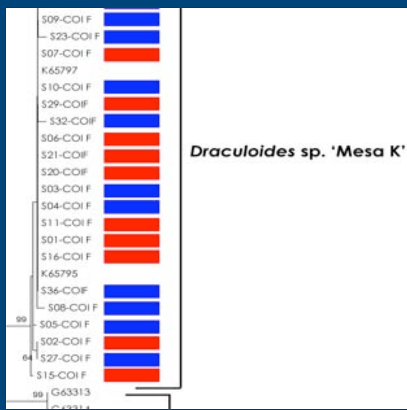
Mesa K Remnant Mining Project Troglobitic Fauna Survey



Prepared for

Pilbara Iron

Prepared by

Biota Environmental Sciences Pty Ltd

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ABN 49 092 687 119
Level 1, 228 Carr Place
Leederville Western Australia 6007
Ph: (08) 9328 1900 Fax: (08) 9328 6138

Project No.: 388

Prepared by: Dan Kamien, Zoë Hamilton, Garth Humphreys

Checked by: Michi Maier

Approved for Issue: Garth Humphreys

Mesa K Remnant Mining Project Troglofauna Survey

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1.0 Introduction

1.1 Description of Mesa K Remnant Mining Project

Robe River Iron Associates (Robe) currently produces pisolite ore from the Mesa J mine site, located approximately 15 km south-west of the town of Pannawonica, in the Pilbara region of Western Australia (Figure 1.1). Current projections show that the Mesa J deposit will be mined to its maximum extent by 2010. Production from the Mesa J mine site is forecast to begin to decline in 2008 as the available dry ore diminishes and the quality of the available ore at Mesa J decreases.

Robe proposes to recommence mining of the nearby Mesa K iron ore deposit (approximately 10 km south-west of Pannawonica), to blend with the Mesa J ore. Mesa K has previously been partially mined, with operations concluding in 1996. Approximately 40% of the original mesa formation remains intact. The company now plans to re-mine only parts of Mesa K, primarily within those areas of the mesa that have been previously disturbed, leaving other areas of the mesa intact. The proposed nominal pit outlines are illustrated in Figure 1.2.

1.2 Background to this Study

Sampling for subterranean fauna was first undertaken by Biota Environmental Sciences (Biota 2004) at Mesa A (approximately 40 km west of Mesa K) as part of exploration stage environmental surveys. This work was focussed on stygofauna (groundwater-inhabiting aquatic fauna; Humphreys 2000). No stygofauna were collected from the drillholes sampled, but four troglobitic taxa (obligate, subterranean terrestrial fauna) were unexpectedly collected from two of the sampled bores.

The collection of troglobitic fauna from Mesa A during this initial study was recognised as a significant outcome. Subsequent to this discovery, troglobitic fauna were recorded at other mesas in the Robe Valley, including Mesa K (Biota 2006a). Troglobitic fauna had never before been documented from mesa formations on the mainland Pilbara region and had previously only been recorded in Western Australia from karstic limestone systems (at Cape Range, Barrow Island and in the Kimberley; Harvey 1988, Biota 2002, Humphreys 2001). The specimens from the Robe River valley mesas are the first documented records of such a fauna occurring in a pisolitic mesa formation. Biota (2004) suggested that the humid, dark, fractured and vuggy environment indicated by drill logs from Mesa A were analogous to the habitats occupied by troglobites in karstic limestone formations.

Troglobitic fauna species have the potential to have restricted distributions. Short-range endemism (Harvey 2002) is common in this fauna (see Biota 2006a for a discussion). In the arid zone, the troglobitic fauna is generally considered to be relictual rainforest litter fauna, having arisen from tropical fauna lineages that descended into subterranean environments during the aridification of Australia (during the late Miocene; Humphreys 1993). This is inferred primarily from affinities of the taxonomic groups represented amongst the troglofauna with other extant surface taxa occurring in tropical or high rainfall regions.

Given the propensity for genetic differentiation in this fauna, it was realised that potential existed for species to be spatially restricted by geological and geographical barriers. The clearest mechanism in this case was the isolated and patchy nature of the mesa formations along the length of the Robe River valley. Subsequent survey work and specimen analysis indicated that the troglobitic taxa collected appear to be restricted to individual mesa formations (Biota 2006a).

This also represents an important environmental assessment issue in respect of proposed recommencement of mining operations at Mesa K. To address this a more comprehensive sampling and research programme was commenced, targeting troglobitic fauna. The approach to, and results of, this work are set out in this report.

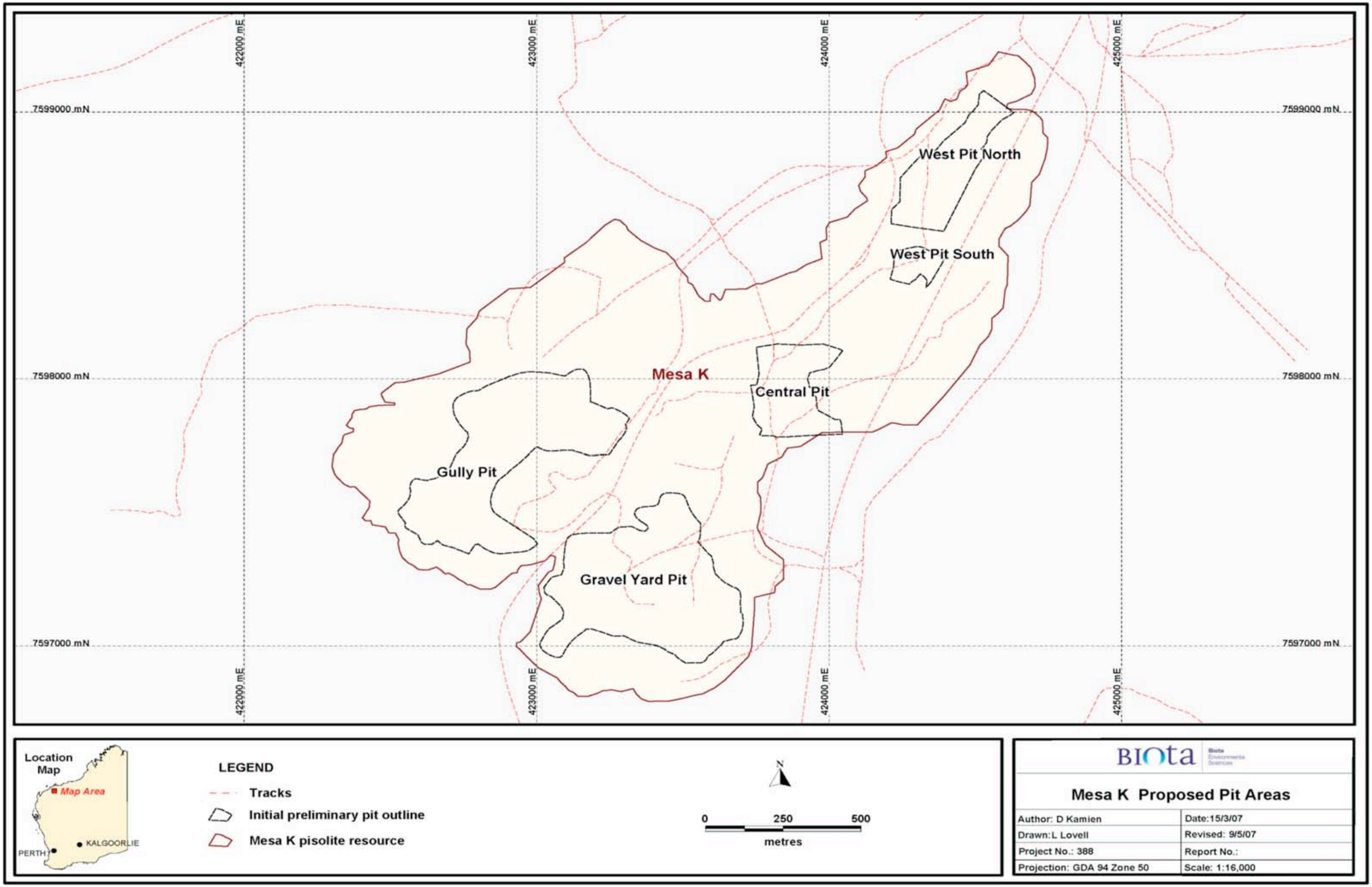

Figure 1.2: Mesa K study area, depicting proposed nominal pit areas.

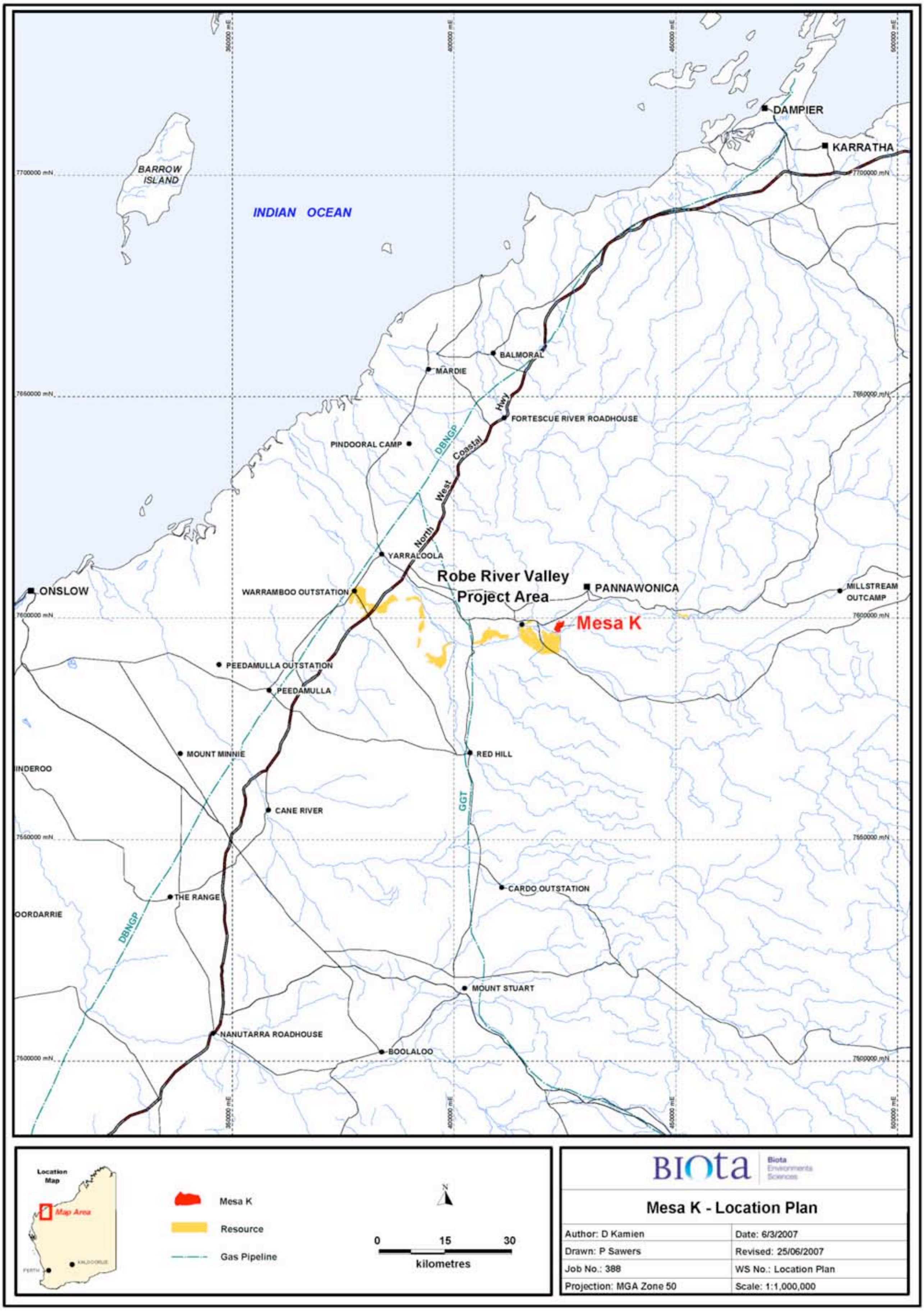

Figure 1.1: Locality map for the Mesa K project area.

1.3 Scope and Role of this Report

The Department of Industry and Resources (DoIR) has previously reviewed and approved a Notice of Intent (NOI) to re-mine Mesa K submitted under the terms of the *Iron Ore (Robe River) Agreement Act 1964*. Subsequent to this process, Biota conducted initial sampling of Mesa K in March 2005 (Phase I) as part of the broader Mesa A study (Biota 2006a). This work revealed the presence of troglofauna at Mesa K. Given this new information, Robe has now referred the proposal to re-mine Mesa K to the Environmental Protection Authority (EPA) assessment under the *Environmental Protection Act 1986*.

This report documents the sampling design, implementation and findings of the troglofauna studies completed at Mesa K. It has been prepared as a supporting technical document for the environmental assessment of the Mesa K remnant mining proposal.

2.0 Methodology

2.1 Approach to Sampling Programme Design

The troglobitic fauna sampling programme was designed by reference to similar subterranean fauna programmes undertaken elsewhere (particularly Biota 2004 and Biota 2006a). The overall approach and methods used were consistent with the guidance provided in EPA Guidance Statement No. 54 (EPA 2005).

The objectives of the troglofauna survey were to:

1. complete targeted sampling for troglofauna within the areas proposed for re-mining at Mesa K;
2. complete similar sampling for troglofauna within other parts of Mesa K not proposed for mining (including previously mined areas that will not be revisited and intact portions of the mesa);
3. assess species level representation of troglofauna across Mesa K and place this into context with regional information;
4. undertake an impact assessment based on the outcomes of point 3, and review potential project impact mechanisms; and
5. collect baseline data for the future monitoring and review of mining-induced changes at Mesa K.

