
Occupational structure 2011 (largest categories)	Labourers, machinery operators and drivers, managers, and community personal services	Managers, labourers, technicians/trade workers and clerical/administrative workers	Professionals, technicians/ trades, managers, and clerical/ administrative workers	Professionals, clerical/ administrative workers, and technicians/trades
Average household size 2011 (persons)	2.3	2.4	2.4	2.6
Average weekly household income 2011 ($)	838	894	961	1,237

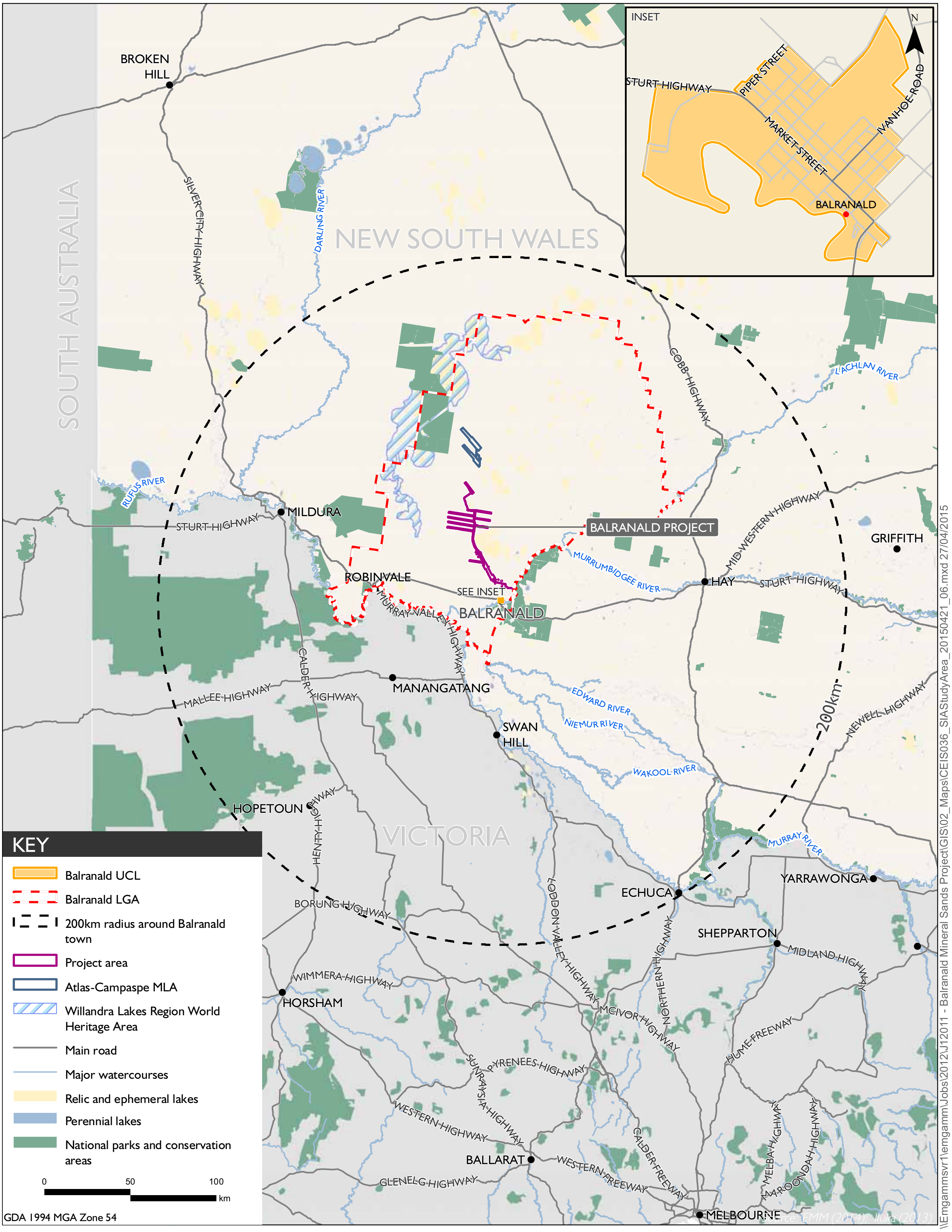
Source: *ABS 2006 and 2012.*

Notes: *1. Changes to ABS collection catchment for Gazetted Localities occurred for 2011 census data.*

2. Department of Planning. 2010. NSW Statistical Local Area Population Projections.

3. The ABS defines the working age (or labour force) as usually resident Australian civilian population aged 15 and over (noting that the retirement age is currently 65).

4. Department of Education, Employment and workplace Relations. Small Area Labour Markets Australia – September Quarter 2014.



Social assessment study area

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 15.1

i Population size, growth and future change

Balranald town and Balranald LGA are characterised by a declining rural population. Balranald town had a population of 1,159 in 2011, which is a decrease of 57 people (or -4.7%) from the population in 2006 (1,216 people). The LGA had a population of 2,283 at the 2011 census. This represented a decline of -6.5% since 2006 census (2,441). This decline is not representative across non-metropolitan NSW, which experienced a population increase of 3.8%, while NSW overall recorded 5.6% population growth during the same period.

Based on the current population trends and NSW Government (DoP 2010) population forecasts, Balranald LGA is likely to experience a continued decline in population through to the year 2036 (-0.7% per year). Non-metropolitan NSW is likely to experience low population growth (1%) over this period.

ii Population structure

In 2011, Balranald town's population had a high representation of people aged between 45 to 54 years (17.4%) and 65 years and over (20.3%) showing an ageing, rural population. Other than the 60 to 84 year and above 85 years cohorts, the smallest cohorts in the town were represented by 25 to 29 year olds and 30 to 34 year olds (3.8 and 3.4% each).

In 2011, the Balranald LGA population was characterised by a 'middle-aged' family structure. Compared to non-metropolitan NSW, the LGA has a higher representation of people aged 45 to 54 years (15.9% to 14.1%) and 35 to 44 years (13.3% to 12.6%), with a higher proportion of children aged 0 to 4 years (7.3% to 6.3%) and 5 to 11 years (9.7% to 9.0%). There is also a high proportion of people aged 65 years and over (15.6%). However, this is lower than non-metropolitan NSW (18.0%). The smallest cohorts in the Balranald LGA, were younger (teenagers) and early working age groups – 12 to 17 year olds (7.6%) and 18 to 24 year olds (6.8%).

In 2011, 50.8% and 51.5% of Balranald town and LGA respectively were male. This compares with 49.3% for NSW overall.

In 2011, 8.6% and 6.8% of the population of Balranald town and Balranald LGA, respectively, were Aboriginal or Torres Strait Islanders. This is higher than non-metropolitan NSW and NSW overall where 4.6% and 2.5% of the population, respectively, were Aboriginal or Torres Strait Islanders.

In 2011, Balranald town had a median age of 44 years and, and Balranald LGA and non-metropolitan NSW had a median age of 41 years. This was above the NSW average (38 years).

iii Household structure

In 2011, Balranald town and LGA had a higher percentage of couples with no children (44.3% and 42.2% respectively) than non-metropolitan NSW and NSW overall. Conversely they each also had a lower percentage of couples with children, particularly in Balranald town. Balranald town and LGA had a much lower proportion of lone person households (15.9% and 12.7% respectively) compared to non-metropolitan NSW and NSW (26.9% and 24.2% respectively).

In 2011, Balranald town, Balranald LGA and non-metropolitan NSW generally had the same average household size of 2.3 or 2.4 persons. This was slightly below the NSW average of 2.6 persons.

iv Economic structure

Reflecting the rural character of the area, in 2011 agriculture, forestry and fishing were the largest employing industries within the LGA (31.2%)with the next largest category being health care and social assistance (9.9%).While agriculture dominated those people employed in Balranald town(sheep, beef cattle (9.2%), and grain farming (6.1%) and fruit and tree nut growing (3.1%)), 7.1% worked in local government administration and 5.9% in school education, reflecting the towns role as a service centre. Employment in the health care and social assistance as well as in the retail trade dominated the rest of NSW and NSW overall.

v Workforce and occupation structure

In 2011, the most common occupations in Balranald town included labourers (18.5%), machinery operators and drivers (13.8%), managers (which include farmers) (13.2%), community and personal service workers (13.2%), and technicians and trades workers (12.2%). The most common occupations in Balranald LGA included managers (28.6%), labourers (17.9%), technicians and trades workers (10.1%), community and personal service workers (9.7%), and clerical and administrative workers (9.7%).

vi Unemployment

Estimates of unemployment are provided by the Commonwealth Department of Employment, generally on a quarterly basis, for statistical local areas (SLAs) as well as on a state and metropolitan/non-metropolitan basis. For Balranald, the Balranald SLA is the same as the Balranald LGA.

The most recently available data is for the first three quarters of 2014. The data indicates that the unemployment rate in the Balranald LGA increased by 1.2% in the first three quarters of 2014 from 3.8% in the March quarter to 5.0% in the September quarter. These quarterly rates were lower than those recorded for NSW. NSWs rate of unemployment stayed at 5.7% for all quarters.

vii Relative disadvantage

Socio Economic Indexes for Areas (SEIFA) is a suite of four summary measures that were created from 2011 Census information. The ABS broadly defines relative socio-economic advantage and disadvantage in terms of people's access to material and social resources, and their ability to participate in society.

The data indicated that Balranald LGA was considered to be relatively disadvantaged in both national and state terms in 2011 as determined by the four indexes. The four indexes are:

- relative socio-economic advantage and disadvantage;
- relative socio-economic disadvantage;
- economic resources; and
- education and occupation.

The relative disadvantage was more pronounced in relation to the overall index and the education and occupation index than in relation to the economic resources and the relative socio-economic disadvantage indexes.

15.2.2 Community services and facilities

i Education

a. Pre-school

The Balranald Early Learning Centre, a community based not-for-profit centre, is located in a BSC-owned building on a large site in Harben Street in Balranald town. The centre is licensed for up to 66 children. It is operated by five permanent part time staff and a cleaner. On average over the last few years, the centre has catered for 25 children (30% pre-school and 70% day care). Staff are employed relative to the number of children enrolled.

As the centre is licensed for 66 children, there is capacity available to accommodate further enrolments, but this would require a commensurate increase in staff.

b. St Joseph's Primary School

St Joseph's Primary School is located in Church Street. It had an enrolment from Kindergarten to Year 6 of 49 pupils in 2014 with five teaching staff and five non-teaching staff. The school is part of the Catholic education system run by the Diocese of Wilcannia-Forbes. The school collaborates with the Balranald Central School on specific events, for example, where a minimum number of pupils are needed to attract particular events.

The 2014 enrolment was the lowest for some years; enrolments have been up to 80 pupils historically.

St Joseph's Primary School's Index of Community Socio-Educational Advantage (ICSEA) rating in 2014 was 953. The ICSEA is a scale that enables comparisons to be made across schools in relation to socio-educational advantage. The value for St Joseph's School represents some slight disadvantage relative to the national average.

c. Balranald Central School (primary component)

The Balranald Central School (primary component), located on a site fronting Wee Street, had 63 pupils in 2014 spread between Kindergarten to Year 6.

Most of these pupils were drawn from Balranald town with a minority drawn from the surrounding areas including Euston to the west, about halfway to Tooleybuc to the south, halfway to Hay to the east and about 40 km to the north of Balranald. According to the school principal, there has been a steady decline in enrolments since 2007.

d. Secondary school

The secondary component of the Balranald Central School is located on the same site with the primary component. The 2014 secondary enrolment in Years 7 to 12 was77 pupils. In 2014, the school (Kindergarten to Year 12) had a teaching establishment of 15 with a total of 23 staff employed (including several permanent part time).

As with the primary component, there has been a steady decline in enrolments since 2007 and it is anticipated that this decline would continue.

Balranald Central School's ICSEA rating in 2013 was 939 which represents some slight disadvantage relative to the national average.

e. Other secondary education

Secondary school students in Balranald have several other schooling options, namely, access by daily bus services to several secondary schools located some 100 km away in Swan Hill (either Swan Hill College or McKillop College). There is also the option to attend boarding schools in country Victoria, NSW or metropolitan Melbourne.

ii Health

a. Balranald Health Service

Balranald Health Service (BHS) provides acute and allied health services to the Balranald community on behalf of the NSW Department of Health and comes under the jurisdiction of the Far West Local Health District based in Broken Hill. BHS provides services from the facility located at the eastern end of Market Street.

The BHS operates:

- the Balranald District Hospital which has eight acute beds and an emergency department;
- high level residential aged care with 15 beds; and
- allied health services including dental, physiotherapy, occupational therapy, speech therapy, dietetics, mental health, psychology and radiography available on a visiting basis at varying frequencies.

BHS has one full time general practitioner and a visiting dentist. Both operate from consulting rooms adjacent to the hospital. The School Dental Services provides dental services to the schools in Balranald.

Higher order specialist health services such as cardiology or paediatrics are available for patients via ground transfer at either Swan Hill or Mildura hospitals and other specialist services by air ambulance retrieval to large hospitals in Melbourne or Adelaide. A pharmacy is located on Market Street.

According to the Commonwealth Government's My Hospitals website, in 2010/11 (the latest comprehensive data available), Balranald Hospital had a total of 304 overnight admissions, including 245 emergency admissions and 59 other admissions. For the same period, there were 20 same-day emergency admissions.

b. Balranald Aboriginal Health Service

The BAHS is a new, purpose-designed medical facility located on the corner of Mayall and Court Streets, completed in early 2011. The BAHS has three full time employees. General practitioner services are conducted on a weekly basis by doctors from Mildura. A nurse provides health checks and services on a weekly basis.

Allied health services are provided at the BAHS premises on a regular visiting basis. These services include dietician, podiatry, speech therapist, nutritionist and drug and alcohol outreach. The BAHS is gradually building up the range of services available to the Aboriginal community in Balranald particularly in relation to mental health services and maternal health. The BAHS works in a complementary manner to the BHS.

c. Community support

Community support is provided through a range of services offered by BSC. These include:

- local home and community care;
- Meals on Wheels;
- Bidgee Haven Aged Care Facility (operation);
- Mandola Place units (for people with disabilities); and
- an emergency accommodation unit.

