Appendix 3 Supporting Technical Studies



Earl Grey Lithium Project SRE and Subterranean Fauna Desktop Assessment

Prepared for: Covalent Lithium

January 2019 Final Report

Short-Range Endemics | Subterranean Fauna

Waterbirds | Wetlands



Earl Grey Lithium Project SRE and Subterranean Fauna Desktop Assessment

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EXECUTIVE SUMMARY

Covalent Lithium proposes to mine lithium at the Earl Grey deposit (the Proposal) approximately 100 km southeast of Southern Cross in Western Australia. This desktop review examines the likelihood that short-range endemic (SRE) invertebrates and listed terrestrial invertebrate species occur in the Proposal area and whether these species are likely to be impacted by proposed development. Previous records of SRE and listed species in the vicinity of the Proposal (a 100 km x 100 km search area) are collated and the prospectivity of habitats in the Proposal area for SRE species is evaluated.

Forty-eight species belonging to SRE Groups (i.e. various ground-dwelling invertebrate groups likely to contain SRE species) have been recorded in the search area. There are no records of confirmed SRE species or listed invertebrate species. Twenty-three of the species belonging to SRE Groups appear to be widespread, six are unlikely (but potential) SRE species and 19 are potential SREs. The relatively high proportion of potential SRE species is partially a reflection of data limitations, including the small number of records for each species and limited information about the habitats the species occupy. In reality, most potential SRE species are probably widespread.

Six SRE habitat units were identified at Earl Grey, predominantly comprising mallee woodlands on various substrates or landforms, but also including shrubland and heathland. These units generally have low prospectivity for SRE species, although widespread species belonging SRE Groups are likely to utilise the habitats. All units extend outside the Proposal with the exception of habitat 3 (open mallee woodland on lateritic clayey sand on slopes and ridges), although in reality it is likely that this habitat also occurs regionally outside the area covered by habitat/vegetation mapping. It is also considered unlikely that habitat 3 provides truly specialised habitat usually necessary to indicate prospectivity for SRE species due to a its lack of truly distinguishing geological features, such as outcropping rock, granites or BIF.

Floristic, soil and climate characteristics are moderately consistent across the habitat units present, suggesting that they are likely to represent similar habitats from the viewpoint of an SRE species. Mesic microhabitats within all six habitats are restricted to litter deposits that occur sparsely within a generally xeric landscape. Rock outcrops suitable for some specialist SRE taxa are absent. Based on the extent and connectivity of habitat units and lack of barriers to dispersal, species from SRE Groups at the Proposal are expected to be widespread and it is considered unlikely that any listed invertebrate species occur.

The size of the area covered by proposed development (total land clearing of ca. 365 ha) is negligible compared with the likely ranges of the SRE Group species that may be present. Overall, it is considered unlikely that the Proposal will have significant conservation implications for SRE or listed terrestrial invertebrate species.



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1. INTRODUCTION

Kidman Resources Limited (the Proponent) proposes to mine lithium at the Earl Grey deposit (the Proposal) via an open pit. The Proposal is located approximately 100 km southeast of Southern Cross in Western Australia (Figure 1) and is part of the historic Mt Holland Project that comprises several deposits. This desktop review assesses the likelihood that short-range endemic (SRE) invertebrates and conservation-listed terrestrial invertebrate species occur in the Proposal area and examines whether these species and communities are likely to be impacted by proposed developments.

The specific aims of the assessment are:

- To describe and evaluate the prospectivity of habitats in the Proposal area;
- To review records of SRE and listed invertebrate species in the vicinity of the Proposal area;
- To determine the likelihood that SRE and listed invertebrate species occur in the Proposal area, based on the types of habitat present and richness of SRE and listed species in surrounding areas; and
- To determine if Proposal is likely to have significant conservation impacts on any SRE and/or listed invertebrate species.

2. BACKGROUND

2.1. Conservation Framework

The Environmental Protection Authority recognises the need to conserve SRE fauna and stipulates their consideration as part of environmental impact assessment process. This is outlined in *Environmental Factor Guideline: Terrestrial Fauna* (EPA 2016a) and supporting sampling guidelines (EPA 2016b).

The conservation of terrestrial invertebrates can be viewed in the wider context of state and federal conservation legislation. At the state level, the *Wildlife Conservation Act 1950* (WC Act) and, in future, the *Biodiversity Conservation Act 2016* provide for the listing of species as Threatened by the Minister for the Environment following recommendations by the Threatened Species Scientific Committee. Threatened species are specially protected because they are under identifiable threat of extinction, are rare, or otherwise in need of protection. Possibly threatened species for which there is not enough information to support listing by the Minister are instead listed by the Department of Biodiversity Conservation and Attractions (DBCA) as Priority species. Species may also be listed at the federal level as Threatened under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

In addition to protecting individual species, ecological communities may be listed to provide protection at both the state and federal levels. At the state level, the Minister may list a community outside of the current WC Act legislation as being a Threatened Ecological Community (TEC) if it is at risk of being totally destroyed. Ecological communities with insufficient information available to be considered as TECs, or which are rare but not currently threatened, are listed informally by Parks and Wildlife as Priority Ecological Communities (PECs). No community is currently listed on the basis of SREs.





2.2. Proposal Description

The Earl Grey lithium deposit is proposed to be mined via an open pit with an area of approximately 166 ha (Figure 2). The total area required for the Proposal is 610 ha, of which 245 ha is already disturbed.

Mining will produce approximately 200 million cubic metres of waste rock over the 30-40 year life of mine. This will be managed using three waste rock landforms. These are a permanent waste rock dump covering the historic Mt Holland TSF1 (WRD1), progressive backfilling of the pit to produce a permanent, raised waste rock landform (WRD2) and a permanent waste rock dump to the immediate east of the pit (WRD3) (Figure 2). Approximately 12 MT of fine tailings will also be produced. Two tailings storage facility (TSF) options will be considered. These are either refurbishment of the existing Mt Holland TSF2 with a 5 m increase to the wall, or development of a new TSF in the historic Bounty mine area encompassing the existing in-pit TSF3 (Figure 2). Both options make efficient use of existing disturbed landforms. Other additional infrastructure and development include an ore processing plant, power supply, workshops, washdown facilities, miscellaneous plant buildings, accommodation, water treatment facilities, fuel storage, airstrip, communications infrastructure, explosive storage, laydown areas, landfill and roads.

