Bennelongia Environmental Consultants

Southern Cross Goldfields Pty Ltd

Marda Gold Project (Mining Leases M77/394, 646, 931 and 962): Subterranean Fauna Risk Assessment

Final Report

Prepared for Southern Cross Goldfields Pty Ltd by Bennelongia Pty Ltd

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Marda Gold Project (Mining Leases M77/394, 646, 931 and 962): Subterranean Fauna Risk Assessment

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EXECUTIVE SUMMARY

The Marda Gold Project (the Project) is located approximately 114 km north of Southern Cross in Western Australia. The Project lies within the Marda-Diemals greenstone belt within the central Yilgarn Craton. Southern Cross Goldfields Pty Ltd (SXG) proposes to develop a mine over a five year period to extract gold from four Marda Central deposits (Python, Dugite, Dolly Pot, Goldstream) and two outlying deposits 13-16 km away (King Brown and Golden Orb).

This report assesses the potential threats to subterranean fauna (troglofauna and stygofauna) species as a result of the Project. The objective of this desktop assessment was to review the current knowledge of subterranean fauna in the region and characterise the subterranean habitat at Marda Central and other deposits within a regional context to provide:

1. A basis for gauging the likelihood of subterranean fauna assemblages inhabiting the Project deposits;
2. A preliminary assessment of the possible conservation significance of such assemblages; and
3. Recommendations about future assessment requirements.

The main threat to any troglofauna species within the Project was considered to be mine pit excavation, while groundwater drawdown associated with mine pit dewatering was considered to be the principal threat to any stygofauna species present.

An assessment of the likely occurrence of subterranean fauna within the Project was based on records of the Western Australian Museum (WAM) database, previous environmental impact assessments and primary literature. All available data within a 50 by 50 km Search Area surrounding the Project were reviewed, with additional information from nearby mine sites.

The WAM database contained no stygofauna records in the Search Area, reflecting both few stygofauna surveys in the Search Area and the depauperate nature of stygofauna communities present where surveys occurred. Other surveys outside the Search Area, although nearby, also yielded few if any stygofauna.

It was concluded that it is most unlikely a significant stygofauna community inhabits the Project area; the few species collected nearby have wide distributions. Given the small groundwater drawdown cone predicted to be associated with the Project and the depauperate stygofauna community, it was recommended that no subterranean surveys are required for the purpose of environmental impact assessment.

At least 15 species of troglofauna have been recorded in the Search Area, including one species of spider, four species of isopod, four species of myriapod and five insect species. Four of these species are currently known only from the Jackson Range and one species is currently known only from the Windarling Range.

Information about troglofauna in the Search Area suggests it is likely that a troglofauna community of low or moderate species richness exists at the Project. It is also likely that some of the species present will have localised distributions, as a number of species recorded within the Search Area are restricted to single rocky ranges.

Despite the potential for species with localised distributions occurring in the Project area, it is considered highly unlikely mining will threaten the persistence of any species because of the small size

of the proposed mine pits. Their total area is 26 ha, with the individual pits ranging in size from approximately 1.5 to 11 ha. Troglofauna surveys of fractured rock habitats in Western Australia indicate that pits of this size are unlikely to threaten troglofauna species. The most comprehensive study of troglofauna ranges in the Western Australia has been for schizomids of the Robe Valley mesas, where the smallest recorded range was approximately 89 ha. The mesas are geologically very isolated, unlike the geology of the Project area. Given the relatively uniform Project area geology, it is most unlikely that species in the Project area have ranges almost two orders of magnitude smaller than schizomids in the Robe Valley.

While recognizing that subterranean fauna may be present in the Project area, given the low level of threat associated with such small mine pits, it is considered that no subterranean survey is required for the purpose of environmental impact assessment.

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1. INTRODUCTION

The Marda Gold Project (the Project) is located approximately 114 km north of Southern Cross in Western Australia. The Project lies within the Marda-Diemals greenstone belt within the central Yilgarn Craton (Figure 1.1). Southern Cross Goldfields Pty Ltd (SXG) proposes to develop a mine over a five year period to extract gold from four Marda Central deposits (Python, Dugite, Dolly Pot, Goldstream) and two outlying deposits 10-30 km away (King Brown and Golden Orb) (Figure 1.1). The Project covers an area of about 2680 ha and key activities and infrastructure will include:

- Open-cut mining extending below watertable;
- Extraction of 0.5 Mtpa of gold ore;
- Processing via a carbon leach plant at Marda Central, requiring annual groundwater extraction of approximately XXX ML from existing and planned production bores;
- Waste dumps to be located outside the pits;
- Tailings storage facility;
- Diesel fired power plant; and
- Air strip, accommodation camp, utilities and other supporting infrastructure.