Mallee Family Care (MFC) offers family services such as counselling, play groups, and foster care to both the Aboriginal and non-Indigenous communities as well as providing other agency services such as Centrelink 20 hours a week from its office.

St Vincent de Paul runs a 'Vinnies' retail outlet in Market Street for fund raising as well as providing charitable and emergency services (such as food assistance and emergency accommodation) for local residents and travellers, all on a voluntary basis. Trained volunteers provide counselling, advice and referrals to other agencies such as MFC in Balranald or Family and Community Services (FACS) in either Dareton or Broken Hill.

iii Retail and commercial services

Most local retail and commercial services in Balranald town are located on Market Street or nearby intersecting streets. Shops include two licensed supermarkets, a butcher, bakery, newsagency, hardware (including electrical and furniture), pharmacy and several clothing and gift shops. Professional and other services include a solicitor, accountant, post office, employment agencies, stock and station agent, real estate agent and IT services.

iv Recreational facilities

The majority of the sporting facilities in Balranald town are within the BSC managed Greenham Park. Facilities located in the park include:

- swimming pool complex which includes a 33 m outdoor pool, a medium pool (less than 33 m), and a hydrotherapy pool;
- sporting ovals (football and cricket) and multi-purpose clubroom/facility;
- tennis and netball courts with club facilities;
- nine hole golf course;
- race course and stables (including a pony club) - two horse race meetings are held each year; and
- BMX circuit.

Sporting clubs and the local schools use these facilities on a regular basis.

v Cultural facilities

Cultural facilities in Balranald town include:

- Theatre Royal, Market Street – multi-purpose hall facility which is a venue for community functions and is available for hire;
- The Gallery, located in the historic Masonic Lodge building at 51 Mayall Street which is owned and operated by Balranald Arts & Craft Inc. It is the venue for a range of arts and crafts activities as well as for temporary exhibitions; and
- Balranald Ex-Servicemens Club, Market Street – which hosts regular visiting performers.

In addition, BSC provides the following indoor facilities that are available for hire for community activities:

- Greenham Park Multi-purpose facility;
- Greenham Park Pavilion; and
- Senior Citizens Centre in Market Street.

vi Religion

Balranald LGA is served by three religious denominations – Anglican, Catholic and Presbyterian – the latter two served by full time clergy. All have churches in Balranald town.

All three congregations are long established, but the congregations are small and ageing.

vii Children and youth services

a. Children

Child and maternal health services are provided on a visiting basis at the BHS along with various playgrounds throughout the town.

b. Youth

One of the community challenges and issues identified are limited youth services and programs. These issues were confirmed in discussion with officers from BSC who identified the need for an indoor fitness centre/gym facility as a priority to respond to youth-related needs in particular, as well as a skate park or casual drop-in centre.

viii Emergency services

a. Police

NSW Police have a police station located on Market Street, which is staffed by five general duties officers and two highway patrol officers. The station is staffed every day between the hours of 8.00 am to midnight from Sunday to Thursday and on Friday and Saturday from 8.00 am to 3.30 am. The area policed from the station extends approximately 35 km towards Euston to the west, 40 km towards Kyalite to the south, 80 km towards Hay to the east and 45 km north.

The major policing issues in and around Balranald town are considered to be offences related to intoxication, domestic violence, malicious damage and traffic matters. However, crime is not considered by the police officers consulted to be a serious issue in the local community and the town is considered to be relatively safe. Data from the NSW Bureau of Crime Statistics and Research confirms that crime rates are relatively low compared to non-metropolitan NSW where the predominant major offences in Balranald LGA in 2011, 2012 and 2013 were in the categories of assault and property-related theft and damage. There was only one recorded robbery with a weapon in 2013.

b. Ambulance

The Ambulance Service of NSW maintains an ambulance station in Balranald town with 24 hour operation. The three-vehicle ambulance station is located in Court Street adjacent to the hospital. Four officers attend the station from 8.00 am to 4.00 pm daily and two officers are on-call between 4.00 pm and 8.00 am daily.

The area served by the Balranald station extends generally 80 km towards Hay to the east, 35 km towards Euston to the west, to the Victorian border (75 km) to the south and up to 155 km north.

The pattern of call outs varies from periods when there are no calls over a couple of days to very busy periods. In quiet periods, the staff undertake community relations activities with schools and other groups. Staff work closely with the hospital and other health services in Balranald and assist Ambulance Victoria with call outs along the Murray River.

According to the Ambulance officers consulted, the current staff and resources could handle more call outs but if there were to be a large increase in demands, additional staff and/or resources would be required.

c. Fire

Balranald town is served by the NSW Fire Brigade with a station located at 123 Market Street with four employees. The NSW Rural Fire Service has a station located in Market Street adjacent to the Voluntary Rescue Association (VRA). It forms part of the Lower Western Region South region. According to personnel consulted, the NSW Rural Fire Service could handle more call outs but if there were to be a large increase in demands, additional staff and/or resources would be requested.

d. Voluntary Rescue Association

The VRA is the primary rescue service for the Balranald LGA and those parts of surrounding LGAs that are closer to Balranald town than other towns – an area of 38,000 km^2.

The VRA has 15 volunteers and is largely self-funded with some support from BSC and the NSW Volunteer Rescue Association. Its base in Market Street, Balranald is equipped with:

- primary rescue truck;
- back up truck;
- troop carrier for personnel transport; and
- spare truck.

The Balranald VRA records an average of 18 call outs annually – mainly motor vehicle crashes on the Sturt Highway, as well as river rescues, farm and industrial accidents, and motor vehicle crashes on minor roads.

ix Public and community transport services

Intra and interstate public bus services serve Balranald town on a regular basis. CountryLink operates a daily service between Cootamundra and Mildura which stops in Balranald town daily.

Long distance bus services between Adelaide and Sydney are provided on weekdays by Greyhound Australia with east and westbound services to Adelaide stopping in Balranald town once daily.

Balranald Community Transport Services (operated by the Far West Health Service) operates two return bus services; on the first Friday of each month from Balranald town to Swan Hill and on alternate Wednesdays from Balranald town to Mildura.

There are no scheduled air services to or from Balranald Airport located to the north of the town.

x Housing and accommodation

Housing in Balranald town is characterised by a high proportion of detached dwellings. In 2011, of the total stock (1,094 dwellings), approximately two thirds were owner-occupied while one third were part of the rental market. 2011 Census data indicated that 15.5% of private dwellings were unoccupied – a higher proportion than for the rest of NSW.

There are minimal issues for vendors wanting to sell for prices under $100,000 while it is harder to sell existing houses over $130,000 to $140,000. At this higher price range, the alternative of buying a residential lot for under $50,000 and building a project house becomes more attractive.

There is a reasonable supply of vacant residential lots, including half acre lots.

The current (January 2015) average house price in the Balranald LGA is $137,500.

Given Balranald town's location on the Sturt Highway, the town is generally well serviced by tourist and temporary accommodation in the form of motels and a caravan park. There are six motels providing up to 95 rooms. The caravan park provides 17 cabins as well as 33 powered and 33 unpowered sites.

For short periods during the year, depending variously on school holidays, local events such as race meetings, fishing competitions, the Balranald 5 Rivers Outback Festival and business demands, all this tourist accommodation may be taken up. At other times there is usually some availability of tourist and temporary accommodation.

15.2.3 Stakeholder engagement

Community consultation is an important part of the Balranald Project as it allows stakeholder values, issues, impacts and opportunities to be identified and included in the Balranald Project's design and implementation. A second important function is to properly inform interested parties about the Balranald Project, its potential impacts, and how they would be managed and mitigated.

Details on stakeholder engagement undertaken for the Balranald Project are provided in Chapter 6. A full list of stakeholders consulted as part of the social assessment is provided in Appendix M.

15.3 Impact assessment

Social impacts of the Balranald project have been considered in terms of the following aspects:

- duration – related generally to the length of, for example, the construction and operations phases;
- significance – whether the impact is considered to be of 'high', 'medium' or low' significance;
- extent – the area, people, facilities and/or services potentially affected;
- potential to mitigate the impact – availability of measures which can reduce or mitigate negative impacts; and
- other considerations – whether the impact is direct or indirect, positive or negative, or cumulative with impacts from other projects in the Balranald LGA.

The potential impacts of the Balranald Project are discussed in the following sections. These are discussed in phases, including:

- planning feasibility and approvals phase;
- construction and operational phases; and
- rehabilitation and decommissioning.

15.3.1 Planning feasibility and approvals phase

Exploration and other investigations related to the Balranald Project have been undertaken by Iluka since at least the mid 1990s. There has been a heightened level of activity in and around Balranald town associated with the investigations supporting the preparation of feasibility studies, engineering studies and the EIS. The awareness of the Balranald Project by the local and regional community is very high. Based on engagement with stakeholders, there is generally a positive and supportive attitude towards the Balranald Project from the local and regional community.

i Affected property owners

A small number of property owners, whose land would be directly and indirectly affected by the Balranald Project during the planning, feasibility and approvals phase, have mixed attitudes towards the project.

Many of the properties that may be affected by mining is currently used for agricultural activities. The area that the Balranald Project would directly impact is sparsely populated.

Where directly impacted land is remote or isolated from the majority of a property's productive area, the relevant property owners have stated that they are not too concerned about the direct impact of the Balranald Project, provided that appropriate commercial and functional arrangements have been negotiated and mitigation measures are put in place to appropriately manage environmental impacts (eg air quality). Most of these property owners have stated that they are seeking a definitive decision about whether and when the Balranald Project would proceed, but are not otherwise unduly concerned on a day-to-day basis about the prospect of the project. However, while generally supportive of the Balranald Project, there appears to be some tendency for property owners to defer investment in the development or maintenance of farm infrastructure which may be subsumed by mining activities until there is a definite commitment to the Balranald Project.

For some other property owners, there is a level of concern regarding a range of potential functional impacts (either directly or indirectly) of the Balranald Project on agricultural activities and productivity, principally related to truck movements, dust generation, noise and the ability to arrive at appropriate compensation agreements with Iluka given individual landholders' circumstances. In this latter group, some property owners are experiencing a degree of concern and anxiety on a day-to-day basis because a decision about the timing of the Balranald Project and related negotiations has greater implications for the next stages of their lives.

Most property owners who would only be affected by the development of lineal infrastructure such as the water supply pipeline are relatively unconcerned at this stage provided appropriate compensation and functional arrangements (ie land access) are negotiated with Iluka.

For directly affected property owners, potential impacts on agricultural activities are generally of high significance, but the ability to resolve these impacts is also high through negotiation of appropriate compensation agreements with Iluka, as well as regular communication on the development of the project and key milestones that impact land access negotiations. Significant progress on land access negotiations has been achieved for many of the relevant properties with further access requirements being identified and confirmed. It is forecasted that the land access negotiations will be finalised in 2015 in readiness for future project development.

ii Community concerns

Based on stakeholder engagement with the broader local and regional community, there is generally a positive attitude towards the Balranald Project. This is particularly emphasised in relation to employment and economic benefits that are perceived to be associated with the Balranald Project.

The main interest in the Balranald Project at the planning, feasibility and approvals phase appears to be from residents who have family members who might seek employment at the mine or from business people who hope to benefit from increased economic activity.

The community are relatively optimistic about the Balranald project but are realistic about the potential population increase, corporate decision making and regulatory approvals required. It is likely that once the Balranald Project completes the regulatory approval process and internal corporate approvals in relation its commencement, prevailing uncertainties about the Balranald Project proceeding would probably be replaced with a sense of certainty, optimism and energy.

It is likely that once detailed construction planning commences there would be a demand for increased temporary accommodation and increased trade for some businesses such as the motels and takeaway food shops. BSC may also be involved in related planning activities to assist the smooth commencement of the construction phase. In conjunction with local providers, Iluka may commence some training programs to assist the availability of local workers.

Given the generally supportive attitude of the local community, the scale of any concern about the Balranald Project is considered to be low (ie low significance).

15.3.2 Construction and operational phases

Apart from the differing duration of these two phases, the likely social impacts would be similar as they are largely related to the workforce and related increased demands on certain community, retail and hospitality services and facilities in Balranald town, as well increased demand for housing and temporary accommodation.

i Workforce

Peak workforce details indicate that:

- the Balranald Project would employ a peak construction and operational workforce of 225 and 550 workers, respectively;
- during the overlap of the construction and operational phases, the peak workforce total about 450 works;
- given leave, including leave between shift rosters, there would be a peak of 158 construction workers and 385 operational workers on-shift at any one point in time;
- during the overlap of the construction and operational phases, there would be a peak of 315 workers on-shift at any one point in time; and
- due to Iluka's work, health and safety policies, it is expected the vast majority of the construction and operational workforce (95%) would stay at the accommodation facility while on-shift, with a minority (5%) commuting to the project area.

It is likely that, given the size and skill set, the majority of both the construction and operational workforces would be sourced from the Balranald regional area (within 200 km) with a proportion drawn from further away. Such an approach is consistent with the labour management on other mineral sands mines in regional areas of Australia.

It has been assumed that a small portion (5%) of the operational workforce would relocate with their families to Balranald LGA. Based on the peak workforce numbers, 28 workers are anticipated to relocate. Based on the NSW average household size of 2.6 persons, this would lead to a population increase of 73 people within the Balranald LGA.

In addition, the Balranald Project would generate indirect or flow-on jobs within the region during both the construction and operational phases. This is anticipated to be approximately 36 indirect jobs generated during the operational phase of the Balranald Project. Should 50% of the indirect jobs generated by the Balranald Project be taken up by the unemployed (52 people in the Balranald LGA as of September 2014) the population increase in the Balranald LGA generated by indirect jobs would be 47 people.

With a population increase of 73 people associated with the relocation of the operational workforce and 47 people associated with the generation of indirect jobs, the Balranald Project could increase the population of the LGA by about 120 people. Given the Balranald LGA is anticipated to experience a continued decline in both its population growth rate and its total population through to 2036 based on a reduction in the birth rate and net migration any population increase associated with the Balranald Project would help offset past and forecast population decline.