2.2 Study Team

Field subterranean fauna sampling was undertaken over four phases for the current study (see Section 2.4). The field surveys were all completed by Biota Environmental Sciences, with the field personnel comprising Mr Garth Humphreys, Mr Dan Kamien, Mr Michael Greenham and Mr Lee Mould. Pilbara Iron staff provided information on drillhole locations and drill logs where available.

Mr Dan Kamien, Mr Garth Humphreys, Mr Lee Mould, Ms Jane Adcroft, Ms Erin Harris and Mr Myles Menz completed specimen sorting. Further identification of troglofauna specimens was conducted at the sorting stage by the sorting team and Dr Mark Harvey of the Western Australian Museum.

Species level identification of troglofauna specimens was primarily completed by Dr Mark Harvey (of the Western Australian Museum). DNA analyses of schizomid specimens were undertaken by Ms Zoë Hamilton (Biota) using laboratory facilities at the University of Western Australia. Field maps and figures for this report were prepared by Mr Paul Sawers and Mr Luke Lovell (Biota).

2.3 Sampling Techniques

Troglofauna were sampled by means of custom-built litter traps suspended within drillholes in each of the various study areas. Drill logs were reviewed, where available, to identify areas where fracture zones or cavities occurred in the profile. Within each hole sampled, traps were suspended such that they aligned with these more prospective zones.

Phase I traps were constructed from 60 mm internal diameter PVC stormwater pipe cut to a length of 120 mm. The external diameter of the completed trap was such that it fit closely against the interior of the sampled drillhole once installed, facilitating fauna entry into the trap. Both ends were sealed with 10 mm spacing aviary mesh after the tubing was filled with wet leaf litter.

Traps used during Phase II, III and IV were constructed from 60 mm internal diameter PVC irrigation pipe cut to a length of 180 mm. Each trap had a series of 20mm holes drilled in the side and traps remained open at the upper end. Traps were installed such that they were in contact with the interior of the sampled drillhole once installed, facilitating fauna entry into the trap.

Leaf litter material was gathered locally from the ground surface in the project area, particularly from the bases of *Acacia* shrubs. The collected litter was soaked in water and irradiated in a microwave oven on maximum power setting (to kill any surface invertebrates present and assist in break-down). Litter was added to the traps wet and kept in sealed containers until immediately prior to insertion into the drillholes. The opening of each drillhole was sealed after the installation of the traps to maintain humidity and to minimise the input of surface fauna. Traps were left in the ground for a minimum period of six weeks to allow sufficient time for troglofauna colonisation (see Section 2.4). Traps were then recovered and stored in labelled zip-lock bags for return to Perth for sorting.

2.4 Survey Effort and Design

Removing overlaps, an overall total of 56 bores was sampled for troglofauna during the four-phase survey. Details of bores sampled per phase and survey phase timing are provided in Table 2.1.

Table 2.1: Mesa K survey timing and trap effort.

	Phase I	Phase II	Phase III	Phase IV
Date installed	02 May 2005	04 Jun. 2006	04 Oct. 2006	15 Nov. 2006
Date recovered	28 Jul. 2005	03 Aug. 2006	15 Nov. 2006	12 Jan. 2007
Total days installed	87	60	42	58
No. traps installed	36	98	126	129
No. bores sampled	10	34	43	44

The distribution of the drillholes sampled for troglofauna during each of the four phases of the study is shown in Figure 2.1. Sampled drillholes were classified according to their potential impact status as 'Inside' (within areas proposed as nominal re-mining pit outlines) or 'Outside' (not within proposed re-mining areas). Twenty-one new boreholes were drilled across Mesa K to ensure adequacy of sampling spread and representation. In total, 23 Impact boreholes and 33 Reference area drillholes were sampled during the four-phase study. Figure 2.2 shows the distribution of sampled points in relation to their potential impact status.

Details on drillhole are provided in Appendix 1.

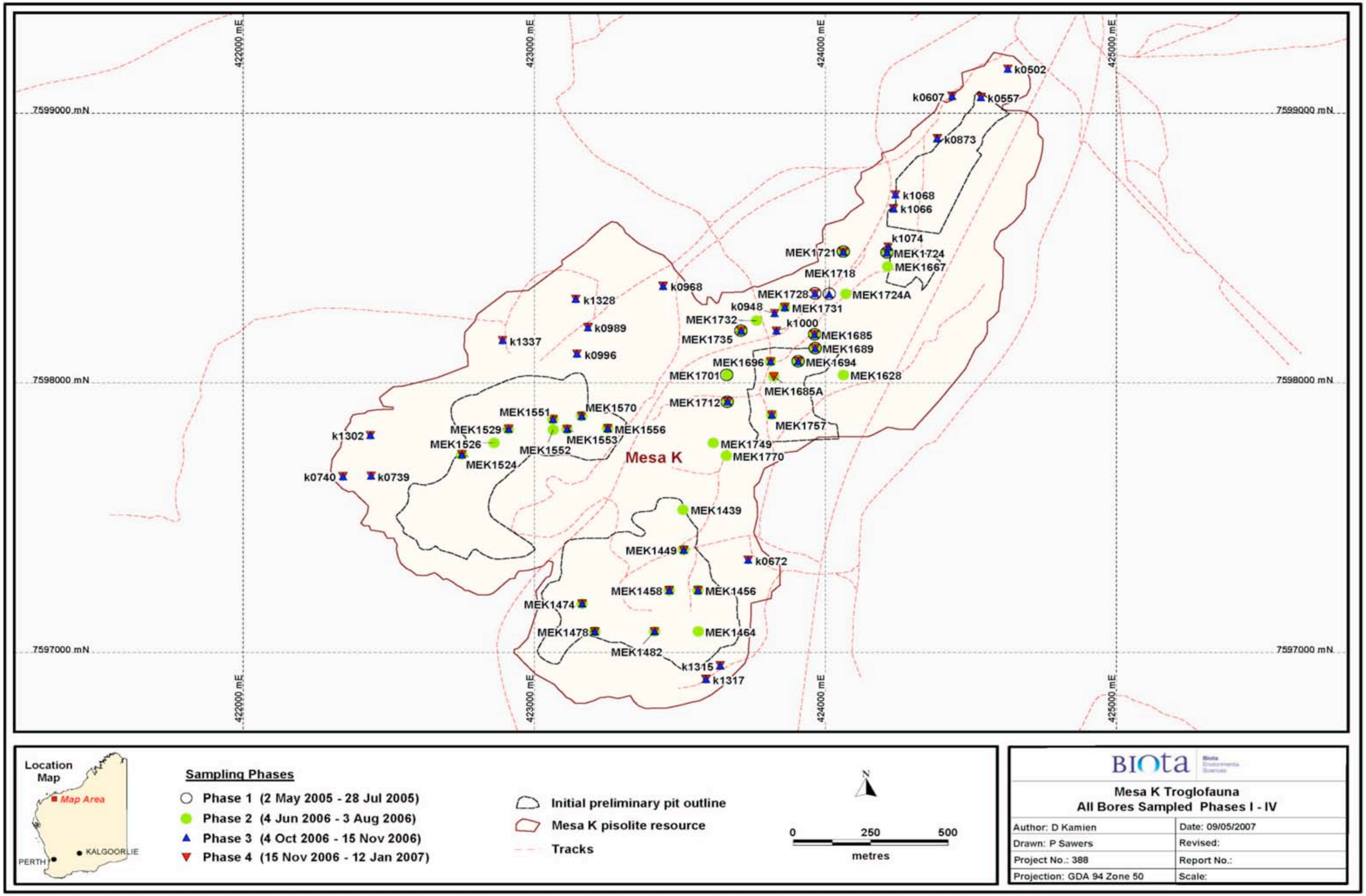

Figure 2.1: Phase by phase breakdown of drillhole locations sampled at Mesa K.

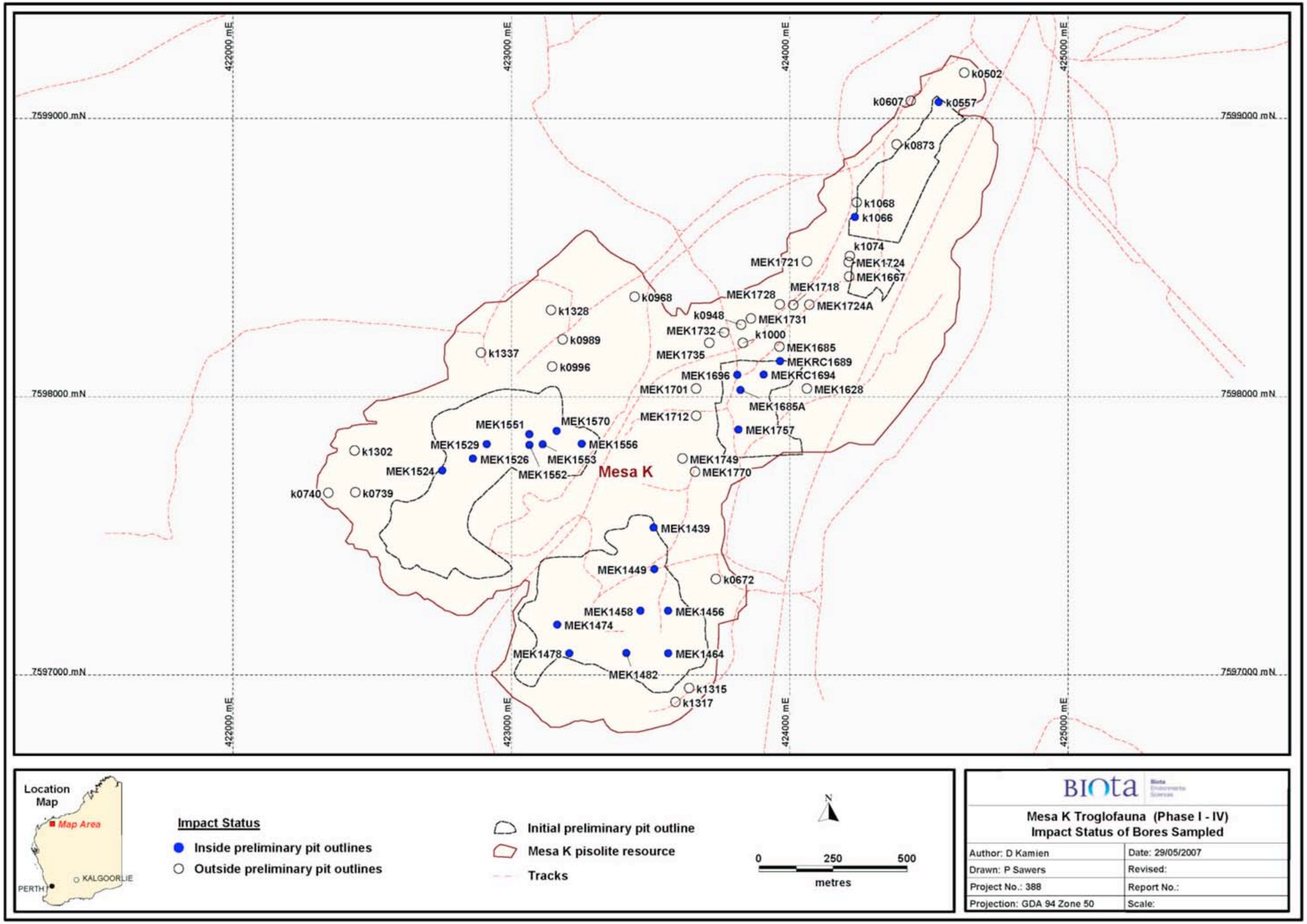

Figure 2.2: Distribution of Impact and Reference drillhole locations sampled at Mesa K during the four-phase study.

2.5 Specimen Sorting, Curation and Data Management

During Phases I and II, leaf litter from recovered traps was hand sorted by zoologists in Perth using Olympus SZ61 and SZ40 dissecting microscopes. During Phases III and IV, fauna specimens were recovered from the traps using specially designed tullgren funnel units (Burkard Scientific Ltd.), based on the original design by P.W. Murphy (1964). Leaf litter from each trap was placed in a sieve over which an aluminium lamp containing a 25-watt bulb was situated. This created a downward heat gradient, causing fauna to move to the bottom of the sample. A funnel was situated below the sieve, onto which a collecting vessel containing 100% ethanol was attached. Leaf litter was left in the tullgren funnels for a period of 24 hours, after which time the leaf litter was dry.

Specimens were subsequently recovered from the bulked sample in the collecting vessel and sorted using Olympus SZ61 and SZ40 dissecting microscopes. Collected specimens were assigned a unique specimen number based on drillhole location and tracked on customised data sheets. All invertebrates, both epigean (surface fauna) and subterranean, were recovered from the samples. Specimens were curated in 100% ethanol to allow for potential DNA analyses. Sub-samples of adults from certain taxa of interest (Schizomida and Pseudoscorpionida) were curated in 70% ethanol to provide for better morphological assessment.

All spatial data utilised in this study uses GDA94 datum.

2.6 DNA Analysis

2.6.1 Approach and Objectives

Schizomids were the most abundant troglobites at Mesa K, as with other mesas sampled in the Robe Valley (Section 4.0 and Biota 2006a). These were therefore selected for DNA sequencing. Sequencing was conducted in order to:

1. increase the number of specimens that could be included in taxon-level distributional analysis across the mesa (many individuals were juvenile and cannot otherwise be identified to species based on morphology); and
2. determine the phylogenetic relationship of Mesa K schizomids with schizomids recorded at other mesas in the Robe valley.

2.6.2 DNA Extraction

DNA was successfully extracted from a total of 42 schizomid specimens (see Appendix 2), including 27 specimens from within the Mesa K study area, using a simple Qiagen Dneasy kit following the prescribed protocol, with the exception of the final elution of extracted DNA in 60 µL volume. DNA was extracted from multiple legs or whole specimens depending upon size of specimen.

