9. Environmental Factors

9.1 Flora and Vegetation

9.1.1 EPA Objective

The EPA's objective for flora and vegetation is:

- To maintain representation, diversity, viability and ecological function at the species, population and community level.

9.1.2 Relevant Legislation and Policy

Relevant legislation and policies to the Project are:

Wildlife Conservation Act 1950

All native plants in WA are protected under the WA *Wildlife Conservation Act 1950* (WC Act). Any activity which involves taking part of or the whole of a native plant may require a licence or permit to do so. Little known or threatened flora are given special protection under this Act and the following conservation categories may be applied to certain species:

> T: Threatened flora - Specially protected under the WC Act, listed under Schedule 1 Wildlife Conservation (Rare Flora) Notice for Threatened Flora (which may also be referred to as Declared Rare Flora). Species which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.
>
> X: Presumed extinct flora - Specially protected under the WC Act, listed under Schedule 2 of the Wildlife Conservation (Rare Flora) Notice for Presumed Extinct Flora. Species which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such

Threatened Flora are further recognised by DPaW according to their level of threat using IUCN Red List[1] criteria as follows:

> Critically Endangered (CR): Considered to be facing an extremely high risk of extinction in the wild.
>
> Endangered (EN): Considered to be facing a very high risk of extinction in the wild.
>
> Vulnerable (VU): Considered to be facing a high risk of extinction in the wild.
>
> Extinct (EX): There is no reasonable doubt that the last individual has died.

One species of Threatened Flora *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) is present within the Study Area and is listed as Vulnerable – D2[2] (Section 9.1.4). This species has also been nominated for listing under the EPBC Act. Taking of Threatened Flora cannot occur without special permission from the WA Minister for the Environment.

DPaW also produces a list of Priority species under the WC Act. Priority flora categories are as follows:

> **Priority One:** Poorly-known taxa. Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known

1. International Union for Conservation of Nature (IUCN) Red List of Threatened Species is a global program that evaluates the conservation status of plant and animal species. The Red List identifies particular species at risk of extinction (see http://www.iucnredlist.org/technical-documents/categories-and-criteria).
2. Population with a very restricted area of occupancy (typically less than 20 km^2) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period.

from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

Priority Two: Poorly-known taxa. Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation (e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc.). Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

Priority Three: Poorly-known taxa. Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

Priority Four: Rare, Near Threatened and other taxa in need of monitoring. (a) Rare: Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands; (b) Near Threatened: Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable; (c) Other: Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Priority Five: Conservation Dependent taxa. Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxa becoming threatened within five years.

Proponents that intend to disturb Priority flora should first consult with DPaW regarding the impact of the proposal on the species' conservation status. There are a number of Priority flora species present within the Project Development Envelope that are discussed below.

Environmental Protection (Clearing of Native Vegetation) Regulations 2004

The WA Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (hereafter referred to as Clearing Regulations) regulate the clearing of native vegetation in the State. Low impact mineral and petroleum activities as defined in the Clearing Regulations, and clearing of up to 10 ha per financial year per 'authority area' regulated under the *Mining Act 1978* (Mining Act), may be exempt from obtaining a clearing permit. However, these exemptions do not apply to environmentally sensitive areas (ESAs) or within non-permitted areas such as wetlands or riparian vegetation. There are no ESAs within or near the development envelope.

A Clearing Permit is not required if the impacts of the proposed clearing have already been assessed by the EPA under Part IV of the EP Act.

EPA Policies

The EPA has produced Position Statement No. 2 (EPA 2000) for the environmental protection of native vegetation in WA specific to the clearing of native vegetation. This document outlines the EPA's position on clearing in agricultural areas and clearing in other areas of WA. It also outlines the elements the EPA will take into consideration when assessing a proposal. Proponents are required to demonstrate in their proposals that all reasonable measures have been undertaken to avoid impacts on biodiversity. Where some impact on biodiversity cannot be avoided, it is for the proponent to demonstrate that the impact will not result in unacceptable loss.

The EPA Position Statement No. 3 (EPA 2002b) outlines the use of terrestrial biological surveys as an element of biodiversity protection in Western Australia. Proponents are expected to undertake field

surveys that meet the standards, requirements and protocols as determined and published by the EPA. Further detail on the requirements for flora and vegetation surveys is provided in EPA Guidance Statement No. 51 (EPA 2004b). The vegetation in the study area was surveyed using the methods set out in accordance with this guidance statement and outlined below.

The EPA also provides guidance on the rehabilitation of terrestrial ecosystems (EPA 2006). The Mine Closure Plan has been prepared in accordance with this guidance (Appendix O1).

9.1.3 Studies and Investigations

The flora and vegetation of the development envelope and the regional surrounds have been extensively surveyed. A summary of botanical surveys that are relevant to the Project are presented in Table 9-1. In addition to those listed in the table, there are other surveys of nearby projects that contribute to the botanical knowledge of the area. Reports of other related work, including for example, site specific soil surveys are also listed. These are listed in Western Botanical (2015a, Appendix E2).

Table 9-1: Summary of previous botanical and related work relevant to the Project

Reference	Scale	Summary Description
Historic Surveys		
Gardner (1942)	Regional	Broad scale regional flora surveys and general account of vegetation for the Murchison
Mabutt *et al.* (1963)	Regional	Descriptions of land systems and vegetation of the Austin Botanical District (Wiluna and Glengarry)
Specht (1970)	Regional	National scale structural vegetation classification and mapping
Beard (1976)	Regional	Broad scale regional vegetation mapping (1:1,000,000) of the Murchison including vegetation unit descriptions.
Western Mining Corporation Ltd (1978)	Local	Vegetation and flora survey of the Yeelirrie Project for draft EIS and ERMP
Pringle *et al*. (1994)	Regional (land systems). Local (vegetation)	Description of broad land systems and local vegetation units of the North-eastern Goldfields. Mapping at 1: 250,000.
Payne *et al.* (1998)	Regional	Floristic inventory, condition assessment, and mapping of the Sandstone, Yalgoo, Paynes Find Area. Mapping at 1:250,000.
Recent Work		
Western Botanical (2011)	Local	Baseline flora and vegetation survey of the Yeelirrie Project. Mapping at 1:10,000. Significant flora and vegetation units of Yeelirrie (Appendix E1)
D.C. Blandford & Associates (2011)	Local	Soil landscapes assessments of the Yeelirrie Project including soils profile descriptions and some soil chemistry (Appendix M1)
Meissner (2011) (Draft)	Regional	Flora and vegetation survey of calcrete palaeodrainage channels in the north-eastern Goldfields.
Clarke *et al*. (2012)	Local	Assessment of genetic variance within *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) to help determine taxonomic and conservation status.
Shepherd *et al.* (unpublished)	Local	Taxonomic resolution of *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) utilising morphological and molecular methods (Appendix E4)

Reference	Scale	Summary Description
Western Botanical (2014)	Local	Review of *Atriplex* sp. Yeelirrie Station population within rehabilitated former stockpile and initial demography assessment of the Western population (Appendix E8)
Western Botanical (2015a)	Local	Reviewing and updating results of Western Botanical (2011) (Appendix E2)
Western Botanical (2015b)	Local	Demography assessment Phase 1, *Atriplex* sp. Yeelirrie Station Eastern, Western and Rehabilitation populations. (Appendix E7)
Western Botanical (2015c)	Local and Regional	Potential Translocation trial site assessment, Lake Mason (Appendix E9)
Soilwater Consultants (2015b)	Local and Regional	Potential Translocation trial site assessment, Lake Mason (Appendix E5)

9.1.3.1 Recent Survey Work

Western Botanical was commissioned in 2008 to undertake a flora and vegetation assessment of the proposed BHP Billiton Project. The outcome of the survey was the Yeelirrie Project Flora and Vegetation Survey Baseline Report, February 2011 (WB653) (Western Botanical, 2011; Appendix E1). The field survey included 16 study areas. Study Areas 1, 2, and 3 are collectively referred to as the Local Study Area and cover the Development Envelope, while areas 4 to 16 are collectively referred to as the Regional Study Area. These areas are shown on Figure 9-1.

A level 2 survey of Study Area 1 was performed in accordance with EPA Position Statement No. 3 (EPA 2002b) and Guidance Statement No. 51 (EPA 2004b), including quadrat based assessment of flora and the mapping of vegetation at a scale of 1:10,000. Study Area 1 includes the pit extent, metallurgical plant, surface water diversion bund and the majority of vegetation within the potential groundwater drawdown zone. Areas of vegetation potentially indrectly affected by the Project are also included withi Study Area 1. Study Area 2, comprising five areas adjacent to and contiguous with Study Area 1 and including the majority of the proposed bore fields, quarry, and buffers around Study Area 1. A level 1 survey of Study Area 2 was performed and focussed on mapping of vegetation units and known Priority Flora populations. Areas proposed to be disturbed such as the quarry and infrastructure corridors will have pre-clearance surveys undertaken as part of ground disturbance procedures. A level 1 survey of Study Area 3 was performed and focussed on mapping of vegetation units, known Priority Flora populations and definition of the extent and size of the Eastern Population of *Atriplex* sp. Yeelirrie Station.

Figure 9-1 shows that the Level 2 survey conducted by BHP Billiton does not cover all of the borefield corridors. Cameco did not undertake further flora surveys over these areas as the layout of the corridors is conceptual and subject to change following further groundwater investigations during future development phases of the Project.

Once the location of the groundwater bores and access corridors have been finalised, further flora surveys will be carried in accordance with the requirements of the Guidance Statement for Level 2 surveys.

Regional study areas 4 through to 16 were areas of palaeodrainage channels and lake systems which contained similar landforms to Study Area 1 and 3. The purpose of the regional study areas was primarily to search for additional populations of *Atriplex* sp. Yeelirrie Station whilst providing a regional context for the distribution of flora species with conservation interest that were recorded within Study Area 1.

In 2014, Cameco commissioned a review of the 2011 report to confirm that the work was undertaken in accordance with current guidance and to update any species name changes, species

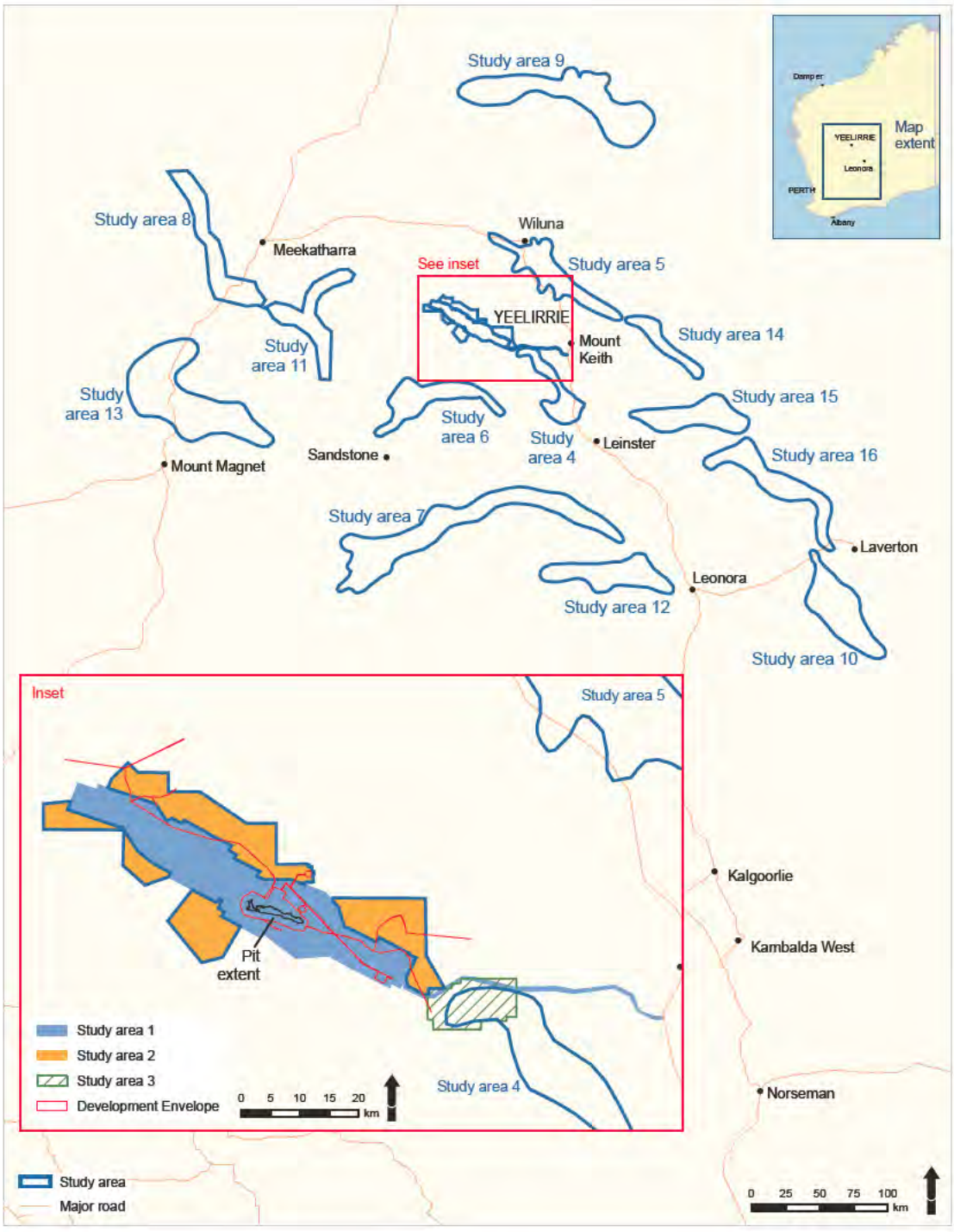

Figure 9-1: Regional and local Study Areas

identification corrections, conservation status, naturalised status, and conformity to known range, that may have occurred since the 2011 report. The review report (Western Botanical 2015a) is attached as Appendix E2. The review determined that the conservation status of four species within the Local Study Areas have changed, notably *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) which has been upgraded from Priority 1 to Threatened.

An independent research project, commissioned by BHP Billiton, investigating the genetic structure of *Atriplex* sp. Yeelirrie Station was undertaken in 2011 (Shepherd *et al.* unpublished). The study assessed genetic variation within the two major populations of *Atriplex* sp. Yeelirrie Station to determine its taxonomic and conservation status. This research project led to the release of a journal paper titled 'Significant population genetic structure detected for a new and highly restricted species of *Atriplex* (Chenopodiaceae) from Western Australia, and implications for conservation management' (Clarke *et al.* 2012).

In August 2014, Western Botanical was commissioned by Cameco to assess the Western population of *Atriplex* sp. Yeelirrie Station located on the Yeelirrie orebody, and also the rehabilitation population noted in the former southern stockpile area (Western Botanical 2014).

In 2015, further investigations were commissioned by Cameco to increase the understanding of the conservation significant species *Atriplex* sp. Yeelirrie Station. These investigations included:

- a study by DPaW to determine the taxonomy of the species comparing both genetic and morphological information (yet to be published);
- life cycle, population dynamics (sex ratios, age structure, seedling recruitment) forming the basis of a population viability analysis (Western Botanical 2015b);
- soil type, structure, moisture and chemistry; hydrological requirements; surrounding vegetation; scale (area of occupancy); slope, aspect and altitude (Western Botanical 2015b, Soilwater Consultants 2015b);
- seed viability and germination (Western Botanical 2015d); and
- potential translocation sites for *Atriplex* sp. Yeelirrie Station outside the current known locations were investigated and the potential short and long term impacts on the ecology of the potential recipient sites were assessed (Western Botanical 2015c).

9.1.4 Existing Environment

9.1.4.1 Land Systems and Vegetation Condition

Land systems of the Yeelirrie area have been described and mapped as part of two rangeland conditions surveys undertaken by the WA Department of Agriculture (now Department of Agriculture and Food) (Pringle *et al*. 1994; Payne *et al*. 1998). Sixteen land systems representing ten land types have been mapped at a scale of 1:500,000 within the Local Study Area. The proportion of each land system which occurs in the Local Study Area is presented in Table 9-2 and illustrated in Figure 9-64 in Section 9.10.

Table 9-2: Land system extent within the local Study Area and regional representation

Land system	Sandston-Yalgoo-Paynes Find area (ha)[1]	North-eastern Goldfields area (ha)[2]	Total area mapped (ha)	Within Local Study Area (ha)	Proportion within Local Study Area (%)
Millrose	n/a	n/a	53,500 [3]	13	0.02
Sherwood	345,800	387,500	733,300	921	0.13
Waguin	124,900	74,500	199,400	254	0.13
Gransal	80,000	274,100	354,100	440	0.12

Land system	Sandston-Yalgoo-Paynes Find area (ha)[1]	North-eastern Goldfields area (ha)[2]	Total area mapped (ha)	Within Local Study Area (ha)	Proportion within Local Study Area (%)
Windarra	37,000	193,800	230,800	99	0.04
Bullimore	624,900	2,401,300	3,026,200	71,530	2.36
Hamilton	32,500	113,000	145,500	46	0.03
Ranch	29,800	65,500	95,300	11	0.01
Monk	182,200	816,200	998,400	247	0.02
Yanganoo	327,600	87,500	415,100	11,202	2.70
Desdemona	4,000	252,400	256,400	141	0.06
Cosmos	5,000	14,100	19,100	1,797	9.41
Cunyu	35,800	31,000	66,800	2,857	4.28
Melaleuca	12,900	26,700	39,600	3,008	7.60
Mileura	70,000	55,000	125,000	3,796	3.04
Carnegie	864,900	550,600	1,415,500	3,525	0.25

Notes:

1. Pringle *et al.* (1994)
2. Payne *et al.* (1998)
3. Millrose land system is not present within either Technical Bulletin No. 87 or Technical Bulletin No. 90. Total mapped area comes from the Millrose land system's presence within Technical Bulletin No. 84.

As evident in Table 9-2 many of the land systems found within the Local Study Area are well represented in the wider biogeographic region. However, there is a considerable representation of land type 18 (Calcrete drainage plains with mixed halophytic and non-halophytic shrublands) and its four component land systems (Cosmos, Cunyu, Melaleuca and Mileura) within the Local Study Area. These land systems are associated with margins of salt lakes and occluded palaeodrainage channels, and are considered an uncommon and geographically isolated series of land systems and vegetation communities within the broader region (Western Botanical 2011).