This review assesses the subterranean fauna habitat, requirement for field survey and risk to subterranean fauna associated with the Proposal. The defining characteristic of subterranean fauna is that they spend all, or most, of their lifecycle underground and are morphologically adapted to the subterranean environment. Adaptations include pallid colouration, reduction or loss of eyes, elongate body, long slender appendages and well developed sensory setae.

A high proportion of subterranean species are short-range endemics (SREs), defined by Harvey (2002) as species with ranges of <10,000 km^2, although subterranean species often have much smaller ranges than this criterion. The restricted ranges of subterranean fauna species mean they are particularly vulnerable to extinction from anthropogenic activities and, hence, are a focus for conservation (see Fontaine *et al*. 2007).

There are two types of subterranean fauna species: stygofauna and troglofauna. Stygofauna occur in groundwater, whereas troglofauna are air-breathing and occur in the various unsaturated layers of the vadose zone (Gibert and Deharveng 2002). In general terms, stygofauna may be threatened by groundwater drawdown and troglofauna by excavation of soil and rock.

The areas of groundwater drawdown and mine pit excavation associated with the Project are likely to be small relative to the ranges of most subterranean fauna species. However, it is theoretically possible that the planned disturbance associated with the Project may threaten highly restricted species of subterranean fauna, if such species exist within the Project footprint.

The objective of this desktop assessment was to review the current knowledge of subterranean fauna in the region and characterise the subterranean habitat at Marda Central and other deposits within a regional context to provide:

1. A basis for gauging the likelihood of subterranean fauna assemblages inhabiting the Project deposits;
2. A preliminary assessment of the possible conservation significance of such assemblages; and
3. Recommendations about future assessment requirements.