Based on experience on other projects in the Murray Basin, there would be opportunities through Iluka's proposed development of a local employment and business policy for local people and businesses to seek employment on or provide additional services to the Balranald Project (refer mitigation measures in Section 19.4. This may put pressure on the available labour pool for existing employers within the town. The prospect of enhanced employment availability in and around Balranald may also attract people from elsewhere to come to the district on the prospect of gaining employment. This may also put additional pressure on the local community services.

The Balranald Project would also generate a large non-local workforce. The size and presence of a large non-local workforce would have several potential impacts for Balranald town, namely:

- an increase in the use of local community, retail and hospitality services and facilities – which may result in some positive and some negative impacts depending on demands generated by the incoming workforce; and
- an increase in the presence of 'non locals' around town with potential for both positive and negative impacts on social amenity.

This impact is considered to be of 'high' positive significance because of the extent of work opportunities generated by the Balranald Project, particularly for the unemployed in the Balranald LGA, and the potential for offsetting of population decline.

ii Increased demand for accommodation

During the construction and operational phases of the Balranald Project, as well as the overlap of both phases, the majority of the workforce would reside in the accommodation facility.

Given the scale and length of the initial construction period of the Balranald Project, it is likely that there would be some indirect impacts on the wider accommodation market in Balranald. There is capacity in the temporary and tourist accommodation sector in Balranald town. However, given the small supply it is possible this would fill up with project related visitors who may not be able to be accommodated in the accommodation facility from time to time. Several operators have indicated to Iluka opportunities to increase accommodation services should a demand be identified.

The population increase generated by the Balranald Project would generate demand for about 46 dwellings in the Balranald LGA. Given the limited existing availability, this increased demand may put some short term stress on the availability and price for the wider community.

Given Iluka's commitment to develop an accommodation facility that would cater for virtually all of the direct workforce during the construction and operations periods, any impacts on wider accommodation resources in Balranald is considered to be of 'low' significance.

iii Demands on community and retail services

There are unlikely to be any substantive demands during either the construction or operational phase on existing community facilities and services that cater principally for children and families because it is anticipated that there would only be a relatively small in-migration of new families to the Balranald LGA directly as a result of the Balranald Project.

Generally, any increased demands on or use of community services and facilities in Balranald as a result of the Balranald Project would only slightly reduce the likelihood of further reductions in these services given the projected population decline for Balranald.

However, there is likely to be some increased demand in the following sectors of Balranald's community infrastructure from the Balranald Project workforce that would reside in the accommodation facility:

- use of local retail and hospitality facilities;
- emergency visits to the local doctor, dentist and hospital resulting from 'normal' health issues or small scale accidents;

- use of local recreation facilities particularly those related to outdoor activities such as swimming, golf and fishing; and

- demand for an indoor fitness centre/gym.

Generally the significance of additional demands on retail, hospitality and community services are considered to be 'low' because of the existing capacity in most community services sectors in Balranald. The lead-up time to project commencement would assist local stakeholders to develop a comprehensive understanding of the size, sourcing and accommodation arrangements for both the construction and operations workforce.

iv Impacts on social amenity

Community image and social cohesion issues related to 'fly-in fly-out communities' (and, by implication, to drive-in drive out communities) in Australia's resource sector were addressed in a recently released report undertaken by the House of Representatives Standing Committee on Regional Australia (2013).

Key issues in relation to community image and social cohesion identified in the Standing Committee's report that have some relevance to the Balranald Project are the potential for:

- the development of an 'us and them' division-between the established Balranald community and the Balranald Project workforce;

- a real or perceived reduction in community safety in and around Balranald town; and

- a lack of respect from the incoming workforce for local community values and the community capital through voluntary effort that has developed many of the local community's facilities.

During both the construction and operational phases of the Balranald Project, there would be the presence of more people and traffic movements in and around the shops and other businesses in the town centre. However, the increased level of activity around Balranald town that would be generated by the Balranald Project workforce is considered to be positive because of the likely economic benefits that would be experienced in the town.

The significance of impacts on the social fabric of Balranald town is considered to be of 'medium' significance because of the peak size of the Balranald Project workforce (up to 550 workers during the operational phase) relative to the permanent population of Balranald town (approximately 1,159 people in 2011).

v Construction and operational traffic impacts

As there are no rail transport connections to the Balranald Project, road transport would be utilised during both the construction and operational phases. There is the potential that vehicle movements generated by the Balranald Project would impact on resident's amenity, such as potential noise impacts.

Traffic and noise assessments of the Balranald Project were undertaken as part of the NSW EIS. These assessments indicate that:

- due to existing low traffic volumes, there would not be any significant traffic impacts in terms of level of service or traffic flow impacts for any road in either Balranald town or Tooleybuc; and

- predicted road traffic levels would satisfy relevant road traffic noise criteria on all transport routes, for construction traffic and product haulage.

The significance of traffic impacts during the construction and operational phases is considered to be of 'low' significance because of the results of the transport and noise assessments.

vi Cumulative impacts with other mining projects

There is the potential for some cumulative social impacts associated with the Atlas-Campaspe Mineral Sands Project. Resource Strategies (2013) estimates that the Atlas-Campaspe Mineral Sands Project could lead to a population increase of 36 people in the Balranald LGA. With the Balranald Project adding to a population increase of approximately 120 people, cumulatively, the two projects could increase the population of the Balranald LGA by 156 people and generate demand for 60 dwellings.

Similarly with workforce and accommodation impacts of the Balranald Project alone, cumulatively the two projects would:

- help to offset population decline in the Balranald LGA and region;
- increase the overall occupancy rates for tourist and temporary accommodation, which could result in short term stresses during community events; and
- place some short term stress on the availability and price of accommodation for the wider community (both in the property market and rental properties).

Cumulative impacts are considered to be of low significance. While there may be some short terms stress on the provision of accommodation, cumulatively the projects would provide greater work opportunities and provide more potential for offsetting of population decline.

vii Impacts on Willandra Lakes Region World Heritage Area

Potentially the greatest social impacts to the WLRWHA would occur as a result of restrictions on access to the site due to additional project related transport movements.

Currently, Balranald Ivanhoe Road, Burke and Wills Road and Arumpo Road provide access to the WLRWHA. These roads would be used by project related traffic, including trucks which would haul ore and product (HMC and ilmenite).

The traffic assessment undertaken for the NSW EIS demonstrates that due to existing low traffic volumes the Balranald Project would not have any significant traffic impacts in terms of level of service or traffic flow impacts on these access roads.

Accordingly, no social impacts on the WLRWHA are expected as a result of the Balranald Project.

15.3.3 Rehabilitation and decommissioning

At the completion of the mining activities, infrastructure would be decommissioned and disturbed areas progressively rehabilitated over several years until they are formally closed.

As result of the completion of the mining activities, most of the Balranald Project's operational jobs would cease for both the non-local and local workforce components. As the Balranald Project workforce winds down, there would be reductions in the use of community services and facilities and the retail and hospitality sector in Balranald. In relation to the retail and hospitality sectors in particular, there may be some job reductions if there are any substantial reductions in levels of business.

However, the history of the mineral sands industry in the Murray Basin indicates that as one mining project is completed, another project generally comes on stream. This is particularly the case with Iluka as they aim to maintain availability of product (HMC) to supply its processing and distribution facilities in Victoria. As a result, a proportion of operational workers usually transfer to the next project in the region.

The decommissioning of the Balranald Project has the potential to result in the permanent loss of the operations jobs for the regional/commuting and locally based workforce together with related flow-on economic benefits within the Balranald community. Assuming that another mineral sand project is not developed in the Murray Basin at the time of decommissioning of the Balranald Project, the significance of this impact is considered to be 'medium. However, assuming another mineral sands project is developed in the Murray Basin as the Balranald Project winds down, which is likely to be the case, the significance of this impact is considered to be 'low'.

15.3.4 Summary of impacts

The results of the social assessment against the phases of the Balranald Project are provided in Table 15.2.

Table 15.2 Summary of potential social impacts during phases of Balranald Project

Potential social impacts by project phase	Duration	Significance	Extent	Potential to mitigate
Planning, feasibility and approvals				
Potential impacts on directly affected property owners	Until negotiations with Iluka completed	High	Directly affected property owners	Yes
Community concerns about the Balranald Project	Until project determination	Low	Balranald town and regional community	Yes
Construction and operations				
Workforce issues related to the limited number and availability of suitably skilled local workforce, requiring much of both workforces to be drawn from the wider regional area	Construction and operational phases (about 10 years)	High (positive)	Balranald LGA and regional area within 200 km	Yes
Increased demand for accommodation and housing (in addition to proposed accommodation village)	As above	Low	Balranald LGA	Yes
Increased demand for retail, hospitality and community facilities or services	As above	Low	Balranald town	Yes
Changes in social amenity	As above	Medium	Project area and Balranald town	Yes
Construction and operational traffic impacts	As above	Low	Public roads	Yes

Table 15.2 Summary of potential social impacts during phases of Balranald Project

Potential social impacts by project phase	Duration	Significance	Extent	Potential to mitigate
Cumulative impacts of the Balranald Project with other mineral sands projects in the LGA (ie Atlas-Campaspe Mineral Sands Project)	As above	Low	Balranald LGA	Yes
Impacts on WLRWHA	As above	Low	Public roads providing access to WLRWHA	Yes
Rehabilitation and decommissioning				
Loss of most Balranald Project jobs	Immediate post completion of mining operations	Low[1]	Balranald LGA and regional area within 200 km	Yes
Related impacts on community services and organisations	As above	Low[1]	Balranald town	Yes

Notes: 1. Assumes that another Iluka project would replace the Balranald Project in the Murray Basin.

15.4 Management and mitigation

This section describes the mitigation measures Iluka proposes to implement to address the potential social impacts outlined previously.

Iluka is committed to entering into an agreement with BSC in relation to Iluka's contributions to the local area and has commenced discussions regarding the scope and terms of the agreement.

15.4.1 Workforce issues

A key matter to be addressed in relation to the Balranald Project's workforce is to ensure opportunities are created for local residents to gain employment on the Balranald Project and resource any local business workforce shortages created by the Balranald Project.

Iluka's approach to employment embodies the following principles:

- a preference for local employment wherever possible - this approach has been employed across the Murray Basin operations, with a large proportion of the workforce drawn from the relevant local region;
- local contractors are encouraged to tender for work, both during the construction and operations phases; and
- use of local businesses such as hotels, motels and restaurants.

In order to achieve this outcome, Iluka proposes to:

- provide advance information about its approach to workforce sourcing, recruitment policies of local people, and work arrangements in relation to matters such as shifts, transport and work, health and safety obligations;

- work with recruitment, education and training providers in Balranald, Swan Hill and Mildura to encourage the provision (in advance of project commencement) of future employment and training opportunities for skills that would be directly and indirectly generated by mining projects;
- continue liaison with relevant agencies to ensure that any wider community issues about training and labour availability for 'vacated' local jobs in favour of jobs on the Balranald Project does not become an 'Iluka' issue;
- participate, as appropriate, in business groups, events or programs as part of a Balranald Business Association and/or provide training programs directly relevant to project needs or broader industry skills; and
- participate in the local mining liaison committee that has been established by BSC so that relevant project information can be provided and community feedback received.

The provision of these activities would be supported by Iluka's proposed development of a local employment and business policy. The intent of this policy is to provide relevant commitments to drive Iluka activity in potential areas including:

- product and service procurement;
- equitable or contracted procurement;
- pre-qualification assistance;
- employment advertising and resourcing;
- training assistance or participation, and
- service referrals.

15.4.2 Housing and accommodation

i Workforce accommodation

To address workforce housing and accommodation requirements, Iluka proposes to develop an accommodation facility for the life of the Balranald Project (including construction, operations and rehabilitation phases).

ii Flow-on accommodation demands

Due to the relatively small volume of potential new residents to Balranald LGA as a result of the Balranald Project, it is not anticipated that this would impact the availability of accommodation for existing or other new residents. Relatively low house prices, along with affordable land and new build developments, would provide an even opportunity for non-project related home purchasing or leasing. In terms of short-term accommodation demand (ie hotels and motels during early construction works), Iluka may restrict availability of supply to other users during peak demand periods. Iluka will investigate opportunities where it may reduce its local short-term accommodation demand, at defined periods, such as during large community events. Iluka will work with local short-term accommodation providers, event planners and BSC's tourism development officer to identify such periods and determine what, if an, modifications can be made to Iluka scheduling and accommodation demand.

iii Rental and housing and land development markets

The Balranald Project may place some short term stress on housing availability and the capacity of some community services in Balranald town. It is likely that the private sector would respond to this demand.

However, to assist the identification and management of any housing availability, Iluka proposes to:

- maintain dialogue with stakeholders who regularly monitor the local housing market relative to any direct Iluka requirements;
- continue engagement with BSC, other mining companies in the LGA and accommodation suppliers, to monitor general short-term accommodation usage by Iluka and any impacts on other accommodation sectors;
- consult with Cristal to ensure that potential negative social impacts result from any concurrent stages of project construction and operation are minimised; and
- augment the accommodation facility with additional temporary accommodation if required.

15.4.3 Community services

Where there may be some project-related demands on certain community services, Iluka proposes to:

- have discussions with health and emergency services (ambulance, fire and rescue services) prior to commencement of construction, to ensure that there would be appropriate interface arrangements for operational matters;
- provide advance briefings about corporate purchasing policies and assistance to local businesses to become pre-qualified to assist them to tender for the supply and/or delivery of goods and services to Iluka during the construction, operational and rehabilitation/decommissioning periods; and
- provide a conduit between local businesses and major Iluka contractors.

15.4.4 Social amenity

To maintain and further develop positive relations between Iluka and the Balranald community, Iluka proposes to:

- build on the existing base of community goodwill in the Balranald community by ensuring, through the nominated mitigation and management measures presented in this social assessment as well as a regular stakeholder communications program, to ensure that the benefits to the community as a result of the Balranald Project are realised; and
- to emphasise acceptable behaviours in the Balranald community as part of its induction program for the incoming workforce.