In addition to the WA Department of Agriculture mapping, broad scale vegetation mapping of the region by Beard (1976) indicates five vegetation units are present within the Local Study Area as follows:

1. Mulga (*Acacia aneura sens. lat.*), Mallee (*Eucalyptus kingsmillii*) and Spinifex (*Triodia basedowii*) shrub steppe on sand plains.
2. Mulga (*Acacia aneura sens. lat.*) and Wattles (*Acacia* spp.) with Saltbush (*Atriplex* spp.) or Bluebush (*Maireana* spp.) succulent steppe.
3. Saltbush (*Atriplex* spp.), Bluebush (*Maireana* spp.) and Samphire (*Tecticornia* spp.) communities succulent steppe.
4. Mulga (*Acacia aneura sens. lat.*) low woodland.
5. Mulga (*Acacia aneura sens. lat.*) and *A. quadrimarginea* shrubland.

Vegetation condition mapping was undertaken within the Local Study Area, based on the Keighery (1994) scale (as presented in Government of Western Australia 2000). The results of this mapping are presented in Figure 9-2. Due to a history of pastoral management and de-stocking, the majority of the vegetation within the Local Study Area is of 'excellent' condition rather than 'pristine' condition. The area immediately surrounding the Yeelirrie homestead and the airstrip is considered

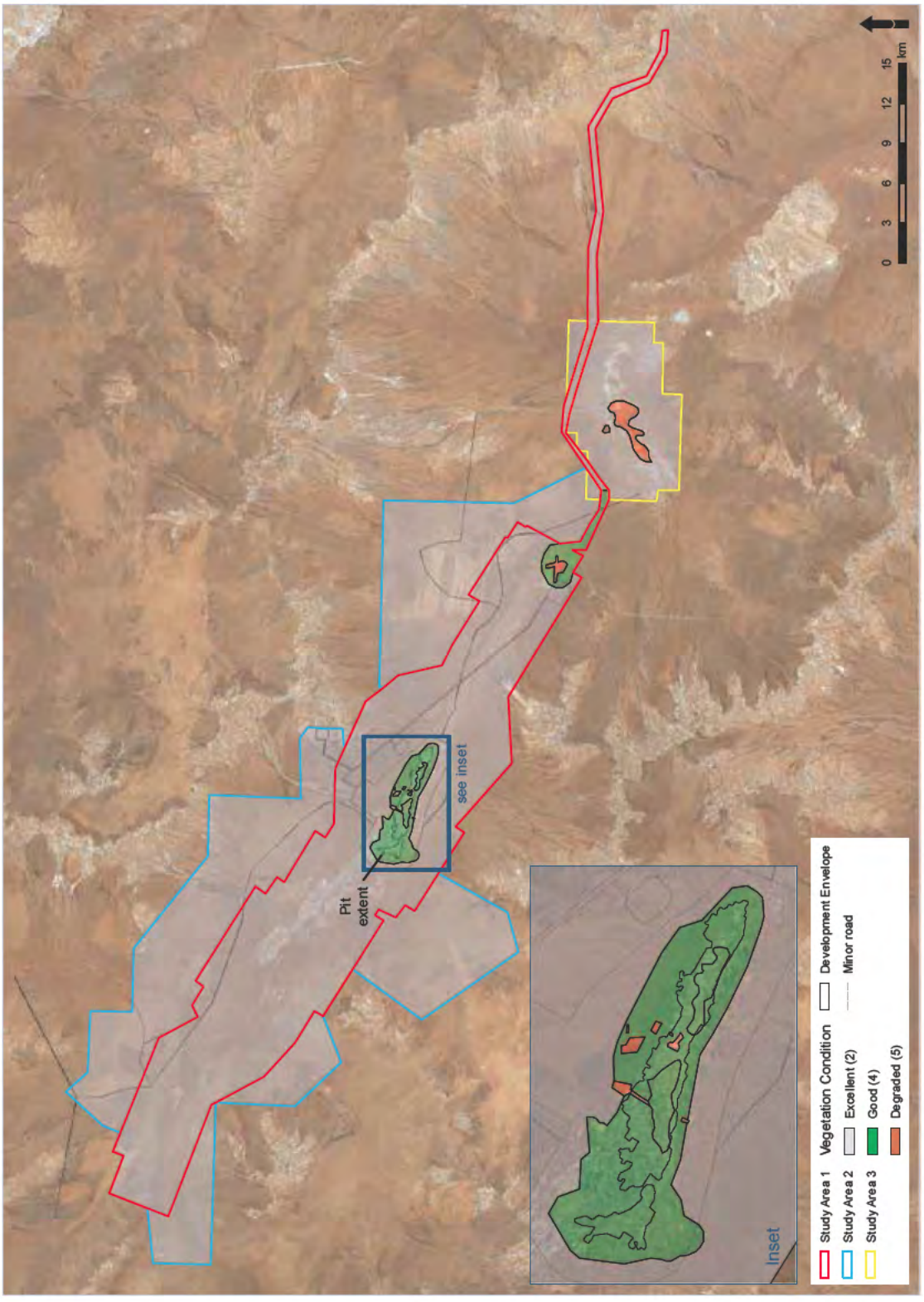

Figure 9-2: Vegetation condition within the local Study Area

'degraded', improving to 'good' with distance from the homestead. Within the mining footprint, exploration activities and some weed incursion have reduced the vegetation condition to 'good'. Exploration tracks, roads and some previously cleared areas were given a condition of 'degraded' (Not illustrated in Figure 9-2).

Atriplex sp. Yeelirrie Station (L. Trotter & A. Douglas 25025) is preferentially grazed (predominantly by cattle) when more palatable feed is unavailable. Correspondingly some areas supporting this species in the Eastern Population were classified as 'degraded-good' but overall the condition of the Eastern population is rated good (Western Botanical 2015a).

9.1.4.2 Vegetation associations and communities of conservation significance

Vegetation association mapping determined fifty-two vegetation associations (National Vegetation Information System [NVIS] Level 5), including one complex, within the Local Study Area, 39 of which were recorded in Study Area 1 by Western Botanical (2011) (Figure 9-3).

No flora-related Threatened Ecological Communities (TECs) listed under the EPBC Act 1999, or Priority Ecological Communities (PECs) listed under the WC Act 1950 were recorded within Study Area 1. Some vegetation communities present within the Calcrete System of Study Area 1, are of interest as they are considered to have a limited distribution. The vegetation communities of interest within Study Area 1 are:

- Communities recognised by Cowan (2001) as being of limited regional distribution and at risk:
  - CEgW *Eucalyptus gypsophila* Woodland on Calcrete, equivalent to Calcrete platform woodlands/shrublands of the north-east Goldfields (Pringle *et al.* 1994 - site type 8);
  - CCpW *Casuarina pauper* Woodland on Calcrete, equivalent to Calcyphytic casuarina acacia woodlands/shrublands of the north-east Goldfields (Pringle *et al.* 1994 - site type 7); and
  - CMxS *Melaleuca xerophila* Shrubland on Calcrete, equivalent to *Melaleuca* sp. nov. Low Closed to Open Forest Strand Community Near Wiluna.
- Communities described by Western Botanical as known from within the Local Study Area only:
  - CApS *Atriplex* sp. Yeelirrie Station Shrubland on Calcrete. A new community described by Western Botanical and is not documented elsewhere to date. CApS is dominated by *Atriplex* sp. Yeelirrie Station on clay in depressions and is confined to clay flats within the Calcrete System. Based on current information available the CApS community is limited in distribution; and
  - CRsS *Rhagodia* sp. Yeelirrie Station Shrubland on Calcrete. A new vegetation community described by Western Botanical and is not documented elsewhere to date. Based on current information available the CRsS community is limited in distribution.

Table 9-3: Summary descriptions of the vegetation communities within Study Area 1 and shown on Figure 9-3.

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
SAES	Stony *Acacia galeata* and *Eremophila* spp. Shrubland	Foot slope deposits of granite breakaway	*Eremophila galeata*, *Acacia aneura*, *A. ayersiana*, *A. tetragonophylla*, *Ptilotus obovatus* (typical Goldfields form), *Eremophila compacta* subsp. *compacta*, *E. latrobei* subsp. *latrobei*, *Senna artemisioides* subsp. x *sturtii*, *S. artemisioides* subsp. *helmsii*, *Sida ectogama*, *Eragrostis eriopoda*
BCLS	Breakaway Chenopod Low Shrubland	Foot slope deposits and undulating alluvial plains at the base of granite breakaway	*Maireana triptera, Sclerolaena diacantha, Ptilotus obovatus* (typical Goldfields form), *Cymbopogon ambiguus*

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
GFGr	Granite Foot Slope Grassland	Foot slope deposits of granite breakaway	*Aristida contorta, Cymbopogon ambiguus, Ptilotus obovatus* (typical Goldfields form), *Sclerolaena* spp., *Eremophila galeata*, *Senna artemisioides* ssp. *helmsii*
GPoS	*Ptilotus obovatus* Shrubland	Foot slope deposits of granite breakaway	*Ptilotus obovatus* (typical Goldfields form), *Maireana pyramidata*, *Eremophila compacta* subsp. *compacta*, *E. maculata* subsp. *brevifolia*, *Senna* spp., *Eragrostis* sp.
Qtz	Quartz Ridge	Hills and foot slopes associated with granite breakaway	*Acacia quadrimarginea, Acacia aneura, Callitris columellaris, Dodonaea petiolaris, Eremophila exilifolia and E. latrobei subsp. latrobei, Ptilotus obovatus* (typical Goldfields form), *Cymbopogon ambiguus*
GR	Granite Rise	Exfoliating granite outcrop	*Acacia quadrimarginea*, *Acacia aneura*, *Callitris columellaris*, *Dodonaea* spp., *Eremophila latrobei* subsp. *latrobei*, *Senna* spp., *Sida* spp., *Cymbopogon ambiguus*, various herbs
GRMS	Mulga Shrubland on Granite Rise	Plains with granite rise	*Acacia aneura*, *A. tetragonophylla*, *A. craspedocarpa*, *A. quadrimarginea*, *Ptilotus obovatus* (typical Goldfields form), *Eremophila* spp., *Sida ectogama*, *Senna* spp.
SASP	Sand plain Spinifex Hummock Grassland	Sand plain	*Triodia basedowii*, *Leptosema chambersii*, *Euryomyrtus inflata* P3, *Prostanthera wilkieana*, *Keraudrenia velutina*, *Acacia effusifolia*, *Grevillea acacioides*
SAWS	Sand plain Spinifex Hummock Grassland with Wattles	Sand plain	*Triodia basedowii*, *Acacia effusifolia*, *A. heteroneura* var. *prolixa*, *A. jamesiana*, *A. prainii*, *A. pachyacra*
SAMA	Sand plain Spinifex Hummock Grassland with Mallee	Sand plain	*Triodia basedowii*, *Eucalyptus leptopoda* ssp. *elevata*, *E. kingsmillii*, *E. trivalva*, *Acacia effusifolia*, *A. heteroneura* var. *prolixa*, *A. prainii*, *A. ligulata*, *Leptosema chambersii*
SAHS	Sand plain Spinifex Hummock Grassland with Heath	Sand plain	*Triodia basedowii*, *Enekbatus eremaeus*, *E. cryptandroides, Acacia effusifolia*, *A. heteroneura* var. *prolixa*, *A. jamesiana*, *Hakea francisiana*
SAGS	Sand plain Spinifex Hummock Grassland with *Eucalyptus gongylocarpa*	Sand plain	*Eucalyptus gongylocarpa*, *Acacia effusifolia*, *A. ligulata*, *A. prainii*, *A. heteroneura* var. *prolixa*, *Eremophila platythamnos* subsp. *platythamnos*, *Halgania cyanea* ssp. Allambi Stn (B.W. Strong 676), *Triodia basedowii*
SAMU	Sandplain Mulga Spinifex Hummock Grassland	Sand plain	*Acacia aneura, A. ayersiana, A. ramulosa* var. *linophylla, A. effusifolia, Melaleuca interioris, Triodia basedowii*

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
WABS	Wanderrie Bank Grassy Shrubland	Sand plain	*Acacia aneura, A. ayersiana, Grevillea berryana, A. ramulosa* var. *linophylla, A. tetragonophylla, Eremophila forrestii* ssp. *forrestii, Ptilotus obovatus* (typical Goldfields form), *Eragrostis eriopoda*
SDSH	Sand Dune Shrubland	Sand dunes	*Callitris columellaris, Acacia aneura, Eucalyptus leptopoda* ssp. *elevata, Bertya dimerostigma, Micromyrtus flaviflora, Hakea lorea* ssp. *lorea, Triodia basedowii*
HPMS	Hardpan Plain Mulga Shrubland	Plains	*Acacia aneura, A. ayersiana, A. ramulosa* var. *linophylla, A. tetragonophylla, Melaleuca interioris, Grevillea berryana, Eremophila* spp.
DRMS	Drainage Tract Mulga Shrubland	Drainage lines on plains	*Acacia aneura, A. ayersiana, Eremophila* spp., *Pluchea dentex*, various herbs
DRES	Drainage Line *Eucalyptus camaldulensis* Woodland	Drainage lines on plains	*Eucalyptus camaldulensis* subsp. *obtusa, Acacia aneura, A. quadrimarginea, A. tetragonophylla, A. ramulosa* var. *linophylla, Cymbopogon ambiguus, Pluchea dentex*
GRMU	Mulga Groves on Hardpan Plain	Plains	*Acacia aneura, A. ayersiana, A. craspedocarpa, A. tetragonophylla, A. ramulosa* var. *linophylla, Eremophila hygrophana, Ptilotus obovatus* (typical Goldfields form)
PLAPoS	*Acacia* spp. and *Ptilotus obovatus* Shrubland	Flats in Playa System	*Acacia aneura, A. ayersiana, A. tetragonophylla, A. ramulosa* var. *linophylla, A. burkittii, Ptilotus obovatus* (typical Goldfields form)
PLAET	*Acacia* spp. and *Eremophila* spp. Thicket	Playas with sink holes	*Acacia aneura, A. tetragonophylla, Eremophila longifolia, Hakea lorea* ssp. *lorea, Eucalyptus lucasii, Grevillea berryana, Santalum lanceolatum, Ptilotus obovatus* (typical Goldfields form), *Senna artemisioides* ssp. *filifolia, Eragrostis setifolia, Eriachne helmsii*
PLAMi	*Acacia* spp. and *Melaleuca interioris* Shrubland	Fringes of playas in Playa System	*Acacia aneura, A. ayersiana, Melaleuca interioris, Ptilotus obovatus* (typical Goldfields form)
PLMf	*Muehlenbeckia florulenta* Shrubs	Playas	*Muehlenbeckia florulenta*
PLCsMp	*Cratystylis subspinescens* and *Maireana pyramidata* Shrubland	Playas	*Maireana pyramidata, M. georgei, Cratystylis subspinescens, Ptilotus obovatus* (typical Goldfields form), *Sclerolaena eriacantha, Solanum lasiophyllum, Frankenia laxiflora*
PLEmc	*Eremophila maculata* ssp. *brevifolia* Shrubland	Scalded areas in Playa System	*Eremophila maculata* ssp. *brevifolia*
PLEml	*Eremophila malacoides* Shrubland	Scalded areas in Playa System	*Eremophila malacoides*
PLEsp	*Eragrostis* sp. Grassland on Playa	Playas	*Eragrostis* sp. LCH26982, *Ophioglossum lusitanicum*

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
PLCh	Chenopods on Scalded Areas	Scalded area in Playa System	*Maireana georgei, M. carnosa, M. triptera, Sclerolaena diacantha, Dissocarpus paradoxus*
CEgW	*Eucalyptus gypsophila* Woodland on Calcrete	Calcrete rises	*Eucalyptus gypsophila, Templetonia incrassata, Eremophila arachnoides* ssp. *arachnoides* P3, *Acacia burkittii, Senna artemisioides* ssp. *filifolia*
CCpW	*Casuarina pauper* Woodland on Calcrete	Calcrete rises	*Casuarina pauper, Acacia burkittii, Templetonia incrassata, Senna artemisioides* ssp. *filifolia*, *Eremophila arachnoides* ssp. *arachnoides* P3, *Ptilotus obovatus* (typical Goldfields form), *Sclerolaena fusiformis*
CMxS	*Melaleuca xerophila* Shrubland on Calcrete	Flats within Calcrete System	*Melaleuca xerophila, Acacia burkittii, Senna artemisioides* ssp. *filifolia*, *Lycium australe, Ptilotus obovatus* (typical Goldfields form), *Sclerolaena fusiformis, Dissocarpus paradoxus, Amyema microphylla*
CAbS	*Acacia burkittii* Shrubland on Calcrete	Calcrete rises	*Acacia burkittii, Grevillea berryana, Eremophila arachnoides* ssp. *arachnoides* P3, *Senna artemisioides* ssp. *filifolia*, *Ptilotus obovatus* (typical Goldfields form)
CMiS	*Melaleuca interioris* Shrubland	Depressions in Calcrete System	*Melaleuca interioris, Acacia ayersiana, A. aneura* and *A. tetragonophylla, Ptilotus obovatus* (typical Goldfields form), *Sclerolaena convexula*
CErG	*Eragrostis* sp. Yeelirrie Calcrete Grassland	Flats in Calcrete System	*Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770), *Lycium australe, Ptilotus obovatus* (typical Goldfields form)
CApS	*Atriplex* sp. Yeelirrie Station Shrubland	Clay Flats in Calcrete System	*Atriplex* sp. Yeelirrie Station (L. Trotter and A. Douglas LCH25025) P1
CRsS	*Rhagodia* sp. Yeelirrie Station Shrubland	Clay Flats in Calcrete System	*Rhagodia* sp. Yeelirrie Station (K.A. Shepherd *et al*. KS1396) P1, *Teucrium racemosa*
CMpS	*Maireana pyramidata* Shrubland	Flats in Calcrete System	*Maireana pyramidata, M. georgei, Sclerolaena fusiformis, Ptilotus obovatus* (typical Goldfields form)
CLaS	*Lycium australe* Shrubland	Flats in Calcrete System	*Lycium australe, Eragrostis* sp. (S. Regan LCH 26770)
CMGbS	Mulga *Grevillea berryana* Shrubland	Outwash zone in Calcrete System	*Acacia aneura, Grevillea berryana, Senna artemisioides* spp. *filifolia, Acacia burkittii*

9.1.4.3 Phreatophytic vegetation

Cameco has undertaken an analysis of groundwater-dependent (phreatophytic) vegetation within the Local Study Area. The following vegetation communities are potentially groundwater dependent due to the specific species found within them:

- CMGbS: Mulga *Grevillea berryana* shrubland on outwash zone in calcrete system;
- CEgW: *Eucalyptus gypsophila* woodland on calcrete rises;
- CMxS: *Melaleuca xerophila* shrubland on calcrete Flats within calcrete system;
- CCpW: *Casuarina pauper* woodland on calcrete rises;

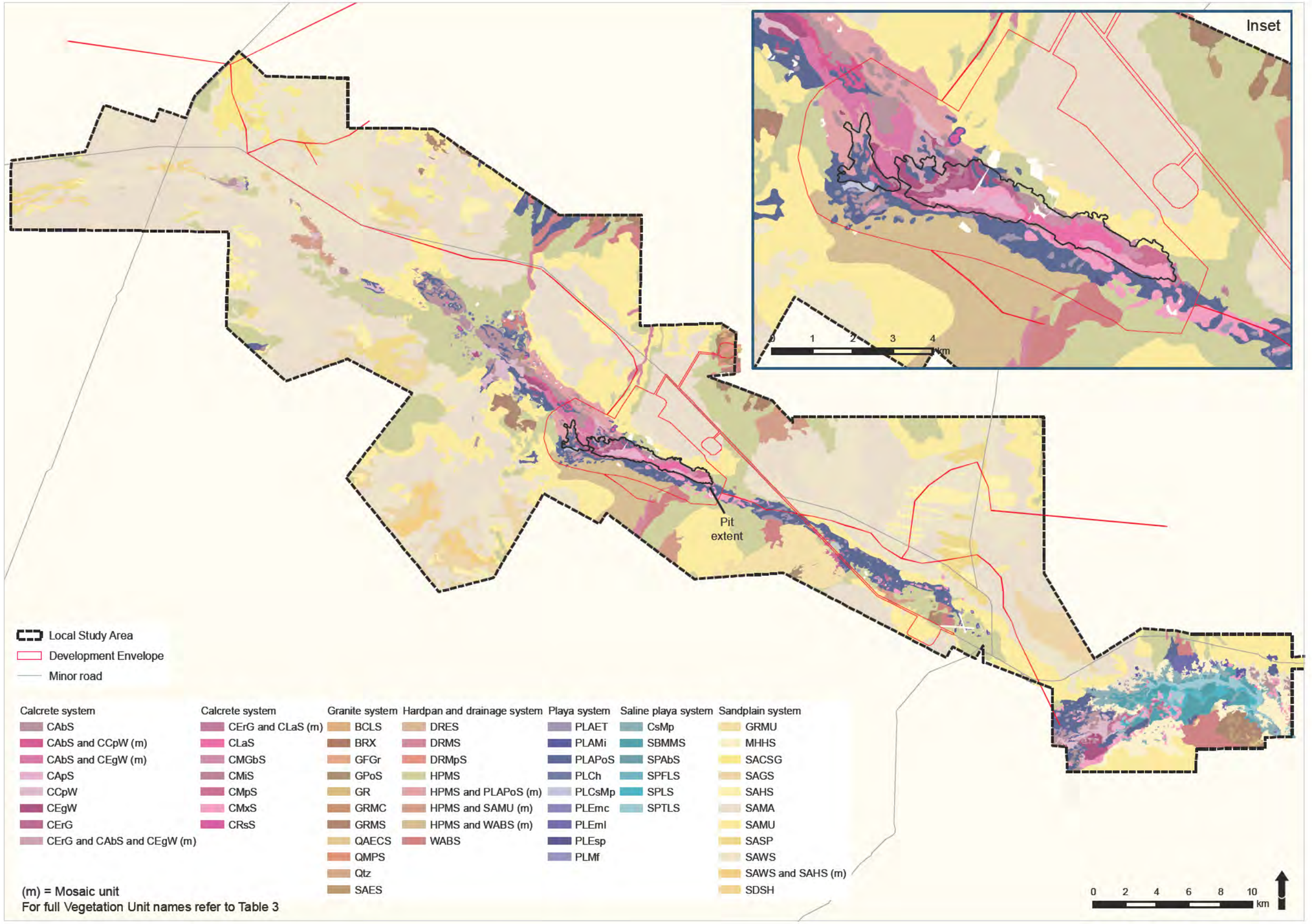

Figure 9-3: Vegetation communities within the local Study Area and development envelope

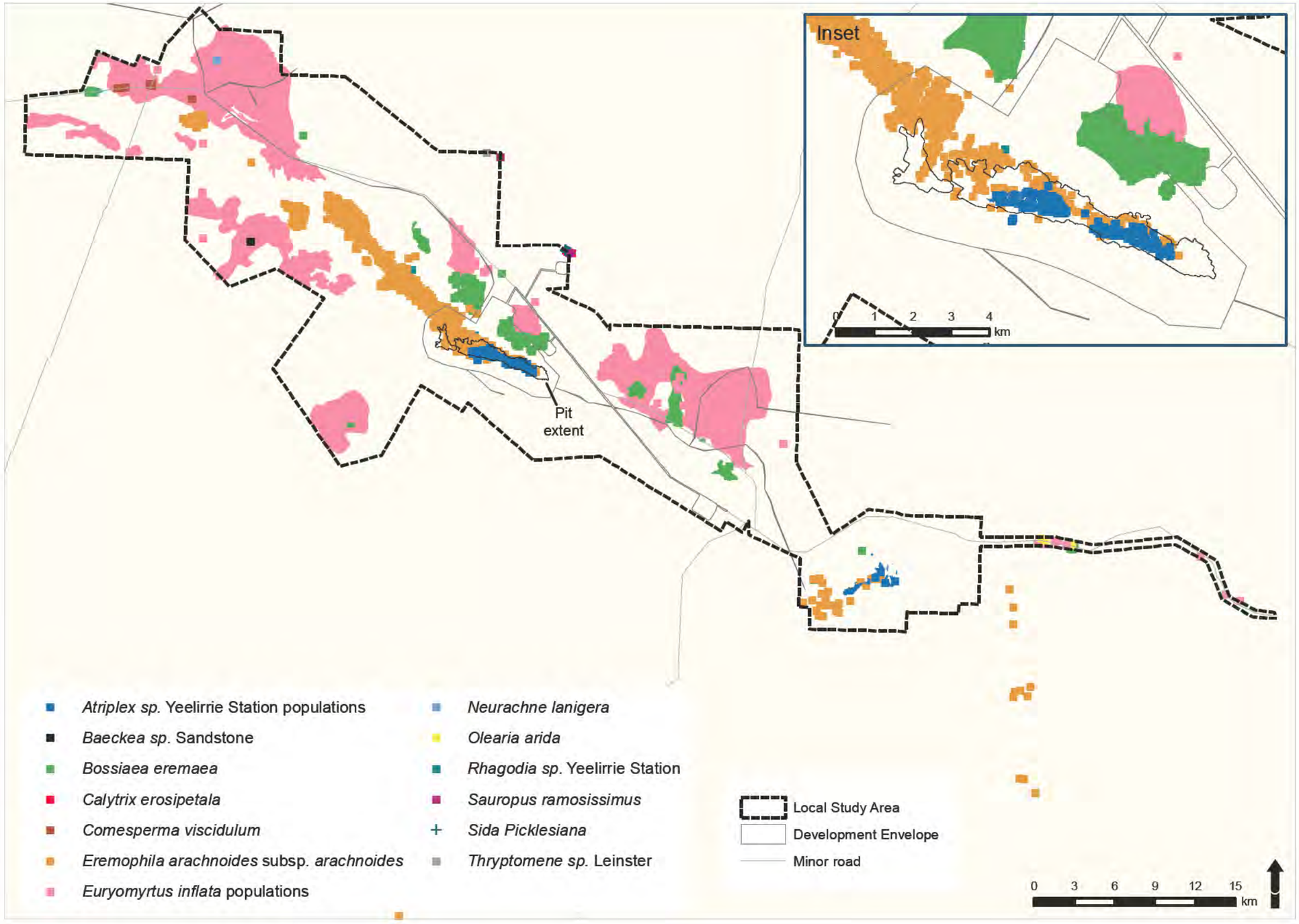

Figure 9-4: Priority species within the Local Study Area

- PLAET: *Acacia* spp. and *Eremophila* spp. thicket on playas with sink holes; and
- PLAMi: *Acacia* spp. and *Melaleuca interioris* shrubland on fringes of playas in playa system.

In addition to these communities, other potentially phreatophytic species are present throughout large expanses of the Sand Plain System and Hardpan and Drainage System. These species include *Melaleuca interioris, Grevillea berryana, Eucalyptus* and *Corymbia* species, which occur in the SAWS, SAMU, SAMA, SAGS, SACSG, SASP and / or HPMS vegetation communities (Appendix E1). Refer to Table 9-3 for descriptions of these vegetation communities.

9.1.4.4 Significant Flora

No flora species of conservation significance listed under the EPBC Act have been recorded in the Local or Regional Study Areas.

One flora species, *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025), that is listed as 'Threatened' under the WC Act has been recorded within the Local Study Area (Western Botanical 2015a). This species is discussed in detail below.

Other priority flora listed under the WC Act, that have been recorded within the Local Study Area are presented in Table 9-4 and shown on Figure 9-4. The conservation status of these species is discussed in detail in Western Botanical (2015a) and in the Conservation Species Management Plan (Cameco 2015b) (Appendix E3). In addition, there are a number of flora species of interest which are discussed in Western Botanical (2015a).

Table 9-4: Priority flora occurring within the local Study Area

Species Name	Conservation Status
Priority Flora	
Neurachne lanigera	P1
Rhagodia sp. Yeelirrie Station (K.A. Shepherd *et al*. KS1396)	P1
Baeckea sp. Sandstone (C.A. Gardner s.n. 26 Oct 1963)	P3
Bossiaea eremaea	P3
Calytrix uncinata	P3
Eremophila arachnoides subsp. *arachnoides*	P3
Euryomyrtus inflata	P3
Sauropus ramosissimus	P3
Sida picklesiana	P3
Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362)	P3
Comesperma viscidulum	P4
Olearia arida	P4

Of the priority flora presented in Table 9-4, only three species, *Bossiaea eremaea* (P3), *Eremophila arachnoides* subsp. *arachnoides* (P3) and *Euryomyrtus inflata* (P3), will be impacted to a small degree by the Project (Section 9.1.5.2).

Atriplex sp. Yeelirrie Station

When discovered during the 2010 survey, *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) was reported as a Priority 1 species listed under the WC Act. The conservation status of the species was upgraded to Threatened on 17 February 2012 (Western Australian Government 2012, No 23). Photos of the species are presented in Plate 9-1 and Plate 9-2.

Plate 9-1: Photos of *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) showing growth habit and divaricate branching structure (in Western Botanical, 2015a)

Plate 9-2: Photos of *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) showing female flowers (top left), male flowers (top right), and two morphotypes of fruiting bracteoles; no appendages (bottom left), and with appendages (bottom right) (photos by Dr Kelly Shepherd; in Western Botanical, 2015a).

Atriplex sp. Yeelirrie Station has been recognised as a rare, new species of *Atriplex* (*Chenopodiaceae*) comprising two genetically distinct populations in arid Western Australia, described here as the Western and Eastern Populations. The Western and Eastern Populations were found to have similar levels of genetic diversity, but exhibited an unexpected level of genetic differentiation given their proximity (Clarke *et al.* 2012). The Western Population lies wholly within the economic orebody and encompasses two sub-populations that are located in close proximity to each other. The Eastern Population, some 30 km south east of the Western Population, encompasses ten sub-populations in close proximity to each other (Figure 9-5).

There is a small number of *Atriplex* sp. Yeelirrie Station plants within rehabilitated areas in close proximity to the orebody: 109 plants at the Southern Stockpile, six plants near the former

communications tower site and a single plant has been recorded adjacent to a track leading to the rehabilitated Northern Stockpile Area (as at August 2014). In addition a single live *Atriplex* sp. Yeelirrie Station plant was observed in March 2015 within the *Rhagodia* sp. Yeelirrie shrubland 1.45 km north of the western subpopulation of the Western (orebody) population. All known locations of the species are located on both Cameco tenure and the Cameco operated Yeelirrie Pastoral Lease.

Western Population of *Atriplex* sp. Yeelirrie Station

The Western population lies wholly within the economic orebody as shown in Figure 9-5. *Atriplex* sp. Yeelirrie Station occurs on clay flats within the Calcrete System, which coincides with the central part of the proposed open pit mine and the drainage line within the palaeochannel. It was primarily recorded within the CApS vegetation unit with scattered individual plants also in surrounding CMxS and CLaS vegetation units. The densest populations were recorded in the central area of the proposed open pit mine.

An estimate of 80,542 plants being wholly within the orebody area is based on an assessment of plant density within quadrats and a measurement of the area of occupancy determined using GIS mapping. These plants occur in two marginally separated sub-populations. The total area of occupancy of *Atriplex* sp. Yeelirrie Station within the orebody area is 76 ha, inclusive of a 10 m buffer around the population (Western Botanical 2015a). The condition of the plants in the Western Population was rated as Good to Excellent.

Eastern Population of *Atriplex* sp. Yeelirrie Station within Study Area 3.

The Eastern population of *Atriplex* sp. Yeelirrie Station supports approximately 190,755 plants over ten sub-populations within an area of occupancy of 1.30 km^2 inclusive of a 10 m buffer around the populations. As in Study Area 1, *Atriplex* sp. Yeelirrie Station within Study Area 3 is restricted to clay flats. The plants in the Eastern Population were rated as being in Good condition.

Atriplex sp. Yeelirrie Station within rehabilitation at Yeelirrie

The baseline survey reported a minor population of *Atriplex* sp. Yeelirrie Station within a previously rehabilitated site at the southern end of the Central Baseline (< 50 individuals) and scattered individuals were also recorded within a rehabilitation site near the communications tower. An assessment in late August 2014 by Western Botanical and Cameco counted and tagged 109 live individual plants within the rehabilitated Southern Stockpile Area. An additional review by Cameco counted six live (and four dead) individuals in a clump in rehabilitation on a calcrete rise near the former Communications Tower and a further single male plant adjacent to a track leading to the rehabilitated Northern Stockpile Area (all within the development envelope). A total of 116 live plants were known within rehabilitation as at the end of August 2014 (Western Botanical 2014). The plants occurred over an area of approximately 1 ha within the 6 ha rehabilitated area.

Description

Atriplex sp. Yeelirrie Station is a long lived, single stemmed, semi-woody, sub-dioecious plant forming mounded shrubs 0.4 – 1 m high x 0.6 – 1.8 m wide. Male plants predominantly have terminal male flowers in dense short panicles and occasional axillary female flowers further down the flowering branch while female plants have sub-terminal axillary female flowers. Fruiting bracteoles, each containing one seed, are sessile and are held securely on the plant for many years. The species is most likely wind pollinated.

Taxonomy

In 2014, the Western Australian Herbarium (Shepherd *et al* 2015 unpublished) undertook a project to determine whether *Atriplex* sp. Yeelirrie Station was distinct from other known species by morphological and molecular evidence. Genetic analyses using Amplified Fragment Length Polymorphisms (AFLPs) showed significant genetic divergence between the two populations. In contrast, an ordination based on elliptic fourier descriptors for leaf and bracteole shape did not identify any consistent morphological differentiation.

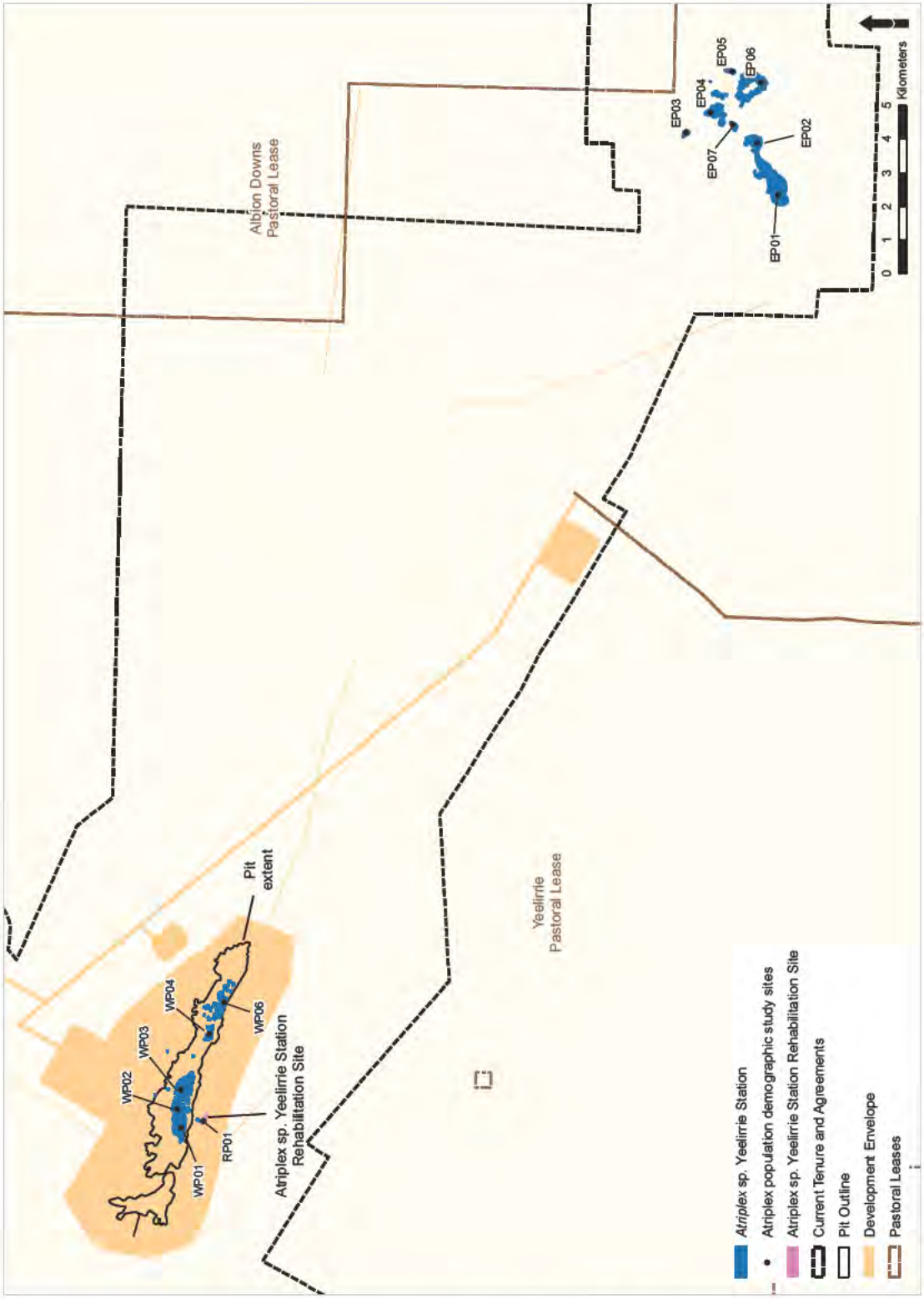

Figure 9-5: Locations of *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025)

Based on the review it was recommended that the new taxon be described as a single species, although the recommendation remains subject to peer review.