2.6.3 Polymerase Chain Reaction (PCR)

Polymerase Chain Reaction (PCR) was used to amplify the cytochrome oxidase c subunit one (COI) mitochondrial gene. This gene was chosen because of the known useful levels of variability of this region in many other phylogenetic investigations, and the reliability of this gene for inferring phylogenetic information (Biota 2006b, 2006c; Hart and Podolsky 2005; Bond 2004; Hebert et al. 2004; Paquin and Hedin 2004; Steinke et al. 2004; Bond and Sierwald 2003; Hebert et al. 2003; Holland and Hadfield 2002; Stothard et al. 2002; Farrell 2001; and Kojima et al. 1995). The gene has also been found to be reliable for 'DNA barcoding' (Hebert et al. 2003).

Primers used to attempt amplification of this region were shiz-CO1-115F and shiz-CO1-863R from Berry (2005) (see Table 2.2). PCRs were 25µl in total volume and contained 5µl of each primer

(2mM), 0.75µl MgCl2 (50mM), 2.5µl 10 x Taq buffer, 2.5µl dNTPs (2mM), 0.2µl Taq polymerase, 6.05µl dH20 and 3µl of DNA template.

Table 2.2: Primers used in this study.

Primer	Gene	Sequence (5' - 3')	Reference
shiz-CO1-115F	CO1	CAGCCCACGCTTTTGTAATAA	Berry 2005
Shiz-CO1-863R	CO1	GGCTGCTGTAAAATAAGCTCGT	Berry 2005
12SAI	12S rRNA	AAACTAGGATTAGATACCCTATTAT	Simon et al. 1994
12SR-J-14199	12S rRNA	TACTATGTTACGACTTAT	Kambhampati and Smith 1995

PCR amplification of double-stranded product was performed using a PTC-200 Peltier Thermal Cycler. Successful reactions for the CO1 gene involved an initial denaturation at 94°C for 2 minutes; the reaction was then cycled through denaturation at 94°C for 30 seconds, followed by annealing at 48°C for 20 seconds and then elongation at 74°C for 15 seconds, and these steps were repeated for 35 cycles, followed by a final elongation at 72°C for 2 minutes.

For each PCR reaction, positive and negative controls were used. The positive control (the standard) consisted of the same PCR mix with extracted schizomid DNA that was previously shown to work with the primers. This control was used to test that PCR conditions were correct. If the positive control did not produce a band of the desired size, then a problem with the PCR conditions was apparent. Alternatively, if the positive control did produce a band of the correct size, and no band was produced for the desired species, then there was a problem with the DNA template. The negative control (the blank) consisted of the same mixture of chemicals, except that dH_2O replaced the DNA template. This control was used to ensure that there was no contamination in the dH_2O used in the reactions.

PCR products were run on a 1% agarose gel in 0.5 x TBE buffer using a constant voltage of 100V (400mA) for 20 minutes. The gels were then stained with SybrSafe for approximately 40 minutes. After staining, the gel was exposed to UV light and photographed in order to visualise the PCR products. Photographs were viewed using AlphaDigiDoc. PCR products were verified against an appropriately sized marker, a GeneRulerTM 100bp DNA ladder Plus. The blank and the standard were also run out on the gel to check for contaminants, and to verify that PCR conditions were stable.

Polymerase Chain Reaction (PCR) was successful for a total of 31 schizomid specimens for the COI gene, across 20 sites from the Mesa K area. PCR products were then purified using an "Ultra Clean PCR Clean-Up DNA Purification kit" (MO BIO Laboratories Inc.) following manufacturers instructions. PCR products were sequenced using the ABI BigDye chemistry by the Macrogen Inc. facility.

2.6.4 Sequence Editing and Analysis

Sequences were checked and edited and chromatograms (Figure 2.3) were visualised using Sequencher software (GENECODES). Sequences were then aligned using ClustalW, and gaps were adjusted by eye.

Phylogenetic and molecular evolutionary analyses were conducted using MEGA version 3.1 (Kumar et al. 2004).

Kimura's 2-parameter model of genetic distance was used to generate a distance matrix in MEGA version 3.1 (Kumar et al. 2004). Kimura's model of genetic distance (Kimura 1980) accounts for the difference in the ratio of transitions to transversions. A transition is the substitution of a purine for another purine or the substitution of a pyrimidine for another pyrimidine. Transversions are all other types of nucleotide substitutions. In most DNA segments, transitional nucleotide substitutions are known to occur more frequently than transversions (Forstner et al. 1995; Nei and Kumar 2000).

A Neighbour joining tree was constructed using all individuals in MEGA version 3.1 (Kumar et al. 2004). A Bootstrap routine with 100 pseudoreplicates was performed to determine the internal support for the individual nodes.

Samples sequenced in this study were analysed together with previously sequenced schizomids from the Pilbara (Biota 2006a and Berry 2005), thus providing context for the observed levels of sequence divergence of Mesa K schizomids.

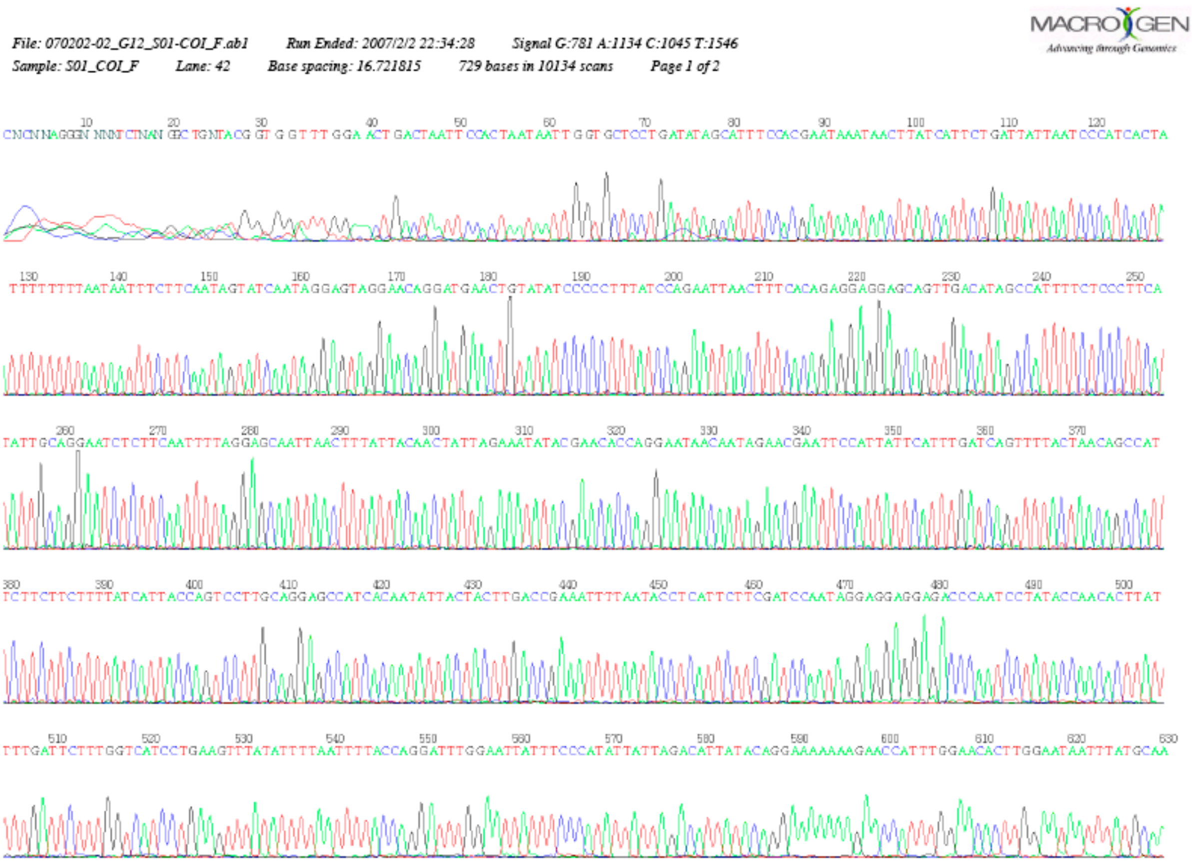

Figure 2.3: Chromatogram showing COI sequence for S01 (sampling location MEK1456).

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3.0 Subterranean Fauna Habitat

3.1 Description of the study area

Mesa K encompasses an area of 365 ha and is typical of other mesas in the Robe River valley in that it is a flat-topped hill, rising 30-50 m in elevation above the adjoining valley floor (Biota 2006a). Mesa K is a partial mesa and adjoins adjacent hills to the north and west. The surface of the mesa, which comprises a hard lateritised goethite cap up to 10 m in thickness, has eroded to produce a free face around the edge of a part of the landform (Plate 3.1 and Plate 3.2). The southern boundary of Mesa K (Plate 3.1) comprises a free-face sitting above a debris slope comprised of a zone of rock-fall accumulation and a lower colluvial zone. The base of the colluvial zone contains a smaller alluvial zone adjoining the major alluvial system of the Robe River.

Plate 3.1: Breakaway at the Mesa K southern boundary.

A considerable portion of the original mesa formation has been subject to historical disturbance due to past mining operations. Some 190 ha of the 365 ha (approximately 52%) has been subject to past disturbance, including open-cut pits, laydown areas, roads and waste dumps (see Plate 3.2). These areas have been subject to varying degrees of rehabilitation.

Stratigraphically, the mesa cap is typically underlain by layers of varying grade pisolite, which represent the iron ore resource of interest to the proposed mining operation. Pisolitic ore comprises a combination of the iron minerals goethite and hematite. The majority of the pisolite is made up of spherical accretions of iron minerals called pisoliths (Ramanaidou et al. 2003, Robe 2005). These formations are also frequently vuggy, fractured and may contain small-scale caverns. The small interstices present in these strata are likely to be of sufficient size to accommodate troglofauna. The pisolitic strata can be interspersed with layers of clay, silica and schists, before a basement of basal pisolite is reached overlaying the Ashburton Formation at valley floor level (Figure 3.1).

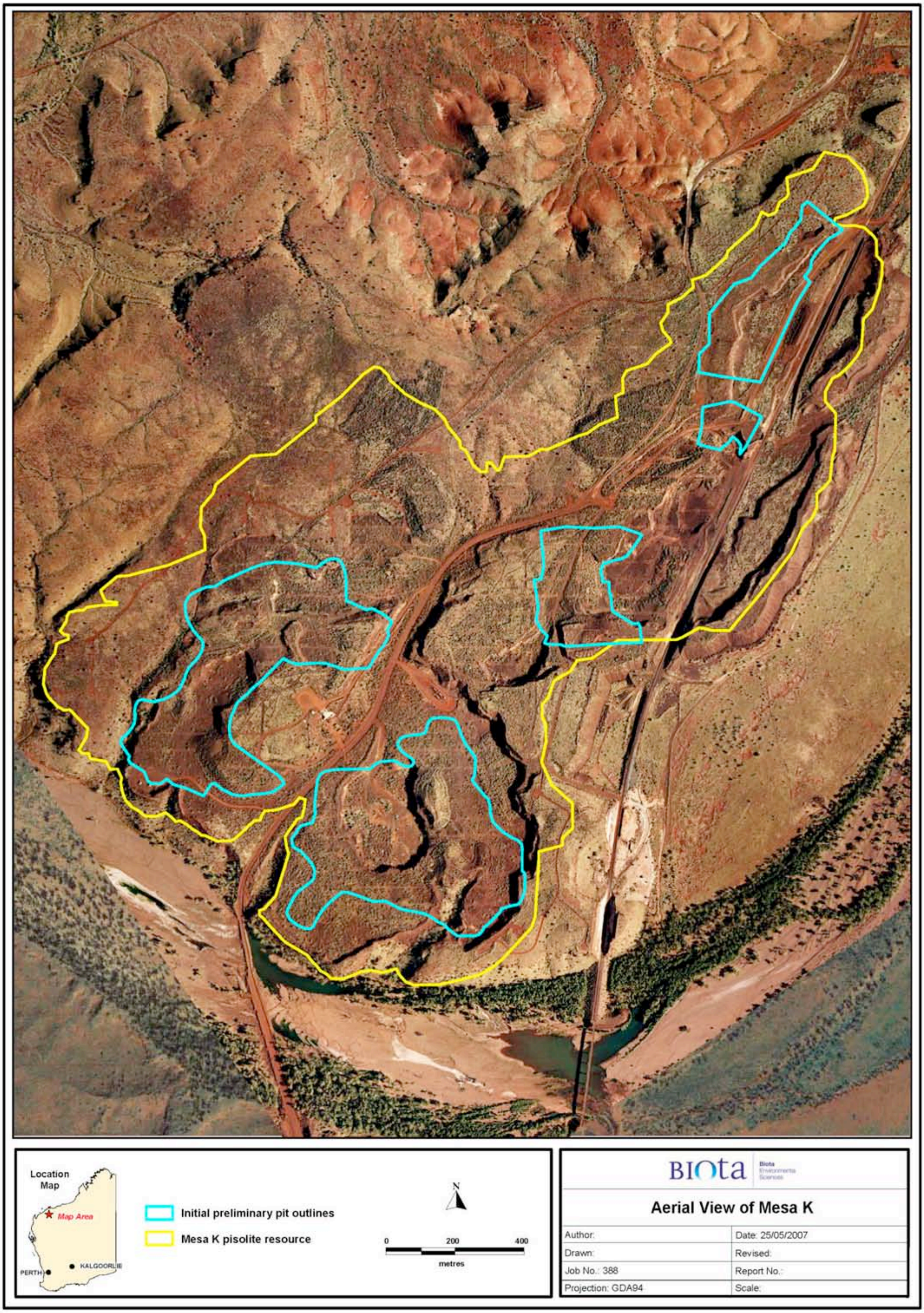

Plate 3.2: **Aerial view of Mesa K.**

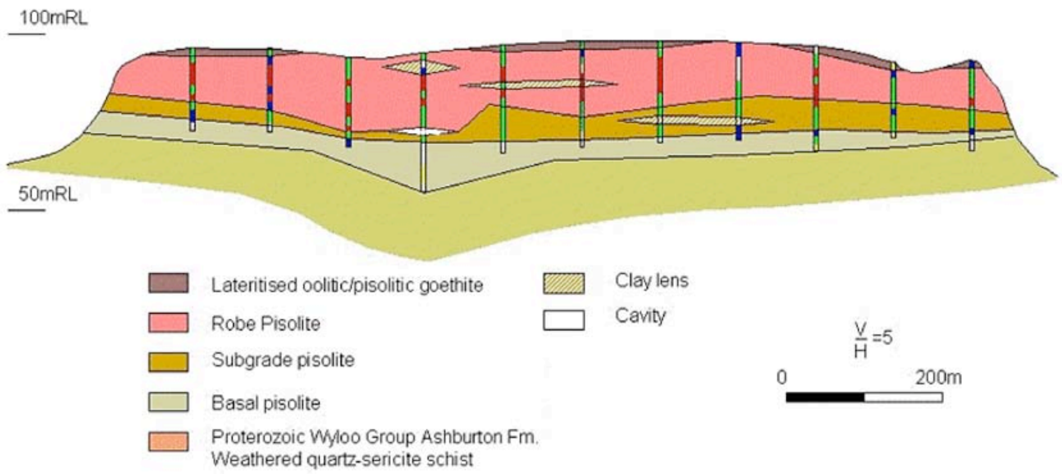

Figure 3.1: **Schematic cross-section of a typical Robe valley mesa** (modified from an original schematic sourced from Robe (2005)).