2.3. Regional Context

The Proposal lies within the Southern Cross (COO2) Interim Biogeographic Regionalisation of Australia (IBRA) sub-region that is characterised by gently undulating uplands dissected by broad valleys with bands of low greenstone hills (Cowan *et al.* 2001). Chains of saline playas occur in valleys surrounded by samphire shrublands. Diverse *Eucalyptus* woodlands also occur in the valleys and on low greenstone hills. Mid-level granite outcrops support *Borya constricta* (Resurrection Bush), *Acacia acuminata* and *Eucalyptus loxophleba*. Upper levels are eroded and yield yellow sandplains, gravelly sandplains and lateritic breakaways and support stands of mallee and scrub-heathland (Cowan *et al.* 2001).

The climate is Mediterranean, with 300–350 mm mean annual rainfall, most of which falls in winter.

3. SRE AND LISTED TERRESTRIAL INVERTERBATES

3.1. SRE Framework

SRE species are defined as those with a patchy distribution of less than 10,000 km² (Harvey 2002). These species also tend to have slow growth, low fecundity, and poor dispersal capabilities. The assessment of SRE invertebrates in WA typically focuses on seven taxonomic groups (the 'SRE Groups') that are known to contain high proportions of SRE species. These are land snails (Gastropoda); millipedes (Diplopoda); centipedes (Chilopoda); pseudoscorpions (Pseudoscorpiones); scorpions (Scorpiones); spiders (Ananeae, particularly Mygalomorphae and their allies, but also some modern spider families such as Selenopidae); and slaters (Isopoda). Some other groups, such as velvet worms (Onychophora), are good candidates for short-range endemism but are restricted to mesic environments and are unlikely to occur in the Proposal area.

SRE species also occur within groups containing species that are mostly widespread due to high vagility, ecological plasticity or xeric adaptation (Framenau *et al.* 2008; Rix *et al.* 2015). It is also noted that most species belonging to SRE Groups are in fact widespread. A major challenge in assessment of SRE species is determining whether or not a species belonging to a SRE Group actually has a highly restricted range. However, if a species is collected from only one habitat and that habitat is restricted in distribution, the species is likely to be an SRE. There is, however, also some species turnover in widespread habitats that may be linked with climatic gradients, with the result a species may only occupy part of a widespread habitat (Rix *et al.* 2015).





The categories used to describe the SRE status of each species in this assessment (Table 1) are based on the SRE classification system of the Western Australian Museum (WAM; Appendix 2) but are modified to take account of the limited information associated with most species recorded in the desktop review process. For example, detailed habitat information is not always available for species in WAM databases and so cannot always be used to predict likely distributions. In order of importance, the factors considered when evaluating the SRE status of each species were:

- The known range of the species;
- Habitat type(s) of collection location(s) and the geographic extent of these habitats; and
- The ranges of suitable, phylogenetically-related proxy species, such as congeners.

Species are considered to be widespread if their known range is likely to exceed 10,000 km². However, even species with small ranges that are clearly Confirmed or Potential SRE species may be locally widespread at the scale of a project area, which may comprise only a few square kilomtres. Thus, it should be recognised that identifying SRE species is only part of a filtering process used to determine whether species will be threatened by development. The actual level of threat to an SRE species depends on the relationship between the species' range and the development footprint. For the persistence of a species to be threatened, its range must lie entirely (or mostly) within an area of disturbance. The important factors when determining the likely level of threat to a species are:

- The extent of the species' preferred habitat in the local area;
- The size of the disturbance footprint; and
- Whether other developments exist (or are proposed) in the local area.

Status	Abbreviation	Definition
Widespread	W1	Known to be widespread (range >10,000 km ² or linear range >100 km) based on previous records in relevant databases and published literature.
	W ²	Likely to be widespread due to collection in extensive or multiple habitat types.
Potential SRE	Ρ*	Potential SRE (known range <10,000 km ² or linear range <100 km) but in reality unlikely to be range-restricted due to habitat, ecology or trends among closely related species. Further data probably required to confirm as widespread.
	Ρ	Potential SRE belonging to closely related species mostly SREs, known only from restricted records and/or confined habitat; complete distribution unknown due to deficient data. Further data (e.g. taxonomic, habitat or further collections) required to confirm status as an actual SRE.
Confirmed SRE	SRE	Known to be range-restricted (range <10,000 km ²) based on multiple previous collections, published literature or is an SRE by expert diagnosis (e.g. WAM).

Table 1. SRE statuses applied to each species in this assessment.



3.2. Recorded Species from SRE Groups

Records of species belonging to SRE Groups and listed species were compiled from the WAM databases for a search area of ca. 10,000 km² surrounding the Proposal (defined by 31.59°S, 119.28°E and 32.59°S, 120.22°E). Published research papers, available environmental reports and online resources such as the Atlas of Living Australia (ALA 2017) and the Australian Faunal Directory (ABRS 2009) were also reviewed. The search area included many habitats that are geologically, climatically and botanically similar to the Project area. Higher-order identifications were not included in the final list of recorded species unless they belonged to taxonomic units that were otherwise not recorded.

At least 48 species belonging to the SRE Groups have been recorded in the search area (Table 2). Some recorded taxa are likely to be polyphyletic (e.g. *Eucyrtops* spp.), but due to taxonomic limitations are listed here as a single unit. The review did not identify any records of confirmed SRE species or listed invertebrate species in the search area. Nearly half of the recorded species (47.9%) were classified as widespread (W¹ or W²), 12.5% as potential but unlikely SREs (P*) and 39.6% as potential SREs with deficient data (P).

Higher-order identifications that were removed from or amalgamated into the final list of species are given in Appendix 1.

3.2.1. Potential SRE Species

While 25 species recorded in the search area were classified as potential SREs, six of these were classified as 'P*' and are probably in fact widespread species. For instance, *Aname* 'MYG010' and *Aname* 'MYG182' have been recorded in widespread habitat types across linear ranges of 100 km and 81 km, respectively, and are therefore likely to occupy areas greater than the 10,000 km² SRE threshold. Neopilionidae sp., *Oratemnus* sp., *Indolpium* sp. and *Pesvarus* sp. were also classified as potential but unlikely SREs because most, if not all, species within these taxa are known to be widespread.