15.4.5 Rehabilitation and decommissioning

At the completion of the mining activities, the Balranald Project's mine infrastructure would be decommissioned and the mine sites progressively rehabilitated over several years. While it is likely there would be some permanent loss of jobs, the timing of operational wind down and ultimate site decommissioning would be known and communicated in advance. Iluka would work with relevant stakeholders to provide information about the timing of these final stages and appropriate support to employees, suppliers and the community as may be required.

There is likely to be the opportunity for a proportion of the Balranald Project workforce to transfer to a subsequent mineral sands project in the region should opportunities eventuate into the future.

15.5 Conclusion

Based on the results of the social assessment, the net community benefit of the Balranald Project for the Balranald community is considered to be positive. This assessment is based on the outcomes of comprehensive stakeholder engagement with the Balranald community and the test of whether a proposal is likely to have, in planning terms, 'acceptable' or 'reasonably acceptable' outcomes.

The key social benefits of the Balranald Project as a result of employment and expenditure are considered to be:

- enhancement of the local and regional economies; and
- assisting to arrest predicted local and regional population decline, diminishing availability of services and facilities in the Balranald region and declining community sustainability.

The Balranald Project has the potential to diversify and strengthen the region's economic base. It would likely increase the size of a number of industry sectors — particularly mining, but also mining related services such as mechanical repairs, utilities, wholesale and retail trade, accommodation and entertainment.

Businesses in the region would likely benefit through direct expenditure and the extra money injected into the area through mine employment and services catering to the Balranald Project.

These factors mean the economy of the Balranald region could be more resilient in the short and longer term. During construction and operations there would be greater economic activity and employment opportunities than currently exist. The social benefits of stronger local and regional economies would include more diverse employment opportunities for local residents and the availability of enhanced retail and other businesses.

Although the Balranald Project has the potential to have some negative social, through the application of identified mitigation measures, the identified impacts could be avoided, reduced to acceptable levels or managed through the life of the Balranald Project. As a result of the key social benefits of the Balranald Project identified above, it is expected that the project would have a net community benefit for the Balranald community.

16 Economics

16.1 Introduction

The EIS Guidelines require an assessment of social and economic matters. They state:

> **10 ECONOMIC AND SOCIAL MATTERS**
>
> The short-term and long-term economic and social impacts of the action, both positive and negative, must be analysed and described. Matters of interest should include, but not be limited to:
>
> a) details of any public consultation activities undertaken, and their outcomes;
>
> b) projected economic costs and benefits of the project, including the basis for their estimation through cost/benefit analysis or similar studies; and
>
> c) employment opportunities expected to be generated by the project (including construction and operational phases).

To address these requirements, social and economic assessments of the Balranald Project were prepared. The results of the social assessment are summarised in Chapter 15. The results of the economics assessment is summarised in this chapter.

The economics assessment for the Balranald Project was prepared by Gillespie Economics (Appendix N). Commercially sensitive information contained in the economic assessment has been blacked out. A copy of the assessment without the information blacked out has been separately provided to DoE for the purpose of its assessment of the Balranald Project.

The economic assessments were completed in accordance with the following guidance documents:

- *Draft Guideline for Economic Effects and Evaluation in Environmental Impact Assessment* (the draft 2002 guideline) (James and Gillespie 2002);
- *Guideline for the use of Cost Benefit Analysis in mining and coal seam gas proposals* (the 2012 guideline) (NSW Government 2012); and
- *NSW Government Guidelines for Economic Appraisal* (NSW Treasury 2007).

This chapter provides a summary of the economic assessment prepared by Gillespie Economics.

16.2 Economic environment

The assessment of the potential economic impacts of the project on agricultural resources provides information of the value of the agricultural and mining industries to the NSW and local/regional economies. For the purposes of the assessment, Gillespie Economics has defined the region as comprising the LGAs in an approximate 200 km radius of the Balranald Project, including the LGAs of Balranald, Deniliquin, Hay, Murray, Wakool, Wentworth, Mildura and Swan Hill.

16.2.1 New South Wales

i Land use

Agricultural lands cover approximately 81% of NSW (Australian Natural Resources Atlas [ANRA] 2009a). While the total agricultural land area in NSW has declined marginally since 1960, the area of land under major food crop production (wheat and barley) has increased.

Mining land use is a small fraction of the area of NSW with less than 0.1% of the total NSW land area taken up by mining (Bureau of Regional Science 2009).

In NSW, dryland and irrigated cropping land covers an area of 84,878 km^2. Mining covers an area of 630 km^2, 0.74% of the area of cropping lands (Table 16.1).

Table 16.1 NSW land use

Land use	Area (km^2)	Area (%)
Nature conservation	61,058	7.6%
Other protected areas	2,478	0.3%
Minimal use	59,178	7.4%
Grazing native vegetation	309,428	38.6%
Production forestry	25,242	3.2%
Plantation forestry	4,200	0.5%
Grazing modified pastures	222,164	27.7%
Dryland cropping	74,692	9.3%
Dryland horticulture	390	0.0%
Irrigated pastures	3,160	0.4%
Irrigated cropping	10,186	1.3%
Irrigated horticulture	1,073	0.1%
Land in transition	951	0.1%
Intensive animal and plant production	243	0.0%
Intensive uses (mainly urban)	10,218	1.3%
Rural residential	4,387	0.5%
Mining and waste	630	0.1%
Water	11,352	1.4%
Total	**801,030**	**100.0%**

Source: Bureau of Rural Sciences (2009).

ii Employment

The NSW agricultural industry directly provides employment for 68,883 people or 2.3% of total employment in NSW (ABS, 2011a). Payment to agriculture, forestry and fishing employees in 2010-11 was $1,539 M and value-added was $7,062 M. Gross operating surplus and gross mixed income from agriculture, forestry and fishing was $6,908 M (ABS 2011b).

Mining directly employs 29,798 or 1.0% of total employment in NSW (ABS 2011a). Payment to mining employees in 2010-11 was $2,466 M and value-added was $10,633 M. Gross operating surplus and gross mixed income from mining was $10,035 M (ABS 2011b).

Mining is a more significant sector than agriculture in terms of payments to employees, value-added and gross operating surplus and gross mixed income. However, agriculture employs more people, albeit while using a much larger area of NSW to achieve this employment.

iii Economic growth

Agriculture has historically supported the economies of regional areas. However, these regional economies are facing a number of trends including:

- loss of significant industries such as abattoirs and timber mills from many rural areas;
- increased mechanisation of agriculture and aggregation of properties, resulting in loss of employment opportunities in this industry;
- preference of Australians for coastal living, particularly for retirement; and
- preference of many of today's fastest growing industries for locating in large cities (Collits 2001).

The result is that there has been declining population growth in 47 out of 96 rural SLAs that are located in non-coastal statistical subdivisions in NSW (excluding Hunter Statistical Division) (ABS 2011c). There has also been a decline in the population of smaller towns even in regions that have been growing.

Trends in agriculture are leading to improved productivity, but reduced economic stimulus in regional areas, as demand for inputs such as labour decline. In general, the prosperity of rural areas that are reliant on agriculture has also been in decline.

It is increased or new spending in regions that contributes to economic stimulus and growth. One potential source of new spending is mining projects that utilise the resource endowments of a region. Studies (Gillespie Economics 2003, 2007) have shown that mining projects provide significant new economic activity to regional and rural economies through direct expenditures on inputs to production as well as the expenditure of employees. This latter stimulus is enhanced by the high wages paid in the mining sector.

Mining projects can also broaden the economic base of regions, thereby insulating the economy from external shocks such as droughts and downturns in agricultural commodity prices (Collits 2001).

iv Water

In NSW, the agriculture sector consumes the largest volume of water with 2,127 GL, or 49% of NSW water consumption in 2009-2010. Mining is a relatively small consumer of water, using 62 GL or 1% of NSW water consumption in 2009-2010 (Table 16.2).

Table 16.2 NSW Water Consumption 2009-2010

Sector	GL	%
Agriculture	2,127	49%
Forestry and fishing	1	0%
Mining	62	1%
Manufacturing	142	3%
Electricity and gas	68	2%
Water supply(a)(b)	1,001	23%
Other industries(c)	357	8%
Household	565	13%
Total	**4,323**	**100%**

Source: *ABS (2011d).*

Notes *(a) Includes sewerage and drainage services.*

(b) Includes water losses.

(c) Includes aquaculture and services to agriculture.

Water productivity is one measure of water efficiency and can be expressed as the amount of output produced from one unit of water. Table 16.3 provides data on water consumption and industry gross value added for 2009–2010, from which water intensity by industry can be calculated. Mining in Australia recorded (on average) $196 M in gross valued added per GL of water consumed in 2009–2010. This compares to the agriculture sector which generated, on average, $3 M in gross value added for every GL of water consumed.

Table 16.3 Industry gross value added for water using industries2009–2010 (Australia)

Industry		Industry gross value added[a]	Water consumption	Industry gross value added per GL of water consumed
		$M	GL	$M/GL
Agriculture, forestry and fishing	Agriculture	24,265	6,987	3
	Aquaculture, forestry, fishing	4,499	200	22
	Total agriculture, forestry and fishing	28,764	7,187	25
Mining	Coal mining	22,576	76	298
	Oil and gas extraction	26,340	34	785
	Other mining[b]	38,880	336	116
	Exploration and mining support services	8,309	44	187
	Total mining	96,105	490	1,386

Table 16.3 Industry gross value added for water using industries2009–2010 (Australia)

Industry		Industry gross value added[(a)]	Water consumption	Industry gross value added per GL of water consumed
		$M	GL	$M/GL
Manufacturing	Food, beverages and tobacco	23,953	301	80
	Wood and paper products	7,736	81	96
	Printing, publishing and record media	4,088	4	941
	Petroleum, coal, chemical and associated products	17,807	77	230
	Non-metallic, mineral products	5,783	33	176
	Metal products	21,310	139	153
	Machinery and equipment	19,881	9	2,134
	Other manufacturing (includes furniture)	3,047	1	2,998
	Total manufacturing	103,605	645	6808
Electricity and gas		18,837	297	64
Water supply, sewerage and drainage		7,191	1,893	4
All other industries		944,442	1,084	871
Total		**1,198,944**	**11,596**	**9,158**

Source: *ABS (2011d).*

Notes: *(a) At 2009–10 current prices.*

(b) Includes services to mining.

16.2.2 Region

As previously stated, the region is defined as the LGAs of Balranald, Deniliquin, Hay, Murray, Wakool, Wentworth, Mildura and Swan Hill. However, some information is also provided in relation to the Balranald LGA and the LGAs of the total region that are located in NSW.

The total region has a combined land area of about 10 million hectares (Mha), of which 79% is agricultural land (see Table 16.4). Of this agricultural land, 3% is irrigated with annual irrigation volumes of approximately 1,099 GL. The total value of agricultural production in the region in 2006 is estimated at $1,379 M. The value of agriculture in Balranald LGA, in 2006, is estimated at $83 M (see Table 16.4).

Table 16.4 Agricultural land use and value of production in region 2006

	Units	Balranald	Balranald, Deniliquin, Hay, Murray, Wakool, Wentworth	Total region
Area				
Land area	ha '000	2,170	7,130	9,951
Area of agricultural land	ha '000	1,727	6,435	7,862
Irrigation				
Area irrigated	ha '000	8	178	236
Irrigation volume applied	ML	42,863	760,165	1,081,614
Other agricultural uses	ML	1,675	14,943	17,608
Total water use	**ML**	**48,443**	**778,851**	**1,117,271**
Area irrigated as proportion of agricultural land	%	1%	2.8%	3.0%
Value				
Gross value of crops	$M	57	401	1,163
Gross value of livestock slaughtering	$M	17	102	134
Gross value of livestock products	$M	8	61	81
Total gross value of agricultural production	**$M**	**82**	**564**	**1,378**

Source: *ABS (2011).*

Note: *Totals may have minor discrepancies due to rounding.*

The input-output table developed for the region (see Appendix P) provides an indication of the direct relative significance of the different agricultural sectors, affirming other agriculture (which includes grapes and fruit growing) and grains as the main agricultural sectors.

Total employment in the agricultural industry in the region in 2011 was 5,353 (ABS, 2013). Table 16.5provides a more detailed employment by industry breakdown which indicates that the main agricultural employment is in grape growing, other grain growing and grain-sheep or grain beef cattle farming.

Table 16.5 Employment by agricultural sectors in the region 2011

Sector	No.
Agriculture, forestry and fishing	30
Agriculture	190
Nursery production (outdoors)	84
Turf growing	9
Floriculture production (outdoors)	15
Mushroom and vegetable growing	3
Mushroom growing	44
Vegetable growing (under cover)	3
Vegetable growing (outdoors)	213
Fruit and tree nut growing	160
Grape growing	1,355
Berry fruit growing	3
Stone fruit growing	184

Table 16.5 Employment by agricultural sectors in the region 2011

Sector	No.
Citrus fruit growing	421
Olive growing	12
Other fruit and tree nut growing	181
Sheep, beef cattle and grain farming	8
Sheep farming (specialised)	356
Beef cattle farming (specialised)	133
Beef cattle feedlots (specialised)	5
Sheep-beef cattle farming	106
Grain-sheep or grain-beef cattle farming	675
Rice growing	7
Other grain growing	723
Cotton growing	12
Other crop growing	15
Dairy cattle farming	98
Pig farming	31
Beekeeping	15
Other livestock farming	11
Aquaculture	3
Onshore aquaculture	6
Forestry	8
Logging	8
Fishing, hunting and trapping	4
Hunting and Trapping	8
Forestry support services	8
Agriculture and fishing support services	3
Shearing services	35
Other agriculture and fishing support services	168
Total	**5,353**

Source: ABS (2013b).

Mining and extractive industries in the region directly employees 348 people, with most of these in mineral sand mining (Table 16.6).

Table 16.6 Employment by mining and extractive industries in the region 2011

Sector	No.
Mining	34
Oil and gas extraction	3
Metal ore mining	4
Iron ore mining	7
Mineral sand mining	252
Non-metallic mineral mining and quarrying	3
Gravel and sand quarrying	4
Other construction material mining	15
Other non-metallic mineral mining and quarrying	7
Exploration	3
Mineral exploration	5
Other mining support services	11
Total	**348**

Source: ABS (2013b).