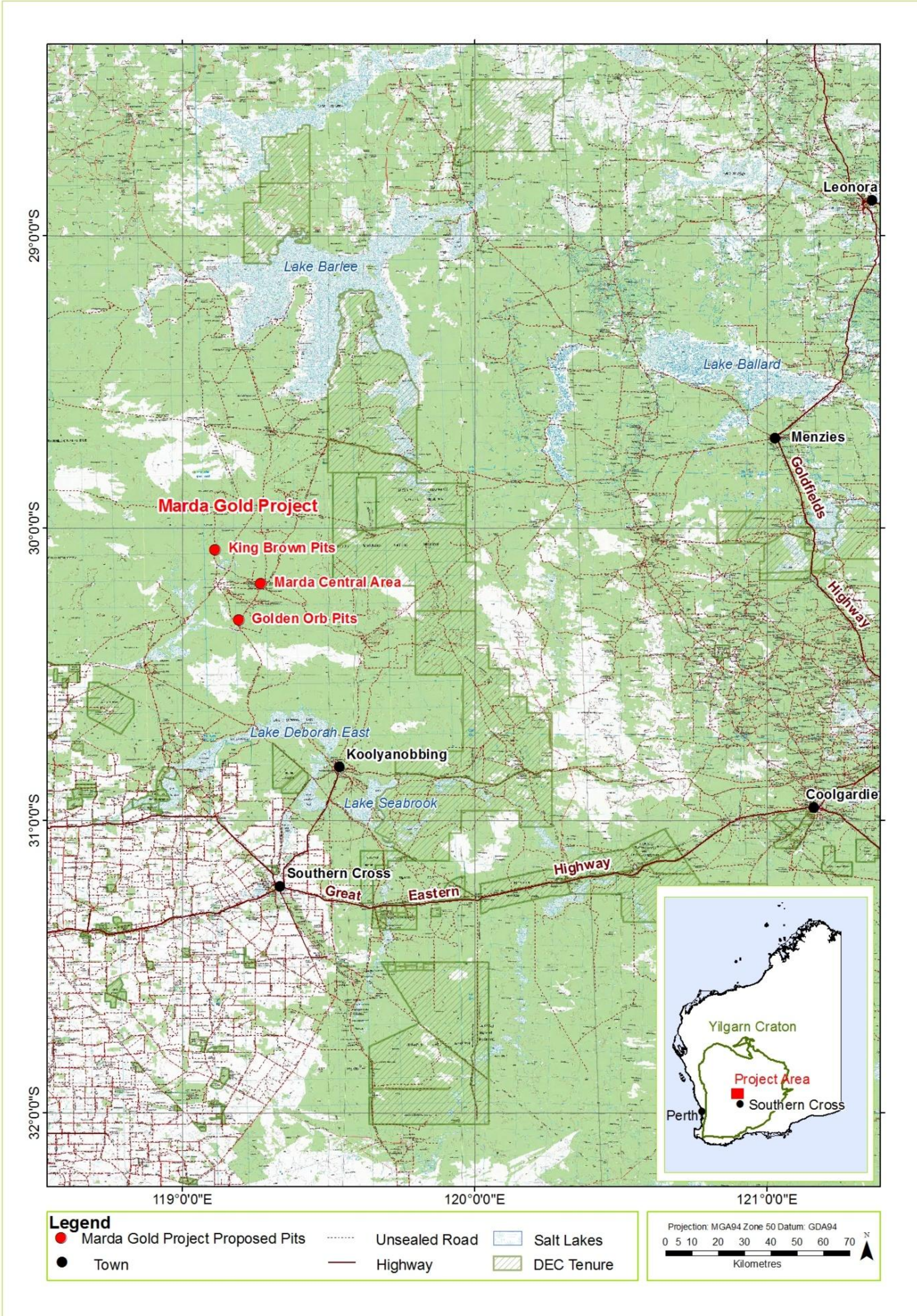

Figure 1.1. Location of the Marda Gold Project.

2. SITE DESCRIPTION

2.1. Geology

The Project is located in the south-eastern part of the Marda-Diemals greenstone belt within the Archaean Yilgarn Block. A craton-scale sinistral fault zone, the Mount Dimer Shear Zone, separates the Marda-Diemals greenstone belt from the Hunt Range greenstone belt to the north (Prodemas 2007).

Chen *et.al.* (2003) subdivided the Marda-Diemals belt into two greenstone successions. The lower 3000 My greenstone succession is characterised by mafic volcanics and Banded Iron Formation (BIF). A sequence of basalt and ultramafic rocks is overlain by the relatively thick BIF/chert unit, which is overlain by mafic volcanics. This lower greenstone succession is unconformably overlain by a 2730 My upper greenstone succession consisting of felsic to intermediate volcanic rocks and clastic sedimentary rocks.

The Project is intended to mine several discrete gold resources within the Marda-Diemals greenstone belt. The Marda Central group, located approximately 114 km north of Southern Cross, comprises the Dolly Pot, Dugite, Python and Goldstream deposits, with King Brown and Golden Orb located 13 km southwest and 16 km northwest respectively. Gold mineralisation occurs within all the major geological formations in the belt. Mineralisation at the Marda Central deposits and Golden Orb is hosted in BIF, whereas at King Brown mineralisation is hosted in basalt and/or ultramafic units.

The Marda Central deposits display common weathering, host rock and mineralisation characteristics and are therefore described as a group. They are found within a highly deformed segment of the Marda BIF and are characterised by strong quartz veining accompanied by silica, pyrite and sericite alteration. The structural context is dominated by isoclinal folds, low angle shears and late, high angle cross faults. Weathering of the deposits is substantially deeper than the surrounding area (Rock Team 2012).

Logged mafic and ultramafic units within the BIF at Marda Central were weathered to the extent of becoming clays. BIF units themselves were often logged as white cherty material, which may reflect pallid weathering of haematite /goethite units (Rock Team 2012). The abundant workings from previous mining confirmed these interpretations. Mullock heaps associated with vertical and northeast inclined shafts contain highly weathered fissile and jaspilitic cherts and BIFs, as well as pallid bleached quartz-kaolin rich units (Rock Team 2012).

Gold mineralisation at Marda Central correlates broadly with the extent of BIF, although differing slightly across the deposits. Python deposit mineralisation is hosted within the fold/fault thickened BIF. The country rock is fine-grained high-magnesium basalt weathered to significant depths. Mineralisation at Goldstream is associated with thin highly fractured/broken sub-vertical haematitic BIF units (Rock Team 2012).