Nineteen species, most of which are mygalomorph spiders, were classified as potential SREs (P). In reality, while the available data are too deficient to distinguish likely SRE species from likely widespread species, most P category species probably also have larger ranges than the SRE threshold. The possible distributions of P category species are discussed below.

Isopods - Buddelundia sp. and Philosciidae sp.

Despite a largely incomplete taxonomic framework for terrestrial slaters in Western Australia, it is recognised that many species are probably range-restricted (Harvey 2002). The genus-level identification *Buddelundia* sp. (family Armadillidae) and the family-level identification Philosciidae sp. were recorded approximately 40–60 km south of the Proposal and both these taxa may consist of multiple species, so that the ranges of species covered by these higher-order identifications are unclear. At a coarse scale, both taxa were collected from widespread, somewhat fragmented medium eucalypt woodland (*Eucalyptus salmonophloia* and *Eucalyptus longicornis*) but precise habitat details are not available. *Buddelundia* sp. and Philosciidae sp. may in fact be widespread, although there is insufficient information to confidently classify them as such.

Missulena `sp. indet (female)`

The genus *Missulena* belongs to the family Actinopodidae and was represented in the search area by a single indeterminate record at Forrestania, approximately 59 km south of the Proposal. The collection location falls within the coarse habitat unit 'medium eucalypt woodland' (Beard *et al.* 2013). Only a small proportion of the Western Australian actinopodid fauna has been described and many specimens belonging to undescribed species, some of which may be range-restricted, have been collected throughout the state (Miglio *et al.* 2014). Without further habitat and taxonomic resolution, it is not possible to determine the range of *Misseluna* `sp. indet (female)`.



Higher Classification	Lowest Identification	No. of Records	SRE Status	Comments
Crustacea				
Isopoda				
Armadillidae	Buddelundia sp.	4	Р	Records clustered 40–60 km south of Proposal, species identifications undefined. Some isopods
Philosciidae	Philosciidae sp.	3	Р	probably SRE ¹ .
Chelicerata				
Arachnida				
Araneae				
Mygalomorphae				
Actinopodidae	Missulena `sp. indet. (female)`	1	Ρ	Recorded ca. 59 km south of Proposal. Most species in genus widespread, some may be range- restricted ^{2,3} .
Barychelidae	Idiommata `yelbeni`	1	Р	Recorded ca. 50 km south of Proposal in widespread woodland ¹¹ . Some species within genus may be range-restricted ⁶ .
	Synothele `forrestiana`	1	Р	Recorded ca. 40 km south of Proposal in widespread woodland ¹¹ . Genus has many range- restricted species ^{4, 5} .
	Synothele longbottomi	1	W ¹	Widely recorded beyond search area ^{5, 6} .
Ctenizidae	Conothele `MYG059`	1	Р	Recorded ca. 59 km south of Proposal. Genus with many undescribed species, some likely to be range-restricted ⁶ .
Idiopidae	Aganippe `MYG064`	25	W1	Numerous records 40–90 km south of Proposal. Known linear range ⁶ ca. 320 km.
	Aganippe `MYG065`	14	Р	<i>Aganippe</i> contains a significant no. of SREs ^{4, 7} . Recorded 40–90 km south of Proposal, known linear range ca. 44 km.
	Aganippe `species A (Biota)`	4	Р	<i>Aganippe</i> contains a significant no. of SREs ^{4, 7} . Recorded 40–60 km south of Proposal, known linear range ca. 19 km.
	Anidiops `MYG063`	11	Р	Records clustered ca. 35 km south of Proposal. Genus contains widespread species as well as undescribed, likely range-restricted species ⁸ .
	Eucyrtops spp.	33	Р	Multiple genus-level identifications recorded ca. 40 km south of Proposal over linear range of ca. 50 km. May comprise multiple species.
Nemesiidae	Aname `MYG010`	8	P*	As any contains growing described and including babitation sights and their CDT 4.8
	Aname `MYG181`	2	Р	Aname contains many undescribed species including habitat specialists and likely SRES ^{**} .
	Aname `MYG182`	2	P*	MIGIOL and MIG401 recorded ca. 55 km and 55 km south of Proposal, respectively.
	Aname `MYG461`	1	Р	Who be and Who be funde restricted due to large known fundes.
	Aname mainae	5	W ¹	Widely recorded outside search area ⁹ .
	Aname `tepperi`	1	W ¹	Widely recorded outside search area ⁹ .
	Kwonkan `MYG060`	2	Р	Genus may contain range-restricted species ⁴ . 'MYG060' and 'MYG183' recorded ca. 39 km and
	Kwonkan `MYG183`	1	Р	54 km south of Proposal.
	Merredinia `MYG480`	1	Р	One widespread species described for genus. 'MYG480' recorded ca. 60 km north of Proposal.
	Merredinia damsonoides	10	W ¹	Widely recorded outside search area ⁹ . Known linear range ca. 214 km.
	Teyl `marked angle door grp`	1	Р	Genus widespread, many undescribed species and some likely SREs ^{7, 8, 11} . MYG457` and
	Teyl `MYG457`	1	Р	`marked angle door grp` recorded ca. 0.6 km apart ⁶ .
Opiliones				
Neopilionidae	Neopilionidae sp.	2	P*	Not identified to species. Harvestmen not recorded within 60 km of the Proposal but may be present; family widespread throughout wider region. Many species with small ranges but mostly greater than SRE threshold ¹ .
Pseudoscorpiones				

Table 2. Invertebrate species from SRE Groups recorded previously in the vicinity of the Proposal. Approximate known ranges are given for undescribed species based on WAM records where possible.





km south of Proposal. Very few SRE despread Oratemnus species occur regionally ⁹ .
despread Oratemnus species occur regionally ⁹ .
y likely to be widespread. Genus also recorded
metid species phoretic on flying insects ¹² and are
tic species ¹³ .
ut species-level taxonomy unresolved; species
stricted ^{3, 14, 15} . Recorded in search area from rocky
ain course restricted encodes. Considerants in conveh
ain some restricted species. Specimens in search
u . Unresolved at species level Indelnium species are
unresolved at species-level. Indolptum species are
ugh likely to contain multiple species ¹⁶ .
y recorded outside search area ^{6, 9, 16} .
ecord 60 km south of Proposal. Family contains

¹Harvey 2002; ²Harms and Framenau 2013; ³Miglio *et al.* 2014; ⁴Castalanelli *et al.* 2014; ⁵Raven 1994; ⁶WAM records; ⁷Framenau *et al.* 2008; ⁸Bennelongia 2016; ⁹ABRS 2009; ¹⁰Burbidge *et al.* 1999; ¹¹Gabbutt 1970; ¹²Harvey and Volschenk 2007; ¹³Harvey 2010; ¹⁴Harvey 2012; ¹⁵Volschenk *et al.* 2010; ¹⁶Koch 1983.