3.2 Hydrological Regime

Water occurs in the bottom of the deeper bores in Mesa K and the presence of water at this depth is most likely associated with spatially discrete clay zones of reduced permeability within the overall mesa stratigraphy. Groundwater recharge within the mesa is dominated by rainfall events where the highly fractured and jointed goethitic cap and mining disturbances provide a zone of enhanced infiltration to the underlying strata. The potential for water mounding through the base of the mesa and contributory recharge via flooding of the adjacent valley floor has not been confirmed at this stage.

Once water infiltrates towards the lower strata, the depth of penetration and flow-paths will be dependent on a range of sub-surface conditions and processes. Well-developed joint sets and fracture zones will provide primary pathways for water movement. Detention and storage will occur at depth when the water is allowed to seep into vugs and small cavities below the depth of evaporation influence.

The presence of zones of decreased permeability, resulting from materials with elevated clay contents, will contribute to sub-surface water movement. These clays are likely to act as zones of storage and may also prevent or reduce further vertical water movement into underlying strata.

The primary troglobitic fauna habitat within mesa is the humidified pisolitic strata. The maintenance of a humid microclimate within the mesas is thought to be central to the suitability of this environment for troglofauna.

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4.0 Results

4.1 Overview

The four-phase troglofauna survey yielded a total of 18,133 invertebrate specimens, representing 22 orders. A summarised order level break-down of specimens collected by drillhole locations in Mesa K is provided in Table 4.1. Details of all troglobitic specimens collected during the survey are provided in Appendix 3.

Table 4.1: **Overview of combined troglofauna sampling results from four phases of sampling at Mesa K** (groups containing troglobites shown in bold; systematic hierarchy after Harvey and Yen (1997)).

Taxon				
Phylum	**Class**	**Order (and Common Name)**	**Total Individuals**	**No. of Bores on Mesa K**
Annelida	Oligochaeta	Haplotaxida (Earthworms)	104	8
Nematoda		(Nematodes)	185	27
Chelicerata	Arachnida	**Schizomida (Schizomids)**	**108**	**28**
		Pseudoscorpionida (Pseudoscorpions)	**5**	**4**
		Opilionida (Harvestmen)	3	2
		Acarina (Mites)	10,357	56
		Araneae (Spiders)	1	1
Crustacea	Malacostraca	Isopoda (Slaters)	2	2
		Amphipoda (Amphipods)	1	1
Uniramia	Chilopoda	**Scolopendrida (Centipedes)**	**1**	**1**
	Diplopoda	**Polydesmida (Millipedes)**	**6**	**3**
		Polyxenida (Pincushion millipedes)*	**3**	**2**
	Symphyla	Symphyla	2	2
	Collembola	Collembola (Springtails)	5,954	55
	Diplura	**Diplura (Diplurans)**	**1**	**1**
	Insecta	Thysanura (Silverfish)	1	1
		Blattodea (Cockroaches)	1	1
		Isoptera (Termites)	57	1
		Coleoptera (Beetles)^	**71**	**19**
		Diptera (Flies)	649	39
		Hymenoptera (Ants, Bees, Wasps)	620	41
		Lepidoptera (Moths, Butterflies)	1	1
		Total individuals:	**18,133**	

* Potentially troglobitic
^ includes epigean specimens

A review and identification of troglobitic groups was carried out as part of the Mesa A study (Biota 2006a). This work was completed with the Western Australian Museum and distinguished groups that may be troglobitic (and therefore potentially restricted) from deep-soil and surface fauna. This framework was used here as the basis for specific examination of the Mesa K fauna, to identify a total of 178 troglobitic (and potentially troglobitic) specimens, representing seven orders across the four sampling phases (Table 4.2, Figure 4.1, Figure 4.2 and Appendix 3).

Sampling over four phases at Mesa K yielded troglobitic records from 33 of 56 drillholes sampled (59%; Table 4.2 and Figure 4.1). This comprised records from across the extent of Mesa K, including historically disturbed and intact portions of the landform (Figure 4.2). Individual capture rates and spatial distributions, however, varied significantly between taxa (Figure 4.2). For example, the Schizomida were recorded in relatively high numbers (108 records from 28 bores), while the Diplura were recorded at low frequency (a single record). Results for each troglobitic group are discussed in more detail in Section 4.2.

This report gives no further consideration to the remainder of the specimens collected, as most clearly represented epigean (surface) forms and are at low risk of species-level spatial restriction.

Table 4.2: Overview comparison of troglobitic orders collected from Mesa K during survey Phases I to IV.

		No. of bores with troglofauna					Total individuals				
Class	**Order**	**P I**	**P II**	**P III**	**P IV**	**Total**	**P I**	**P II**	**P III**	**P IV**	**Total**
Arachnida	Schizomida	5	21	18	1	**28**	12	60	35	1	**108**
	Pseudoscorpionida	-	2	1	1	**4**	-	3	1	1	**5**
Chilopoda	Scolopendrida	-	-	1	-	**1**	-	-	1	-	**1**
Diplopoda	Polydesmida	-	-	2	1	**3**	-	-	5	1	**6**
	Polyxenida	-	-	1	2	**2**	-	-	1	2	**3**
Insecta	Coleoptera	-	1	7	1	**9**	-	1	42	11	**54**
Diplura	Diplura	-	1	-	-	**1**	-	1	-	-	**1**
	Total	**5**	**22**	**21**	**9**	**33**	**12**	**65**	**85**	**16**	**178**

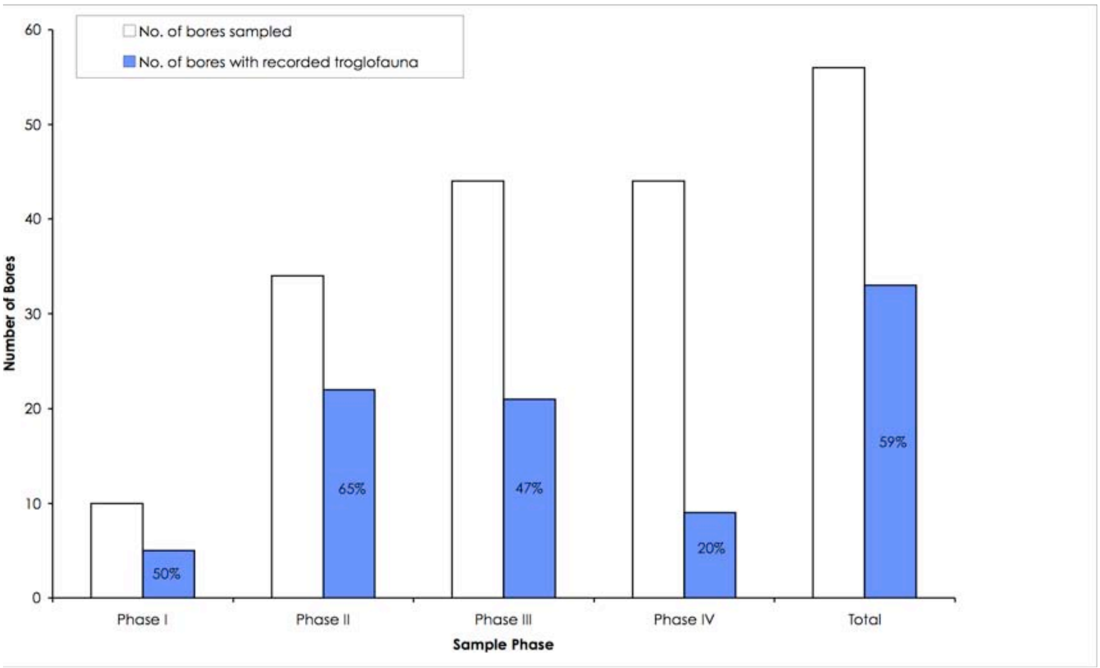


Figure 4.1: Number of bores with troglofauna in relation to sampling effort during each sampling phase.

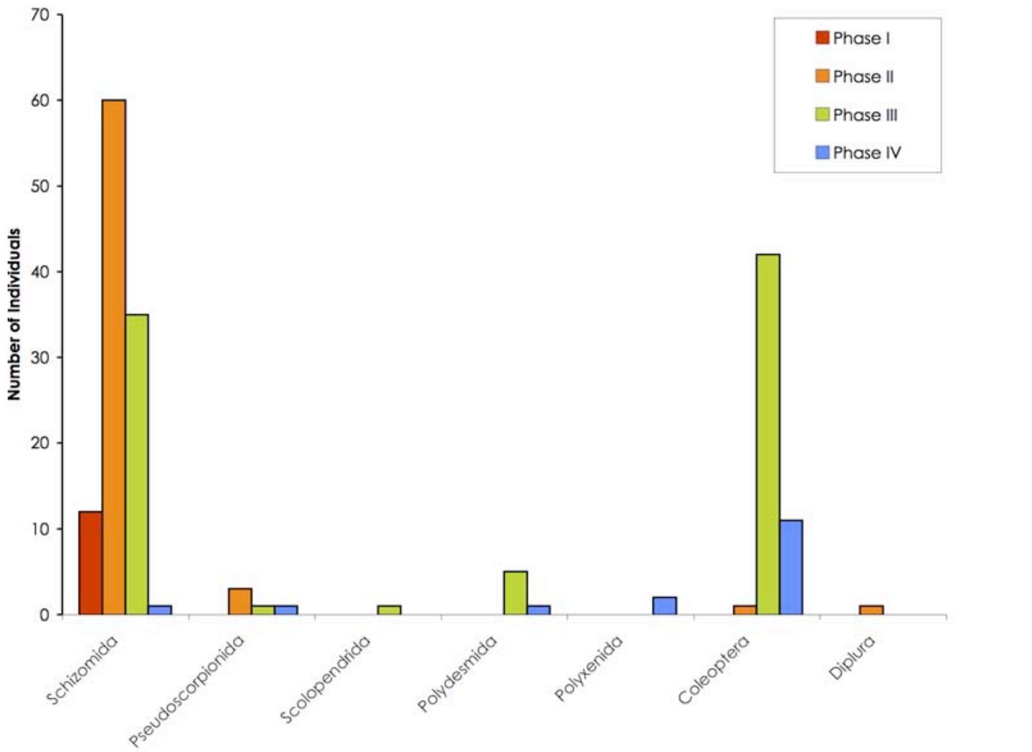


Figure 4.2: Taxa and number of troglobitic specimens recorded during each sampling phase.