South of Marda Central, Golden Orb exhibits similar degrees of weathering. The deposit is strongly weathered to an average depth of 80 m. Pallid clays were encountered at depths ranging from 25 to 40 m whilst mottled and ferruginous clays persisted to a vertical depth of between 60 m and 90 m. Gold mineralisation at Golden Orb followed the host chert unit over approximately 650 m of strike (Rock Team 2012).

Weathering of Marda BIF can also be seen north of Marda Central. The King Brown deposit is hosted by highly weathered ultramafic saprolitic clays with interspersed narrow highly degraded BIF units. Gold mineralisation is visible as platy flakes on fracture surfaces in quartz veins. These veins are associated with haematite staining on the footwall of a fractured and degraded BIF (Rock Team 2012).

2.2. Hydrogeology

The Project lies within the internal drainage division of Western Australia. The surface drainage of the Project area is poorly defined and consists mainly of broad sheet wash following short duration, high intensity storms. Occasional shallow, ephemeral drainage channels are present and small ephemeral creek beds arising within the project area flow north or north-west towards a chain of unnamed salt lakes. There are no salt lakes or significant claypans within the Project area (Pendragon 2013).

Ground water levels across Marda Central, King Brown and Golden Orb range lie approximately 11 to 76 m below the ground surface, depending on local topography. The main aquifer at Python is reported to be associated with highly fractured and jointed banded iron formation. Drilling records indicate that the degree of fracturing and associated main water strikes increased around the mafic contacts between 95 and 126 m below surface. Significant fracturing of the banded iron formation was recorded as deep as 154 m, while the vertical extent of the aquifer is currently undefined (Pendragon 2013).

Groundwater quality at Marda is variable, with circumneutral pH (7.0-8.4) and salinities ranging from fresh to hypersaline (860-118,000 µS/cm) (Pendragon 2013).

3. PROJECT DESCRIPTION AND POTENTIAL IMPACTS

3.1. Mining Activities Relevant to Subterranean Fauna

The Project proposes to mine gold in oxide and primary ore from multiple open pits and has an expected life of approximately five years. Activity will be concentrated in the Marda Central area at four mine pits (Python, Dugite, Dolly Pot and Goldstream). Satellite operations are planned a further two pits at King Brown and Golden Orb (located 16 and 13 km, respectively from Marda Central). The four pits of Marda Central are expected to have a total area of 11.3 ha, with the smallest pit occupying about 1.5 ha. The King Brown and Golden Orb pits are expected to be 3.5 and 11 ha, respectively.

Ore from all pits will be trucked to a 0.5 Mtpa conventional carbon in pulp/carbon leach (CIP/CIL) gold processing facility to be developed at Marda Central. Water for mining and operational purposes will be extracted from a BIF aquifer (approximately 60 m below ground surface).

Other major infrastructure at the Project will include a tailings storage facility, diesel fired power plant, water treatment facilities, communication facilities, new airstrip, accommodation camp, sewerage treatment ponds and landfill, all of which will be located at Marda Central.

3.2. Potential Impacts on Subterranean Fauna

Two types of mine-related impacts are recognised in this report: 1) *Primary Impacts* have the potential to threaten the persistence of subterranean fauna through direct removal of habitat; and 2) *Secondary Impacts* reduce habitat quality rather than removing it and are expected to have the potential to reduce population densities rather than threatening species persistence. Examples of secondary impacts are reduction in habitat quality as a result of nutrient enrichment from sewerage or increased turbidity from mine blasting (Scarsbrook and Fenwick 2003; Masciopinto *et al*. 2006).

When assessing the threat to subterranean fauna species from the proposed Project, only primary impacts were taken into consideration although it is recognised that the cumulative effect of secondary impacts may also be detrimental. Background on factors causing secondary impact is given in Appendix 1.

3.2.1. Potential Impacts on Stygofauna

Modelling indicates that, if significant groundwater impact as a result of dewatering is defined as drawdown ≥5 m, the approximate extent (i.e. radius) of groundwater impact around each mine pit will vary from 350 to 780 m (Table 3.1). Thus, the area of potential impact on stygofauna at King Brown is about 1.9 km^2. The area of impact at Golden Orb will be similar, while it will be less at the Marda Central deposits.

Table 3.1. Predicted dewatering flow rate and approximate radial extent of drawdown >5 m at different deposits (Pendragon 2013).