Idiommata `yelbeni`

This species belongs to the family Barychelidae and was represented by a single record approximately 50 km to the south of the Proposal area, while another indeterminate congener was recorded nearby. Both records fall within the widespread, somewhat fragmented, broad-scale habitat unit 'medium eucalypt woodland' (Beard *et al.* 2013). Genetic research suggests that some species within *Idiommata* have short ranges (Castalanelli *et al.* 2014) but it is not possible to estimate the range of this putative species without further collections or better habitat definition.

Synothele `forrestania`

A single specimen of this barychelid specimen was recorded at Forrestania approximately 40 km south of the Proposal. An additional juvenile congener was recorded within several kilometres, although the genus does not appear to have been widely recorded in the region. The collection locations occur in the generic habitat unit 'medium eucalypt woodland' (Beard *et al.* 2013). *Synothele* contains a large number of SRE species, many of which are undescribed, as well as more widespread species (Raven 1994; Castalanelli 2014). It is not possible to accurately postulate the range of *Synothele* `*forrestania*` and it is therefore classified as a potential SRE.

Conothele `MYG059`

This species belongs to the family Ctenizidae and was recorded as a singleton approximately 59 km south of the Proposal, while an indeterminate congener was collected some 18 km further north. Both locations coincide with the broad 'medium eucalypt woodland' habitat unit (Beard *et al.* 2013), although no further habitat information is available for collection sites. *Conothele* has been widely but sparsely recorded in the region and records predominantly comprise genus-level identifications. Like many other trapdoor spider groups in Western Australia, *Conothele* contains many undescribed species and some are probably SREs (Castalanelli *et al.* 2014). *Conothele* `MYG059` is currently classified as a potential SRE pending further taxonomic and habitat information.

Aganippe `MYG065`

This species belongs to the family Idiopidae and was represented by three female and 11 juvenile specimens 45–90 km south of the Project over a linear range of approximately 44 km. The majority of collections were made in medium eucalypt woodland, with some additional records from abutting mallee shrubland. The genus *Aganippe* contains a high proportion of likely SRE species (Framenau *et al.* 2008; Castalanelli *et al.* 2014) and the species `MYG065` is here categorised as a potential SRE, despite occurring in two habitat types.

Aganippe `species A (Biota)`

Four specimens of this idiopid species were recorded 40–60 km south of the Proposal. These sites occur in medium eucalypt woodland, as described by Beard *et al.* (2013). The genus *Aganippe*, which has been widely and frequently recorded across the Avon Wheatbelt, Coolgardie and Mallee regions, contains a significant number of SRE species. *Aganippe* `species A (Biota)` is classified as a potential SRE due to a lack of taxonomic and habitat data for the species.

Anidiops `MYG063`

The genus *Anidiops* (Idiopidae) was represented in the search area by the species `MYG063`, which was recorded over a linear range of just 3 km approximately 32 km south of the Proposal. The species has been recorded from juvenile, female and male specimens. Several unidentified congeners have also been recorded in the search area and the genus has been recorded throughout the wider region. Based on habitat mapping (Beard *et al.* 2013), the collection locations of *Anidiops* `MYG063` occur very close to salt lakes and it is possible that the species is associated with this landscape feature, although this is speculative and no habitat details were provided in WAM data. The family Idiopidae is currently under taxonomic review and it is likely that a number of new SRE species will be identified.



Eucyrtops spp.

A third idiopid genus, *Eucyrtops*, has been commonly recorded in the Mallee and Coolgardie regions. Species-level taxonomy is incomplete within the genus and only indeterminate specimens have been recorded in the search area. A total of 33 records of the genus have been made across multiple habitat units in the search area and it is likely that multiple species are present. Given the lack of taxonomic certainty it is not possible to estimate ranges for species within the complex and *Eucyrtops* spp. is a potential SRE.

Aname `MYG181`

Two specimens of the species *Aname* `MYG181` (Nemesiidae), including a juvenile specimen identified through genetic analysis, were recorded within 3 km of one another, approximately 50 km south of the Proposal area. Collection sites occurred in medium eucalypt woodland (Beard *et al.* 2013) but no fine-scale habitat information is available. As with many other mygalomorph taxa, *Aname* is largely undefined at the level of species and indeed the genus, as currently known, is intertwined with lineages of another nemesiid genus, *Kwonkan* (Castalanelli *et al.* 2014). Many undescribed species are habitat specialists that are likely to be range restricted (Bennelongia 2016). The distribution of *Aname* `MYG181` cannot be estimated confidently using available information and the species is categorised as a potential SRE.

Aname `MYG461`

Aname `MYG461` has been recorded in the search area as a singleton approximately 35 km south of the Proposal. Fine-scale habitat information is not available, although broad-scale mapping puts the collection site in medium eucalypt woodland (Beard *et al.* 2013). Given the lack of additional collections, habitat or taxonomic information of this species it is not possible to estimate its range.

Kwonkan `MYG060`

Two male specimens of the nemesiid species *Kwonkan* `MYG060` have been recorded in the search area approximately 39 km south of the Proposal. The specimens were collected from the same site within the broad-scale medium eucalypt habitat (Beard *et al.* 2013), however this is not sufficient to estimate a range for the species with any confidence.

Kwonkan `MYG183`

This species was recorded as a singleton approximately 54 km south of the Proposal. Estimating ranges for singletons is difficult and there is insufficient habitat data accompanying this record to deduce range based on habitat, although the collection site may lie in medium eucalypt woodland, which is widespread (Beard *et al.* 2013). *Kwonkan* `MYG183` is categorised as a potential SRE.

Merredinia `MYG480`

This species of the nemesiid genus *Merredinia* was recorded in the search area as a single female specimen approximately 65 km north of the Proposal. The widespread species *Merredinia damsonoides* may also occur in the vicinity and has been recorded both south and north of the Proposal area. Habitat information for *Merredinia* `MYG480` is insufficient to estimate range and this species is classified as a potential SRE.