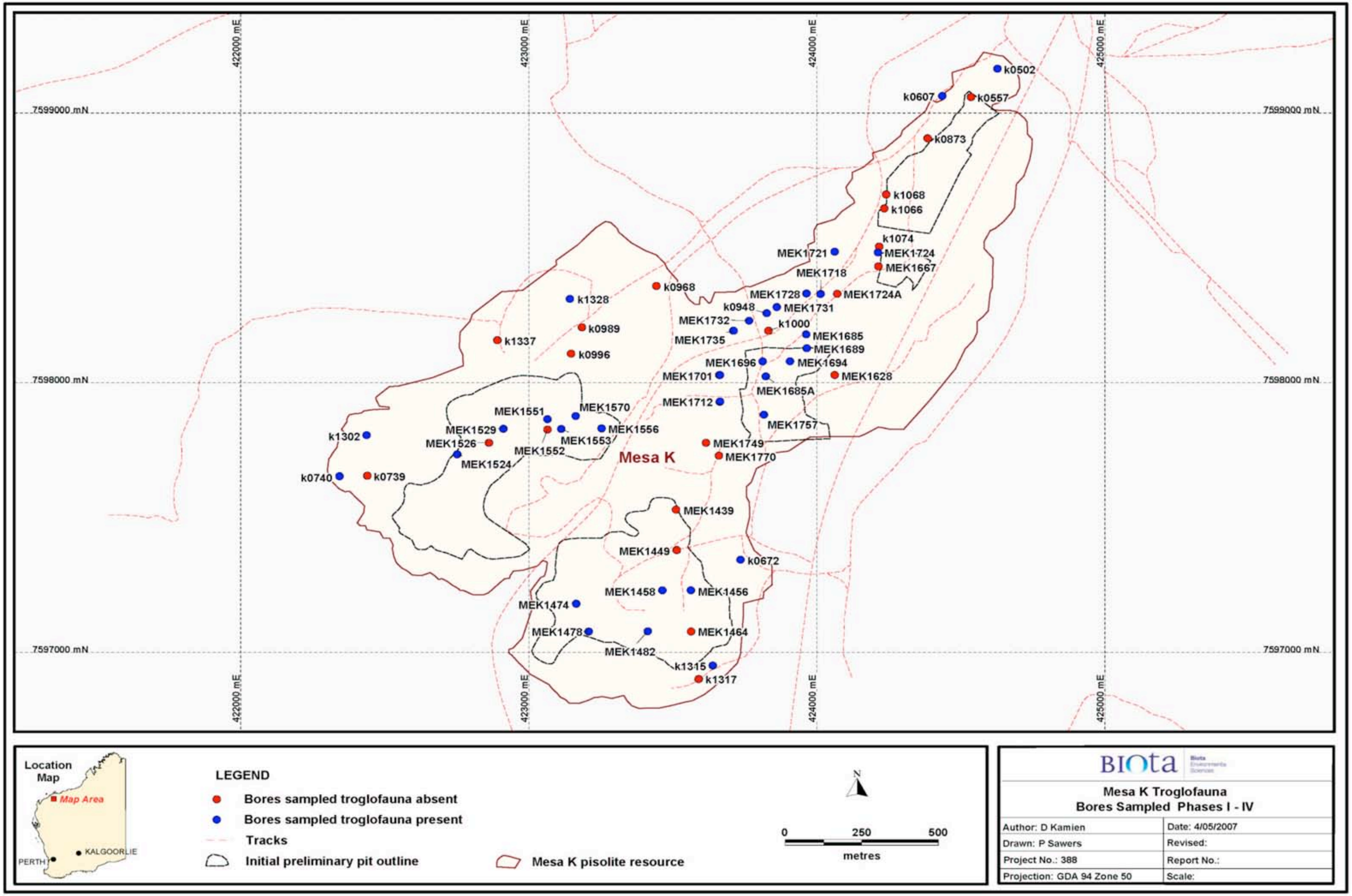


Figure 4.3: Sampled drillhole locations at Mesa K during Phase I to Phase IV, denoting presence and absence of troglofauna.

4.2 Account of the Troglobitic Fauna

A summary of the troglofauna identifications completed as part of this study is provided for higher order taxonomic groups in the following annotated list. As noted in Section 4.1, only taxonomic groups that contained troglobitic specimens have been considered in detail. Each group is also discussed in the framework of 'Inside' and 'Outside' preliminary pit impact areas (see Section 2.4).

4.2.1 Order Schizomida (Schizomids)

Schizomids are fast moving, predatory arachnids that mostly live in tropical climates (Harvey 2000). They superficially resemble spiders but have a tail-like structure at the end of the abdomen (the flagellum) and long, sensory front legs (Harvey and Yen 1997; Plate 4.1 and Figure 4.4). There are currently 48 species of schizomids described from Australia, all of which belong to a single family, the Hubbardiidae (Harvey 1992, 2001). The Western Australian fauna contains eight described species, all of which occur in subterranean habitats in the north-west of the State (Cape Range, Barrow Island and the Kimberley; Harvey 1988, 1992, 2001). A further five species from the Robe River valley are currently being described in a pending publication (Harvey et al. 2007).

Plate 4.1: ***Draculoides* sp. 'Mesa K' (male).**

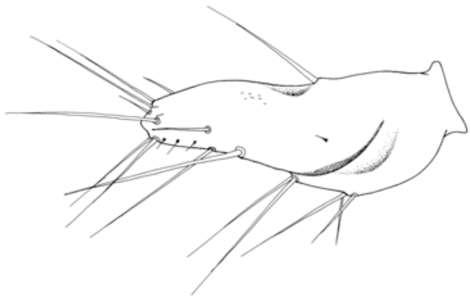


Figure 4.4: Lateral detail of flagellum of male *Draculoides* sp. 'Mesa K' (drawn: K. Edward).

Schizomids numerically dominated the collected troglofauna. During the four sampling phases, a total of 108 schizomid specimens were collected at Mesa K, accounting for 60% of the total troglofauna recorded (Table 4.2, Table 4.3 and Figure 4.5). This is consistent with the wider Robe River valley survey (Biota 2006a), and is probably attributable to their high mobility as active predators (Harvey and Yen 1997). The results indicated that schizomids are widespread throughout the sampling areas on Mesa K, having now been recorded from 28 bores spanning the extent of the study area (Figure 4.5).

All mature specimens collected were identified from morphology as belonging to the same, as yet undescribed, species belonging to the genus *Draculoides* (Schizomida: Hubbardiidae). This species (*Draculoides* sp. 'Mesa K') is currently considered endemic to Mesa K (Biota 2006a, Harvey et al. 2007).

Table 4.3: Summary of *Draculoides* sp. 'Mesa K' specimens recorded from Mesa K during four sampling phases (Impact status = location of record Inside or Outside of planned pit outlines).

Drillhole	Impact status	Phase I	Phase II	Phase III	Phase IV	Total
K0607	Outside	–	–	2	–	**2**
K0672	Outside	–	–	1	–	**1**
K0740	Outside	–	–	1	–	**1**
K1328	Outside	–	–	1	–	**1**

Drillhole	Impact status	Phase I	Phase II	Phase III	Phase IV	Total
MEK1456	Inside	–	2	–	–	**2**
MEK1458	Inside	–	2	–	–	**2**
MEK1474	Inside	–	–	1	–	**1**
MEK1482	Inside	–	1	–	–	**1**
MEK1524	Inside	–	6	1	–	**7**
MEK1529	Inside	–	8	4	–	**12**
MEK1551	Inside	–	2	3	–	**5**
MEK1553	Inside	–	3	1	–	**4**
MEK1556	Inside	–	2	–	–	**2**
MEK1570	Inside	–	1	4	–	**5**
MEK1685	Outside	4	1	1	–	**6**
MEK1685A	Inside	–	3	–	–	**3**
MEK1689	Inside	1	4	–	–	**5**
MEK1694	Inside	4	3	3	–	**10**
MEK1696	Inside	–	4	1	–	**5**
MEK1712	Outside	–	1	1	–	**2**
MEK1718	Outside	–	–	5	–	**5**
MEK1721	Outside	2	4	2	–	**8**
MEK1724	Outside	–	1	–	–	**1**
MEK1728	Outside	1	–	2	1	**4**
MEK1731	Outside	–	2	1	–	**3**
MEK1732	Outside	–	4	–	–	**4**
MEK1735	Outside	–	1	–	–	**1**
MEK1757	Inside	–	5	–	–	**5**
	Total	**12**	**60**	**35**	**1**	**108**

4.2.2 Schizomid DNA Sequencing and Sequence Variation

A 698 base pair (bp) segment of the COI gene was sequenced and analysed from 31 schizomids from 20 sampling locations across Mesa K. This included 18 sampling locations from within proposed pit areas and 13 sampling locations outside of the proposed pit areas (see Appendix 2 and Figure 4.5 for details). These haplotypes contained 13 variable sites and 4 parsim-informative sites.

There were 17 haplotypes of schizomids from Mesa K. No stop codons were observed within the protein coding COI gene, indicating that the sequences did not derive from nuclear paralogues (insertions of mitochondrial DNA into the nuclear genome).

- **Blastn Search Results**

The Blastn search in GenBank of the schizomid sequences from this study confirmed that the correct segment of DNA was amplified and sequenced. There were 190 blast hits on the schizomid COI sequence.

4.2.3 Phylogenetic Relationships

- **Sequence Divergence**

Kimura's two parameter genetic distances between all individuals of schizomids indicated a large range of genetic distances (discussed here as percent sequence divergence) (see Appendix 4). The relationship of schizomids from various locations included as contextual information in this report have previously been discussed in detail (Biota 2006a and Berry 2005) and will not be discussed in this report.

Sequence divergence between individuals of schizomids from across Mesa K was low, ranging from 0.0% to 0.8%, eliminating the possibility that they represent more than one species.

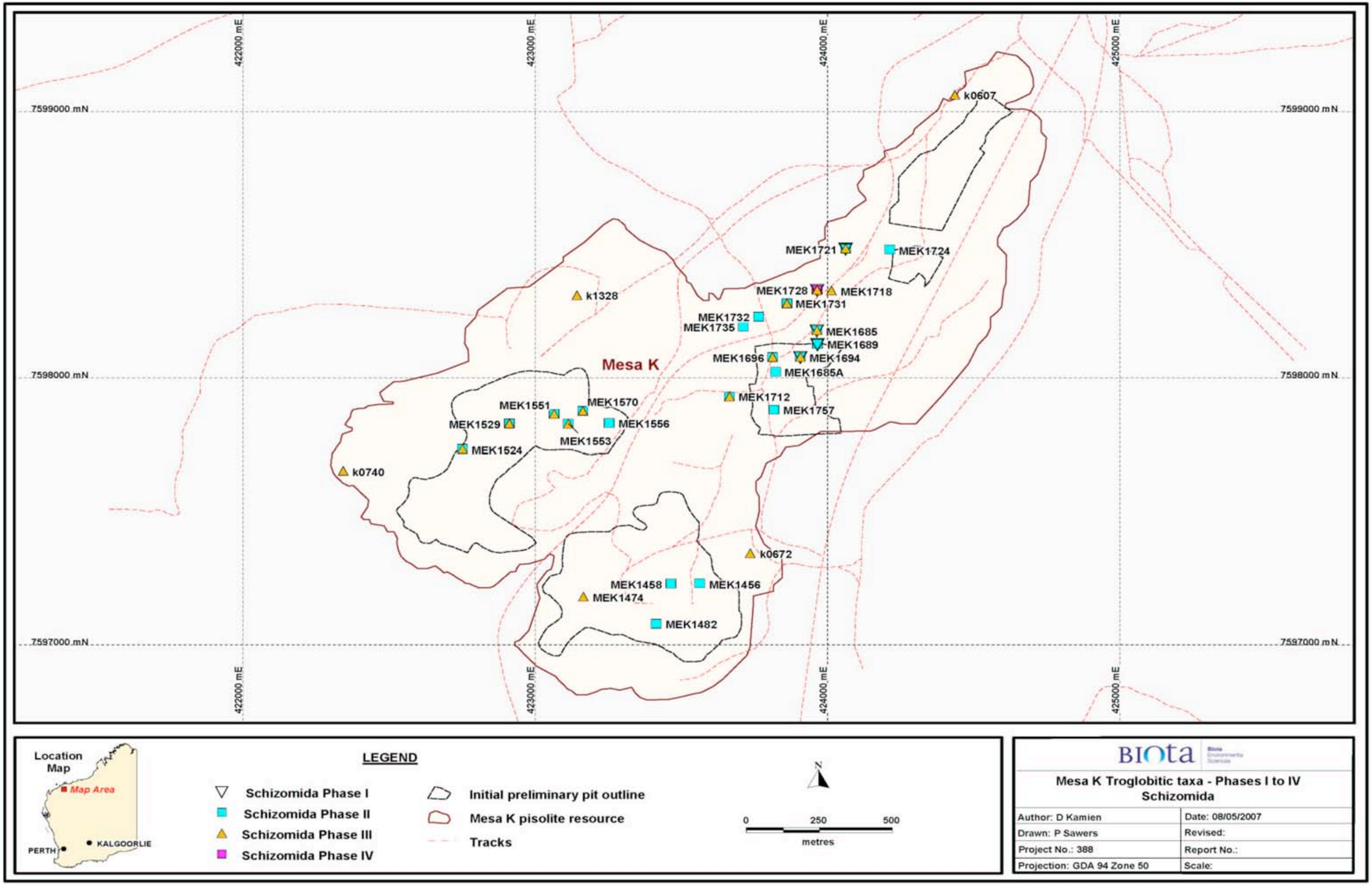


Figure 4.5: **Distribution of troglobitic schizomids recorded from four sampling phases at Mesa K.**

- **Evolutionary Relationships**

The neighbour-joining tree for the COI analysis had strong internal support for the branches defining the major clades (see Figure 4.6). High bootstrap values also supported the majority of the branches within each clade. The statistical support for these groupings is measured by bootstrap values, which are the numbers above or below internal branches in the tree. These represent the level of support for the adjacent "node" (i.e. branching pattern to the right of the number). Bootstrap values greater than 75% are considered well supported and those with less than 50% are not considered reliable (Hillis et al 1996). Nodes on the tree in Figure 4.6 without bootstrap values indicate that bootstrap support was less than 50%.

The horizontal branch length that separates each haplotype or group of haplotypes is also of interest for identifying biological entities with long-separate evolutionary histories: longer branches are an indication of greater genetic divergence, and therefore a longer time since individuals shared a common ancestor (Berry 2005). The scale bar at the bottom left of the tree provides a measure of this divergence.

There are two aspects of a phylogenetic tree that are of interest: the branching pattern and the length of the branches. In the case of the schizomids studied here, the point of interest is whether haplotypes group according to a discernible geographic feature or spatial pattern (e.g. Mesa K).

The inclusion of additional schizomids from Mesa K in this study did not change the overall shape of the phylogenetic tree presented in Biota (2006a) and Berry (2005). Furthermore, the relationships between schizomids of different localities also remained unchanged. Schizomids from Mesa K group cohesively together on the one clade with less than 1% sequence divergence across all individuals (Figure 4.6). This indicates that a single, widespread taxon (*Draculoides* sp. 'Mesa K') occurs across the site, and the very high bootstrap support (99%), indicates that this relationship can be confidently interpreted. This finding was also consistent with the outcomes of morphological identifications for this group (see Section 4.2.1).

4.2.4 Pseudoscorpionida (Pseudoscorpions)

Pseudoscorpions are small arachnids that superficially resemble scorpions, but lack the stinging tail. Five troglobitic pseudoscorpion specimens representing at least four different species from four different families were recovered from Mesa K during this programme (Table 4.4 and Figure 4.7).