16.3 Impact assessment

16.3.1 Assessment method

Two economic aspects of the Balranald Project have been considered:

- its economic efficiency (ie consideration of costs and benefits), which was evaluated using benefit cost analysis (BCA); and
- its economic impacts (ie the economic activity that the Balranald Project will provide to the local/regional and NSW economy).

The draft 2002 guideline identifies economic efficiency as the key consideration of economic analysis. It identifies BCA as essential for a proper economic evaluation of proposed developments that are likely to have significant environmental impacts. The 2012 guideline endorses BCA as the appropriate methodology for evaluating mining proposals. A consideration of the economic efficiency of the Balranald Project based on a BCA is provided in the following sections.

The 2012 guideline indicates that regional economic impact assessments may provide more information as an adjunct to the economic efficiency analysis. Economic stimulus to the local economy can be estimated using input-output modelling of the regional economy.

It is important not to confuse the results of the economic impact assessment, which focuses on indicators of economic activity (ie direct and indirect output (expenditure/revenue), value-added, income and employment) in a specific region, with the results of BCA which is concerned with the net benefits from a project.

16.3.2 Benefit cost analysis

For a project to be economically desirable, it must be more economically efficient (or beneficial) than a no-project scenario. A project is more economically efficient than having no project if the benefits to society exceed the costs. For mining projects, the main benefit is the producer surplus (net production benefits) generated, while the main costs are any adverse environmental, social and cultural impacts.

i Steps in BCA

BCA of the Balranald Project involves the following key steps:

- identification of the base case;
- identification of the Balranald Project and its implications (ie benefit and costs);
- quantification and valuation of the incremental benefits and costs;
- consolidation of value estimates using discounting to account for temporal differences;
- application of decision criteria;
- undertake sensitivity testing; and
- consideration of non-quantified benefits and costs.

The BCA is based on financial, technical and environmental information reported in this EIS.

ii Base case

BCA has to identify a base case or 'no-project' scenario for a comparative measurement of the benefits and costs of the Balranald Project. For the Balranald Project, the base case would continue existing rural and other land uses in the project area.

In contrast, the Balranald Project comprises mineral sand mining for a period of about nine years, materials handling and transport of minerals to port for export. At the end of the project it is assumed that the residual value of capital equipment and land would be realised through sale or alternative use.

Alternatives for the Balranald Project have been considered. However, the Balranald Project assessed in the EIS and evaluated in the BCA is considered by Iluka to be the most feasible alternative for minimising environmental and social impacts whilst maximising resource recovery and operational efficiency. It is therefore this alternative that is proposed by Iluka and was subject to detailed economic analysis.

iii Identification of benefits and costs

Relative to the base case, the Balranald Project may have the potential incremental economic benefits and costs shown in Table 16.7. The main potential economic benefit is the producer surplus (net production benefits) generated by the Balranald Project and any non-market employment benefits it provides, while the main potential economic costs relate to any environmental, social and cultural costs.

Table 16.7 Potential incremental economic benefits and costs of the Balranald Project

Category	Benefits	Costs
Net production benefits and costs	• Value of minerals • Residual value of capital equipment and land at end of project	• Opportunity costs of capital equipment • Opportunity cost of land[1] • Development costs including labour, capital equipment and acquisition costs for impacted properties and offsets[1] • Operating costs of mine including labour and mitigation measures • Rehabilitation and decommissioning costs at end of the project
Potential environmental, social and cultural benefits and costs	• Any non-market benefits of employment	• Greenhouse gas impacts • Noise impacts • Air quality impacts • Surface water impacts • Groundwater impacts • Ecology impacts • Transport impacts • Aboriginal heritage impacts • Non-Aboriginal heritage impacts • Visual impacts

Notes: 1 = the value of foregone agricultural production is included in the value of land.

It should be noted that the potential environmental, social and cultural costs are only economic costs to the extent that they affect individual and community well-being through direct use of resources by individuals or non-use. If the potential impacts do not occur or are mitigated to the extent where community wellbeing is insignificantly affected (ie those bearing the costs are fully compensated), then no environmental, social or cultural economic costs should be included in the BCA apart from the mitigation, compensation or offset costs.

iv Quantification and valuation of benefits and costs

Consistent with NSW Treasury (2007) guidelines, the analysis has been undertaken in real values with discounting at 7% and sensitivity testing at 4% and 10%. The analysis period is 15 years. Any impacts that occur after the analysis period are included in the analysis as a present value in the final year of the analysis.

Where competitive market prices are available, they have generally been used as an indicator of economic values. Environmental, cultural and social impacts have initially been left unquantified and interpreted using the threshold value method. An attempt has also been made to estimate environmental, cultural and social impacts using market data and benefit transfer. However, even with the inclusion of these values, the estimated net social benefits of the Balranald Project provide a threshold value that any residual or non-quantified economic costs would need to exceed to make the Balranald Project questionable from an economic efficiency perspective.

a. Net production benefits

The following production benefits have been included in the BCA.

Value of minerals

The main economic benefit of the Balranald Project is the market value of the mineral concentrates of zircon, rutile, leucoxene and ilmenite. Both demand and supply of these minerals influences current and projected prices. Iluka has provided its projection of annual revenue that it expects would be generated from the project and this has been included in the analysis. There is uncertainty around future prices (valued in USD) as well as the AUD/USD exchange rate. Iluka has provided a projection of annual revenue that is based on current forecast pricing by an independent consulting company (in US dollars) and an assumed AUD/USD exchange rate.

Residual value of capital equipment and land

The estimated residual value of capital equipment and land was considered for the Balranald Project economic assessment.

b. Net production costs

Opportunity costs of land and capital

There is an opportunity cost associated with using land already owned by Iluka instead of its next best use (ie rural production). However, Iluka advises that all land required for the Balranald Project will be purchased as part of the development costs of the Balranald Project.

Iluka propose to relocate the processing facilities currently located at WRP to the Balranald Project. There is an opportunity cost associated with using this and other equipment that is already in Iluka ownership for the Balranald Project, instead of sale. However, there would only be a limited number of potential purchasers of this equipment for reuse in mineral sand mining operations and given the cost of dismantling and relocating it for use by any prospective purchaser the willingness to pay for it is expected to be modest. An indicator of the opportunity cost of using this equipment in the Balranald Project was estimated using its scrap metal value.

Development costs

Development costs of the Balranald Project are associated with the purchase of equipment, development of the project area, land acquisitions and sustaining capital. These costs include labour costs during the development of the Balranald Project, which reflect the value of labour resources in their next best use.

These development costs include an allowance for environmental mitigation costs including acquisition of land for properties adversely affected by noise and biodiversity offsets. Development costs are included in the economic analysis in the years that they are expected to occur.

Annual operating costs

The operating costs of the Balranald Project include those associated with mine operation, processing of extracted ore, transportation of the HMC and ilmenite, minerals delivery (rail freight and port handling and loading) and general costs (including overheads and administration). These costs include labour costs, which reflect the value of labour resources in their next best use. The Balranald Project's average annual operating costs (excluding royalties) are estimated at 96 M present value.

Rehabilitation and decommissioning costs

At the end of the Balranald Project, the mine site will be rehabilitated and decommissioned over a two to five year period. Rehabilitation and decommissioning costs were included in the assessment based on estimates provided by Iluka.

c. Potential environmental, social and cultural benefits

The Balranald Project will directly employ a large construction and operational workforce over a number of years. Using benefit transfer from studies undertaken on other mining operations (Gillespie Economics 2013) and applying the employment value to the estimated incremental direct employment of the Balranald Project gives an estimated $16 M for the nonmarket employment benefits of the Balranald Project to NSW households. At a regional level the benefit would be $0.2 M.

Gillespie Economics (2013) states that due to the potential for contention about the inclusion of the increased the values of employment, the results have been reported both with and without it.

d. Potential environmental, social and cultural costs

Potential environmental, social and cultural costs have been estimated based on the results of all technical studies. These cost estimates can be seen in Section 3.4.2 of the economic assessment.

v Consolidation of value estimates

The present value of costs and benefits, using a 7% discount rate, is provided in Table 16.8. The main decision criterion for assessing the economic desirability of a project to society is its net present value (NPV). NPV is the present value of benefits less the present value of costs. A positive NPV indicates that it would be desirable from an economic perspective for society to allocate resources to the project, because the community as a whole would obtain net benefits from the project.

The Balranald Project is estimated to have total net production benefits of $149 M. Assuming 55% foreign ownership, $132 M of these net production benefits would accrue to Australia. This is the net production benefits of the project minus net profit accruing to the proponent.

The estimated net production benefits that accrue to Australia can be used as a threshold value or reference value against which the relative value of the residual environmental impacts of the Balranald Project, after mitigation, may be assessed. This threshold value is the opportunity cost to society of not proceeding with the project. The threshold value indicates the price that the community must value any residual environmental impacts of the project (be willing to pay) to justify in economic efficiency terms the no development option.

For the Balranald Project to be questionable from an economic efficiency perspective, all incremental residual environmental impacts from the project, that impact Australia, would need to be valued by the community at greater than the estimate of the Australian net production benefits (ie greater than $132 M). This is equivalent to each household in the region valuing residual environmental impacts at $3,270. The equivalent figure for NSW and Australian households is $50 and $16, respectively.

Instead of leaving the analysis as a threshold value exercise, an attempt has been made to quantify the residual environmental impacts of the Balranald Project that are associated with mining and transportation within NSW. From Table 16.8 it can be seen that most of the potential impacts are internalised into the operating costs of Iluka Resources via mitigation, offset or compensation, and hence are incorporated into the estimate of net production benefits. Other impacts to Australia are estimated at $1 M, considerably less than the estimated net production benefits of the Balranald Project to Australia.

Overall, the Balranald Project is estimated to have net benefits to Australia of between $132 M and $148 M, and hence is desirable and justified from an economic efficiency perspective.

While the major environmental, cultural and social impacts have been quantified and included in the BCA, any other residual environmental, cultural or social impacts that remain unquantified would need to be valued at greater than between $123 M and $148 M for the Balranald Project to be questionable from an Australian economic perspective.

Table 16.8 Results of BCA (present values @7% discount rate)

	Costs **Description** **Value ($M)**		**Benefits** **Description** **Value ($M)**
Production	Opportunity cost of land		Value of minerals
	Opportunity cost of capital		Residual value of capital
	Development costs		Residual value of capital
	Operating costs ex royalties		-
	Decommissioning and rehabilitation costs		-
Net production benefits			**$149 ($132)**
Non-market impacts in NSW	Greenhouse gas impacts	$19 ($0)	Non-market values of employment
	Agricultural impacts	Opportunity cost of foregone agriculture included in capital costs (land acquisitions)	-
	Noise impacts	Allowance for acquisition and mitigation measures included in capital costs	-
	Air quality impacts	No material impacts	-
	Surface water	Cost of water included in capital costs	-
	Groundwater	Cost of water and licensing of return flows including in capital costs	-
	Ecology	Some loss of values but offset. Cost of biodiversity offset included in capital costs and operating costs	-
	Road transport impacts	Required road works and road maintenance costs included in the capital and operating costs of the Project	-
	Aboriginal heritage	Unquantified but costs of implementing the recommendations of the archaeological investigations included in capital and operating costs	-

Table 16.8 Results of BCA (present values @7% discount rate)

	Costs Description Value ($M)		Benefits Description Value ($M)
	Non-Aboriginal heritage impacts	No material impacts	-
	Visual impacts	Costs of mitigation included in capital costs of the Project. Residual impacts not material	-
Non-market impacts outside NSW	Material handling and transportation	Unquantified but activities regulated	-
Net social benefits – including employment benefits			**$146 M ($148)**
Net social benefits – excluding employment benefits			**$130 M ($132)**

Note: *Totals may have minor discrepancies due to rounding. When impacts accrue globally, the numbers in brackets relates to the level of impact estimated to accrue to Australia.*

** from an aggregate economic efficiency perspective.*

vi Sensitivity analysis

Uncertainty in a BCA can be addressed through changing the values of critical variables in the analysis (James and Gillespie, 2002) to determine the effect on the NPV. Accordingly, a sensitivity analysis was undertaken on the results of the BCA, where the results were tested for 20% (+ and -) changes to the following variables at a 4%, 7% and 10% discount rate:

- opportunity costs of land;
- opportunity costs of capital equipment;
- development costs;
- operating costs;
- rehabilitation and decommissioning costs;
- mineral value;
- residual value of capital;
- residual value of land; and
- greenhouse costs.

What the analysis indicates is that BCA undertaken at the national level is most sensitive to changes in revenue (reflecting production levels, the value of minerals in USD and the AUD/USD exchange rate) and operating costs, with the former impacting royalties and company tax estimates and the latter impacting company tax estimates only. The analysis is not sensitive to changes in capital costs, opportunity costs of land and capital equipment, decommissioning and rehabilitation cost, residual capital and land costs or environmental costs that have not already been internalised into production costs, such as greenhouse gas costs.

16.3.3 Economic impacts

The focus of regional economic impact assessment is the effect (impact) of a project on the economy in terms of a number of specific indicators of economic activity, such as gross regional output, value-added, income and employment. These indicators can be defined as follows:

- gross regional output – the gross value of business turnover;
- value-added – the difference between the gross regional output and the costs of the inputs of raw materials, components and services bought in to produce the gross regional output;
- income – the wages paid to employees including imputed wages for self-employed and business owners; and
- employment – the number of people employed (including full-time and part-time).

A range of methods can be used to examine the economic impacts of an activity on an economy including economic base theory, Keynesian multipliers, econometric models, mathematical programming models and input-output models (Powell et al, 1985). Gillespie Economics used input-output analysis, consistent with the draft2002 guideline.

i Input-output analysis

Input-output analysis essentially involves two steps:

- construction of an appropriate input-output table (regional transaction table) that can be used to identify the economic structure of the region and multipliers for each sector of the economy; and
- identification of the initial impact or stimulus of the Balranald Project (construction and/or operation) in a form that is compatible with the input-output equations so that the input-output multipliers and flow-on effects can then be estimated (West, 1993).

ii Economic structure of region

A highly aggregated input-output table for the regional economy in 2011 (refer to Table 4.1 in economic assessment) shows that output for the regional economy is estimated at $16,206 M.