Teyl `marked angle door group` and Teyl `MYG457`

Both *Teyl* species recorded in the search area were collected as singletons and no detailed habitat information accompanies these records. They were recorded approximately 65 km north of the Proposal. The taxonomy within *Teyl* is incomplete (Castalanelli *et al.* 2014) and some species are habitat specialists with restricted ranges, including the listed Minnivale trapdoor spider *Teyl* sp. (BY Main 1953/2683, 1984/13). Both *Teyl* `marked angle door group` and *Teyl* `MYG457` are categorised as potential SREs.

Synsphyronus sp.

Two specimens of the pseudoscorpion genus *Synsphyronus* were recorded in rocky habitats in the search area, specifically, under rocks on granite outcrop and in rocky *Allocasuarina* woodland. Species within



this group are often confined to rocky habitats. For example, *Synsphyronus christopherdarwini* is likely to be an obligate granite inhabitant and also an SRE (Harvey 2012). *Synsphyronus* specimens in the search area were recorded over 100 km apart and may be separate species, although further taxonomic work would be required to evaluate whether this is the case. Considering the association of both specimens with specialist habitat, *Synsphyronus* sp. is a potential SRE.

Siphonotidae sp.

This is the only family within the millipede order Polyzoniida (sucking millipedes) that occurs in Australia. Four siphonotid specimens have been recorded 63–72 km to the north of the Proposal area in mixed eucalypt and sheoak woodland and melaleuca thicket, while a single specimen has also been recorded 60 km south of the Proposal. Specific habitat information was not available for the latter record, although based on vegetation mapping (Beard *et al.* 2013) it was taken from widespread eucalypt woodland. The family Siphonotidae contains some likely SRE species, although the family has not been the focus of detailed taxonomic work (Framenau *et al.* 2008). It is possible that collections within the search area represent multiple species.

3.2.2. Listed Species

A total of four invertebrate species listed under the WC Act are known from the wider Wheatbelt region. They are the trapdoor spiders *Idiosoma nigrum*, *Kwonkan eboracum*, *Teyl* sp. (BY Main 1953/2683, 1984/13) and the arid bronze azure butterfly *Ogyris subterrestris petrina*. Two of these species, *Idiosoma nigrum* and *Ogryris subterrestris petrina*, are also listed under the federal EPBC Act. A further three Priority species – the trapdoor spider *Aganippe castellum*, the woolybush bee *Hylaeus globiferus* and the cricket *Ixalodectes flectocercus* – are known from the region.

Desktop review did not identify any records of listed invertebrate species from the search area and it is considered that most of the listed Wheatbelt species are highly unlikely to occur in the vicinity of the Proposal. The exceptions are *Idiosoma nigrum* and *Aganippe castellum*, which may possibly occur in the vicinity of the Proposal although it is unlikely in both cases. The distribution and potential conservation implications of these species relative to the Proposal are discussed below.

Shield-backed trapdoor spider Idiosoma nigrum

This trapdoor spider is listed as Schedule 3 (Vulnerable) under the WC Act and as Vulnerable under the EPBC Act. *Idiosoma nigrum* is now known to be restricted to the central Avon Wheatbelt and eastern Jarrah Forest IBRA bioregions (Rix *et al.* 2017). The Proposal occurs in the abutting Southern Cross subregion within the Coolgardie bioregion. The primary habitat for *Idiosoma nigrum* is recognised as coincident open eucalypt woodland and *Acacia acuminata* understorey (Avon Catchment Council 2007a) and similar vegetation units were identified in the Proposal area during previous flora surveys (Mattiske 2017). Despite this apparently suitable habitat, the Proposal area is too far east for the occurrence of *Idiosoma nigrum* and sampling in the vicinity of the Proposal has not collected it (WAM records). Therefore, the Proposal will not impact the conservation of *Idiosoma nigrum*.

Tree-stem trapdoor spider Aganippe castellum

This mygalomorph is listed as P4 (Rare, Near Threatened and other species in need of monitoring) by Parks and Wildlife. The species was previously listed under the WC Act as Schedule 1 Fauna (Avon Catchment Council 2007b), although this listing has since been revoked. The species is geographically moderately-widespread but is restricted to hillslopes (lower slopes to upper ridges) and banded ironstone formations in gravelly-loam soils, and has been found to be reasonably common around hills at Windarling, Mt Jackson and Koolyanobbing (Bamford *et al.* 2009). The nearest record of *A. castellum* to the Proposal is approximately 71 km to the north (WAM records). The Proposal landscape in terms of soil and topography consists gently undulating sandplain with duplex sandy gravel soil, and broad valleys and drainage lines with loamy duplex soils in low-lying areas (MBS 2017). Given the lack of suitable topographical formations in the Proposal area, the occurrence of *Aganippe castellum* is unlikely and the species is unlikely to be affected by proposed developments.



3.3. Assessment of SRE Habitats

Habitat units for SRE invertebrates in and around the Proposal development envelope (Figure 3) were identified, and their prospectivity for SRE species (as opposed to SRE Groups) assessed, using several sources of information. Firstly, broad-scale habitat units across the surrounding region and within the Proposal area were identified using available vegetation mapping at the 1:3,000,000 scale (Beard et al. 2013; Figure 4) and geological mapping at the 1:500,000 scale (Marnham and Morris 2003). The vegetation mapping of Beard et al. (2013) classifies some 900 vegetation associations into 50 major vegetation types and 20 vegetation mosaics across Australia based on structure, physiognomy, floristics and ecological and regional attributes. The digital 1:500,000 regolith map of WA (Marnham and Morris 2003) is a compilation of finer-scale (1:250,000 and 1:100,000) geological maps and simplifies prevailing geologies into nine subdivisions, including areas of outcrop, residual or relict units, and seven depositional regolith units. In combination, these resources provide a reasonable indication of regional and, to a lesser extent, local habitat units. Classifications of microhabitats within larger habitat units is not practicable without ground proofing, which somewhat limits the assessment of SRE habitat prospectivity via desktop. Therefore, previous assessments of flora and vegetation (Mattiske 2018) and fauna (Western Wildlife 2017) were reviewed to incorporate finer-scale habitat information for the Proposal area. Habitat units identified in those assessments were appropriately modified to reflect the context of SRE invertebrates. For example, some vegetation units were amalgamated into single SRE habitats due to similarity from the viewpoint of ground-dwelling invertebrates.