During Phase II, a single nymphal specimen of the pseudoscorpion genus *Lagynochthonius* (family Cthoniidae) was collected from Mesa K (drillhole MEK1689; Plate 4.2). Another individual was also collected from drillhole MEK1689, however the damaged nature of the specimen prevented species level identification. Both of these sites are located within the preliminary 'Central Pit' boundary (see Figure 4.7).

A single juvenile specimen (tritonymph) of an unnamed species of Hyidae (genus *Indohya*) was also collected from Mesa K (drillhole MEK1696; Plate 4.3). The genus *Indohya* is an ancient Gondwanan group with eight epigean species known from India, Madagascar and the Kimberley region of northern Western Australia, and a number of species from caves or other subterranean cavities in Western Australia (Harvey 1993). This discovery of an unnamed species of *Indohya* from Mesa K represents a significant range extension for the genus (and family) and highlights the higher-level taxonomic diversity of troglobitic organisms in many of the Robe Valley mesas (see also Biota (2006a)).

A single specimen from the family Syarinidae (genus *Ideoblothrus*) was also recorded during the Phase III survey, from outside the proposed pit area (drillhole MEK1721; Figure 4.7; Plate 4.4). This taxon was unrecorded prior to the Phase III sampling.

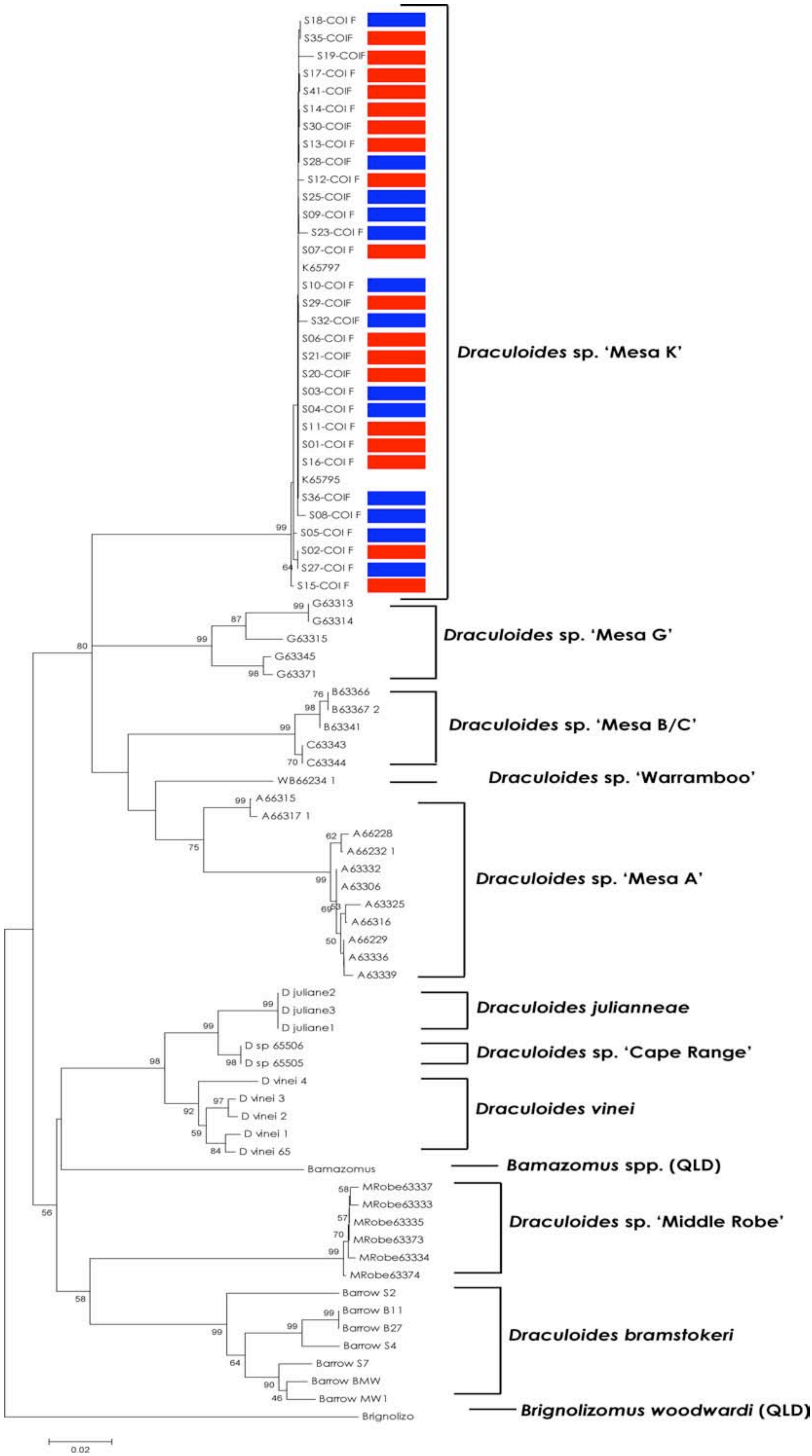


Figure 4.6: Neighbour-Joining Tree for schizomid individuals collected from Mesa K (adapted from Berry 2005) (red codes indicate samples from inside the proposed pit areas and blue codes denote samples from outside of the preliminary pit areas; scale bar indicates genetic divergence).

Finally, a single male specimen belonging to the family Olpiidae was recorded during Phase IV from outside the preliminary proposed pit area (drillhole K0502; Figure 4.7; Plate 4.5). This was a find of some interest as the specimen represents the first known troglobitic Olpiidae recorded anywhere in the world. This specimen is likely to be one of three genera including *Euryolpium, Xenolpium* or *Austrohorus* (Dr Mark Harvey, Western Australian Museum, pers. comm. 2007). However, the exact genus of this specimen remains ambiguous, as examination of a female specimen is required for further determination.

Table 4.4: Summary of pseudoscorpions recorded from Mesa K during four sampling phases (Impact status = location of record Inside or Outside of preliminary pit outlines).

Phase	Drillhole	Impact status	Family	Taxon	n
2	MEK1689	Inside	Cthoniidae	*Lagynochthonius* or *Tyrannochthonius* sp. indet.	1
2	MEK1689	Inside	Cthoniidae	*Lagynochthonius* sp. nov.	1
2	MEK1696	Inside	Hyidae	*Indohya* sp. nov.	1
3	MEK1721	Outside	Syarinidae	*Ideoblothrus* sp. nov.	1
4	K0502	Outside	Olpiidae	Olpiidae sp. nov.	1

Plate 4.2: *Lagynochthonius* sp. nov.

Plate 4.3: *Indohya* sp. nov.

Plate 4.4: *Ideoblothrus* sp. nov.

Plate 4.5: Olpiidae sp. nov.

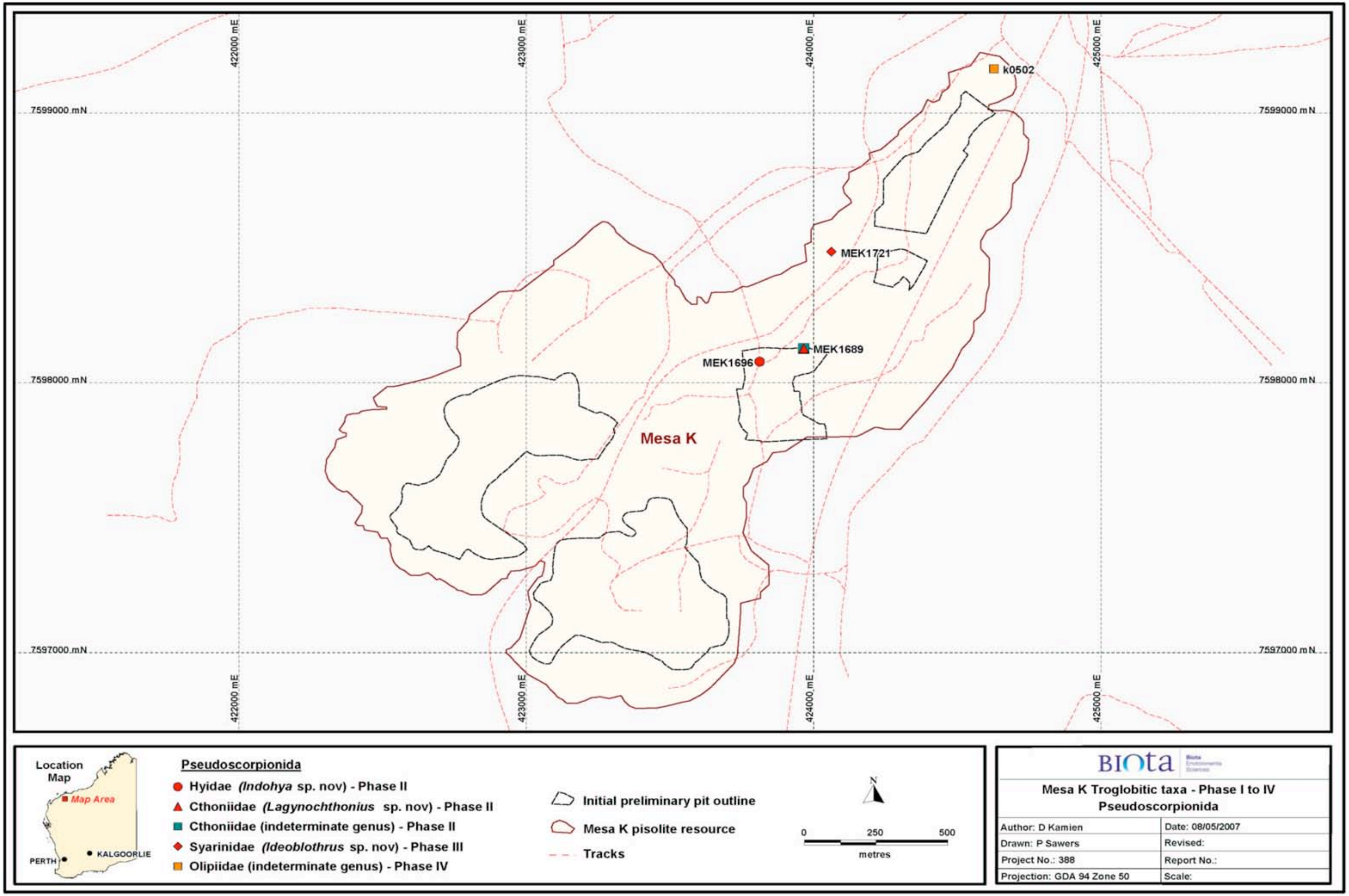


Figure 4.7: Distribution of troglobitic pseudoscorpions recorded from four sampling phases at Mesa K.

4.2.5 Order Scolopendrida (Centipedes)

A single troglobitic specimen was recorded at Mesa K during Phase III (family Cryptopidae; *Cryptops* sp. 1; Plate 4.6).

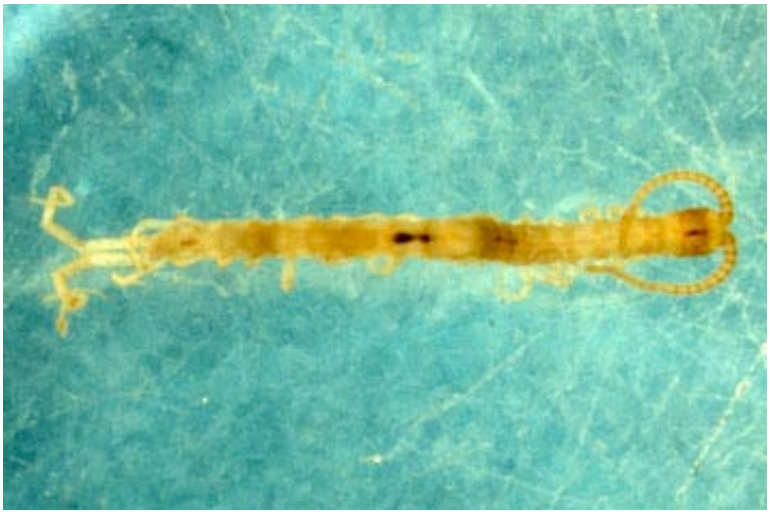


Plate 4.6: ***Cryptops* sp. 1.**

This specimen was recorded from drillhole MEK1570 (Figure 4.8), located within the pit floor of the previously mined Gully Pit (and within the preliminary proposed pit area).

This specimen represents the only troglobitic Scolopendrid recorded at Mesa K to date. Other troglobitic scolopendrids belonging to the same family have previously been recorded from Mesa A and Mesa C, where this group was also at relatively low frequency (Biota 2006a).

4.2.6 Order Polydesmida (Polydesmid Millipedes)

A total of six millipedes were recorded during the survey. Five of these specimens were recorded from Phase III, comprising one specimen from drillhole K0740 and four specimens from drillhole K1315, with both records outside the nominal proposed pit area (Table 4.5 and Figure 4.8).

Plate 4.7: **Juvenile ?Polydesmid millipede.**

It should be noted that all the specimens collected during Phase III were juveniles, and as a result they could not be conclusively identified as belonging to the order Polydesmida (Plate 4.7). However, polydesmid millipedes (family Haplodesmidae) have been previously recorded in the Robe Valley at both Mesa A and Mesa C (Biota 2006a), and by inference, it is probable that the Mesa K specimens also belong to the order Polydesmida.