The review also recommended that the two populations of *Atriplex* sp. Yeelirrie Station should be managed as separate units for conservation to preserve the genetic diversity exhibited between the two populations.

Reproduction and Survival

Measures taken at both the Eastern and Western populations show a male:female sex ratio of around 50% with no significant differences between sites. While mature plants are long lived, and fruiting bracts containing viable and germinable seeds are held on the plants for many years, the presence of new season seedlings within both the Eastern and Western populations noted in August 2014 and again in March 2015, from two separate recruitment events, indicate that some seed is dispersed from bracts on occasion. Observed seedling numbers varied considerably between sample plots in March 2015 with an average of 22,800 seedlings per ha with a 95% confidence level and a range between 13,420 to 32,580 per ha (Western Botanical 2015b). However, the large numbers of newly germinated seedlings observed in August 2014 suffered a relatively high mortality rate (probably due to the lack of summer rain and were largely absent in the same areas observed at the Eastern population in March 2015. The mechanism triggering seed fall/dispersal from the enclosing bracts is not yet understood.

Population Statistics

Western Botanical (2011) reported an overall mature plant population estimate of ~275,297 across both populations where an average of 1,112 mature plants per ha were reported in the Western population (84,510 plants over 76 ha) and 1,467 mature plants per ha were reported in the Eastern population (190,646 plants over 130 ha).

The assessment of *Atriplex* sp. Yeelirrie Station undertaken in March 2015 established a baseline data set for future assessment of population dynamics and population viability analysis.

During the baseline field surveys, a third population of the species was assessed. This population of 109 individuals is growing in an area that was disturbed by exploration activities conducted in the 1980s and was subsequently rehabilitated in 1994. A further seven live plants have been noted in rehabilitation north of the deposits. It is believed that *Atriplex* sp. Yeelirrie Station seed was introduced to the site with soil. The population, described as the Rehabilitation Population, has been assessed and statistically compared with the Western Population in August 2014:

- There was no significant difference in the ratio of male to female plants between the populations.
- There was no significant difference in the proportion of plants scored as juvenile vs mature between the populations.
- Plants in the Rehabilitation Population were significantly larger in all dimensions, 24% taller, 99% wider and 75% broader than plants in the Western Population. Consequently, plants in rehabilitation had a larger overall plant volume (72%).
- Plants in the Rehabilitation Population also had large portions of their canopies that were dead. When this was taken into account and the live volumes of plants were assessed, plants in the Rehabilitation Population had live canopies that were 42% smaller than those in the Western Population.
- As no plants in either the Rehabilitation Population or Western Population were flowering, there was no difference in flowering rate between these two sites. However, the mature plants at the Eastern Population were noted as flowering (and growing) vigorously. This probably reflected the higher soil moisture noted in soil samples taken at the Eastern Population in August 2014.
- Plants holding fruiting bracteoles were scored on a scale of 0 to 3 (nil to large amounts of fruits on the plant). Plants in the Rehabilitation Population scored 239% higher for the number

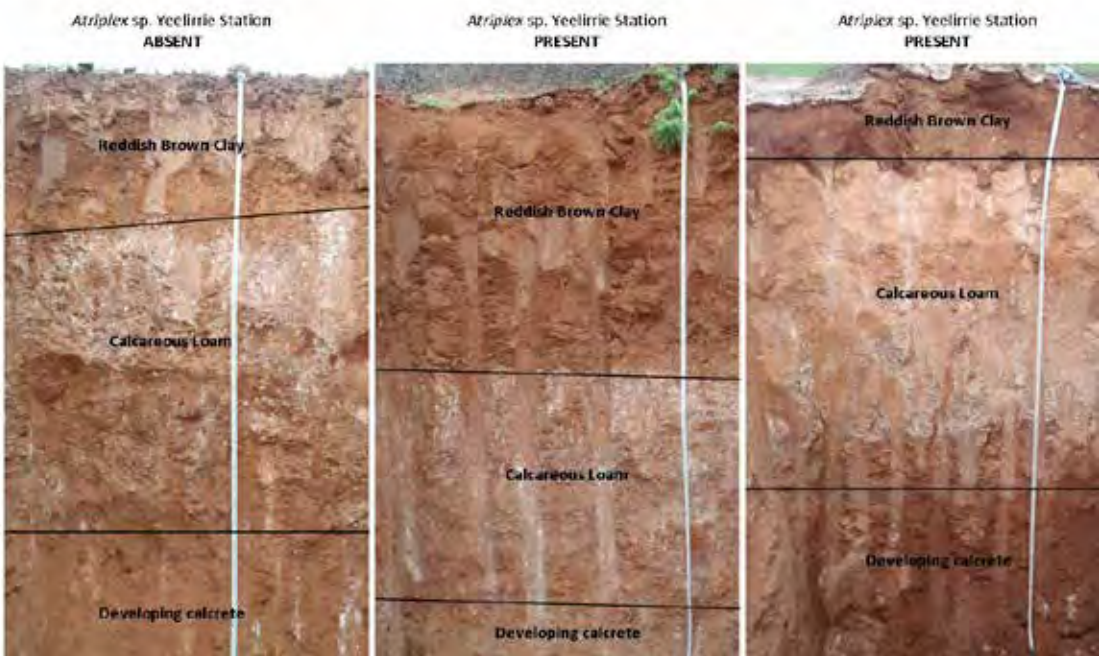

Plate 9-3: Soil profiles within the clay pans where *Atriplex* sp. Yeelirrie Station is absent and present

of plants holding fresh fruits on the plant and had a higher score (252%) for the amount of fresh fruits held on the plants compared to the Western Baseline Population. Some fruits were dissected in-situ at the Rehabilitation Population and were found to consistently have a firm, robust viable seed within. The fruits collected from plants under the DRF permits issued (35- 1415 and 162-1415) have not yet been assessed for seed fill, viability or germinability.

- There was no difference in the frequency of plants holding older fruits and no difference in the abundance of older fruits held on plants between populations.

Associated Species

In its preferred habitat at the Western population, *Atriplex* sp. Yeelirrie Station is the dominant perennial shrub species with occasional *Lycium australe* shrubs scattered within the population. It is associated with annuals *Lawrencia densiflora*, *Zygophyllum compressum* and *Salsola australis*. Small numbers of *Atriplex* sp. Yeelirrie Station may also be found as scattered individuals in fringing vegetation associations including under *Melaleuca xerophila* scrubland on calcrete and *Lycium australe* shrubland on the fringes of the clay flats at the Western population. At the Eastern population, *Atriplex* sp. Yeelirrie Station is associated with the perennial shrubs *Lycium australe*, *Frankenia* spp. and a range of annual herbs and grasses including *Eragrostis* spp. In some cases *Tecticornia* sp. LCH37319 and *Tecticornia* sp. LCH37320 (identifications still in progress) are also associated.

Soil Characteristics

The soil profile within the clay pans supporting the *Atriplex* sp. Yeelirrie Station within both the Eastern and Western Populations was investigated in detail by Soilwater Consultants (SWC 2015b) (Appendix E5). This work involved excavating shallow (i.e. maximum 2 m depth) soil trenches, using an 8 t backhoe, in clay pan areas where *Atriplex* Yeelirrie Station plants were present and where they were absent to elucidate potential differences that may facilitate understanding of their ecophysiological function and requirements.

Soil profiles within the clay pans supporting the existing Western and Eastern Populations were relatively uniform, and little observable difference existed between areas where *Atriplex* Yeelirrie Station plants were present and absent (Plate 9-3). All profiles generally comprised 10 – 80 cm of a reddish brown clay, overlying a brown loam trending to a calcareous loam at depth. These surficial

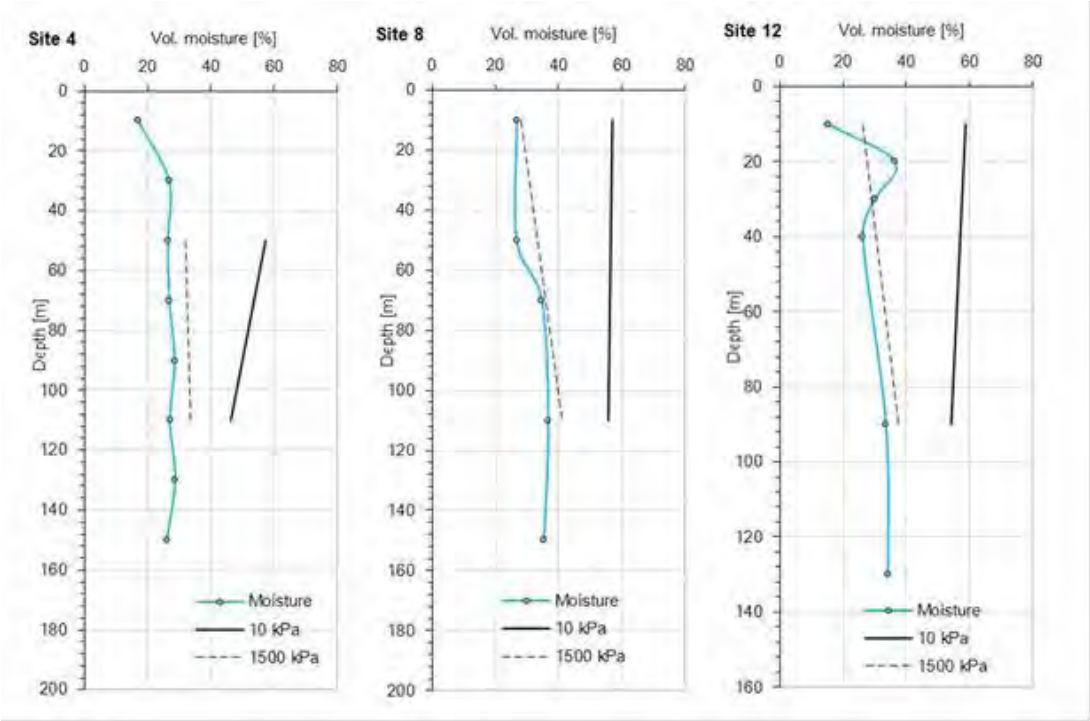

Plate 9-4: Soil moisture profiles for representative clay pan soil profile supporting *Atriplex* sp. Yeelirrie Station

earthy soils had been deposited directly onto the pre-existing calcrete (paleo) surface, resulting in an abrupt boundary at around 1.5 m depth. Although there was uniformity in the morphological structure of the profiles between sites and populations, internally there was appreciable complexity in the soils, such that within the surficial clay or loam horizon, a definite lens of coarse sand or a gravel layer were sometimes present.

The SWC (2015b) investigation analysed a full suite of physical and geochemical properties of the soils within the Western and Eastern Populations. This included particle size distribution, bulk density, field moisture, water retention properties, basic chemistry (i.e. pH and EC) and total and plant available (trace) metals and nutrients. In addition, exchangeable cations and corresponding Cation Exchange Capacity (CEC), and mineralogy were determined on representative materials from each soil horizon.

The results from this detailed analysis showed that no discernible difference in the majority of the physical, chemical or hydraulic properties exist within the clay pans between areas that support *Atriplex* sp. Yeelirrie Station and those areas that do not. At the time of sampling (mid – late April; where around 120 mm of rainfall occurred in the preceding six weeks – i.e. from the 1st March 2015) the soil profiles were effectively dry throughout, with field moisture contents at or just below Permanent Wilting Point (PWP, 1,500 kPa matric suction; Plate 9-4). Water retention results for the various soil types within the clay pan are provided in Table 9-5. These results highlight the clayey nature of all materials with PWPs > 24% (v/v).

Table 9-5: Average water retention results for the major soil types occurring within the clay pans

Soil material	Volumetric water content (%)					Plant Available Water (PAW) content
	0 kPa	10 kPa	33 kPa	100 kPa	1,500 kPa	
Clay	64.94	47.41	42.05	34.32	24.13	23.28
Loam	61.23	49.01	46.08	38.61	27.41	21.60
Calcareous Loam	70.63	52.48	49.96	41.39	31.51	20.98
Calcrete	73.33	46.29	53.55	43.36	33.57	12.72

There was no apparent difference in mineralogy between the various soils in the clay pan, and all were dominated by quartz and kaolinite, with minor smectite, trace mica and calcite and accessory iron oxides (goethite and hematite). The geochemical results for each of the soils types within the clay pan are provided in Table 9-6 to Table 9-8. These illustrate there is little variation in geochemical properties of the various soils that comprise the areas where *Atriplex* sp. Yeelirrie Station is both present and absent.

Table 9-6: Average multi-element composition of the dominant soil types within the clay pans

Element	Clay		Loam		Calcareous Loam	
	Avg	Max	Avg	Max	Avg	Max
Yeelirrie Sites						
Al	40,240	69,800	16,723	27,600	41,200	69,800
As	7	11	5	8	12	16
B	125	250	30	41	147	260
Ba	70	160	23	30	43	57
Ca	34,710	88,000	50,867	130,000	59,200	160,000
Cd	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Co	7.2	8.7	7.1	12.0	6.7	8.6
Cr	53	71	32	46	46	70
Cu	14	22	6.6	9.7	13	21
Fe	21,790	34,000	10,533	16,000	20,460	34,000
Mg	61,200	84,000	24,400	48,000	51,200	67,000
Mn	255	410	98	160	199	350
Mo	1.0	2.4	0.3	0.5	1.1	1.8
Na	5,670	28,000	513	1,200	5,448	11,000
Ni	15	23	7	11	14	23
Pb	4.5	8.1	2.9	3.5	4.7	7.9
V	89	110	55	71	100	150
Zn	38	61	14	24	33	56

Table 9-7: Average bioavailable trace element composition of the dominant soil types within the clay pans

Element	Clay		Loam		Calcareous Loam	
	Avg	Max	Avg	Max	Avg	Max
Yeelirrie Sites						
Al	348	>550	360	480	266	>550
As	0.4	0.7	0.8	1.7	1.1	2.1
B	46	100	4.4	6.6	56	100
Ca	>5,500	>5,500	4,400	>5,500	5,500	>5,500
Cd	0.01	0.02	0.01	0.01	0.01	0.01
Co	0.31	0.91	0.51	0.99	0.31	0.77
Cu	0.2	0.5	0.2	0.4	0.2	0.3
Fe	64	120	52	62	61	110
K	511	>550	283	>550	550	>550
Mg	500	500	643	930	500	500
Mn	29	74	23	33	18	38
Mo	0.04	0.15	0.01	0.02	0.13	0.30
Na	552	>1,000	347	960	810	>5,500
Ni	0.4	0.6	0.3	0.4	0.3	0.3
P	18	48	4	6	13	30
Pb	1.2	1.8	0.9	1.3	1.4	2.1
S	90	160	157	>250	0	>250
Se	0.3	0.6	0.1	0.2	0.2	0.3
Zn	0.2	0.3	0.2	0.3	0.1	0.2

Table 9-8: Average nutrient composition of the dominant soil types within the clay pans

Element	Clay			Loam			Calcareous Loam		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Yeelirrie Sites									
Total N	0.018	0.044	0.077	0.012	0.021	0.039	0.016	0.021	0.027
Total P	89	174	300	43	68	89	54	143	250
Colwell P	2	10	21	4	5	6	2	5	6
Total K	2,300	4,790	9,300	500	1,650	3,500	2,500	6,380	11,000
Colwell K	410	1,510	3,300	150	527	1,200	1,000	1,640	2,600
Total S	110	3,138	25,000	92	33,511	100,000	520	24,524	85,000
KCl ext. S	4	717	4,000	32	2,167	6,300	320	3,224	7,200

It was reported by SWC (2015b) that the *Atriplex* sp. Yeelirrie Station occurs within the same micro-topographic or geomorphic position within all clay pans. In all cases this species was positioned on a slight rise above the surrounding clay pan surface, such that it likely remained 'dry' when the

clay pans became inundated following heavy rainfall or flooding. The slight rises that the *Atriplex* sp. Yeelirrie Station occupy only extend 10 – 20cm above the clay pan surface, and no *Atriplex* sp. Yeelirrie Station was observed occurring within the main clay pan. Detailed sampling and testing of the salinity of the soils within these rises and the adjacent clay pan highlighted that in areas where healthy *Atriplex* sp. Yeelirrie Station occurred, soil salinity was significantly lower (Table 9-9). It is likely that the clay soils within the slight rise have experienced more leaching than the surrounding soils, given their elevated nature above the surrounding plain, and are not (in most rainfall events) inundated, which has the potential to increase soil salt content.

Table 9-9: Summary of soil salinity results for the slight rises supporting the *Atriplex* sp. Yeelirrie Station and areas where it is absent

Environment	Mean (mS/m)	Median (mS/m)	High (mS/m)	Low (mS/m)
Clay Rise (*Atriplex* sp. Yeelirrie Station performing well)	520	331.5	1874	12.82
Clay Pan Surface (*Atriplex* sp. Yeelirrie Station performing poorly)	1676	1591	2605	918
Clay Pan Surface – No *Atriplex* sp. Yeelirrie Station	577	535.2	1135	102
Loam (*Atriplex* sp. Yeelirrie Station performing well)	511	505	1,122	10.31
Loam (*Atriplex* sp. Yeelirrie Station performing poorly)	693	709	793	517
Loam – No *Atriplex* sp. Yeelirrie Station	926	933	1,133	712

Based on field observations and physical, chemical and hydraulic properties of the soils it suggests that the *Atriplex* sp. Yeelirrie Station is susceptible to a combination of salinity and inundation, and therefore is occupying a niche habitat within clay pans. The results suggest that inundation is likely to be the dominant limiting factor, as even if the salinity is within the apparent tolerable range (i.e. around 500 mS/m) any inundation is expected to inhibit the establishment of this species.