Habitat suitability for SREs was then assessed using five criteria: the availability of moisture; soil structure; geological diversity; vegetation type; and degree of shade and shelter. Emphasis is usually placed on identifying relict, isolated, sheltered or moist habitats but 'specialist' habitats such as rock outcrops and ranges may also harbour SRE species. The extent of habitat types beyond the Project area was also evaluated, as well as the extent of habitat connectivity and the presence of habitat isolates, which might restrict dispersal by the SRE fauna.

3.3.1. Habitat units in the Proposal area

A total of six habitat units (disregarding cleared land) were identified for the Proposal and surrounds (Table 3; Figure 3) and are described below. The merging of a number of vegetation communities into broader SRE habitat types is considered justified, with the delineation of vegetation communities often simply reflecting the dominance of a particular eucalypt species or the presence of a particular understorey species (Mattiske 2018). These differences are considered unlikely to significantly affect the provision of SRE habitats.

1. Mallee woodland on clay/sandy clay soils on flats and slopes

This unit is an amalgamation of four vegetation communities (Table 3 characterised by low and mid mallee woodland over sparse shrubland or heathland on red, orange and brown clays or sandy clays on flats and slopes. These communities are considered likely to provide more or less the same habitat to SRE Groups as one another. This SRE habitat type covers 593 ha, or 30% of the Proposal development envelope (Figure 3), and is likely to occur as part of regionally extensive vegetation associations, such as association 519 (shrublands; mallee scrub, *Eucalyptus eremophila*) outside the development envelope (Figure 4). Deposits of leaf litter, especially at the base of mallees, provide some refuge for mesic and soil-dwelling groups, while clayey soils may impede vertical drainage and help to retain moisture. Surface rocks are occasional, or absent, throughout. Although SRE Groups are likely to occur in deposits of leaf litter, this unit is of low prospectivity for SRE species due to its wide extent and good regional connectivity.

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SRE Habitat					
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3. Open mallee sand on slopes	woodland on lateritic clayey and ridges	Kilome	etero	These	
4. Open mallee pebbles on flats	woodland on sandy clay with and slopes	Benne	longia	Figure 3 Ha	hitat unite for SPE
5. Open heathla slopes	nd on rocky, sandy clay with on	Envir	onmental S	invertebrate	s in the Proposal
6. Tall shrubland on glats and slo	l on clay soils with some rocks pes	Author: A Date: 11-0	A_1994 A. Mittra 01-2019	aiea.	

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SRE Habitat	Vegetation Communities (Mattiske 2018)	TOTAL AREA MAPPED (ha)	AREA WITHIN DEVELOPMENT ENVELOPE (ha)	PERCENTAGE OF DEVELOPMENT ENVELOPE AREA
1. Mallee woodland on clay/sandy clay soils on flats and slopes	W8, W9 W10, W11	1467	593	30
2. Open mallee woodland/woodland on clay/sandy clay on flats and slopes	MW6, MW7, MW8, W3, W5, W6, W7, W12, W13, W14, W15, W16, W18, W19, W20, W21, W22	1652	667	33
3. Open mallee woodland on lateritic clayey sand on slopes and ridges	W17	3	3	0.14
4. Open mallee woodland on sandy clay with pebbles on flats and slopes	W4	236	27	1
5. Open heathland on rocky, sandy clay with on slopes	Н1	2	0	0
6. Tall shrubland on clay soils with some rocks on flats and slopes	S1, S2, S3	399	200	10
Cleared land	CL	647	504	25
Total		4406	1994	100

Table 3. Summary of SRE habitat units identified in the Proposal area and surrounds.

2. Open mallee woodland/woodland on clay/sandy clay on flats and slopes

This is the most common and widespread SRE habitat type in the mapped area, combining 15 mallee and two non-mallee open woodland communities (Table 3) and covering 667 ha, or 33% of the development envelope (Figure 3). It is characterised by open mallee woodland (or less commonly open non-mallee or gimlet woodland) over sparse shrubland or heathland on grey, brown, orange, yellow and red clays and sandy clays on flats and slopes. It differs from SRE habitat unit 1 above in having a more open structure, although given limited scope for field observations it is possible that a suite of fauna from SRE Groups is common to both units, due to the similar microhabitats present. Pebbles and rocks are present in some constituent vegetation types (W3 and W22), although are generally uncommon and unlikely to provide significant, specialised rocky habitats. Clays may act to aid soil moisture retention and deposits of bark and leaf litter around the bases of trees are likely to be utilised by species from SRE Groups. However, due to the wide extent both within and beyond the development envelope and wider region, a low degree of prospectivity for SRE species is inferred.

3. Open mallee woodland on lateritic clayey sand on slopes and ridges

This habitat comprises a single vegetation association, W17, and occurs towards the eastern edge of the development envelope (Figure 3). It covers a very small area relative to the entire development envelope (3 ha or less than 1%) but was not identified in the mapped area outside the development envelope (Figure 3). The separation of this habitat from other open mallee woodland units is based on the presence of lateritic surface rocks [although Mattiske (2018) state that banded ironstone formation or any form of outcropping rock is absent throughout the development envelope] that may offer some specialist microhabitats for a range of specialist species, such as selenopid wall crab spiders, pseudoscorpions and burrowing species such as mygalomorphs and *Urodacus* scorpions that may favour rocky substrate. In reality, however, the absence of outcropping rock reduces the likelihood of species being restricted to this small area of habitat, with species instead being likely to utilise microhabitats present in surrounding mallee woodland (Figure 3). In addition, SRE Group species are likely to reside in deposits of bark and leaf litter, especially at the bases of larger trees. The significance of this small area of laterite within the local landscape is unclear, although is likely to be low on a regional scale. A moderate degree of prospectivity for SRE species is inferred for this habitat, although this may be



overestimated by desktop and species from SRE Groups utilising this small pocket of habitat may also occur in surrounding mallee woodlands.

4. Open mallee woodland on sandy clay with pebbles on flats and slopes

This habitat unit also comprises a single vegetation community, W4, although there may be some justification for its amalgamation into habitat 2. Although similar to habitat 2 in terms of vegetation, habitat 4 is separated on the basis of having some rocks (mainly ironstone and quartz pebbles), which may alter the structure of soil in such a way as to favour some specialised species that burrow in rocky substrate, at the expense of generalist burrowing species or those that prefer finer soils (such as those in habitat 2). It is also possible, although unlikely, that non-burrowing specialist species that favour rocky habitats (such as some spiders and pseudoscorpions) occur in this unit. As with other mallee woodland habitats, SRE Group species may utilise leaf litter and fallen bark. Within the development envelope, habitat 4 covers an area of 27 ha (approximately 1%), and is highly likely to occur within regionally extensive and interconnected vegetation associations. Therefore, it is inferred to have a low degree of prospectivity for SRE species.