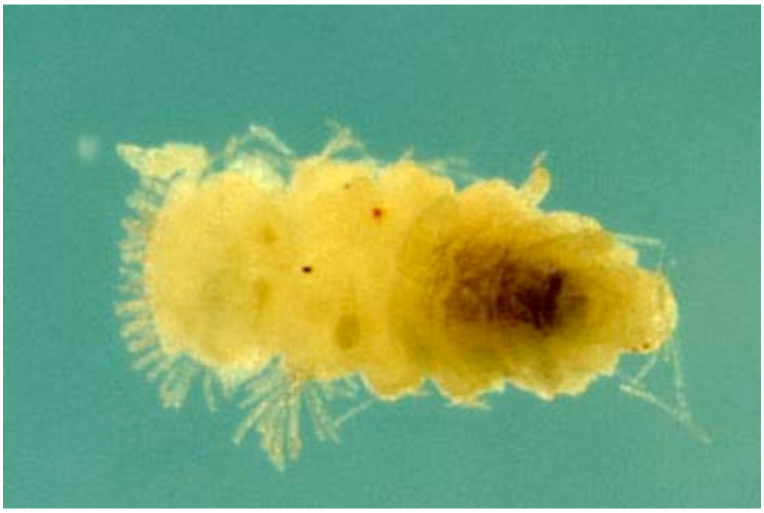
A single damaged polydesmid exoskeleton was also recorded during Phase IV at drillhole K0948, which is also outside the nominal proposed pit areas.

Table 4.5: **Summary of polydesmid millipedes recorded from Mesa K during four sampling phases** (Impact status = location of record Inside or Outside of preliminary pit outlines).

Phase	Drillhole	Impact status	Family	Taxon	n
3	K0740	Outside	Potentially Polydesmidae	?Polydesmidae sp. indet.	1
3	K1315	Outside	Potentially Polydesmidae	?Polydesmidae sp. indet.	4
4	K0948	Outside	Polydesmidae	Polydesmidae sp. indet.	1

4.2.7 Polyxenida (Pincushion Millipedes)

Pincushion millipedes are a primitive diplopod group, seldom achieving a length of 5 mm (Harvey and Yen 1997). Three polyxenid millipedes (Plate 4.8) were recorded at Mesa K from two bores, both located inside the preliminary 'Gully Pit' pit area. One individual was recorded during Phase III from drillhole MEK1551. A further two specimens were recorded during Phase IV, with single records from bores MEK1551 and MEK1556 (Table 4.6 and Figure 4.8). The collected specimens were all juvenile and as a result identification to the family level was not possible.



The polyxenid specimens collected at Mesa K lack eyes and pigment (characteristic of troglobites) (see Plate 4.8). However, there is some uncertainty as to whether this species is truly troglobitic with a distribution limited to Mesa K (Dr Mark Harvey, Western Australian Museum, pers. comm. 2007). It is possible that this species is instead edaphobitic (a deep soil inhabitant) or troglophilic (a facultative troglobite).

Plate 4.8: Juvenile Polyxenida sp. indet.

To fully determine if the Mesa K polyxenid millipedes have a restricted distribution and are indeed endemic to Mesa K, DNA sequencing would ideally be conducted. A comparison of the molecular data obtained from specimens collected at different mesas within the Robe River valley would greatly assist in clarifying any patterns of short range endemism that may be present. To date, 35 polyxenid specimens have also been collected from two bores at Mesa A, but limitations in comparison currently exist due to the small sample size obtained from Mesa K (only three individuals). This DNA analysis work will be pursued when sufficient sample sizes are available. In the interim, the polyxenids have been conservatively treated as 'potentially troglobitic' for the purposes of this report.

Table 4.6: Summary of polyxenid millipedes recorded from Mesa K during four sampling phases ('Impact status' = location or record Inside or Outside of preliminary pit outlines).

Phase	Drillhole	Impact status	Family	Taxon	n
3	MEK1551	Inside	Undetermined	Polyxenida sp. indet.	1
4	MEK1551	Inside	Undetermined	Polyxenida sp. indet.	1
4	MEK1556	Inside	Undetermined	Polyxenida sp. indet.	1

4.2.8 Order Diplura (Diplurans)

A single dipluran specimen belonging to the genus *Heterojapyx* (family Heterojapygidae) was recorded from drillhole MEK1478 (Figure 4.8) during Phase II of the Mesa K survey.

This drillhole lies in a historically disturbed area within the proposed 'Gravel Yard Pit' nominal pit area. Within the Robe River valley, troglobitic Diplura have also been recorded from Mesas A, B, C, F and G, and Warramboo (Biota 2006a). The specimen from Mesa B is, however, the only other representative of the family Heterojapygidae from within the Robe River Valley (Biota 2006a).

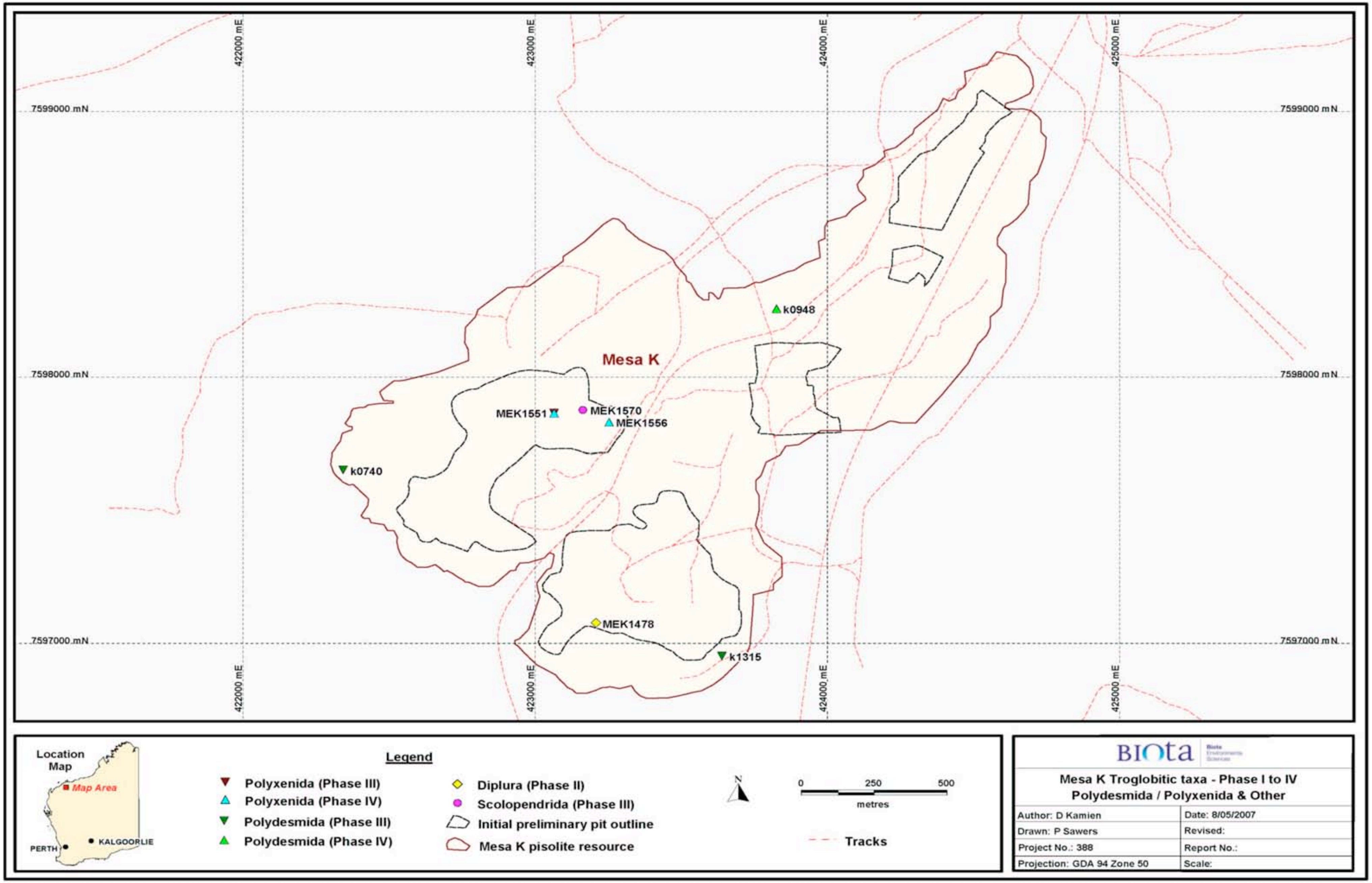


Figure 4.8: **Distribution of other troglobitic and potentially troglobitic taxa recorded from four sampling phases at Mesa K.**

4.2.9 Coleoptera (Beetles)

Fifty-four troglobitic beetles were collected from nine bores at Mesa K during the four-phase survey (Table 4.7 and Figure 4.9). Forty-two (78%) of these were collected during the Phase III sampling. Only one coleopteran was collected during Phase II and 11 were collected during Phase IV.

Plate 4.9: Coleoptera sp. 1.

Examination of the beetles at the Western Australian Museum confirmed that they all represent a single species (Plate 4.9). However, their placement at family level within the Coleoptera remains undetermined. It is expected that specialist morphological examination of this species will resolve this. It should be noted that troglobitic beetles have previously been collected from Mesas A and B, but it is yet to be confirmed if these are the same taxon as the Mesa K specimens.

Table 4.7: Details of troglobitic Coleoptera recorded from Mesa K during four sampling phases ('Impact status' = location or record Inside or Outside of preliminary pit outlines).

Phase	Drillhole	Impact status	Family	Taxon	n
2	MEK1701	Outside	Undetermined	Coleoptera sp. 1	1
3	K0607	Outside	Undetermined	Coleoptera sp. 1	2
3	K1302	Outside	Undetermined	Coleoptera sp. 1	1
3	MEK1718	Outside	Undetermined	Coleoptera sp. 1	20
3	MEK1728	Outside	Undetermined	Coleoptera sp. 1	3
3	MEK1731	Outside	Undetermined	Coleoptera sp. 1	3
3	MEK1735	Outside	Undetermined	Coleoptera sp. 1	3
3	MEK1694	Inside	Undetermined	Coleoptera sp. 1	10
4	MEK1478	Inside	Undetermined	Coleoptera sp. 1	11

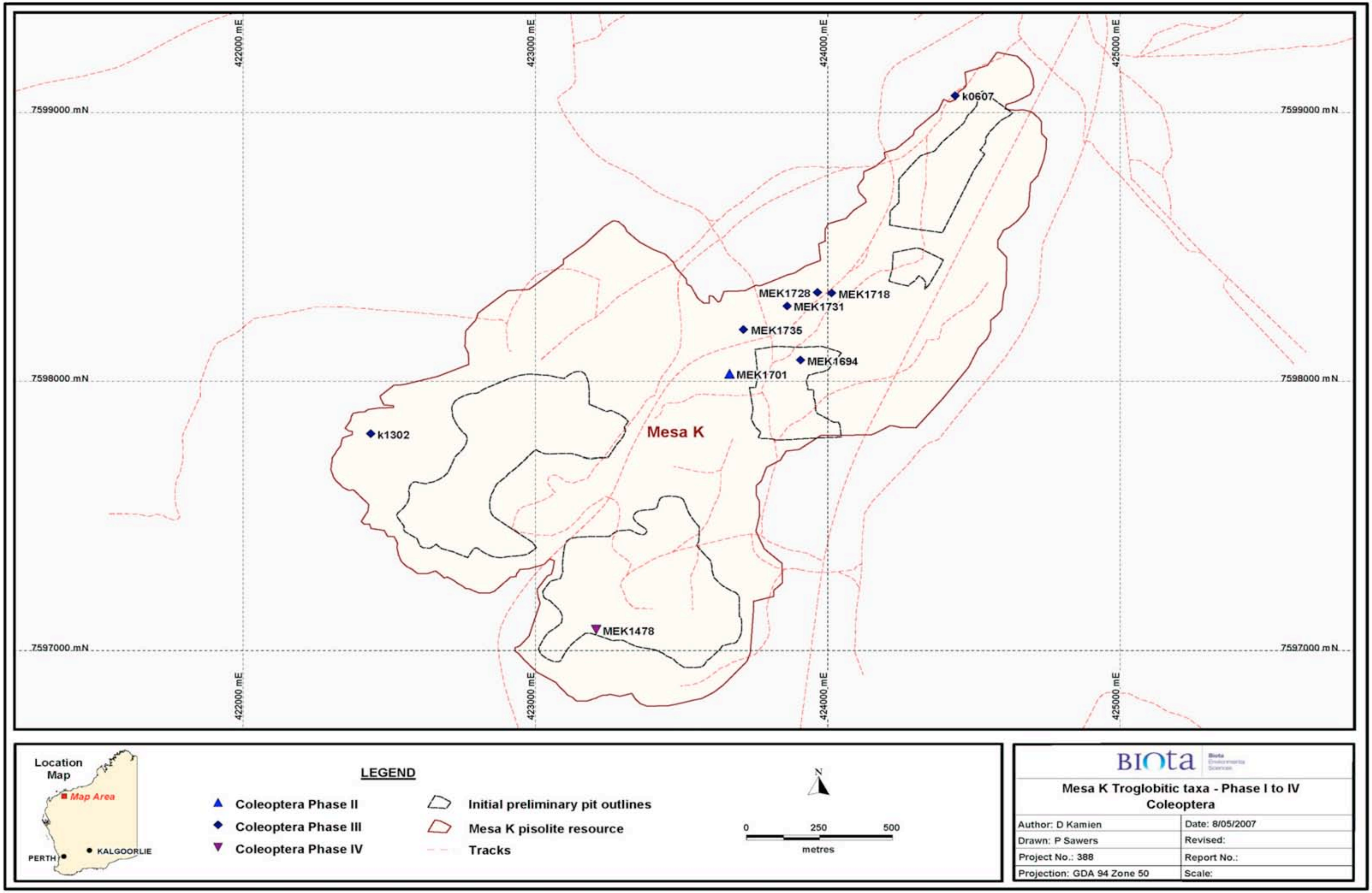


Figure 4.9: Distribution of troglobitic Coleoptera recorded from four sampling phases at Mesa K.