The soils which appear to be associated with the *Atriplex* sp. Yeelirrie Station distribution have been classified as 'Self-mulching'. Based on laboratory work undertaken by Soilwater Consultants in 2015 (SWC 2015b) in accordance with the established procedure of Grant and Blackmore (1991), all surface clay soils sampled from the *Atriplex* sp. Yeelirrie Station areas are not classified as Self-mulching. The cracking clay surface is therefore incorrectly labelled as Self-mulching, and is simply a function of desiccation and shrinkage of the clays upon drying. It is important to note that whilst these clays exhibit surface desiccation cracks they are not cracking clays, and a more appropriate classification of them would be 'Red/Brown Clay' according to the Soil Groups of Western Australia (Schoknecht 2002).

9.1.5 Potential Impacts and Management

The potential impacts on flora and vegetation that have been identified are:

- clearing of up to 2,421.8 ha of native vegetation;
- indirect impacts on groundwater dependent vegetation due to groundwater abstraction and reinjection;
- indirect impacts to vegetation dependent of surface water due to alterations and disruptions to surface water flows;
- indirect impacts on flora and vegetation from dust;
- introduction of weeds and spread of weeds into mining areas and adjacent native vegetation through movement of vehicles and materials;

- impacts on plants from feral animals and introduction of plants from outside the local area;
- uptake of radionuclides or other contaminants;
- altered fire patterns; and
- introduction of plants from outside the local area.

9.1.5.1 Impacts on vegetation communities

Impacts of clearing

Approximately 726 ha of native vegetation will require clearing from the open pit area, and up to 1,695 ha will require clearing for associated infrastructure.

Land Systems

An assessment of impacts from clearing to vegetation at the Land System level within the Local Study Area is presented in the Table 9-10. As evident in Table 9-2, the majority of the Land Systems are well represented across the north-eastern Goldfields and therefore the overall regional impact each individual Land Systems is low. No management measures are required to reduce impact or protect the land systems within the local area.

Table 9-10: Impacted land systems within local Study Area

Land System (Pringle *et al*. 1994, Payne *et al*. 1998)	Total Area of Land System within Local Study Area (ha)	Total Area to be Cleared (ha)	Percentage to be Cleared (%)
Millrose	13	2.5	19.23
Sherwood	921	32.9	3.57
Waguin	254	0	0
Gransal	440	0	0
Windarra	99	11	11.1
Bullimore	71530	850	1.19
Hamilton	46	0	0
Ranch	11	0	0
Monk	247	1.4	0.57
Yanganoo	11202	157.2	1.40
Desdemona	141	0	0
Cosmo	1797	0	0
Cunyu	2857	316.6	11.08
Melaleuca	3008	98	3.26
Mileura	3796	940.5	24.78
Carnegie	3525	0	0

Vegetation Associations

The vegetation associations of the study area have been mapped at NVIS Level 5 Vegetation Association. This level of definition is only available within Study Areas 1, 2 and 3 and is not available on a wider local or regional scale. Figure 9-6 shows the mapped vegetation associations of the study area, the Project footprint that is proposed to be cleared, and the broader development envelope. Table 9-11 lists the proportion of the total mapped area of each vegetation association and how much of each association is proposed to be cleared.

Table 9-11: Vegetation associations within Local Study Area to be impacted by the proposal

Vegetation community code	Vegetation Community Name	Area of Community within Local Study Area (ha)	Total Area to be Cleared (ha)	Percentage to be Cleared (%)
SAES	Stony *Acacia galeata* and *Eremophila* spp. Shrubland	311.1	0	0%
BCLS	Breakaway Chenopod Low Shrubland	54.4	0	0%
GFGr	Granite Foot Slope Grassland	43.4	0	0%
GPoS	*Ptilotus obovatus* Shrubland	133.8	2.3	1.7%
Qtz	Quartz Ridge	15.8	0	0%
GR	Granite Rise	47.7	0	0%
GRMS	Mulga Shrubland on Granite Rise	1159.4	1.9	0.2%
SASP	Sand plain Spinifex Hummock Grassland	2052.1	7.3	0.4%
SAWS	Sand plain Spinifex Hummock Grassland with Wattles	16698.8	94	0.6%
SAMA	Sand plain Spinifex Hummock Grassland with Mallee	30112.2	429.9	1.4%
SAHS	Sand plain Spinifex Hummock Grassland with Heath	2258.5	11.2	0.5%
SAGS	Sand plain Spinifex Hummock Grassland with *Eucalyptus gongylocarpa*	2885.6	0	0%
SAMU	Sandplain Mulga Spinifex Hummock Grassland	14186.9	270.5	1.9%
WABS	Wanderrie Bank Grassy Shrubland	1684.5	5.2	0.3%
SDSH	Sand Dune Shrubland	164	0	0%
HPMS	Hardpan Plain Mulga Shrubland	11198.5	187.4	1.7%
DRMS	Drainage Tract Mulga Shrubland	283.3	1.9	0.7%
DRES	Drainage Line *Eucalyptus camaldulensis* Woodland	5	0	0%
GRMU	Mulga Groves on Hardpan Plain	1410	0	0%
PLAPoS	*Acacia* spp. and *Ptilotus obovatus* Shrubland	2798.6	343.8	12.3%
PLAET	*Acacia* spp. and *Eremophila* spp. Thicket	384.3	36.4	9.5%
PLAMi	*Acacia* spp. and *Melaleuca interioris* Shrubland	101.4	0	0%
PLMf	*Muehlenbeckia florulenta* Shrubs	17.7	0	0%
PLCsMp	*Cratystylis subspinescens* and *Maireana pyramidata* Shrubland	639.3	7.9	1.2%
PLEmc	*Eremophila maculata* ssp. *brevifolia* Shrubland	8.5	0	0%
PLEml	*Eremophila malacoides* Shrubland	197.8	0	0%
PLEsp	*Eragrostis* sp. Grassland on Playa	15.2	8.1	53.6%
PLCh	Chenopods on Scalded Areas	55.8	0	0%
CEgW	*Eucalyptus gypsophila* Woodland on Calcrete	309.9	87.7	28.3%
CCpW	*Casuarina pauper* Woodland on Calcrete	682.3	5.6	0.8%
CMxS	*Melaleuca xerophila* Shrubland on Calcrete	664.4	175.1	26.4%
CAbS	*Acacia burkittii* Shrubland on Calcrete	1543.3	89.8	5.8%
CMiS	*Melaleuca interioris* Shrubland	6.3	0	0%
CErG	*Eragrostis* sp. Yeelirrie Calcrete Grassland on Calcrete	119.6	54.7	45.8%

Vegetation community code	Vegetation Community Name	Area of Community within Local Study Area (ha)	Total Area to be Cleared (ha)	Percentage to be Cleared (%)
CApS	*Atriplex* sp. Yeelirrie Station Shrubland	192.2	71	36.9%
CRsS	*Rhagodia* sp. Yeelirrie Station Shrubland	22.1	0	0%
CMpS	*Maireana pyramidata* Shrubland	147.5	45.2	30.6%
CLaS	*Lycium australe* Shrubland	140.6	94.8	67.4%
CMGbS	Mulga *Grevillea berryana* Shrubland	47.9	43.3	90.4%

EPA Position Statement No. 2 (EPA, 2000) indicates that "there would be an expectation that a proposal would demonstrate that the vegetation removal would not compromise any vegetation type by taking it below the "threshold level" of 30% of the pre-clearing extent of the vegetation type". i.e. more than 70% of the pre-clearing extent is proposed to be disturbed.

As presented in Table 9-11 the Project will directly impact one vegetation association CMGbS (Mulga *Grevillea berryana* Shrubland) beyond this threshold level within the Local Study Area. The Mulga *Grevillea berryana* Shrubland (which includes *Acacia ayersiana*) on Calcrete is a small vegetation association situated on the flanks the calcrete landforms of the Yeelirrie palaeochannel. The component species are widespread and abundant where they occur, however the regional representation of Mulga - *Grevillea berryana* Shrubland on Calcrete is not known past the Local Study Area. This is most likely due to low intensity mapping outside Local Study Area.

Two other vegetation associations that will have more than 50% (but less than 70%) cleared within the Local Study Area are *Lycium australe* shrubland (CLaS) and *Eragrostis* sp. Yeelirrie Calcrete on Playa (PLEsp).

- *Lycium australe* is a common species of salt lake margins in the eastern part of the south-west and the Western part of the Eremaean Botanical provinces where it often grows as a dominant to codominant shrub. At Lake Mason, it may be associated with *Cratystylis subspinescens*, *Eremophila arachnoides* subsp. *arachnoides* (P3), *Maireana pyramidata* or *Tecticornia* spp. shrubs. The regional representation of *Lycium australe* shrubland on Calcrete vegetation association similar in species composition to that at Yeelirrie is currently not known, most likely due to the low intensity mapping outside the study area.
- *Eragrostis* sp. Yeelirrie Calcrete is a common species occuring on calcrete platforms on lake margins and is known from near Yalgoo to east of Wiluna. It is particularly abundant at Lake Mason and was noted extensively in recent surveys by Western Botanical. However, the regional representation of *Eragrostis* sp. Yeelirrie Calcrete grasslands, either as the dominant vegetation association or in mosaics with other adjacent vegetation types, is currently not known outside the study area.

The Project will not have any impacts on vegetation associations which are listed as PECs or TECs by DPaW or TECs listed under the EPBC Act.

Impact of Groundwater drawdown on potentially phreatophytic vegetation

Groundwater drawdown impacts are discussed in detail in Section 9.5. Cameco has mapped the vegetation communities containing potentially phreatophytic vegetation that occur within the 1 m drawdown contour, over the life of the mine (Figure 9-6). Table 9-12 shows the percentage of the total mapped area of the potentially phreatophytic vegetation communities that occur within the 1 m drawdown contour. Cameco has also considered the impacts on phreatophytic vegetation from reinjection. However the entire area affected by reinjection is within the proposed pit and 1 m drawdown contour.

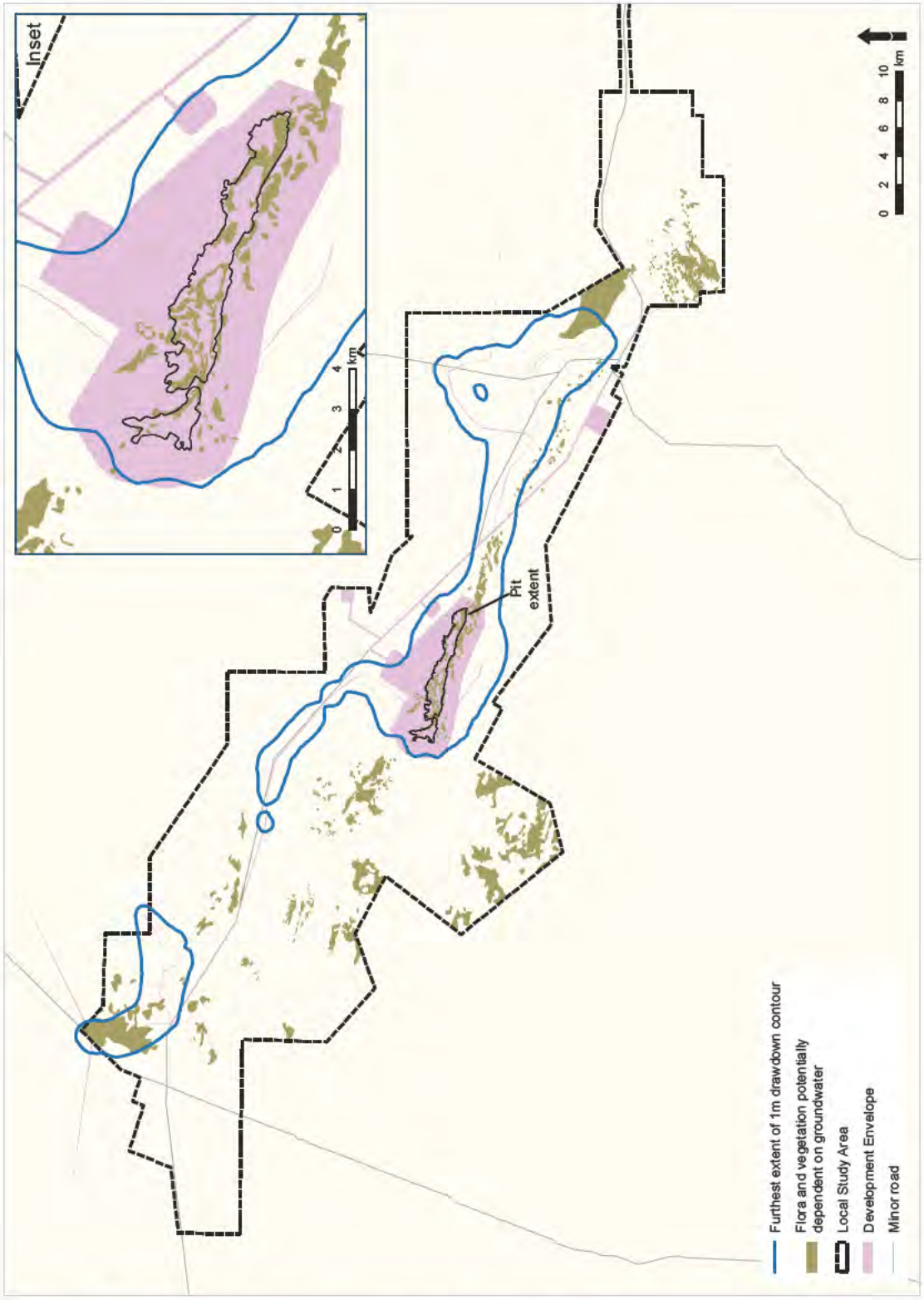

Figure 9-6: Phreatophytic vegetation associations within local Study Area

As previously mentioned the Mulga - *Grevillea berryana* Shrubland with *Acacia ayersiana* on Calcrete, is a small vegetation association that is situated on the flanks the calcrete landforms of the Yeelirrie palaeochannel. Both the component species are widespread and abundant where they occur, however the regional representation of the association is not known beyond the Local Study Area. This is most likely due to low intensity mapping outside Local Study Area.

A vegetation condition monitoring program will be implemented within the Area likely to be affected by groundwater abstraction. The program would include monitoring control sites and potential impact sites in the vegetation communities outlined in Section 9.1.4.2 within the predicted drawdown zone. The vegetation monitoring results would be correlated with changes in groundwater levels, and contingency measures developed, should a change be observed that can be attributed to these activities. Contingency measures are expected to include rotation of bores to minimise drawdown or irrigation of susceptible communities outside of the Development Envelope (but within the drawdown zone), if practical.

Table 9-12: Phreatophytic vegetation associations within 1 m groundwater drawdown

Vegetation Community Code	Phreatophytic Vegetation Community	Area within Local Study Area (ha)	Area to be Cleared (ha)	Area within modelled 1 m drawdown	Total % Potentially Impacted
PLAET	*Acacia* spp. and *Eremophila* spp. Thicket	384.3	36.4	123.2	41.53
PLAMI	*Acacia* spp. and *Melaleuca interioris* Shrubland	101.4	0	15.3	15.09
CEgW	*Eucalyptus gypsophila* Woodland on Calcrete	309.9	87.7	23.4	35.85
CCpW	*Casuarina pauper* Woodland on Calcrete	682.3	5.6	19	3.61
CMiS	*Melaleuca interioris* Shrubland	6.3	0	3.7	58.73
SASP	Sand plain Spinifex Hummock Grassland	2052.1	7.3	764.6	37.62
SAGS	Sand plain Spinifex Hummock Grassland with *Eucalyptus gongylocarpa*	2885.6	0	285.3	9.89
SMGbS	Mulga *Grevillea berryana* Shrubland	47.9	43.3	4.5	99.79
CMxS	*Melaleuca xerophila* Shrubland on Calcrete	664.4	175.1	149.4	48.84
	Total	7134.2	355.4	1388.4	24.44

Effects of changes to surface water flow

As part of monitoring of the integrity of surface water diversion and management structures (Section 9.4), Cameco will also monitor nearby vegetation health to determine if water ponding, water starvation or erosion and sedimentation is occurring that could adversely affect vegetation condition. Whilst flood water depth is expected to increase (from baseline) upstream of the mine site as a result of the surface water diversion bund, the effects are expected to be localised.

Introduction of weeds

In addition to direct impacts of clearing, the Project has the potential to introduce weeds to, or spread weeds within, the Project Area. Seeds may be carried into the Project on vehicles and machinery, or in soil moved within the Project Area.

All earth moving equipment and other vehicles or machinery will be cleaned of all soil and seeds before mobilisation into new clearing areas. Weed control will be undertaken for infestations with the potential to spread. Vegetation removed during clearing activities will be temporarily stockpiled to be used as mulch and a seed source in progressive revegetation. Soil that is suitable for rehabilitation will be stripped and stored in low stockpiles to retain seed viability and be protected from erosion and accidental disturbance.

Cameco will develop a Flora and Vegetation and Management Plan to minimise and manage potential impacts of the Project on the flora and vegetation communities of the Project Area. As part of this management plan Cameco will implement a ground disturbance procedure that will apply to all clearing activities. Areas proposed to be cleared will first be inspected by environmental personnel to determine if there are any significant flora present within the area or other sensitive environmental areas, and to ensure clearing is conducted in accordance with the necessary approvals. Clearing will be kept to the minimum area required for safe and efficient operation. Clearing will not be conducted during or immediately after significant rain to reduce the risk of erosion and damage to soil structure.

Impacts from dust and radiation

This section discusses the potential radiological effects of the operation on flora and vegetation. The assessment considers the primary pathway for impacts outside the operation, which is the release of airborne dusts and their deposition in the environment. The Project has been designed to prevent off-site release of water for events up to 1:1,000 ARI rainfall event therefore this pathway was not considered further.

The deposition of Project-originated dust could result in the deposition of radionuclides onto soils and their subsequent incorporation into the soils.

The assessment utilises the Environmental Risk from Ionising Contaminants (ERICA) software tool and the change in soil radionuclide concentrations to make a qualitative assessment of potential risk to a set of standard flora species. For this assessment, Cameco has derived some area and plant species-specific concentration ratios from radionuclide surveys conducted in 2010 and 2011 by BHP Billiton. As there is limited Australian concentration ratio data for flora species in ARPANSA (2014), the site specific concentration ratios have been used.