Pit	Dewatering flow rate (L/s)	Approximate Radial Influence (m)
King Brown	24	780
Golden Orb	16	740
Dolly Pot	7	565
Python	1	350

3.2.2. Potential Impacts on Troglofauna

Of all the mining activities at the Project, only *pit excavation* will represent significant habitat loss. This totals an area of approximately 26 ha.

4. SUBTERRANEAN FAUNA OCCURRENCE

4.1. Stygofauna

4.1.1. Habitats

Stygofauna inhabit subterranean spaces (fissures and voids) and occur in an array of different groundwater habitats including porous, karstic and fractured-rock aquifers, springs and the hyporheos of streams (Eberhard *et al*. 2005). In general terms, the likelihood of stygofauna occurring in an aquifer is directly related to its transmissivity (Gibert and Deharveng 2002).

The physiochemical tolerances of stygofauna have not been well defined, although some information is available on salinity tolerances and some broad principles can be inferred from the information available for surface species. Stygofauna have mostly been recorded in fresh to brackish groundwater but may occur in salinities up to 60,000 mg/L TDS (Watts and Humphreys 2006; Reeves *et al*., 2007; Ecologia 2009a).

4.1.2. Stygofauna of the Yilgarn

Considerable stygofauna survey has been undertaken by the Western Australian Museum (WAM) in calcretes of the palaeovalleys of the Yilgarn. It has been shown that individual calcrete aquifers frequently contain beetles, amphipods, isopods and bathynellids endemic to that aquifer (Cooper *et al*.

2002, 2007, 2008; Guzik *et al*. 2008). These restricted stygofauna communities have often been listed as either Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) (DEC 2009; 2010). In both cases, the communities are seen as having high conservation value during the assessment process.

Calcrete and, to a lesser extent, alluvium are typically considered to be the productive habitats for stygofauna in the Yilgarn. The relatively few surveys of stygofauna in other Yilgarn lithologies suggest other lithologies support at most few stygofauna species in low numbers. Most surveys in BIF have not found stygofauna, although a single *Microcyclops* copepod was recorded at Koolanooka (Ecologia 2007, 2008a,b; Bennelongia 2009a; GHD 2009).

4.1.2.1. Stygofauna in the Vicinity of the Project

A literature review of stygofauna records in the vicinity of the Project was used to assess the likelihood of stygofauna occurring at the Project itself. Records were compiled from previous environmental impact assessments, the WAM database and primary literature. All available data within a 50 by 50 km Search Area surrounding the Project (29°44'13.20"S to 30°38'49.20"S, 118°45'7.20"E to 119°47'2.40"E, Appendix 2) were reviewed.

The WAM database contained no records for the Search Area. This result reflects both the lack of stygofauna surveys in the Search Area and also the depauperate nature of stygofauna communities present where surveys have been done. The stygofauna survey at Windarling Range collected no animals (Bennelongia 2010a).

Surveys conducted in the vicinity of the Search Area have also yielded few, if any, stygofauna. Only nematodes or no stygofauna at all were collected from BIF aquifers in pilot-scale surveys at Lake Giles (80 km north-east of the Project) and Parker Range (190 km south-east) (Rockwater 2012). Bennelongia (2009b) collected no stygofauna from 20 samples at Carina deposit in the Hunt Range 73 km south-east of the Project (once again in BIF).

4.2. Troglofauna

4.2.1. Habitats

Troglofauna habitat is usually considered to occur between the lower layers of loose soil and sand (starting 3-4 m below the ground surface in Australia) and the interface with the groundwater (see Juberthie *et al*. 1981). Troglofauna presence is dependent on the structure of subterranean habitat and, as with stygofauna, if no fissures or voids are present in the subterranean strata no troglofauna will occur. Lateral connectivity of spaces is crucial to underground dispersal. Geological features such as major faults and dykes that block the continuity of habitat may act as barriers to dispersal, leading to species having highly restricted ranges.

Most troglofauna surveys for environmental assessment have been undertaken in areas of pisolite or BIF and it is been demonstrated in many surveys that these habitats are suitable for troglofauna. Information about the occurrence of troglofauna outside mineralized habitats is limited because mine development has been the primary reason for most of the surveys. However, troglofauna have also been collected from calcrete and alluvium in the Yilgarn and from karst in the Swan Coastal Plain (Barranco and Harvey 2008; Platnick 2008).