Value-added for the regional economy is estimated at $4,474 M, comprising $1,689 M to households as wages and salaries (including payments to self-employed persons and employers) and $2,785 M in other value-added goods and services imported from outside the region.

The total number of people employed and in the regional economy was 37,689.

The economic structure of the regional economy can be compared with that for NSW through a comparison of results from the respective input-output models. This reveals that the agriculture sectors, trade and accommodation sectors and public/personal services sectors in the regional economy are of greater relative importance than they are to the NSW economy, while the business services sectors are of less relative importance than they are to the NSW economy. The mining sectors, manufacturing sectors, utilities sectors and building sectors are of similar relative importance in the regional and NSW economy.

In terms of output, retail trade, other agriculture and food manufacturing are the most significant sectors to the regional economy. For value-added, the retail trade sectors, other agriculture sectors and the ownership of dwellings sectors are the most significant. The education sectors, retail trade sectors, health sectors, public administration sectors, and community care sectors are the most significant sectors for household income. The retail trade sector, accommodation and restaurants sectors, other agriculture sectors and education sectors are the most significant employer in the regional economy. The food manufacturing sectors and other agriculture sectors are the most significant sectors for regional imports and exports.

iii Economic impact

a. Construction

Given the largely specialist nature of capital equipment and the relatively small size of the regional economy, it has been assumed that all purchases and the leasing of machinery are made outside the regional economy. Thus regional economic activity from the construction phase of the Balranald Project primarily relates to the heavy and civil engineering construction sector and construction services sector.

The average construction workforce required for the Balranald Project during the construction period is 209 (with a peak of 450). Based on the input-output coefficients of the heavy and civil engineering construction sector and construction services sector in the regional economy transactions table (indexed to 2014), approximately $75 M per annum of the development costs would need to be spent in these sectors within the region to result in a direct workforce of 209 people. The direct and indirect regional economic impact of this level of expenditure in the regional economy is reported in Table 16.9.

Table 16.9 Economic impacts of construction on the regional economy

	Direct effect	Production induced	Consumption induced	Total flow on	Total
Output ($'000)	75,422	45,408	15,044	60,452	135,873
Type 11A ratio	1.00	0.60	0.20	0.80	1.80
Value added ($'000)	24,663.4	17,708.8	8,295.2	26,003.9	50,667.3
Type 11A ratio	1.00	0.72	0.34	1.05	2.05
Income ($'000)	12,742	8,179	2,846	11,024	23,766
Type 11A ratio	1.00	0.64	0.22	0.87	1.87
Employment (no.)	209	141	70	211	420
Type 11A Ratio	1.00	0.68	0.33	1.01	2.01

In total, annual impact of construction of the Balranald Project on the regional economy is estimated at up to:

- $136 M in annual direct and indirect regional output or business turnover;
- $51 M in annual direct and indirect regional value added;
- $24 M in annual direct and indirect household income; and
- 420 direct and indirect jobs.

The Type 11A ratio multipliers for the construction phase in the regional economy range from 1.80 for output up to 2.05 for employment.

Flow-on impacts from the construction phase of the Balranald Project are likely to affect a number of different sectors of the local and regional economy. The sectors most impacted by output, value-added and income flow-ons are likely to be construction services, wholesale and retail trade, ownership of dwellings, road transport, heavy and civil engineering construction and food and beverage.

iv Operations

a. Regional economy

The annual economic impacts of the Balranald Project on the regional economy are shown in Table 16.10.

Table 16.10 Economic impact of operations on the regional economy

	Direct effect	Production induced	Consumption induced	Total flow-on	Total
Output ($'000)	618,148	294,752	51,794	346,546	964,694
Type 11A ratio	1.00	0.48	0.08	0.56	1.56
Value added ($'000)	152,657	118,437	28,559	146,996	299,653
Type 11A ratio	1.00	0.78	0.19	0.96	1.96
Income ($'000)	47,438	24,590	9,798	34,388	81,825
Type 11A ratio	1.00	0.52	0.21	0.72	1.72
Employment (no.)	554	496	239	735	1,289
Type 11A Ratio	1.00	0.90	0.43	1.33	2.33

During the operational phase, the Balranald Project is estimated to make up to the following annual contribution to the regional economy:

- $965 M in annual direct and indirect regional output or business turnover;
- $300 M in annual direct and indirect regional value added;
- $82 M in annual direct and indirect household income; and
- 1,289 direct and indirect jobs.

The Type 11A ratio multipliers for the Balranald Project impact on the regional economy range from 1.56 for value-added up to 2.33 for employment.

Flow-on impacts from the Balranald Project are likely to affect a number of different sectors of the regional economy. The sectors most impacted by output, value-added and income flow-ons are likely to be the:

- road transport sector;
- professional, scientific and technical services sector;
- retail trade sector;
- wholesale trade sector;
- electricity supply sector;

- food and beverage sector;
- ownership of dwellings;
- electricity transmission sector;
- residential building sector;
- construction service sector;
- education and training sector;
- building cleaning, pest control, administrative and other support services sector; and
- health care services sector.

b. NSW economy

The annual economic impacts of the Balranald Project on the NSW economy are shown in Table 16.11.

Table 16.11 Economic impact of operations on the NSW economy

	Direct effect	Production induced	Consumption induced	Total flow-on	Total
Output ($'000)	618,148	86,949	15,279	102,228	720,376
Type 11A ratio	1.00	0.14	0.02	0.17	1.17
Value added ($'000)	152,657	34,938	8,425	43,363	196,020
Type 11A ratio	1.00	0.23	0.06	0.28	1.28
Income ($'000)	47,438	7,254	2,890	10,144	57,582
Type 11A ratio	1.00	0.15	0.06	0.21	1.21
Employment (no.)	554	146	71	217	771
Type 11A Ratio	1.00	0.26	0.13	0.39	1.39

The Balranald Project is estimated to make up to the following annual contribution to the NSW economy:

- $720 M in annual direct and indirect regional output or business turnover;
- $196 M in annual direct and indirect regional value added;
- $58 M in annual direct and indirect household income; and
- 771 direct and indirect jobs.

The Type 11A ratio multipliers for the Balranald Project impact on the NSW economy range from 1.17 for output up to 1.39 for employment.

v Other economic impacts

a. Contraction in other sectors

Economic impacts for regional and State economies modelled using input-output analysis represent only the gross or positive economic activity associated with the Balranald Project. Where employed and unemployed labour resources in the region are limited and the mobility of in-migrating or commuting labour from outside the region is restricted there may be competition for regional labour resources that drives up local and regional wages. In these situations, there may be some 'crowding out' of economic activity in other sectors of the regional economy.

Crowding out would be most prevalent if the regional/NSW economy was at full employment and it was a closed economy with no potential to use labour and other resources that currently reside outside the region. However, the regional and State economy are not at full employment and they each have access to external labour resources. Consequently, little crowding out of economic activity in other sectors would be expected as a result of the project.

However, even where there is some crowding out of other economic activities this does not indicate losses of jobs but the shifting of labour resources to higher valued economic activities. This reflects the operation of the market system where scarce resources are reallocated to where they are most highly valued and where society would benefit the most from them. This reallocation of resources is therefore considered a positive outcome for the economy not a negative.

b. Regional economic impacts of displaced agriculture

The Balranald Project will result in a reduction in agricultural activity from:

- the agricultural disturbance area;
- the biodiversity offsets; and
- use of surface water resources.

The direct and indirect regional economic impacts of a reduction in regional agricultural output have been estimated using input-output analysis. A comparison of the regional economic impacts of the Balranald Project and the foregone agricultural production during the Balranald Project operation is provided in Table 16.12. The foregone agricultural regional economic activity impacts are between 0.1% and 0.8 of the regional economic activity impacts of the Balranald Project.

Table 16.12 Regional economic impacts of the Balranald Project and Displaced Agriculture

	Project	Agriculture Land	
	Impact	Impact	% of Project
Annual direct output value ($000)	618,148	748	0.1%
Annual direct value-added ($000)	152,657	410	0.3%
Annual direct income ($000)	47,438	111	0.2%
Direct employment (No.)	554	5	0.8%
Annual direct and indirect output ($000)	964,694	1,228	0.1%
Annual direct and indirect value-added ($000)	299,653	632	0.2%
Annual direct and indirect income ($000)	81,825	190	0.2%
Direct and indirect employment (No.)	1,289	6	0.5%

The BCA included estimation of the present value of production costs and benefits of the Balranald Project. The present value of net production benefits of the Balranald Project to Australia are estimated at $149 M, with in the order of $132 M accruing to Australia. These estimates include an allowance for the opportunity costs of the agricultural land. In contrast, the present value of foregone agriculture in perpetuity is estimated at $4 M.

The net production benefits of the Balranald Project to Australia are therefore 38 times those of displaced agriculture.

c. Wage impacts

In the short-run, increased regional demand for labour as a result of the Balranald Project could potentially result in some increases pressure on wages in other sectors of the economy. The magnitude and duration of this upward wages pressure would depend on the level of demand for additional labour, the availability of labour resources in the region and the availability and mobility of labour from outside the region. Where upward pressure on regional wages occurs it represents economic transfer between employers and owners of skills and would attract skilled labour to the region leading to downward pressure on wages.

vi Mine cessation

As previously outlined, the Balranald Project would stimulate demand in the regional and NSW economy during the construction and operational phases leading to increased business turnover in a range of sectors and increased employment opportunities. Conversely, the cessation of the mining operations in the future could result in a contraction in local, regional and NSW economic activity.

The magnitude of the local and regional economic impacts of cessation of the Balranald Project would depend on a number of interrelated factors at the time, including:

- the movements of workers and their families;
- alternative development opportunities; and
- economic structure and trends in the regional economy at the time.

Ignoring all other influences, the impact of Balranald Project cessation on the local and regional area would depend on whether the workers and their families affected would leave the local and regional area. If it is assumed that some or all of the workers remain in the local and regional area, then the impacts of Balranald Project cessation would not be as severe compared to a greater level leaving the local and regional area. This is because the consumption-induced flow-ons of the decline would be reduced through the continued consumption expenditure of those who stay (Economic and Planning Impact Consultants, 1989). Under this assumption, the regional economic impacts would approximate the direct and production-induced effects in Table 16.10. However, if displaced workers and their families leave the region then impacts would be greater and begin to approximate the total effects in Table 16.10.

The decision by workers, on cessation of the Balranald Project, to move or stay would be affected by a number of factors including the prospects of gaining employment in the local and regional economy compared to other regions, the likely loss or gain from homeowners selling, and the extent of attachment to the local and regional areas (Economic and Planning Impact Consultants, 1989).

To the extent that alternative development opportunities arise in the local and regional economy, the regional economic impacts associated with mining closure that arise through reduced production and employment expenditure can be substantially ameliorated and absorbed by the growth of the region. One key factor in the growth potential of a region is its capacity to expand its factors of production by attracting investment and labour from outside the region (BIE, 1994). This in turn can depend on a region's natural endowments. In this respect, the local and regional area is prospective with other mineral sand resources, including other resources that Iluka has access to.

It is therefore likely that, over time, new mining developments would occur, offering potential to strengthen and broaden the economic base of the local and regional area and hence buffer against impacts of the cessation of individual activities.

Ultimately, the significance of the economic impacts of cessation of the Balranald Project would depend on the economic structure and trends in the local and regional economy at the time. For example, if Balranald Project cessation takes place in a declining economy, the impacts might be significant. Alternatively, if Balranald Project cessation takes place in a growing diversified economy where there are other development opportunities, the ultimate cessation of the Balranald Project may not be a cause for concern.

Nevertheless, given the uncertainty about the future complementary mining activity in the local and regional economy it is not possible to foresee the likely circumstances within which Balranald Project cessation would occur.

16.3.4 Government finance

i Commonwealth

The main financial benefit from the Balranald Project to the Commonwealth Government is company tax and income tax from mine employees. Personal income tax from direct employees is estimated at $16 M present value.

ii State

The main financial benefit of the Balranald Project to NSW is the royalties paid. These are estimated at $96 M present value. In addition, the payroll tax to NSW from the operational employees of the Balranald Project is estimated at $3 M present value.

iii Local

BSC may directly benefit from higher rates on land used for the Balranald Project since rates for mining are generally higher than the land uses that it replaces.

While the Balranald Project will result in some increased demands on local roads, Iluka will negotiate equitable road maintenance agreements with the BSC to proportionally fund the ongoing road maintenance requirements for the council roads affected along the product transport route. Iluka will also contribute to the remedying of a number of existing deficiency is the road network (refer to the transport assessment in Appendix N).

Iluka is committed to entering into an agreement with BSC in relation to Iluka's contributions to and involvement in the local area and has commenced discussions regarding the scope and terms of such an agreement.

16.4 Management and mitigation

The Balranald Project will provide substantial economic benefit to the regional and NSW economies. Accordingly, no mitigation measures are considered necessary.

16.5 Conclusion

The Balranald Project is estimated to have total net production benefits of $148 M. Assuming 55% foreign ownership, $132 M of these net production benefits would accrue to Australia. This is the net production benefits of the project minus net profit accruing to the proponent.

Instead of leaving the environmental, cultural and social impacts unquantified an attempt was made to quantify them. The main quantifiable environmental impacts of the Balranald Project that have not already been incorporated into the estimate of net production benefits via mitigation, offset and compensation costs, relate to greenhouse gas emissions. These impacts to Australia are estimated at less than $ 1M, considerably less than the estimated net production benefits of the Balranald Project. There may also be some non-market benefits of employment provided by the Balranald Project which are estimated to be in the order of $16 M. Overall, the Balranald Project is estimated to have net social benefits to Australia of between $132 M and $148 M and hence is desirable and justified from an economic efficiency perspective.