The ERICA Tool

The ERICA Assessment tool was developed under the European Commission to provide a method of assessing the impact of radiological contaminants on the natural environment (Brown et al. 2008; Larsson 2008). The tool contains two major data sources. The first, the database FREDERICA, contains information on the effects of radiation exposure on populations, and includes data on four main "endpoints": morbidity, mortality, reproduction and mutation (Copplestone *et al*. 2008). The second is a collection of databases that allows estimation of the radiation doses that will accrue to biota from radiological contaminants in their environment.

The International Commission on Radiological Protection has recommended that environmental radiological effects should be assessed on a series of "reference organisms", and these are incorporated into the ERICA tool (ICRP 2003).

The starting point for an ERICA assessment is the radionuclide concentrations of the medium in which or on which the reference organisms are living, in this case soil. This allows the external dose rate for the organisms to be derived, and in addition "concentration ratios" from the ERICA database are used to calculate the radionuclide concentrations in the organisms, and hence the internal dose rates.

The ERICA assessment process can be carried out in three "tiers".

Tier 1 is a simple highly conservative assessment, designed to easily identify situations which can be considered of negligible radiological concern.

Tier 2 is used where a Tier 1 assessment indicates that there may be organisms at risk, and allows the use of more realistic and less conservative parameters to allow the estimation of dose rates to the organisms. These dose rates are then assessed against a screening dose rate to determine if there is a likelihood that populations could suffer harm.

Tier 3 is not a screening tier but is designed to provide guidance in further investigation of situations where Tier 2 indicates that there may be a significant concern of radiological harm.

The default screening dose rate adopted by ERICA is 10 µGy/h. This dose rate (described as the "predicted no-effect dose rate", PNEDR) was derived from the dose estimated to give a 10% effect (i.e. to one of the end points noted above) to 5% of the species present by applying a safety factor of five. This screening rate is expected to protect the most radiosensitive organisms likely to be present in an environment (Garnier-Laplace *et al*. 2008; Copplestone *et al*. 2008).

The ERICA tool allows other screening dose rates to be adopted. For example, several organisations have suggested that no measureable effects would be observed for dose rates of 40 µGy/h (terrestrial animals) and 400 µGy/h (terrestrial plants) (IAEA 1992; UNSCEAR 1996; United States Department of Energy 2002). The ERICA tool presents the results as the dose rates to the organisms, and also in terms of the "Risk Quotient" (i.e. the ratio of the dose rate to the screening rate). Dose rates and risk quotients are presented both for the "expected value" and a "conservative value". The default conservative value is three times higher than the expected value and represents the value at which there is only a 5% chance that the calculated dose rate exceeds the screening level. This represents a further level of conservatism.

The results of an ERICA assessment can be described in terms of three dose rate bands (Brown *et al*. 2008):

RQExpt > 1 (i.e. expected dose rate > 10 µGy/h)
: Screening dose is exceeded. Further assessment needed.

RQCons > 1 but RQExp < 1 (i.e. expected dose rate 3.3 – 10 µGy/h)
: Substantial probability that screening dose rate is exceeded. Assessment should be reviewed.

RQCons <1 (i.e. expected dose rate <3.3 µGy/h)
: Low probability that screening dose rate will be exceeded. Environmental risk is considered negligible.

A potential disadvantage of using the ERICA tool for Australian situations is that many of the parameters are derived for temperate northern hemisphere flora and fauna which do not directly equate with Australian flora and fauna. The standard ERICA factors are generally used because there is a lack of specific Australian data. However, in this instance there is some region specific radionuclide concentration data that was collected by BHP Billiton and that has been used to develop local flora concentration ratios.

Soil Radionuclide Concentrations

The air quality modelling has produced dust deposition estimates (Section 9.8.5). The modelling produces estimates of the potential impact that the operation will have irrespective of the naturally occurring background levels. This assessment has been conducted at the modelled project impact contour of 0.4g/m^2/month, which occurs at approximately the operations boundary. For a 15 year project, the total predicted dust deposition is calculated to be 72 grams per m^2. For the whole operation, the average radionuclide content of the emitted dust is 9.4Bq/g per radionuclide.

Once deposited, the Project dust would mix with the soil through a combination of physical, chemical and biological processes. For this assessment, it has been assumed that the mixing depth

is 10 mm (Kaste *et al*. 2007). The soil density was assumed to be 1.5 t/m^3.

Therefore the increase in radionuclide concentration in the soil at the Project boundary after 15 years of operations is calculated as follows;

- total radionuclide deposition per m^2 = 72 g x 9.4 Bq/g = 677 Bq
- total mass of soil per m^2 = 1 m x 1 m x 0.01 m x 1.5 t/m3 = 15 kg
- increase in soil radionuclide concentration = 677 Bq/15 kg = 45 Bq/kg

Concentration Ratios

Concentration ratios for flora sampled during 2010 is presented in Table 9-13. These figures were obtained from the baseline radionuclide surveys by taking the average radionuclide concentrations in flora and dividing by the average soil concentrations.

Table 9-13: Summary of concentration ratios for sampled vegetation

Species	Concentration Ratios				
	U^{238}	Th^{230}	Ra^{226}	Pb^{210}	Po^{210}
Acacia aneura	0.10	0.30	0.01	0.31	0.56
Acacia ayersiana	0.11	0.03	0.01	0.36	0.56
Ptilotus obovatus	0.17	0.07	0.06	0.20	0.20

The derived concentration ratios for each local flora species have been averaged to provide a single figure and Table 9-14 provides a comparison of the default ERICA concentration

Table 9-14: Comparison of concentration ratios

Element	Concentration Ratios			
	ERICA Default (Tree)	ERICA Default (Shrub)	Cameco (Tree/ Shrub)	Shrubs (ARPANSA 2014)
Uranium	0.007	0.061	0.130	-
Thorium	0.001	0.061	0.130	-
Radium	0.012	0.330	0.030	0.15
Polonium	0.073	0.330	0.440	-
Lead	0.070	0.320	0.290	-

ERICA Assessment

A Tier 2 ERICA assessment was conducted using a soil radionuclide concentration of 45 Bq/kg (each uranium series radionuclide) and the derived concentration ratios (see Table 9-14) and the resulting derived dose rates are shown in Table 9-15.

Table 9-15: Tier 2 ERICA Assessment

Organism	CR Origin	Risk Quotient (expected value)	Risk Quotient (conservative value)
Lichen & bryophytes	Default	1.06	3.18
Grasses & herbs	Default	0.20	0.60
Shrub	Experimental	0.13	0.38
Tree	Experimental	0.13	0.38

Note that Table 9-14 shows that the ERICA default value for radium for shrubs is approximately 10 times higher than the local derived result. An additional ERICA assessment was conducted using the higher radium concentration ratio value and this gave results three times higher than those shown in Table 9-15,

however, both the expected value and conservative values were less than the screening value.

The assessment identified lichen and bryophytes as species that would trigger the screening level of 10 µGy/h. The baseline flora surveys conducted (Western Botanical 2011) made general observations for lichen, which showed that they were relatively abundant through the region.

The expected dose rate derived for lichen and bryophytes is just higher than the screening level of 10 µGy/h. The reason for this is likely to be that lichens (in particular) do not have a well-developed root system, and derive most of their nutrients from dust falling on them. Consequently, they receive a higher dose from the deposition of dusts than for other organisms.

Lichen and bryophytes are known to be particularly radio-resistant and a threshold no-effect dose rate has been estimated at approximately 125,000 µGy/h, with some diversity reduction observed at 1.1 Gy/h (UNSCEAR 1996). These dose rates are over 10,000 times the default screening dose rate used in ERICA, and indicate that no effect would be expected from any potential dust emissions from the Project.

Dust management and suppression measures will be undertaken as outlined in Section 9.8.5. Water used for dust suppression may be saline (up to 100,000 mg/L Total Dissolved Solids [TDS]) and therefore care will be taken not to spray this water on vegetation, and control run off into vegetated areas.

Impact from altered fire patterns

Alteration of natural fire regimes as a result of improved access and increased human activity can lead to a change in the floristics of an area.

Cameco will manage this risk through implementation of a fire ban across the Project Area and education of the workforce. Hot work permits will be required prior to commencing any work activity that may create an ignition source. Fire extinguishers will be available in all hot work areas and personnel will be trained in their use.

Combined worst-case impacts on vegetation communities

Cameco has looked at the potential combined worst-case impacts on vegetation communities as a result of clearing, dust deposition, groundwater drawdown and inundation as a result of altered surface drainage patterns. For this assessment, the following criteria were used to map and calculate these impacts:

- the clearing footprint;
- dust deposition (>2 g/m^2/month);
- groundwater drawdown (>1 m); and
- inundation (from a 1:1,000 year ARI) rainfall event of >0.5 m).

The areas potentially impacted are shown on Figure 9-7. However, in reality these combined worst-case conditions are not expected to occur.

The figure shows that dust deposition will be mostly restricted to the pit and plant area due to the dust controls to be implemented for the Project (Section 9.8). Groundwater drawdown encompasses the pit area and extends to the north, northwest, and south east of the pit as a result of pit dewatering and borefield operations (Section 9.5). Under a 1:1,000 year ARI event, flooding of more than 0.5 m is expected to extend to the north and south of the pit, and upstream (northwest) of the pit, as a result of the surface water diversion bunding (Section 9.4).

Areas of vegetation communities potentially affected in the worst-case scenario are presented in Table 9-16. It should be noted however, that a number of vegetation communities within the drawdown contour are not expected to be groundwater dependent and therefore are unlikely to

be affected by drawdown of greater than 1 m. The results indicate that there are three vegetation communities with more than 75% of the community (mapped within the study area) occurring within the footprint of the combined worst-case impacts:

- Mulga Shrubland on Granite Rise (GRMS) – approximately 97.9% of this community that is mapped within the study area could be affected, as a result of inundation from a 1:1,000 year ARI rainfall event. However, the likelihood of this occurring during the life of the Project is extremely low and the predicted impact on this community is expected to be restricted to clearing (0.16%).
- Hardpan Plain Mulga Shrubland (HPMS) – approximately 79.1% of this community that is mapped within the study area could be affected as a result of inundation from a 1:1,000 year ARI rainfall event. This does not include the area within the groundwater drawdown contour of 0.5 m as this vegetation community is not expected to be groundwater-dependent. However, the likelihood of this occurring during the life of the Project is extremely low and the predicted impact on this community is expected to be restricted to clearing (1.67%).
- Mulga *Grevillea berryana* Shrubland (CMGbS) – approximately 99.8% of this community that is mapped within the study area could be affected as a result of clearing and groundwater drawdown impacts. However, as discussed above, the component species are widespread across the region, and abundant where they occur.

Table 9-16: Combined worst-case impacts on vegetation associations within the Local Study Area

			Direct Impacts (ha)	Additional area potentially affected by indirect impacts (ha)			
Vegetation community code	Vegetation Community Name	Area of Community within Local Study Area (ha)	Total Area to be Cleared (ha)	Dust Deposition (>2 g/m²/month)	Groundwater drawdown (>1 m drawdown)	Surface Water (>0.5 m flooding after 1,1000 year ARI)	Worst Case percentage impacted (%)
SAES	Stony *Acacia galeata* and *Eremophila* spp. Shrubland	311.1	0	0	0	0	0
BCLS	Breakaway Chenopod Low Shrubland	54.4	0	0	0	0	0
GFGr	Granite Foot Slope Grassland	43.4	0	0	0	0	0
GPoS	*Ptilotus obovatus* Shrubland	133.8	2.3	0	0	47.8	37.4
Qtz	Quartz Ridge	15.8	0	0	0	0	0
GR	Granite Rise	47.7	0	0	0	0	0
GRMS	Mulga Shrubland on Granite Rise	1159.4	1.9	0	0	1132.9	97.9
SASP	Sand plain Spinifex Hummock Grassland	2052.1	7.3	0	764.6	0	37.6
SAWS	Sand plain Spinifex Hummock Grassland with Wattles	16698.8	94	0	4910*	152.4	1.48
SAMA	Sand plain Spinifex Hummock Grassland with Mallee	30112.2	429.9	0	3869.3*	3123.7	11.8
SAHS	Sand plain Spinifex Hummock Grassland with Heath	2258.5	11.2	0	1088.3*	165.6	7.8

			Direct Impacts (ha)	Additional area potentially affected by indirect impacts (ha)			
Vegetation community code	Vegetation Community Name	Area of Community within Local Study Area (ha)	Total Area to be Cleared (ha)	Dust Deposition (>2 g/m²/ month)	Groundwater drawdown (>1 m drawdown)	Surface Water (>0.5 m flooding after 1,1000 year ARI)	Worst Case percentage impacted (%)
SAGS	Sand plain Spinifex Hummock Grassland with *Eucalyptus gongylocarpa*	2885.6	0	0	285.3	0	9.9
SAMU	Sandplain Mulga Spinifex Hummock Grassland	14186.9	270.5	19.5	1803.7*	2426.6	19.2
WABS	Wanderrie Bank Grassy Shrubland	1684.5	5.2	0	215.5*	347.7	21
SDSH	Sand Dune Shrubland	164	0	0	0	0	0
HPMS	Hardpan Plain Mulga Shrubland	11198.5	187.4	0	1150.9*	8672.7	79.1
DRMS	Drainage Tract Mulga Shrubland	283.3	1.9	0	164.1*	0	0.7
DRES	Drainage Line *Eucalyptus camaldulensis* Woodland	5	0	0	0	0	0
GRMU	Mulga Groves on Hardpan Plain	1410	0	0	114.4*	2.5	0.2
PLAPoS	*Acacia* spp. and *Ptilotus obovatus* Shrubland	2798.6	343.8	0	467.7*	266.2	21.8
PLAET	*Acacia* spp. and *Eremophila* spp. Thicket	384.3	36.4	0	123.2	33.1	50.14
PLAMi	*Acacia* spp. and *Melaleuca interioris* Shrubland	101.4	0	0	15.3	0	15.1
PLMf	*Muehlenbeckia florulenta* Shrubs	17.7	0	0	4*	4.1	23.2
PLCsMp	*Cratystylis subspinescens* and *Maireana pyramidata* Shrubland	639.3	7.9	0	0	0	1.2
PLEmc	*Eremophila maculata* ssp. *brevifolia* Shrubland	8.5	0	0	0	0	0
PLEml	*Eremophila malacoides* Shrubland	197.8	0	0	6.0*	0	0
PLEsp	*Eragrostis* sp. Grassland on Playa	15.2	8.1	0	0.5*	0.5	53.3
PLCh	Chenopods on Scalded Areas	55.8	0	0	0	35	62.7

			Direct Impacts (ha)	Additional area potentially affected by indirect impacts (ha)			
Vegetation community code	Vegetation Community Name	Area of Community within Local Study Area (ha)	Total Area to be Cleared (ha)	Dust Deposition (>2 g/m²/month)	Groundwater drawdown (>1 m drawdown)	Surface Water (>0.5 m flooding after 1,1000 year ARI)	Worst Case percentage impacted (%)
CEgW	*Eucalyptus gypsophila* Woodland on Calcrete	309.9	87.7	0	23.4 (entirely within >0.5 m flooding after 1,1000 year ARI)	56	46.4
CCpW	*Casuarina pauper* Woodland on Calcrete	682.3	5.6	0	19 (entirely within >0.5 m flooding after 1,1000 year ARI)	285.8	42.7
CMxS	*Melaleuca xerophila* Shrubland on Calcrete	664.4	175.1	0	105.4*	0	26.4
CAbS	*Acacia burkittii* Shrubland on Calcrete	1543.3	89.8	0	12.7*	782	5.82
CMiS	*Melaleuca interioris* Shrubland	6.3	0	0	3.7	2.6	26.35
CErG	*Eragrostis* sp. Yeelirrie Calcrete Grassland on Calcrete	119.6	54.7	0	0	0	5.82
CApS	*Atriplex* sp. Yeelirrie Station Shrubland	192.2	71	0	0	0	36.9
CRsS	*Rhagodia* sp. Yeelirrie Station Shrubland	22.1	0	0	0	2	9
CMpS	*Maireana pyramidata* Shrubland	147.5	45.2	0	21.3	0	45.1
CLaS	*Lycium australe* Shrubland	140.6	94.8	0	0	0	67.4
CMGbS	Mulga *Grevillea berryana* Shrubland	47.9	43.3	0	4.5	0	99.8

*Not expected to be groundwater dependent

9.1.5.2 Impacts on Conservation Significant Flora

Impacts on Priority flora

Direct impacts to known flora with conservation significance are discussed in detail in the Conservation Species Management Plan prepared by Cameco. Of the 12 known Priority species presented in Table 9-4 and present within the Local Study Area, only three species, *Eremophila arachnoides* subsp. *arachnoides* P3, *Bossiaea eremaea* P3 and *Euryomyrtus inflata* P3 will be

directly impacted by the Project. The impact to these species is considered to be low due to the small percentage of impact (Table 9-17) within the Local Study Area and due to them being well represented in the broader north-eastern Goldfields. The location of these species within the Study Area is also shown in Figure 9-4.

Table 9-17: Priority flora to be impacted by the proposal

Species Name	Status	Number of Plants within Local Study Area	Plants Proposed to be Cleared	Plants Proposed to be cleared (%)
Bossiaea eremaea	P3	36442	1562	4.29
Eremophila arachnoides subsp. *arachnoides*	P3	43255	5120	11.84
Euryomyrtus inflata	P3	134520	410	0.30

It should also be noted that the priority one species *Rhagodia* sp. Yeelirrie Station (K.A.Shepherd *et al*. KS1396) occurs both within and outside the Development Envelope. Cameco proposes to avoid this species and will establish a conservation area for the population (~100 plants) inside the development envelope as shown in Figure 9-8. However, due to proposed alterations in the surface water flow there is the potential for an indirect impact on the 100 plants (4.8%). As this population of *Rhagodia* sp. Yeelirrie Station (K.A. Shepherd *et al*. KS1396) occurs on the fringes of a clay pan that already experiences long periods of inundation it is unlikely that the plants will be significantly impacted.

Management of conservation significant flora will be in accordance with the Conservation Species Management Plan (Appendix E3). Should Priority flora species be recorded during pre-disturbance checks these would not be disturbed without consultation with DPaW to ensure the species conservation status is not adversely affected.