4.2.2. Troglofauna of the Yilgarn

The limited surveys that have been undertaken in the Yilgarn, for which information is available, have recorded modest troglofauna communities in calcretes above the watertable. Groups collected include palpigrads (Barranco and Harvey 2008), pseudoscorpions (Edward and Harvey 2008), spiders (Platnick 2008; Baehr *et al.* 2012) and isopods (S. Taiti in litt.). Outback Ecology (2011) collected 20 troglofauna species at Lake Way near Wiluna and cited unpublished WAM reports referring to "numerous [other] troglomorphic species" in Lake Way calcretes.

Other lithologies in the Yilgarn appear to support few troglofauna. Only three species representing three taxonomic groups (isopods, diplurans and thysanurans) were recorded in saprolitic rock at the Duketon Gold Project (Bennelongia 2010b). Only four species from four taxonomic groups (isopods, centipedes, diplurans and cockroaches) were collected at the Tropicana Project (Ecologia 2009b,c, 2010). Studies in BIF at Koolyanobbing, Mount Jackson and Hunt Range, Mt Dimmer and Yendilberin Hills have documented either depauperate or modest troglofaunal communities, depending on site, that include species of isopods, millipedes, centipedes, spiders, silverfish, beetles, symphylans, cockroaches, pauropods, bristletails and bugs (hemipterans) (Bennelongia 2008a,b, 2009a,b).

4.2.2.1. Troglofauna in the Vicinity of the Project

At least 15 species of troglofauna have been collected in the Search Area (Table 4.1). This includes one species of spider, four species of isopod, four species of myriapods and five insect species (Table 4.1). Four of the species are currently known only from Jackson Range (*Buddelundia?* sp. B02, *Cryptops* [*Trigonocryptops*] sp. B03, *Myrtonymus* sp. B05 and Pselaphinae sp. B04) and one species is currently known only from the Windarling Range (*Trichorhina* sp. B04).

Table 4.1. Troglofauna species collected in the Project Search Area.

Taxonomic Rank	Location in Search Area	Other Occurrences/Known Range
Arachnida		
Araneae		
Araneomorphae (nr Gnaphosidae) sp. B04	Jackson Range	Koolyanobbing Range (Bennelongia 2008a)
Malacostraca		
Isopoda		
Buddelundia? sp. B02	Jackson Range	Only known from Jackson Range
Philosciidae (*Haloniscus*?) sp. B04	Jackson Range	Koolyanobbing Range (Bennelongia 2008a)
Trichorhina sp. B02	Jackson Range	Koolyanobbing Range (Bennelongia 2008a)
Trichorhina sp. B04	Windarling Range	Only known from Windarling Range
Chilopoda		
Geophilomorpha		
Chilenophilidae sp. B01	Jackson Range	Hunt Range (Bennelongia 2009b)
Scolopendromorpha		
Cryptops (*Trigonocryptops*) sp. B03	Jackson Range	Only known from Jackson Range
Diplopoda		
Polyxenida		
Lophoproctidae sp. B01	Jackson Range and Windarling Range	Koolyanobbing Range (Bennelongia 2008a)
Pauropoda		
Pauropodina		
Pauropodidae sp. B08	Jackson Range	Lake Giles (Rockwater 2012)
Symphyla		
Cephalostigmata		
Hanseniella sp. B03	Jackson Range	Koolyanobbing Range (Bennelongia 2008a)
Insecta		
Thysanura		

Taxonomic Rank	Location in Search Area	Other Occurrences/Known Range
Hemitrinemura sp. B02	Jackson Range	Koolyanobbing Range (Bennelongia 2008a)
Hemiptera		
Meenoplidae sp.	Windarling Range	Immature specimen, very likely to be the same species that occurs at Koolyanobbing and Hunt ranges (Bennelongia 2008a, 2009a,b)
Coleoptera		
Curculionidae Genus 2 sp. B04	Jackson Range	Koolyanobbing Range (Bennelongia 2008a)
Myrtonymus sp. B05	Jackson Range	Only known from Jackson Range
Pselaphinae sp. B04	Jackson Range	Only known from Jackson Range

5. CONCLUSION AND RECOMMENDATIONS

Threats to the conservation of subterranean fauna from mining Marda Gold Project are related to both the likelihood of conservation significant subterranean fauna occurring and the spatial extent of predicted impacts from mining, relative to the distributions of restricted subterranean species.