5. Open heathland on rocky, sandy clay with on slopes

This habitat comprises a single vegetation association, H1, covering an area of 2 ha to the south of the main portion of the development envelope. It is absent from within the development envelope and as such will not be threatened by the Proposal. Given the general lack of eucalypts or other species that would generate significant amounts of leaf litter and provide cover, this habitat is highly exposed, and few (if any) moist microhabitats are present. Rocky substrate may provide some, though probably limited, habitat for specialist species including burrowing forms and, to a lesser extent, non-burrowing rock specialists. Given the absence of regionally significant geological features and high degree of exposure, this habitat is considered to have low prospectivity for SRE species, although species from SRE Groups may occur in low abundance. Larger areas of heathland occur outside the Proposal area in vegetation associations 1148 and 2048 and possibly amongst areas of mallee woodland (Figure 4).

6. Tall shrubland on clay soils with some rocks on flats and slopes

This habitat is made up of three similar vegetation associations (Table 3) and is characterised by tall shrubland (ranging from open to closed) over sparse heathland and shrubland on clay soils. It covers 200 ha within the development envelope (approximately 10%) as well as occurring in externally in the mapped area and probably also in regionally extensive vegetation associations (519 and 1413 and possibly others, Figure 4). Significant microhabitats for SRE species are unlikely to occur in this habitat, with larger trees that would provide leaf litter, bark and shade cover absent. Significant surface rocks are absent, although soils are pebbly or gravelly in places, possibly favouring burrowing species that prefer coarse media over generalists. Overall, a low degree of prospectivity is inferred.

3.3.2. Overview of SRE Habitat Prospectivity

The southwest of Western Australia is an old, climatically buffered, infertile landscape that hosts a mosaic or patchwork of vegetation types (Hopper 2009). In keeping with the wider landscape, the Proposal area contains a few, mostly widespread and generally well-connected habitats. Major geographical barriers that would impede the dispersal of species are largely absent.

Habitat units within the Proposal area reflect the wider landscape, as illustrated by both broad-scale regional vegetation mapping (Beard *et al.* 2013) and more detailed assessments of vegetation communities and fauna habitats across the Earl Grey (Mattiske 2018; Western Wildlife 2017). While detailed mapping shows some habitat fragmentation, particularly of habitat 3 (Figure 3), all units in the Proposal area also occur externally. The similarity of terrain in the vast majority of habitats makes it unlikely that habitat characteristics will prevent long-term dispersal of any SRE species. All habitats units have similarly high exposure and low moisture retention characteristics as one another and in most cases are likely to provide similar or analogous microhabitats. There is a lack of moist microhabitats and even rocky areas are limited and there are no outcrops, breakaways, banded ironstone formations or other



significant geological structures that would form isolated habitats. Thus, it is considered likely that species present at the Proposal belonging to the SRE Groups will for the most part have relatively widespread ranges.

Existing WAM records and reports suggest there is likely to be at least moderate diversity of SRE Group species at the Proposal, with mygalomorphs, scorpions, pseudoscorpions, geophilid centipedes, millipedes and isopods recorded in similar habitats nearby (Bennelongia 2016; Bennelongia 2017). Most species in the SRE Groups at the Proposal are not restricted to highly prospective SRE habitats (e.g. habitats comprised primarily of moist relict microhabitats or isolated geological structures) and instead utilise habitats containing a range of relatively unspecialised and xeric microhabitats.

4. POTENTIAL IMPACTS

There are broadly two types of impact on fauna associated with the development of mining infrastructure and subsequent mining operations:

- 1. *Primary impacts*. Activities that result in complete loss of habitat cause a primary impact, with the expectation that no animals in the area of lost habitat will survive. Species with a range (or local population) restricted to the area of primary impact are likely to become extinct of to lose the local population. In the case of SRE species, land clearing is the most common activity causing primary impact; and
- 2. Secondary impact. Activities that result in degradation (but not total loss) of habitat cause secondary impact and the species with a range (or local population) restricted to the area of secondary impact are likely to experience reduced population size. However, persistence of the species will not be threatened directly by the secondary impact. In the case of SRE species, vehicle movements (because of the dust generated), fire, grazing, and clearing of small areas and infrastructure corridors (because of fragmentation and edge effects) are common activities causing secondary impact. Activities such as blasting may also have a secondary impact around mine pits.

There has no detailed analysis of species distributions in relation to areas of impact associated with the Proposal because the results of this desktop survey provide only a picture of the type of SRE Group community that will occur in the Proposal area and the broad characteristics of the species in the community. Habitat mapping in the Proposal area also provides information about the likely ranges of the SRE Group species occurring in the Proposal area.

5. CONCLUSIONS: SRE AND LISTED INVERTEBRATES

The desktop review of SRE and listed invertebrates aimed to combine habitat information and regional invertebrate records to assess the likelihood that SRE or listed invertebrate species occur in the Proposal area. Additionally, the likelihood for the Proposal to significantly impact the conservation of such species was assessed.

At least 48 species from SRE Groups have been recorded in the 100 km x 100 km vicinity of the Proposal. No confirmed SRE invertebrate species have been recorded in this area. Of the species recorded, almost half (47.9%) are widespread, 12.5% are potential but unlikely SRE species and 36.9% are potential SREs. Potential SRE species include 15 mygalomorphs, two isopods, a pseudoscorpion and a millipede. In reality, many of these potential SRE species are likely to be widespread (relative to the SRE threshold of 10,000 km²), but current records are insufficient to accurately predict their distributions. No listed invertebrate species has been recorded in the search area and it is unlikely that any occur.

Six habitat units were identified at the Proposal, predominantly comprising mallee woodlands on various substrates or landforms, but also including shrubland and heathland. These units reflect the wider



landscape with which they are well-connected and major geographic barriers to dispersal are absent. All units are relatively similar in terms of flora, soil, climate, exposure and moisture retention and probably provide more or less analogous SRE microhabitats. Relict and mesic microhabitats within the Proposal area are limited to only moderate deposits of litter, while rocky areas lack outcropping rock that would provide very prospective for specialist species. The overall prospectivity of habitats in the Proposal area for SRE species is low.