While the main environmental, cultural and social impacts have been quantified and included in the Balranald Project BCA, any other residual environmental, cultural or social impacts that remain unquantified would need to be valued at greater than between $132 M and $148 M for the Balranald Project to be questionable from an Australian economic efficiency perspective.

While the major environmental, cultural and social impacts have been quantified and included in the BCA, any other residual environmental, cultural or social impacts that remain unquantified would need to be valued at greater than between $132 M and $148 M for the Balranald Project to be questionable from an Australian economic perspective.

Input-output analysis found that the operation of the Balranald Project is estimated to make up to the following contribution to the regional economy:

- $965 M in annual direct and indirect regional output or business turnover;
- $300 M in annual direct and indirect regional value added;
- $82 M in annual direct and indirect household income; and
- 1,289 direct and indirect jobs.

For the NSW economy, the operation of the Balranald Project is estimated to make up to the following contribution:

- $720 M in annual direct and indirect regional output or business turnover;
- $196 M in annual direct and indirect regional value added;
- $58 M in annual direct and indirect household income; and
- 771 direct and indirect jobs.

While the Balranald Project would result in some displacement of agricultural activity, these economic impacts are estimated at between 0.1% and 0.8% of the regional economic activity benefits of the project.

17 Rehabilitation and closure

17.1 Introduction

The EIS Guidelines require a description of the action including rehabilitation components. They state that the EIS must include a description of the action including:

> all the components of the action, including construction, operation, decommissioning and rehabilitation components;

A rehabilitation and closure strategy (RCS) for the Balranald Project was prepared by EMM (Appendix F). The RCS was prepared in accordance with the following regulations, methods and guidelines:

- *Mining Act 1992*;
- EDG03 – *Guidelines to the Mining, Rehabilitation & Environmental Management Process* (NSW Department of Trade and Investment 2012);
- *The Strategic Framework for Mine Closure* (ANZMEC and MCA 2000);
- *Mine Rehabilitation – Leading Practice Sustainable Development Program for the Mining Industry* (Commonwealth of Australia 2006); and
- *Mine Closure and Completion - Leading Practice Sustainable Development Program for the Mining Industry* (Commonwealth of Australia 2006).

This chapter is a summary of the RCS in Appendix F.

17.2 Rehabilitation objectives

The primary objectives for rehabilitation of the project area are to:

- create safe, stable and non-polluting landforms;
- restore self-sustaining ecosystems suitable for a final use determined in consultation with landholders and relevant government agencies; and
- progressively rehabilitate disturbed areas to make best use of favourable climatic and intrinsic conditions.

The secondary objectives are to:

- establish a 'base-case' plan that can be reviewed and updated during the life of the project;
- provide relevant information upon which stakeholders can comment and have input through the approval process; and
- ensure that closure planning (including accountability and resourcing) is incorporated into the on-going project operations.

The above objectives are considered consistent with the NSW *Mining Act 1992*, which is the principle legislation guiding rehabilitation of mines in NSW, and relevant government guidelines.

17.3 Operational rehabilitation

The following sections describe the general strategies and methods that would be implemented prior to and during operations in order to facilitate an effective rehabilitation program.

17.3.1 Seed collection

Where possible, seed would be collected from the disturbance area prior to ground disturbing activities.

It is possible that some plant species required for rehabilitation will not be able to be grown from seed collected from the disturbance area. In this case, discussion with OEH and/or DRE will be undertaken to use off-site plant material.

17.3.2 Vegetation clearing

Clearing of vegetation would be required ahead of the mining activities. Clearing of native vegetation would be performed in accordance with procedures developed specifically to meet the rehabilitation objectives for the project area.

Some overstorey timber would be retained and stockpiled for habitat enhancement purposes (see Section 17.6.5); the remainder may be mulched and stockpiled separately. For low open shrubland areas it may be appropriate to clear the understorey with the top soil layer. In other areas, the understorey may be cleared separately to the top soil.

A range of techniques would be considered for vegetation clearing depending on the location within the project area.

17.3.3 Surface soil stripping, stockpiling and management

The following would be considered when stripping top soil:

- top soil from different vegetation communities (where appropriate) would be maintained in separate stockpile categories;
- records would be maintained of top soil movements including soil type, quality, location, vegetation community, weeds present (if any), removal date, storage location and dust suppression treatment (if any);
- stripping would be completed in a way that, where possible, retains biological activity in the top soil and sub soil (which in turn would aid rehabilitation);
- the volume of soil retained and subsequently required for rehabilitation would be determined by availability (ie area available to be stripped and depth of stripping);
- earthmoving plant operators would be trained and supervised to ensure that stripping operations are conducted in accordance with stripping plans and in situ conditions;

- soil, where possible, should be stripped in a slightly moist condition and appropriate machinery would be used to minimise structural degradation without being trafficked or deep ripped prior to stripping;

- deep ripping may be necessary for deeper layers followed by dozing or scraping to remove the remainder of the soil with care taken not to mix any remaining top soil with sub soil;

- where practical the inclusion of obviously poorer quality material would be avoided (eg material dominated with stones);

- all machinery used in the stripping operation would be inspected to ensure that it is clean and free of soils and weed seeds prior to mobilisation;

- disturbance areas would be stripped progressively (ie only as required); and

- rehabilitation of disturbed areas (ie roads, embankments and batters) would be undertaken as soon as practicable after these structures are completed or as areas are no longer required.

Subsoil would be stripped separately to the top soil and stockpiled separately. The placement of sub soil during rehabilitation activities needs to be assessed with reference to the landscape position it was stripped from.

Once stripped, top soil and sub soil would be stockpiled for rehabilitation as follows:

- soil types with significantly different properties should be stockpiled separately;

- stockpiles would be located so that they would not be further disturbed by mining activities and positioned to avoid surface water flow;

- erosion and sediment controls would be installed around stockpile areas and regularly maintained;

- locations of stockpiles would be recorded using GPS and an inventory of data relating to the soil type, volumes and use in rehabilitation maintained by appropriate personnel;

- topsoil stockpiles would be retained at a height of no more than 3 m, while subsoil can be stockpiled to a maximum of 10 m dependent on soil properties, with slopes of both top soil and sub soil stockpiles no greater than a grade of approximately 1V:3H and a slightly roughened surface to minimise erosion;

- where ameliorants such as lime, gypsum or native suitable fertiliser are needed to improve the condition of stripped soil, it will be either applied to the stockpiles in-between the application of separate layers from the scrapers, or be spread on the soil prior to scraping;

- vehicle access on soil stockpiles would be prohibited except when necessary for soil quality monitoring; and

- weed management will be applied to stockpiles to minimise the accumulation of weed seed in the soil.

17.3.4 Overburden removal, handling and backfilling

Overburden would be removed using earthmoving equipment such as scrapers, excavators, shovel and trucks. Saline groundwater would not be used to control dust during top soil, sub soil or overburden stripping unless it can be shown that groundwater quality would not affect rehabilitation outcomes.

The majority of SOB would be returned directly to the backfill face and would not need to be stockpiled, except for initial stages of mining during the establishment of the initial boxcut. NSOB would be managed through a combination of stockpiling and replacement in the pit as backfill, or, retained in stockpile and rehabilitated, or returned directly to the backfill face.

Rehabilitation material volumes necessary to complete the earthworks associated with rehabilitation are summarised in Table17.1.

Table 17.1 Summary of rehabilitation material volumes

Mine	Rehabilitation material volumes (Mm^3)							
	SOB		NSOB			Tailings	MBP[4]	Final void volume (following reshaping to 1:10)
	Stockpiled and then backfilled	Backfilled immediatel y	Stockpiled and then backfilled	Backfilled immediately	Stockpiled - part of final landform	capped	All backfilled - at West Balranald	
West Balranald	5.5	128.0	26.8	26.7	16.1	NSOB s/p #6 is for capping TSF	8.3	5Mbcm
Nepean	n/a	n/a	5.9	29.2	n/a	n/a	2.3	<1 Mbcm

17.3.5 Acid mine drainage management implications for rehabilitation

Assessment of the geochemical characteristics of the ore body and overburden has been undertaken. Table 17.2 provides a summary of the handling and storage methods to mitigate any effect from potential acid mine drainage.

Table 17.2 Summary of overburden and ore geochemistry and storage strategies

Material		PAF/NA F	General geochemical properties	Storage Infrastructure	
				Operational storage (Short-Term)	Final storage (post-mining)
West Balranald mine	Overburden-non saline (NSOB)	NAF	Shallow, high in natural organic matter, above water table, low potential for leaching salts or metals.	Stockpiled (more than 6 months).	Used for revegetation or final covers where possible (as identified in rehabilitation methods).
	Overburden-saline (SOB)		Below water table, high in salinity, leaching of constituents elevated in saline groundwater including Na, Cl and Sulphate.	Stockpiled (initial boxcut ~6-30 months).	Returned to the pit.

Table 17.2 Summary of overburden and ore geochemistry and storage strategies

Material		PAF/NAF	General geochemical properties	Storage Infrastructure	
				Operational storage (Short-Term)	Final storage (post-mining)
	Overburden organics (OOB)	PAF	Highly reactive; testing shows a strong tendency to acidify rapidly. May generate acid, sulphate and metals.	Stockpiled (initial boxcut) 3 - 4 months.	This material is preferentially placed (over the overburden) into the pit void. It would remain dry for a brief period prior to rewetting due to groundwater recovery.
	Ore	PAF	Highly reactive; testing shows a strong tendency to acidify rapidly. May generate acid, sulphate and metals.	Transferred to ROM pad for a minimum of approximately 4 weeks prior to processing.	Transferred to the MUP for processing.
Nepean mine	Overburden	NAF	Non-reactive, showing a rapid leaching of soluble salts at moderate concentrations.	Stockpiled (initial boxcut ~6-30 months).	Returned to the pit.
	Ore	NAF	Non-acid forming but initially elevated in macro constituents.	Transferred to ROM pad for ~4 weeks prior to processing.	Transferred to the MUP for processing.
Process stream materials (underflow, sand tails, modified co-disposal (ModCoD), MBP)		All PAF	Most are acid forming with variable rates of reactivity.	Refer geochemistry assessment.	Once dried, are mostly placed into lower levels in the West Balranald pit void. Some would remain in TSF to be capped with NAF material.

17.4 Decommissioning

The following sections summarise the key aspects related to the decommissioning and closure of the various infrastructure components of the Balranald Project.

17.4.1 Mine services

All services including power, water and telecommunications would be isolated, disconnected and terminated to make them safe. Generally all underground services would be made safe and left buried in the ground. Overhead power lines would be removed and the materials (ie poles and wire) recovered for potential re-sale or recycling as applicable.

17.4.2 Infrastructure and buildings

The decommissioning of infrastructure and buildings would include:

- de-watering and de-silting of sumps prior to demolition;
- de-oiling, degassing, depressurising and isolation of equipment;
- the removal of all hazardous materials;

- removing or demolishing all buildings, including the administration building, workshop and processing facilities from site;
- breaking all concrete footings up to at least 1.5 m below the surface;
- all wastes would be assessed and classified in accordance with the *Waste Classification Guidelines* (DECC 2008) prior to disposal; and
- inert concrete waste would be crushed and then buried in the final void.

Where possible, assets may be re-used at, or sold to, other mines. After the completion of decommissioning, all areas would be reshaped, deep ripped, subsoiled, topsoiled and seeded in accordance with the RCS.

17.4.3 Roadways, car parks and hardstands

The roadways, car parks and hardstand areas around the workshop and administration areas would be ripped up and the inert waste material placed in the final void. All areas would then be reshaped, deep ripped, top soiled and seeded as required.

17.4.4 Fuel storages

Leading up to closure, a preliminary sampling and analysis program would be implemented to determine whether a more detailed contamination assessment is required for the fuel storages, including the diesel storage and refuelling area, gas storages and area where other hydrocarbons and chemicals are stored. This would assist to quantify the amount (if any) of contaminated material requiring remediation on-site or sent off-site for disposal at a licensed facility.

17.4.5 Water storage infrastructure

Water storage infrastructure would be decommissioned as follows:

- all sedimentation basins which assist in water flow from the final rehabilitated surface would be retained following closure;
- all basins would be assessed for structural integrity and upgrade works completed if the dam is to be retained;
- any remaining basins that are not required would be removed and the original drainage paths re-established wherever possible; and
- drainage lines would be restored with adequate controls to minimise the erosion within the channel, along with controls to prevent the migration of any erosion upstream or downstream.

17.4.6 Borrow pits

Borrow pits will be closed and rehabilitated earlier if the resource is exhausted prior to mine closure. Rehabilitation of borrow pits will typically include:

- removal of all infrastructure from site;
- deep ripping of compacted areas;

- placement of any material that was not suitable for construction purposes back into the excavation;
- pit walls will be battered to an appropriate angle to ensure they are safe, stable and suitable for the surrounding land use;
- previously stockpiled topsoil will be spread over the final landform and disturbed areas; and
- revegetation, seeding and/or planting (depending on the final land use).

17.5 Post mining land use

Establishment of native vegetation communities suitable for intermittent and low intensity grazing uses is the preferred final land use option. However, most areas are unlikely to be suitable for any form of grazing until such time that a successful and sustainable coverage of vegetative rehabilitation has been achieved.

The Balranald Project was broken up into seven domains as defined in the *Guidelines to the Mining, Rehabilitation & Environmental Management Process* (NSW Department of Trade and Investment 2012). Domains are defined as land management units within the Balranald Project with similar geophysical characteristics.

The seven proposed primary domains and secondary domains, their respective operational areas and post-mining land use are listed in Table 17.3. The pre-mining land use for all domains is described as grazing on pasture and shrublands. The proposed post mining land use is shown in Figure 17.1.