5.1. Stygofauna

Information about the likelihood of stygofauna occurring within the Project and the possible threat to such communities suggests that there is little conservation threat to stygofauna species as a result of the project development for the following reasons:

1. No records of stygofauna were found within the Search Area around the Project;
2. Stygofauna communities in similar lithologies at neighbouring mine sites outside the Search Area are also depauperate;
3. The few stygofauna species collected at the neighbouring mine sites do not have tightly restricted distributions;
4. Mine operations will not impact calcrete or any other habitat type in which diverse subterranean communities have been recorded in the Yilgarn; and
5. The areas that may be potentially impacted by groundwater drawdown are significantly smaller than both the area of continuous subterranean habitat and the likely ranges of stygofauna species that may occur in the vicinity.

It is recommended that no subterranean surveys are required at for the purpose of environmental impact assessment of stygofauna.

5.2. Troglofauna

Information about the likelihood of troglofauna occurring within the Project area suggested it was likely that a troglofauna community of low or moderate species richness exists at the Project. It is also likely that some of the species present will have localised distributions, as a number of species recorded within the Search Area are restricted to single ranges.

Despite the potential for species with localised distributions occurring in the Project area, it is considered highly unlikely mining will threaten the persistence of any species because of the small size of the proposed mine pits. Their total area is 26 ha, with the individual pits ranging in size from approximately 1.5 to 11 ha. Troglofauna surveys of fractured rock habitats in Western Australia indicate that pits of this size are unlikely to threaten troglofauna species. The most comprehensive study of troglofauna ranges in the Western Australia has been for schizomids of the Robe Valley mesas, where the smallest recorded range was approximately 89 ha (Biota 2006; Harvey *et al*. 2008). The mesas are geologically very isolated, unlike the geology of the Project area. Given the relatively uniform Project area geology, it is most unlikely that species in the Project area have ranges almost two orders of magnitude smaller than schizomids in the Robe Valley.

While recognizing that subterranean fauna may be present in the Project area, given the low level of threat associated with such small mine pits, it is considered that no subterranean survey is required for the purpose of environmental impact assessment.

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7. APPENDICES

7.1.1. Appendix 1: Secondary Impacts of Mining on Subterranean Fauna.

De-watering below Troglofauna Habitat

The impact of a lowered watertable on subterranean humidity and, therefore, the quality of troglofauna habitat is poorly studied, but it may represent risk to troglofauna species in some cases. The extent to which humidity of the vadose zone is affected by depth to the watertable is unclear. Given that pockets of residual water probably remain trapped throughout de-watered areas and keep the overlying substrate saturated with water vapour, de-watering may have minimal impact on the humidity in the unsaturated zone. In addition, troglofauna may be able to avoid undesirable effects of a habitat drying out by moving deeper into the substrate if suitable habitat exists at depth. Overall, de-watering outside the proposed mine pits is not considered to be a significant risk to troglofauna.

Percussion from Blasting

Impacts on both stygofauna and troglofauna may occur through the physical effect of explosions. Blasting may also have indirect detrimental effects through altering underground structure (usually rock fragmentation and collapse of voids) and transient increases in groundwater turbidity. The effects of blasting are often referred to in grey literature but are poorly quantified and have not been related to ecological impacts. Any effects of blasting are likely to dissipate rapidly with distance from the pit and are not considered to be a significant threats to either stygofauna or troglofauna outside the proposed mine pits.

Overburden Stockpiles and Waste Dumps

These artificial landforms may cause localised reduction in rainfall recharge and associated entry of dissolved organic matter and nutrients because water runs off stockpiles rather than infiltrating through them and into the underlying ground. The effects of reduced carbon and nutrient input are likely to be expressed over many years and are likely to be greater for troglofauna than stygofauna (because lateral movement of groundwater should bring in carbon and nutrients). The extent of impacts on troglofauna will largely depend on the importance of chemoautotrophy in driving the subterranean system compared with infiltration-transported surface energy and nutrients. Stockpiles are unlikely to cause species extinctions, although population densities of species may decrease.

Aquifer Recharge with Poor Quality Water

Quality of recharge water declines during, and after, mining operations as a result of rock break up and soil disturbance (i.e. Gajowiec 1993; McAuley and Kozar 2006). Impacts can be minimised through management of surface water and installing drainage channels, sumps and pump in pits to prevent of recharge though the pit floor.

Contamination of Groundwater by Hydrocarbons

Any contamination is likely to be localised and may be minimised by engineering and management practices to ensure containment.

7.1.2. Appendix 2. Project Search Area