Based on habitat and records from the vicinity, it is highly likely that SRE Group invertebrates will occur within the development envelope of the Proposal. However, it is emphasised that all habitat units within the area are widespread and well-connected across the wider landscape, meaning that any SRE Group species within the Proposal area are highly likely to occur outside the development envelope as well. The area covered by proposed developments is small compared with the likely ranges of SRE Group species that may be present, including confirmed SREs. Overall, it is unlikely that the development of the Proposal will have significant conservation implications for SRE or listed terrestrial invertebrate species.

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7. APPENDICES



Appendix 1. SRE Groups species identified to higher-order levels.

The following higher-order identifications of SRE taxa were omitted from in the final species list, or were amalgamated with species-level identifications or other indeterminate higher-order identifications (*), to avoid artificial inflation.

Higher Classification	Lowest Identification	No. of Records
Chelicerata		
Arachnida		
Araneae		
Mygalomorphae		
Barychelidae	Barychelinae sp.	1
	Idiommata `sp. indet. (juvenile)`	1
	Synothele `sp. indet. (juvenile)`	1
Ctenizidae	Conothele sp.	1
Idiopidae	`Aganippe/Eucyrtops` `sp. indet. (female)`	4
·	`Aganippe? (female)` sp.	1
	Aganippe `MYG064 (female)`*	24
	Aganippe `MYG064 (iuvenile)`*	1
	Aganippe `MYG065 (female)`*	3
	Aganippe `MYG065 (iuvenile)`*	11
	Aganinpe `sn_indet (female)`	30
	Aganippe 'sp. indet. (iuvenile)	6
		1
	Aganippe sp.	
	Apidione (MVC062 (female))*	
	Anidiops MYCOC2 (intentite)*	0
	Anidiops (invoids (juvenile) *	2
	Anidiops sp. (fragments)	1
	Anidiops sp. indet. (juvenile)	3
	Arbanitinae sp. indet. (juvenile)	3
	Eucyrtops sp. (fragments)	1
	Eucyrtops `sp. indet. (female)`	17
	Eucyrtops `sp. indet. (juvenile)`	15
Nemesiidae	Aname `mainae?`*	1
	Aname `MYG181 (juvenile)`*	1
	Aname `sp.`	1
	Aname sp.	5
	Teyl sp.	3
Opiliones		
Neopilionidae		
Pseudoscorpiones		
Atemnidae	`Genus indet.` sp.	1
Chernetidae	Chernetidae sp.	1
	Chernetinae `sp. indet. (juvenile)`	1
	Chernetinae sp.	4
	Haplochernes `sp.`	1
	Haplochernes sp.	1
Garvpidae	Synsphyronus `sp.`	1
Olpiidae	Beierolnium `sp. indet`	2
	Beierolnium `sn`	1
	Olniinae `sn indet (iuvenile)`	3
	Pseudoscorpiones sp	1
Scorpiones		1
Bothriuridaa	Corconhonius `michaolsoni2`*	1
Bothnundae		1
	Cercophonius sp.	2
	Cercophonius sp.	2
Buthidae	Buthidae sp.	2
	Isometroides sp.	2
	Isometroides sp.	5
	Lychas sp.	3
Urodacidae	Urodacus sp.	1
	Scorpiones sp.	1
Myriapoda		
Chilopoda		
Scolopendrida		
Scolopendridae	Cormocephalus sp.	1
Scutigerida		
Scutigeridae	`gen. nov.``sp. nov.`	1
	Scutigeridae sp.	2
Diplopoda		
Polyzoniida		
Siphonotidae	Polyzoniida sp.*	1



Appendix 2. SRE categories applied by the WAM.

Confirmed SREs are species with well understood taxonomy that are well represented in collections or come from areas that have been well sampled and have a known distribution range <10,000 km².

Potential SREs are species that belong to genus or other taxonomic grouping for which there are gaps in our knowledge, either because the taxon is not well represented in collections, taxonomic knowledge is incomplete, or species distributions are imperfectly understood because sampling has been patchy.

Widespread (not SRE) species have a known distribution range >10,000 km². The taxonomy of the species is well understood and it is well represented in collections.

The WAM uses five further sub-categories if a species is determined to be a "Potential SRE". These relate to the reasons for treating a species as a Potential SRE:

- 1. <u>Data deficient</u>: This is a precautionary sub-category because classification because the species is treated as a Potential SRE because there are insufficient data available to determine SRE status, either because there is a lack of geographic and taxonomic information, or because the individuals sampled cannot be identified to species level (e.g. wrong sex, juvenile, damaged);
- 2. <u>Habitat Indicators</u>: Here and in the following sub-categories, there is some evidence available from which the likely SRE status of the species may be inferred. For example, habitat indicators may suggest a species is likely to be an SRE because of its association with a particular habitat;
- 3. <u>Morphological Indicators</u>: The likely SRE status of a species may be determined through its morphological characteristics;
- 4. <u>Molecular Evidence</u>: DNA sequence data reveal patterns congruent with the species being an SRE; and
- 5. <u>Research & Expertise</u>: Available research data and/or WAM expertise may provide the basis for considering a species likely to be an SRE.



Appendix 3. Vegetation association codes presented in Figure 4 (Beard et al. 2013).

Vegetation Association	Beard Code	Description
125	sl	Bare areas; salt lakes
128	r	Bare areas; rock outcrops
676	k3Ci	Succulent steppe; samphire
511	e8,9Mi	Medium woodland; salmon gum & morrel
8	e8,34Mi	Medium woodland; salmon gum & gimlet
522	e10,11Mi	Medium woodland; redwood (<i>Eucalyptus transcontinentalis</i>) & merrit (<i>E. floctoniae</i>)
941	e8,9Mi/e10Si	Mosaic: Medium woodland; salmon gum & morrel / Shrublands; mallee scrub, redwood
1413	acmSc	Shrublands; acacia, casuarina & melaleuca thicket
519	e15Si	Shrublands; mallee scrub, Eucalyptus eremophila
1148	x12SZc	Shrublands; scrub-heath in the Coolgardie Region
2048	x13SZc	Shrublands; scrub-heath in the Mallee Region