Table 17.3 Primary and secondary domains and final land use

Primary domain (area)	Description of operational use	Secondary domain (area)	Description of operational use	Post-mining land use
1. West Balranald mine (2,987 ha)	Mine path/mine void, associated access roads, stockpiles, dewatering infrastructure and gravel extraction areas	1a:Final Void (40 ha)	Final pit battered to 1:10 plus associated runoff controls and public/stock access protection	Chenopod shrublands-not grazed (fenced) until stable
		1b: Mine path – backfilled (506 ha)	Backfilled pit- subject to ongoing consolidation – residual depression	Grazing on chenopod shrublands Native woody vegetation
		1c: NSOB stockpiles (151 ha)	Final rehabilitated stockpiles #1 to #5	Grazing on chenopod shrublands Native woody vegetation
		1d:Residual mine area (external to pit) (2,290 ha)	Access pathways/service roads, former stockpile site footprints	Grazing on chenopod shrublands Native woody vegetation
2. Nepean mine (804 ha)	Mine path, associated access roads, dewatering infrastructure	2a:Final mine path backfilled including residual depression (136 ha)	Backfilled pit- subject to ongoing consolidation	Grazing on chenopod shrublands Native woody vegetation
		2b:Residual mine area (external to pit) (668 ha)	Access pathways/service roads, former stockpile footprints	Grazing on chenopod shrublands

Table 17.3 Primary and secondary domains and final land use

Primary domain (area)	Description of operational use	Secondary domain (area)	Description of operational use	Post-mining land use
3. West Balranald processing area (71 ha)	Processing plant, tailings storage facility, maintenance areas/workshops, final product stockpiles and truck load-out area, administration offices and amenities, top soil and other material stockpiles, internal road network and ancillary infrastructure	3a: TSF (26 ha)	Capped TSF and associated main collection dam	Grazing on chenopod shrublands (refer text)
		3b: Other infrastructure (45 ha)	Concentrator and all other infrastructure	Grazing on chenopod shrublands
4. Nepean infrastructure area (0.62 ha)	Maintenance areas/workshops, truck load-out area, offices and amenities, top soil and other material stockpiles, internal road network and ancillary infrastructure	n/a	n/a	Grazing on chenopod shrublands Native woody vegetation
5. West Balranald access road (72 ha)	Access road and accommodation facility	n/a	n/a	Grazing on chenopod shrublands or access road left in place
6. Nepean access road (15 ha)	Access Road	n/a	n/a	Grazing on chenopod shrublands or access road left in place as may be negotiated with landolder. Native woody vegetation
7. Injection borefield (1,435 ha)	Access tracks and borefield infrastructure	7a:Access Roads and pipelines (220 ha)	n/a	Grazing on chenopod shrublands. Access road left in place as may be negotiated with landholder
		7b:Borefield infrastructure (1,215 ha)		Grazing on chenopod shrublands

Revegetation of the domains from seed collected prior to ground disturbing activities and topsoil stockpile seed stores will be as follows:

- final void: selected native revegetation species following backfilling of the final void (subject to climatic conditions or water availability);
- mine path: belah woodland, dune Mallee and Sandplain Mallee;
- final NSOB stockpiles: initial cover crop to stabilise the growth medium material and then reseeding chenopods and other selected native revegetation species;
- residual mine areas (external to pit): regraded to the original ground level, top soiled and then reseeding with selected native revegetation species;

- processing area: reseeding selected native revegetation species, being primarily saltbush with a minor area of native woody species; and
- access roads, accommodation facility, borrow pits and injection borefields: reseeding selected native revegetation species.

Further information on the domains and how rehabilitation would be achieved is detailed in Section 3.6 of the RCS contained in Appendix F.

The most significant variation in the post-mining landform compared to pre-mining conditions would be the rehabilitated mine pit, including the final void at West Balranald, and areas where NSOB stockpiles remain in situ. These landforms would be rehabilitated in order to be compatible with the surrounding environment.

17.6 Rehabilitation methods for closure

Rehabilitation and decommissioning is expected to take a further two to five years following Year 9 of the operational phase.

17.6.1 Top soil and sub soil reinstatement, compaction and remediation

Upon decommissioning of infrastructure and hardstand areas at closure, compacted top soil and sub soil would be ripped under dry conditions to break up hard layers and provide a favourable root zone. These areas would be seeded with species appropriate to the identified post-mining land use. To alleviate any compaction that may have been caused by the movement of heavy machinery, all mined areas may be ripped to aid in reducing compaction of earth.

Subject to a mine specific evaluation, in areas of native vegetation rehabilitation, deep ripping may be implemented after the replacement of sub soil, but prior to replacement of the top soil.

Top soil and sub soil would be applied to landforms once they are re-contoured and drainage works are complete. Contour or diversion banks with stable discharge points would be constructed to limit slope lengths and control runoff. Collection drains and sedimentation dams would be installed to collect runoff and remove suspended sediment.

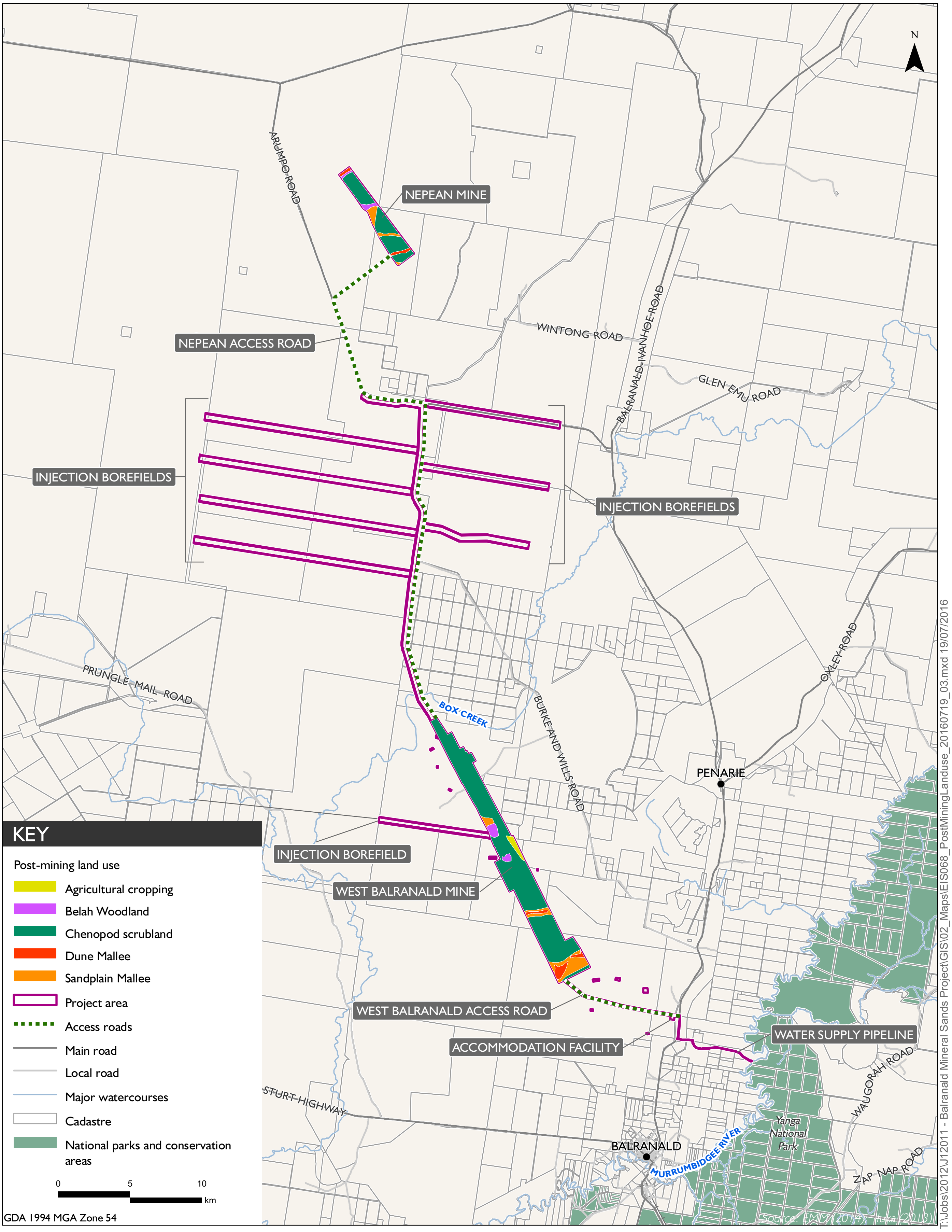
A number of matters would be addressed during the top soil and sub soil reinstatement. These are outlined in Section 4.1.2 of the RCS in Appendix F.

17.6.2 Drainage and erosion control

Restored surfaces would be stabilised as soon as practicable to reduce potential wind erosion and subsequent dust.

All rehabilitation areas and stockpiles would require stabilisation to protect them against the risk of erosion from wind or water. The most effective strategy for stabilisation would be trialled during the early stages of mining.

Drainage zones would not receive special erosion control treatments due to the infrequency of rainfall and subsequent flow events. If excessive sediment movement occurs then supplementary earthworks would be undertaken to return the drainage channels to design levels.



EMM ILUKA

Post-mining land use

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 17.1

17.6.3 Control of surface water inflow to void

The control of surface water inflow into the final void would be directed away from the void batters through the construction of interceptor channel drains around the perimeter of the final void batters. Uncontrolled surface water has the potential to cause slope deterioration and ultimate failure.

17.6.4 Revegetation

Disturbed areas will be revegetated predominantly from the top soil seed store. Direct seeding, planted seedlings and transplanting of seedlings would be introduced into the revegetation program if considered necessary, after assessment of rehabilitation germination success.

Revegetation practices are expected to evolve over the life of the Balranald Project, as part of the process of continual improvement. If required, seedlings shall be propagated from seed, cuttings or tissue culture. The target species for nursery propagation, and method of planting would subject to ongoing trials.

Tube stock is expected to be used only in strategic landscape planting in certain domains where native woody vegetation is to be established.

Species selected would encourage the re-establishment of the pre-agricultural vegetation communities in those areas defined for woody vegetation establishment. Areas identified for shrublands and chenopod re-establishment would have stock excluded until it can be demonstrated that the vegetation is stable and self-sustaining, and that gazing would not impact upon its establishment.

17.6.5 Brush/timber spreading

Revegetation would include the spreading of brush and timber across the rehabilitated land, focussing on those areas where woody native vegetation is to be established. Subject to availability of material, the timber and or mulch would be spread thick enough to provide the desired benefits, but not so thick as to inhibit germination of seed.

Mulch would be spread following top soil replacement. Methods for spreading the understorey brush would be trialled and refined as rehabilitation progresses.

Larger stockpiled timber may also be utilised to develop fauna habitat piles.

17.7 Rehabilitation maintenance

Rehabilitated areas would be assessed against performance indicators and regularly inspected for key aspects outlined in Section 4.1.6 of the RCS in Appendix F. Where rehabilitation criteria have not been met, maintenance works would be undertaken.

17.7.1 Weed management

Weed management and mitigation measures to ensure rehabilitation and surrounding agricultural enterprises are successful would include:

- hosing down equipment in an approved wash down area before entry to the project area;
- herbicide spraying or scalping weeds from topsoil stockpiles prior to re-spreading topsoil;
- rehabilitation inspections to identify potential weed infestations; and

- identifying and spraying existing weed populations together with ongoing weed spraying over the life of the mine.

The spread of declared noxious weeds would be managed by using the measures above. Records would be maintained of weed infestations and control programs would be implemented according to industry best management practice for the weed species concerned.

17.7.2 Feral species management

A feral animal control strategy would be implemented to contain the spread of weeds and other detrimental impacts on rehabilitation areas by feral animals.

17.7.3 Infill planting and seeding

Rehabilitated areas may be planted and/or seeded opportunistically to take advantage of infrequent rainfall events. Monitoring of rehabilitation would identify any areas of low plant recruitment to be targeted for such supplementary planting and/or seeding programs.

17.7.4 Fire control

Developing vegetation within the revegetation areas would not be able to withstand fire for many years. Prior to the completion of mining, Iluka would consult with the appropriate agencies to ensure appropriate fire control strategies are developed.

17.7.5 Access

Access tracks would need to be required to facilitate the revegetation and ongoing maintenance of the mine. These tracks would be kept to a practical minimum and would be designated prior to the completion of mining in consultation with agencies.

17.7.6 Public safety

Environmental management controls would be implemented in the project area to minimise the potential for impacts on public safety by the maintenance of fencing around those sections of the perimeter of the final void or any graded areas that have the potential to cause harm, that are accessible to the public.

17.8 Rehabilitation schedule

The progressive formation of the post-mining landform and the establishment of a vegetative cover would vary throughout the life of the Balranald Project, depending on the annual areas of disturbance and the availability of land for rehabilitation once mining activities have ceased.

17.9 Rehabilitation criteria

Rehabilitation criteria would be used as the basis for assessing when rehabilitation of the Balranald Project is complete.

The rehabilitation criteria would be subject to periodic formal review in consultation with relevant stakeholders. Amendments to the rehabilitation criteria would be subject to regulatory approval.

The rehabilitation criteria need to demonstrate that the rehabilitation objective has been achieved. Consequently, interim rehabilitation criteria are presented in Appendix F.

17.10 Rehabilitation monitoring

Regular monitoring of the rehabilitated areas would be required during the initial vegetation establishment period and beyond to demonstrate whether the objectives of the closure and rehabilitation strategy are being achieved and whether a sustainable and stable landform has been provided. Monitoring would be conducted periodically by suitably skilled and qualified persons at locations which would be representative of the range of conditions on the rehabilitating areas. Regular reviews of monitoring data would be undertaken to assess trends and monitoring program effectiveness.

Monitoring is proposed for different issue areas and is detailed in Section 5.2 of the RCS in Appendix F.

17.11 Conclusion

The RCS for the Balranald Project establishes clear and achievable objectives for the rehabilitation of land that will be disturbed due to the project. One key objective is that rehabilitation will aim to create a stable landform with the maximum possible post-mining land use capability and/or suitability. This will be achieved by setting clear rehabilitation success criteria and outlining the monitoring requirements that assess whether or not these criteria are being accomplished.

The Balranald Project will be progressively rehabilitated as mining operations move. Regular monitoring of the rehabilitated areas will be undertaken to demonstrate whether the objectives of the rehabilitation strategy are being achieved and whether a sustainable and stable landform has been achieved. The rehabilitation program will also be assessed against success criteria.