Combined worst-case impacts on significant flora

Cameco has looked at the potential maximum worst-case impacts on significant flora as a result of clearing, dust deposition, groundwater drawdown and inundation as a result of altered surface drainage patterns. For this assessment, the following criteria were used to map and calculate these impacts:

- the clearing footprint;
- dust deposition (>2 g/m^2/month);
- groundwater drawdown (>1 m); and
- inundation (1:1,000 year ARI event of >0.5 m).

The areas potentially impacted are shown on Figure 9-7. However, as noted above, these conditions are not expected to occur simultaneously.

The impacts of dust deposition are expected to occur within the pit and plant area. *Eremophila arachnoides* subsp. *arachnoides* is present in this area. However, this area will largely be disturbed as a result of clearing. Inundation as a result of a 1:1,000 year ARI rainfall event could affect populations of *Rhagodia* sp. Yeelirrie Station, *Bossiaea eremaea* and *Eremophila arachnoides* subsp. *arachnoides*. However, the likelihood of this occurring during the life of the Project is considered extremely low. *Euryomyrtus inflata*, *Bossiaea eremaea*, and *Eremophila arachnoides* subsp. *arachnoides* occur within the 1 m drawdown contour. However, these species are not considered groundwater-dependent.

Numbers of plants of each priority species potentially affected in the worst-case scenario are presented in Table 9-18. The results indicate that less than 30% each of the priority flora populations recorded within the Local Study Area will potentially be affected under worst-case conditions.

The impacts on the threatened species *Atriplex* sp. Yeelirrie Station are discussed in more detail below.

Table 9-18: Combined worst-case impacts on Priority flora within the Local Study Area

			Direct Impacts (#plants)	Additional plants potentially affected by indirect impacts (#plants)			
Species Name	Status	Number of Plants within Local Study Area	Plants Proposed to be Cleared	Dust Deposition (>2 g/m²/ month)	Groundwater drawdown (>1 m draw-down)	Surface Water (>0.5 m flooding after 1,1000 year ARI)	Worst Case percentage impacted (%)
Bossiaea eremaea	P3	36442	1562	0	14504*	4139	15.6
Eremophila arachnoides subsp. *arachnoides*	P3	43255	5120	0	285*	6350	26.5
Euryomyrtus inflata	P3	134520	410	0	42775*	0	0.3
Neurachne lanigera	P1	300	0	0	300*	0	0
Rhagodia sp. Yeelirrie Station	P1	2200	0	100	100* (same plants that are potentially affected by dust)	100 (same plants that are potentially affected by dust)	4.5

* Not considered groundwater dependent

9.1.5.3 Impacts on Theatened Flora (*Atriplex* sp. Yeelirrie Station)

As previously discussed, the Eastern and Western populations of *Atriplex* sp. Yeelirrie Station are genetically distinct, and that the two populations (genotypes) should be treated separately with regard to conservation measures. The Western Population of *Atriplex* sp. Yeelirrie Station lies wholly within the economic orebody and encompasses two sub-populations that are located in close proximity to each other. Implementation of the Project will involve total removal of the Western Population, taking 84,542 plants over an area of 76 ha, representing 30.71% of the overall population and 36.69% of the overall area of occupancy of this species. The Eastern Population of *Atriplex* sp. Yeelirrie Station, 190,755 plants over an area 130 ha, will be conserved and will not be impacted. As the Western Population genotype of *Atriplex* sp. Yeelirrie Station lies wholly within the economic orebody, minimisation or avoidance of impacts is not possible.

Protection of the Eastern genotype

The eastern genotype of *Atriplex* sp. Yeelirrie Station will not be affected by development activity related to the Project and Cameco proposes permanent protection from external pressures of the entire Eastern population as presented in Figure 9-9. This will be achieved through fencing of the population to exclude livestock from neighbouring pastoral leases. Tenure options, including the establishment of a Conservation Area, will be investigated to determine the best option to ensure long term protection.

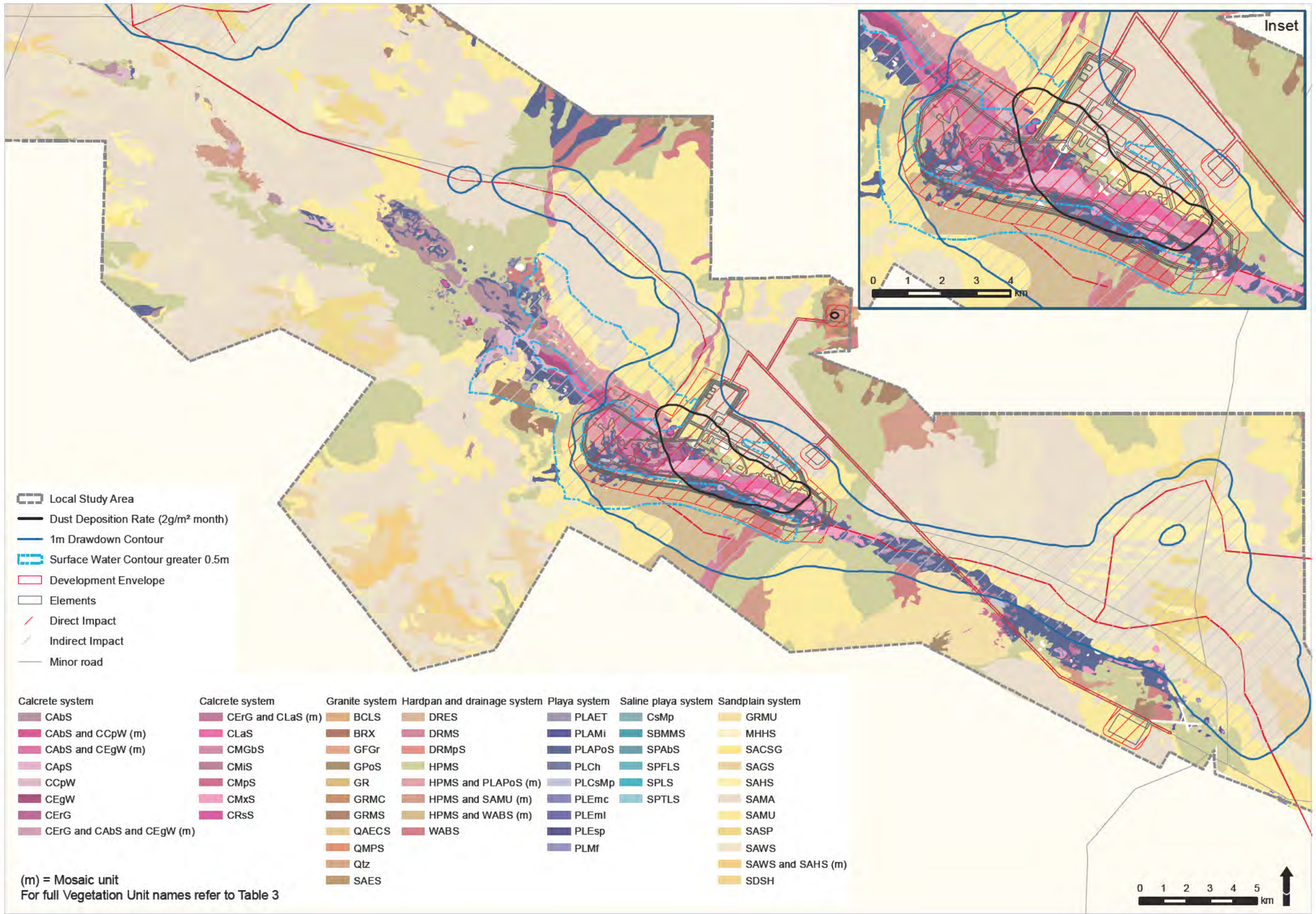

Figure 9-7: Combined worst-case impacts on vegetation communities within the local study area

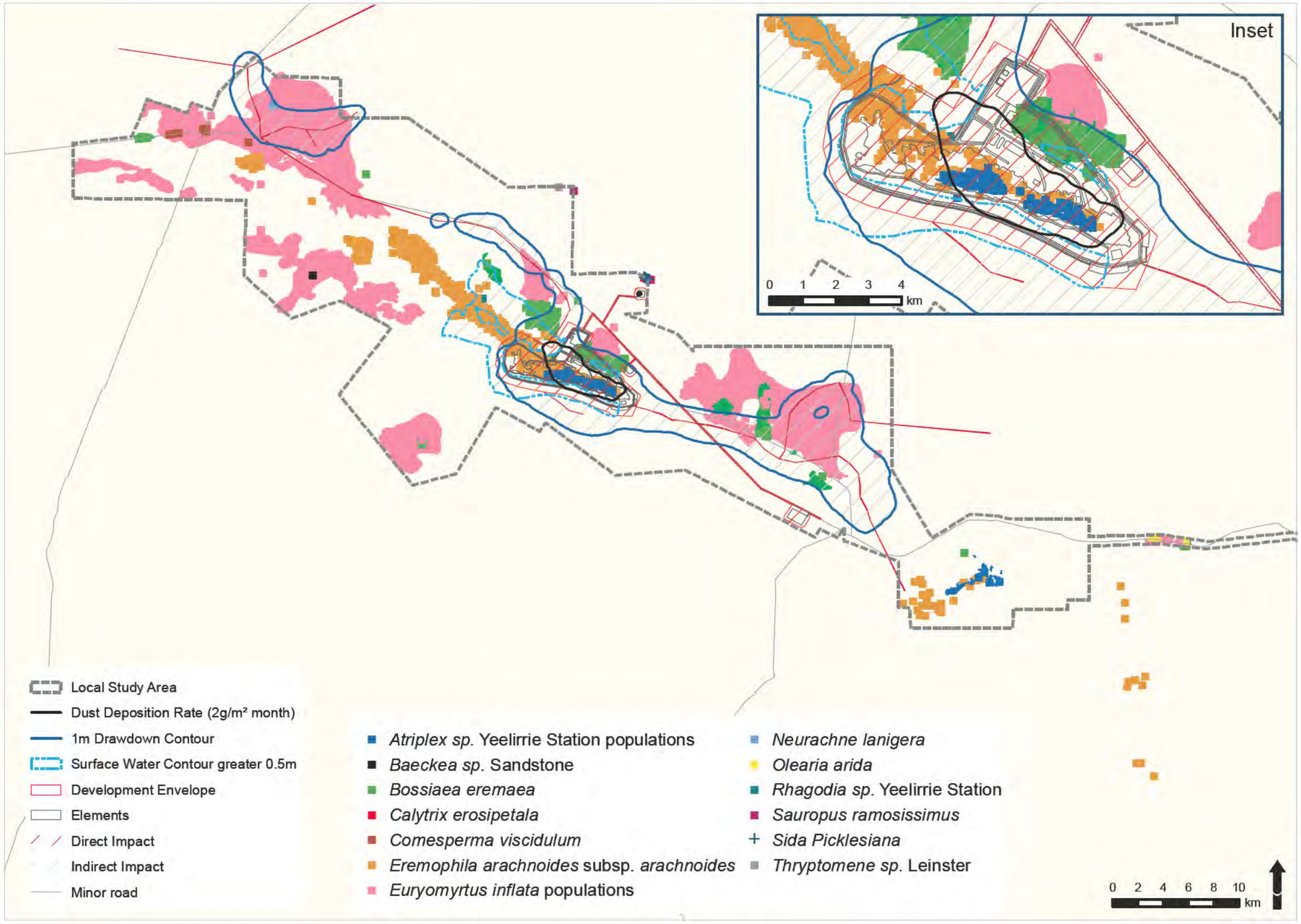

Figure 9-8: Combined worst-case direct and indirect impacts on significant flora in the study area

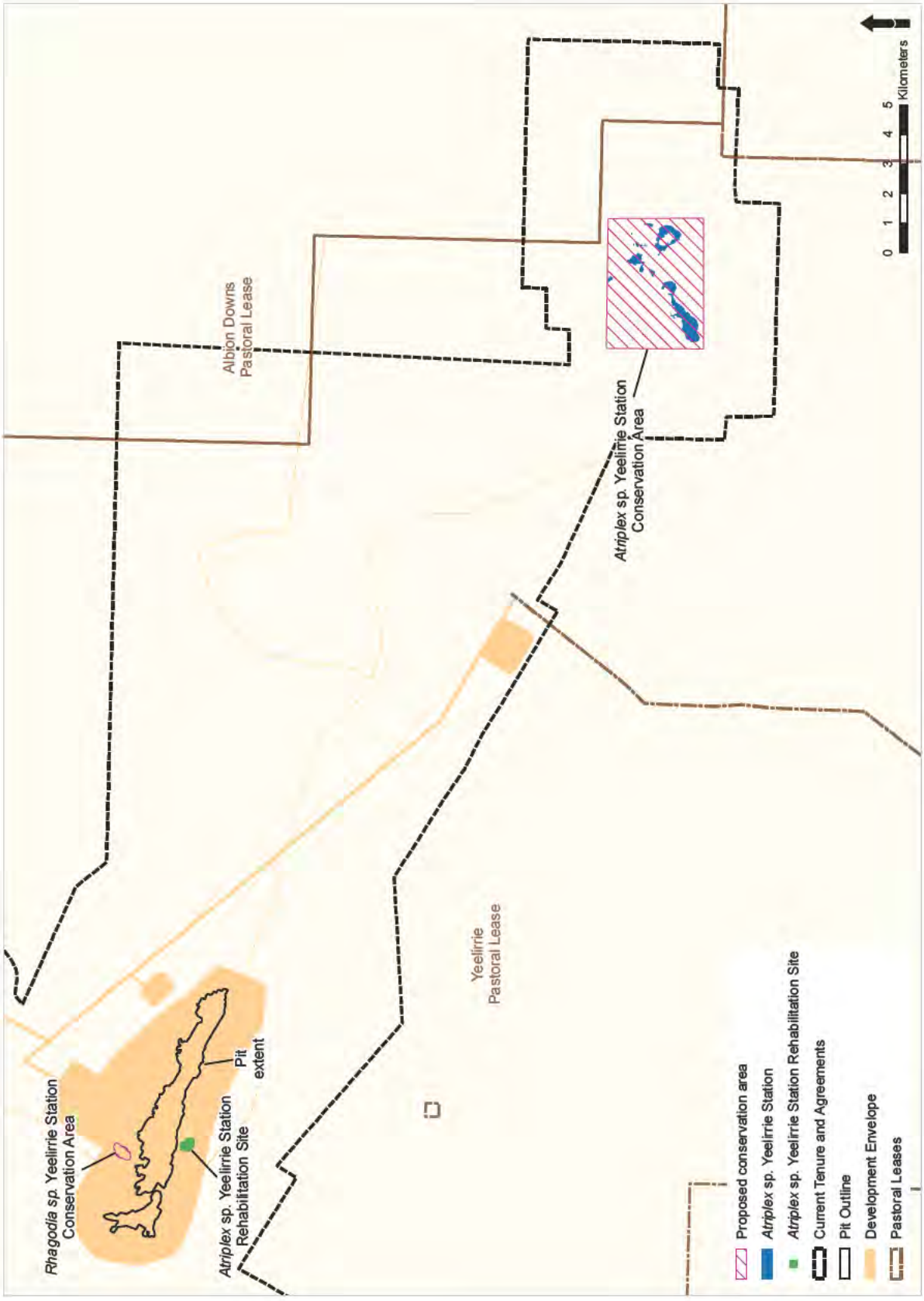

Figure 9-9: Proposed conservation areas

Measures will also be taken to protect the Rehabilitation population to ensure it is not cleared during mine development. Long term protection of this site will continue to provide a useful reference point for the comparison of population dynamics of the species.

Preservation by re-establishment of the Western genotype

In order to preserve the Western genotype, Cameco proposes to establish new populations of *Atriplex* sp. Yeelirrie Station (Western genotype) and has commenced investigations and research to provide some reasonable evidence that this can be achieved.

The multiple lines of investigation include the following:

- Investigations into seed collection, storage and long term seed viability, to ensure that seed harvested from natural populations can be stored for future use.
- Population demographic studies, to understand the population structure of the natural populations so that it can be used to assess the structure of future established populations.
- Hydrogeological studies of the natural habitat of the species so that potential new sites can be assessed.

The results of the investigations are discussed further below.

Seed collection, storage and viability

Atriplex sp. Yeelirrie Station produces seed annually, generally following significant rainfall events. A single seed is held in each bract. Bracts are indehiscent and stay on the plant for a period greater than 12 months. The seed is tightly held in the bract but can be extracted mechanically. Seed was collected from *Atriplex* sp. Yeelirrie Station during October and November 2010. At the time of collection both fresh bracts (produced in 2010) and old bracts (produced prior to 2010) were present on the plants in the populations that were targeted on the resource areas. The purpose of the seed collection program was to collect, process and store seed to undertake investigations into its viability and germination and for future use in rehabilitation or translocation trials. Approximately 3.69 million seeds were collected and continue to be stored for future use (Landcare Services 2011).

Germination and Viability testing was conducted on representative samples of fresh and old seed in 2011. The results are shown in (Table 9-19).

Table 9-19: Seed germination and viability results, 2011

Material tested	Germination Rate	Viability
Fresh excised seed	78%	96%
Old excised seed	73%	79%
Fresh seed in-bract	0%	85%
Old seed in-bract	22%	66%

Additional germination testing was conducted in late 2014 on the seed collected in August that year under DRF Permit 35-1415. The results showed germination rates of old and new seed did not vary significantly with rates between 72% and 92% observed, however, seed retained within the bracts did not begin to germinate at high rates (up to 50%) until three weeks of testing while excised seeds germinated rapidly in the second week. The results are reported in Western Botanical (2015d) (Report WB849; Appendix E6).

In summary, fresh seed has a higher viability rate than older seed and fresh seed excised from the bracts germinates at a higher rate than old excised seed. Germination rates are lower when the seed is retained in the bract, presumably due to a physical or chemical germination inhibition, which does begin to break-down after about three weeks. As fruits age, the rate of germination inhibition is reduced.

Plant demographics

Western Botanical (2011) reported an overall mature plant population estimate of ~275,297 across both populations where an average of 1,112 mature plants per ha were reported in the Western population (84,510 plants over 76 ha) and 1,467 mature plants per ha were reported in the Eastern population (190,646 plants over 130 ha).

The assessment of *Atriplex* sp. Yeelirrie Station undertaken in March 2015 established a baseline data set for future assessment of population dynamics and population viability analysis.

During the baseline field surveys, a third population of the species was assessed. This population of 109 individuals is growing in an area that was disturbed by exploration activities conducted in the 1980's and was subsequently rehabilitated in 1994. A further seven live plants have been noted in rehabilitation north of the deposits. It is believed that *Atriplex* sp. Yeelirrie Station seed was introduced to the site with soil.

Field assessment sites were established and the three populations have been assessed and statistically compared with the purpose of i) establishing a baseline data set of "mature" populations upon which to compare any new population that might be established in the future, and ii) to determine the performance of the rehabilitation population compared to the natural populations. The results are reported in Western Botanical (2015b) (Report WB844; Appendix E7).

- There was no significant difference in observed adult plants between the western and eastern populations, but a significant difference between the two natural populations and the rehabilitation population.
- Observed juvenile numbers within strip plots did not significantly differ from expected numbers between Western and Eastern populations, but no juvenile plants were recorded in the monitoring plots of the rehabilitation population. A high rate of seedling mortality was observed on the natural populations.
- No significant difference was found between populations in the observed proportion of male and female plants.
- Female canopy condition at the rehabilitation population was significantly lower than the two natural populations.
- There was no significant differences in adult plant variables including volume index, leading shoot length, male canopy condition, male flower abundance, and male fruit abundance amongst populations.

These results confirm physical observations that the rehabilitation population, on different and probably sub-optimal soils compared to the natural populations, does not function as successfully as the natural populations, but does perhaps demonstrate that the species is adaptable to sub-optimal soils and will have generational survival.

Identification of suitable translocation sites

The identification of potential new sites for the Western Population of *Atriplex* sp. Yeelirrie Station was undertaken by Western Botanical (2015c), with their suitability investigated by SWC (2015b). Potential sites outside of the two known populations of *Atriplex* sp. Yeelirrie Station were identified using regional airborne radiometric data (i.e. K, U, Th) to identify locations hosting similar clay soils that may be capable of supporting the *Atriplex* sp. Yeelirrie Station. Identified sites were then assessed for access rights and protection from potential threats. Western Botanical (2015c) then completed a field survey, and preliminary soil testing, of all short-listed locations to establish whether the pedogenic and hydrologic conditions were similar to those within the Western population of the Yeelirrie palaeochannel.

Several sites within the Lake Mason palaeodrainage channel, which is located on neighbouring Lake Mason Station and managed for conservation purposes by DPaW, were identified as potentially suitable based on the criteria listed in the Western Botanical (2015c) report. SWC (2015b) investigated each of these using the same methodology as that employed to characterise the ecophysiological functioning of the *Atriplex* sp. Yeelirrie Station Western and Eastern populations at Yeelirrie. (Tables 9-21 to 9-23)

Based on the need for slight rises above a clay pan surface, and salinity levels in the surface clays around 500 mS/m, three sites (Sites 4 – 6; Table 9-20) were identified as potentially suitable. SWC (2015b) identified that the physical, geochemical and hydraulic properties of these sites were similar to those occurring within the Western and Eastern Populations of the Yeelirrie paleodrainage channel.

The areas of sites thought to be suitable translocation sites within Sites 4 to 6 is shown in Table 9-20 and compared with the Western Population area at Yeelirrie. It can be seen that the combined area of Sites 4 – 6 is 24.3 ha, which is around 32% of the total area occupied by the Western Population at Yeelirrie.

Sites 1, 2, 3 were also assessed during the investigation but are currently thought to be sub-optimal sites. At these sites the same micro-topographic relief doesn't exist so the *Atriplex* sp. Yeelirrie Station may experience greater levels of inundation, restricting their establishment.

However, the level and length of time these areas are inundated would need to be quantified as it may be similar as for the Yeelirrie sites. Alternatively, direct seeding methods (used in seeding *Atriplex* species on saline agricultural land) that create minor mounding for the placement of seed may be employed to assist in the development of the micro habitat. An additional 59.39 ha, in and around the sites, has been assessed as likely possessing optimal – suboptimal conditions, and these sites will be further explored to assess their suitability.

Table 9-20: Areas of suitable Lake Mason translocation sites compared to the Yeelirrie western population

Site	Area (ha)	% of Yeelirrie Western Population
Optimal sites		
Site 4	11.64	15.3
Site 5	8.97	11.8
Site 6	3.72	4.9
Sub-optimal sites		
Site 1	13.59	17.9
Site 2	6.29	8.3
Site 3	3.37	4.4
Other potential sites	59.39	78.1
Total	106.97	140.8

Table 9-21: Average multi-element composition of the dominant soil types within the clay pans

Element	Clay		Loam		Calcareous Loam	
	Avg	Max	Avg	Max	Avg	Max
Yeelirrie Sites						
Al	40,240	69,800	16,723	27,600	41,200	69,800
As	7	11	5	8	12	16
B	125	250	30	41	147	260
Ba	70	160	23	30	43	57

Element	Clay		Loam		Calcareous Loam	
	Avg	Max	Avg	Max	Avg	Max
Ca	34,710	88,000	50,867	130,000	59,200	160,000
Cd	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Co	7.2	8.7	7.1	12.0	6.7	8.6
Cr	53	71	32	46	46	70
Cu	14	22	6.6	9.7	13	21
Fe	21,790	34,000	10,533	16,000	20,460	34,000
Mg	61,200	84,000	24,400	48,000	51,200	67,000
Mn	255	410	98	160	199	350
Mo	1.0	2.4	0.3	0.5	1.1	1.8
Na	5,670	28,000	513	1,200	5,448	11,000
Ni	15	23	7	11	14	23
Pb	4.5	8.1	2.9	3.5	4.7	7.9
V	89	110	55	71	100	150
Zn	38	61	14	24	33	56
Lake Mason Sites						
Al	29,900	49,200	23,100	36,300	42,400	-
As	3	4	8	14	5	-
B	244	370	133	330	120	-
Ba	39	61	30	48	68	-
Ca	54,000	92,000	88,250	130,000	72,000	-
Cd	<0.05	<0.05	<0.05	<0.05	<0.05	-
Co	5.9	11.0	6.0	8.5	9.4	-
Cr	57	100	41	56	87	-
Cu	14	27	12	20	23	-
Fe	20,000	36,000	14,775	22,000	29,000	-
Mg	77,333	81,000	43,750	89,000	71,000	-
Mn	243	420	123	180	340	-
Mo	0.6	1.0	0.3	0.3	0.9	-
Na	10,633	20,000	3,633	6,700	17,000	-
Ni	17	33	10	16	26	-
Pb	2.6	4.1	3.7	7.1	3.0	-
V	62	83	96	220	80	-
Zn	31	55	22	36	45	-

Table 9-22: Average bioavailable trace element composition of the dominant soil types within the clay pans

Element	Clay		Loam		Calcareous Loam	
	Avg	Max	Avg	Max	Avg	Max
Yeelirrie Sites						
Al	348	>550	360	480	266	>550
As	0.4	0.7	0.8	1.7	1.1	2.1
B	46	100	4.4	6.6	56	100

Element	Clay		Loam		Calcareous Loam	
	Avg	Max	Avg	Max	Avg	Max
Ca	>5,500	>5,500	4,400	>5,500	5,500	>5,500
Cd	0.01	0.02	0.01	0.01	0.01	0.01
Co	0.31	0.91	0.51	0.99	0.31	0.77
Cu	0.2	0.5	0.2	0.4	0.2	0.3
Fe	64	120	52	62	61	110
K	511	>550	283	>550	550	>550
Mg	500	500	643	930	500	500
Mn	29	74	23	33	18	38
Mo	0.04	0.15	0.01	0.02	0.13	0.30
Na	552	>1,000	347	960	810	>5,500
Ni	0.4	0.6	0.3	0.4	0.3	0.3
P	18	48	4	6	13	30
Pb	1.2	1.8	0.9	1.3	1.4	2.1
S	90	160	157	>250	0	>250
Se	0.3	0.6	0.1	0.2	0.2	0.3
Zn	0.2	0.3	0.2	0.3	0.1	0.2
Lake Mason Sites						
Al	437	>550	211	480	480	-
As	0.3	0.7	0.7	1.3	0.3	-
B	71	100	28	100	44	-
Ca	>5,500	>5,500	>5,500	>5,500	>5500	-
Cd	0.01	0.01	0.02	0.06	<0.01	-
Co	0.13	0.24	0.10	0.16	0.13	-
Cu	0.2	0.3	0.1	0.1	0.2	-
Fe	149	180	75	200	49	-
K	533	>550	385	>550	>550	-
Mg	500	500	463	500	500	-
Mn	12	17	4.7	8.9	8.5	-
Mo	0.07	0.12	0.02	0.06	0.02	-
Na	>1,000	>1,000	810	>1,000	>1,000	-
Ni	0.4	0.4	0.2	0.4	0.3	-
P	24	29	11	13	12	-
Pb	1.2	1.3	1.2	1.8	1.4	-
S	130	140	113	125	125	-
Se	0.2	0.4	0.1	0.2	0.2	-
Zn	0.1	0.1	0.1	0.2	<0.1	-

Table 9-23: Average nutrient composition of the dominant soil types within the clay pans

Element	Clay			Loam			Calcareous Loam		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Yeelirrie Sites									
Total N	0.018	0.044	0.077	0.012	0.021	0.039	0.016	0.021	0.027
Total P	89	174	300	43	68	89	54	143	250
Colwell P	2	10	21	4	5	6	2	5	6
Total K	2,300	4,790	9,300	500	1,650	3,500	2,500	6,380	11,000
Colwell K	410	1,510	3,300	150	527	1,200	1,000	1,640	2,600
Total S	110	3,138	25,000	92	33,511	100,000	520	24,524	85,000
KCl ext. S	4	717	4,000	32	2,167	6,300	320	3,224	7,200
Lake Mason Sites									
Total N	0.009	0.013	0.017	0.021	0.040	0.070	-	0.017	-
Total P	120	187	310	80	138	240	-	230	-
Colwell P	17	22	25	5	8	15	-	7	-
Total K	1,200	2,633	4,300	1,400	2,150	4,000	-	4,700	-
Colwell K	580	1,093	1,500	240	473	740	-	1,400	-
Total S	970	34,990	54,000	1,400	38,500	77,000	-	26,000	-
KCl ext. S	140	4,113	7,100	14	3,401	6,800	-	3,000	-

Summary

The work outlined above, while preliminary, provides reasonable evidence to support a proposition that a population of *Atriplex* sp. Yeelirrie Station could be established to replace the Western population that would be lost as a result of proceeding with the Project. The work indicates the following:

- Individual plants hold seed over several seasons. Seed can be readily harvested and stored and will maintain viability for reasonable periods of time.
- Seed is readily able to be germinated and should respond well to direct seeding methods. Atriplex species have been cultivated for agricultural applications on a range of soil types and there is a strong body of expertise supporting techniques for successful revegetation from seed and seedlings.
- As evidenced by the rehabilitation population, the species is able to grow on a range of soil types, including soils that exhibit different salinity and profile characteristics to the soils of the natural populations.
- Potential translocation sites with similar soil and landscape characteristics have been identified and briefly assessed. These locations occur on land with tenure that would allow long term protection.

Prior to commencing work on the ground to establish the new population, Cameco would initiate a program to address the following:

- Ongoing implementation of activities contributing to a research plan to further understand the species and to support potential translocation, including seed collection and propagation research and trials.

- Development of an Interim Recovery Plan (IRP), leading to the development and approval of a full Recovery Plan in consultation with the Department of Parks and Wildlife (DPaW).
- Development of a Trial Translocation Plan (TTP) in consultation with DPaW.

Research Programme

Table 9-24 summarises the research completed to date and outlines a plan for work to be undertaken over the next three years.

Table 9-24: *Atriplex* sp. Yeelirrie Station Research Programme - Completed and Proposed.

Task	Status/Description
2014	
Undertake a preliminary assessment of the Rehabilitation Population of *Atriplex* sp. Yeelirrie Station and compare population dynamics with the Western Population.	Population census of Rehabilitation Population undertaken, demographic studies commenced, vegetation and soil profiles described (Western Botanical 2014).
Undertake seed germination testing of *Atriplex* sp. Yeelirrie Station western genotype seed collected in 2010.	Seed germination testing undertaken, demonstrated viable and germinable seed present within populations in both 2010 and 2014. Demonstrated short term dormancy which is overcome by removal of the enclosing bracts and/or leaching (Landcare Services 2011, Western Botanical 2015d, unpublished data).
2015	
Undertake a preliminary assessment of the Rehabilitation Population of *Atriplex* sp. Yeelirrie Station and compare population dynamics with the Western Population.	Demographic studies expanded in March 2015 (Western Botanical 2015c) and further soil profile assessments undertaken in April 2015.
Resolve the taxonomic status of *Atriplex* sp. Yeelirrie Station.	Part funding was provided to DPaW's Western Australian Herbarium to assist them to undertake a review to define the taxonomy of *Atriplex* sp. Yeelirrie Station, Eastern and Western Genotype. A paper dealing with the taxonomy of the species has been prepared by K.A. Shepherd and K.R.Thiele but remains unpublished at this stage. In summary, the research paper describes "A rare, new, tetraploid *Atriplex* located ... c. 30 km apart in arid Western Australia, is supported as distinct from other known species by morphological and molecular evidence. While the level of genetic differentiation is similar to that previously reported between subspecies in other *Atriplex*, the new taxon is described as a single species".
Establish a statistical framework that can be applied to measure the success of any future translocation program.	Meetings have been held with DPaW and agreement on sampling methodology for the demographic assessment and statistical framework for analysis has been developed. Data from the Western and Eastern Populations of *Atriplex* sp. Yeelirrie Station has been collected and will be presented for review to confirm the analysis techniques are suitable to use in the future to assess new translocated populations.
Identify possible translocation sites and undertake site analysis and hydrogeological assessment	A field trip to identify potential translocation sites at Lake Mason has been completed and a number of sites identified. Test pits have been dug to assess soil test in comparison to soil types on the Western populations. Western Botanical 2015b, 2015c)
2016	

Task	Status/Description
Undertake an environmental assessment for the introduction of *Atriplex* sp. Yeelirrie Station into new locations.	Undertake a field assessment and prepare an impact assessment report as required for the IRP and TTP.
Continue to develop Conservation Species Management Plan in consultation with DPaW.	Develop plan internally with advice from DPaW
Develop IRP in consultation with DPaW	Develop plan internally with advice from DPaW
Develop TTP in consultation with DPaW	Develop plan internally with advice from DPaW
Collect and process seed from the Western Population of *Atriplex* sp. Yeelirrie Station to increase seed bank. Lodge seed with the DPaW Seed Bank.	Obtain licence and undertake seed collection. Prepare (clean and fumigate) seed for storage
Undertake seed treatment, germination trials and pot trials. Testing on newly collected seed and stored seed of various ages.	Trials to be planned with input from Chatfield Nursery, WA's largest agricultural nursery with experience in seed treatments and germination trials.
2017	
Collect and process seed from the Western Population to increase seed bank.	As above
Undertake planting in selected and approved translocation trial sites.	Design plan with input from Chatfield Nursery
Field visit to trial translocation sites to monitor success and produce internal memo.	
2018	
Assess and report on the success of the 2017 plantings.	Undertake population dynamic assessment of the trial translocation sites.
Undertake planting in translocation sites.	As above
Field visit to trial translocation sites.	Inspection and review of progress of translocation sites with DPaW and OEPA.

9.1.5.4 Summary of Management Measures

General - Avoid and Minimise

- Clearing will be kept to the minimum area required for safe and efficient operation.
- Cameo will conduct Level 2 surveys of borefields and corridors and any other areas not covered by the existing Level 2 flora survey and provide a report of the survey as part of an application for a Clearing Permit prior to the commencement of ground disturbing activity.
- Cameco will implement ground disturbance procedures that will apply to all clearing activities. Clearing will not be conducted during or immediately after rain to reduce the risk of erosion and damage to soil structure.
- All earth moving equipment and other vehicles or machinery will be cleaned of all soil and seeds before mobilisation into new clearing areas. Weed control will be undertaken for infestations with the potential to spread.
- A vegetation condition monitoring program will be implemented to monitor potentially groundwater dependent vegetation communities within the drawdown zone and compare with control sites. Contingency measures will be developed, should there be a risk of impacts on groundwater dependent communities.
- As part of monitoring of the integrity of surface water diversion and management structures, Cameco will also monitor nearby vegetation health.
- Dust management and suppression measures will be undertaken (refer to Section 9.8.6).

- Hot work permits will be required for any work that may generate an ignition source. Fire extinguishers will be available in all work areas and personnel will be trained in their use.

Rehabilitate

- Vegetation removed during clearing activities will be temporarily stockpiled to be used as mulch and a seed source in revegetation. Overburden material that is suitable for rehabilitation will be stripped and stored in low stockpiles to retain seed viability and be protected from erosion and accidental disturbance.
- Disturbed areas that are no longer required will be progressively rehabilitated over the life of the mine. The pit will be progressively backfilled and rehabilitated from year 11.

Conservation Significant Species - Avoid and Minimise

- Cameco will continue to develop and implement the Conservation Species Management Plan. Measures will include protection of the Eastern Population of *Atriplex* sp. Yeelirrie Station by fencing and the establishment of firebreaks, and implementation of a research plan for the reestablishment of the Western Population of the species, through translocation. Work undertaken to date provides reasonable evidence to indicate that this could be achieved.
- Cameco will avoid direct disturbance of *Rhagodia* sp. Yeelirrie Station where practicable. Cameco is proposing to establish a conservation area for the known population present inside the Development Envelope.
- Protection of the Eastern Population of *Atriplex* sp. Yeelirrie Station through fencing and land tenure changes (if practicable).
- Implementation of the research plan for the reestablishment of the Western Population of *Atriplex* sp. Yeelirrie Station.
- Protection of *Rhagodia* sp. Yeelirrie Station Population within the Development Envelope.
- Progressive rehabilitation of the Project area in accordance with the Mine Closure and Rehabilitation Plan.

9.1.6 Commitments

Cameco commits to:

- Developing and implementing a Flora and Vegetation Management Plan.
- Developing and implementing the Conservation Species Management Plan.

9.1.7 Outcomes

Residual impacts on significant flora are predicted to occur as a result of implementation of the Project and therefore offsets are proposed. These are discussed in Section 12.4.

Taking into account the Project design, the proposed management measures, and the proposed implementation of a revegetation and offset strategy to replace the Western population genotype of *Atriplex sp.* Yeelirrie Station, Cameco believes that the Proposal will meet the EPA's objectives of maintaining the representation, diversity, viability and ecological function at the species, population and community level.