4.3 Troglofauna Distribution and Habitat Variables

4.3.1 Effect of Rainfall

Rainfall events result in recharge of the mesa formations and inputs of water and organic matter (in both particulate and dissolved forms). Work completed by Humphreys (1991) has shown that inputs of water into dry superficial strata can stimulate increased activity in troglofauna. Based on the abundance of fauna collected, there was some evidence of a similar response in the troglobitic fauna during sampling conducted at Mesa A (Biota 2006a).

To assess whether this pattern was evident at Mesa K, the total number of troglobitic specimens collected during each phase was related to monthly rainfall recorded at nearby Mesa J from 2005 to 2007 (Figure 4.10). Abundances were standardised by sample effort to provide an unbiased comparison between phases.

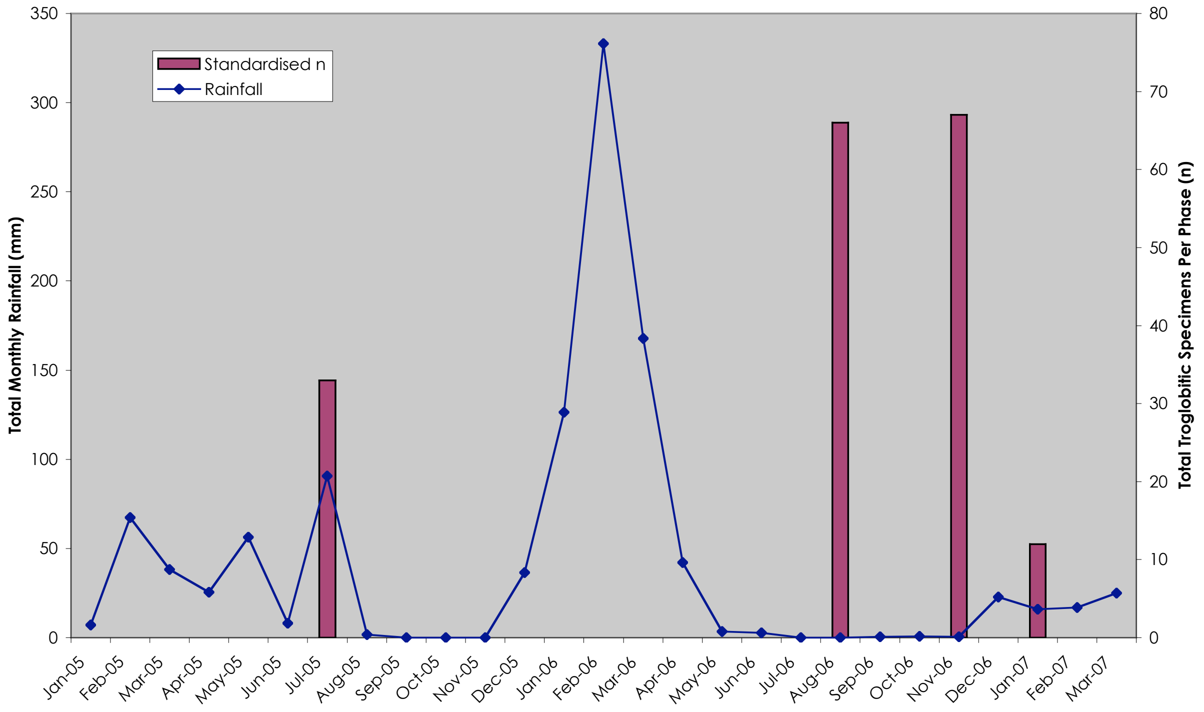


Figure 4.10: Relationship between rainfall events during the survey period and total troglofauna catch from Mesa K across the four sampling phases (values for each phase standardised to number of individuals per 100 litter traps; data lumped for all troglobitic orders collected from Mesa K).

While there are limitations on the data, the standardised yields from the Mesa K sampling programme also showed a positive relationship with rainfall events experienced up to six months prior to sampling (Figure 4.10). This is presumably due to increased activity in the fauna following wet conditions, including moving into strata which may have been previously dry. It is interesting to note that this effect appears to lag for several months after the main rainfall event, possibly reflecting saturation of clay lenses and gradual drainage through the structure. By the time Phase IV of the sampling was undertaken (some eight months after the major rainfall event of March 2006), the standardised number of troglofauna records had fallen considerably compared to Phases II and III (see Figure 4.10). These trends should be borne in mind in the timing of future sampling efforts targeting this fauna.

4.3.2 Level of Historical Disturbance

The Mesa K study area has experienced varying degrees of historical mining disturbance (see Section 1.1 and Plate 3.2). It is therefore of interest, and relevance to current and future impact assessments, that troglofauna still occur in disturbed and partially disturbed portions of the mesa.

To review the survey results in this context, the type and extent of historical disturbance in the study area was broadly categorised as set out in Table 4.8. Note that the classification provided in this table is distinct from the 'Impact Status' categorisation provided elsewhere in this report, which is based on proposed re-mining areas, not historical disturbance locations as considered here.

Table 4.8: Categories of historical disturbance within Mesa K in relation to study sample points (listed in decreasing order of perceived disturbance level; see Figure 2.2 for drillhole locations).

Type of historical disturbance	Sample Areas and Drillholes	Total n
1. Historical open-cut pits; not-partially rehabilitated	Gully Pit (MEK1524, MEK1526, MEK1529, MEK1551, MEK1552, MEK1553, MEK1556, MEK1570*) Gravel Yard Pit (MEK1439, MEK1449, MEK1456, MEK1458, MEK1464, MEK1474, MEK1478, MEK1482) Central Pit (MEK1628, MEK1685A, MEK1689, MEK1694, MEK1696, MEK1718, MEK1724A, MEK1749, MEK1757, MEK1770) West Pit (MEK1667, MEK1724)	28
2. Rehabilitated waste dumps	MEK1721, MEK1728	2
3. Historical exploration drilling; partially-fully rehabilitated	MEK1685, MEK1701, MEK1712, MEK1731, MEK1732, MEK1735	6
4. Intact portions of mesa (exploration drilling only)	Ridge south-east of Gravel Yard Pit (K0672, K1315, K1317) Ridge north-east of Gully Pit (K0739, K0740, K0968, K0989, K0996, K1302, K1328, K1337) Ridge north-east of West Pit (K0502, K0557, K0607, K0873, K0948, K1000, K1066, K1068, K1074)	20

* Situated in unrehabilitated backfill in Gully Pit.

At the coarsest level then, the study sampled 26 drillholes within essentially undisturbed areas (rows 3. and 4. in Table 4.8), and 30 drillholes within significant historical mining disturbance (row 1.). Troglofauna distribution and abundance data are subject to considerable variation and the available dataset is likely to be strongly influenced by ecological sampling effects (see Biota 2006b for a related discussion). This study therefore has insufficient power to make meaningful statistical comparisons between disturbed and undisturbed areas. It is still informative, however, to examine any trends in the available data. Table 4.9 provides a comparison of taxonomic ('species') richness and standardised abundance between essentially intact and historically disturbed portions of Mesa K.

Table 4.9: Comparison of taxonomic richness and troglofauna abundance in different disturbance areas within Mesa K (standardised abundance = n per 100 litter traps).

	Broad Disturbance Category	
	Historically mined	**Superficial - Undisturbed**
Raw total abundance	123	55
Total No. of bores sampled	24	32
Total No. of litter traps	181	203
Standardised total abundance	68	26
Taxon richness	6	5

Interestingly, considerably more troglobitic animals were collected from historically mined pit areas than areas that had been subject to more superficial disturbance, and standardising for sampling effort did not change this trend (Table 4.9). Taxonomic richness was also slightly greater, although this is probably a function of the larger number of specimens collected.

Taxon level data showed that three orders occurred in both disturbed and undisturbed habitats, in similar abundances (see Table 4.10). The only order collected from undisturbed areas not currently known from the historical mine areas was the polydesmid millipedes. This group has, however, generally been the most difficult to collect in the Robe Valley (Biota 2006a) and this result is probably due to sampling effects. It is likely that troglobitic millipedes occur more widely at Mesa K than currently documented.

Table 4.10: Representation of troglobitic taxa in different disturbance areas within Mesa K (shading indicates presence at the order level, numbers = raw total numbers of individual taxa)**.**

	Broad Disturbance Category	
Taxon	**Historically mined**	**Superficial - Undisturbed**
Schizomida		
Draculoides sp. 'Mesa K'	74	34
Pseudoscorpionida		
Lagynochthonius sp. nov.	2	-
Indohya sp. nov.	1	-
Ideoblothrus sp. nov.	-	1
Olpiidae sp. nov	-	1
Scolopendrida		
Cryptops sp. 1	1	-
Polydesmida		
Polydesmidae sp. indet.	-	6
Polyxenida		
Polyxenida sp. indet	3	-
Coleoptera		
Coleoptera sp. 1	41	13
Diplura		
Heterojapyx sp. nov.	1	-

It is important to note that these differences are not statistically significant and other factors have probably contributed to the finding. Many of the undisturbed areas holes were recently drilled and this may have contributed to lower sampling efficiency (compared to the older holes in disturbed areas). The available data do not, however, show any evidence of a substantial decline in troglofauna abundance or diversity in historically mined areas compared to intact areas within Mesa K. Depth of historical mining and the relatively short time since mining ceased also need to be considered, and the current results may not be indicative of long term viability of the troglobitic community.

Considered in toto however, the results from Mesa K show that the mesa, which is a substantially disturbed landform, still supports a troglobitic community of similar abundance and diversity to the undisturbed habitats of Mesa A (Biota 2006a), 10 years after completion of mining.

4.4 Troglofauna Species Accumulation and Sampling Adequacy

Species accumulation curves are a means of depicting the increased total number of species with some measure of increasing sampling effort (Colwell and Coddington 1994). The curve rises rapidly initially as the common species and more easily collected taxa are added. The accumulation then begins to flatten out as fewer and fewer species are added with increased sampling effort. The curve eventually approaches an asymptote as most species in the spatial scope of the survey are collected. Thus, the degree to which an acceptable level of flattening of a species accumulation curve is achieved provides a measure of how well the survey effort has documented the species richness of the group in question.

The accumulation of species can be compiled in varying ways, including against number of individuals collected, number of sampling units (boreholes in this study), or number of sampling events over time. EstimateS v7.5 (Colwell 2005) was used to calculate a species rarefaction curve, based on 100 random resampling events of the individual troglofauna records from Mesa K. This interpolative process produced a randomised or idealised curve that generates the expected number of species with collections of decreasing sample sizes (Gotelli and Colwell 2001).

EstimateS can also be used to extrapolate the available data to estimate the total species pool within a given area. There are varying methods available to estimate expected total species richness based on available survey data.

Various studies have evaluated these against empirical data and some of the more promising are non-parametric methods (Butler and Chazdon 1998, Colwell and Coddington 1994, Gotelli and Colwell 2001). These are typically based on the occurrence of "singletons" (taxa represented by only one individual) or "doubletons" (two individuals) (Gotelli and Colwell 2001). The more singletons in a dataset, the more likely it is that other species are present in the study area that were not collected (Chao 2004). The estimators presented here for the Mesa K data have been shown to generally produce less biased results with smaller sample sizes (Butler and Chazdon 1998, Colwell and Coddington 1994, Chao 2004).

An individuals-based rarefaction curve and a sample-based curve were compiled, and these are presented in Figure 4.11 and Figure 4.12 respectively.

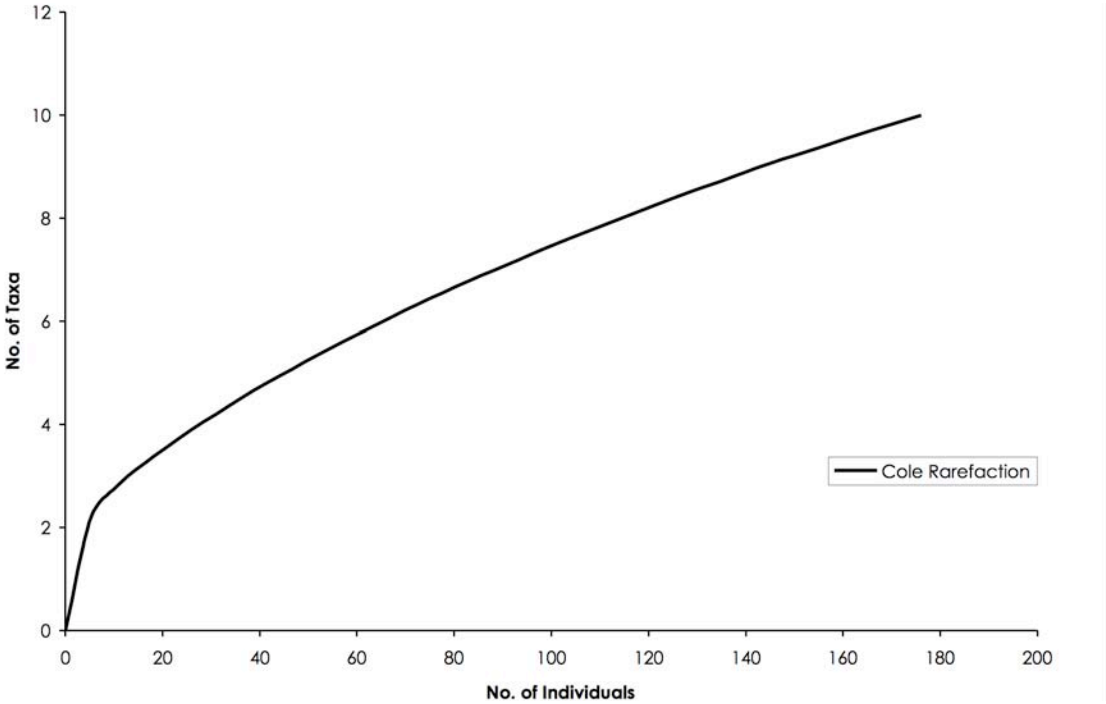


Figure 4.11: Individual-based rarefaction curve for troglobitic fauna collected at Mesa K (rarefaction curve generated with EstimateS (Colwell 2005).

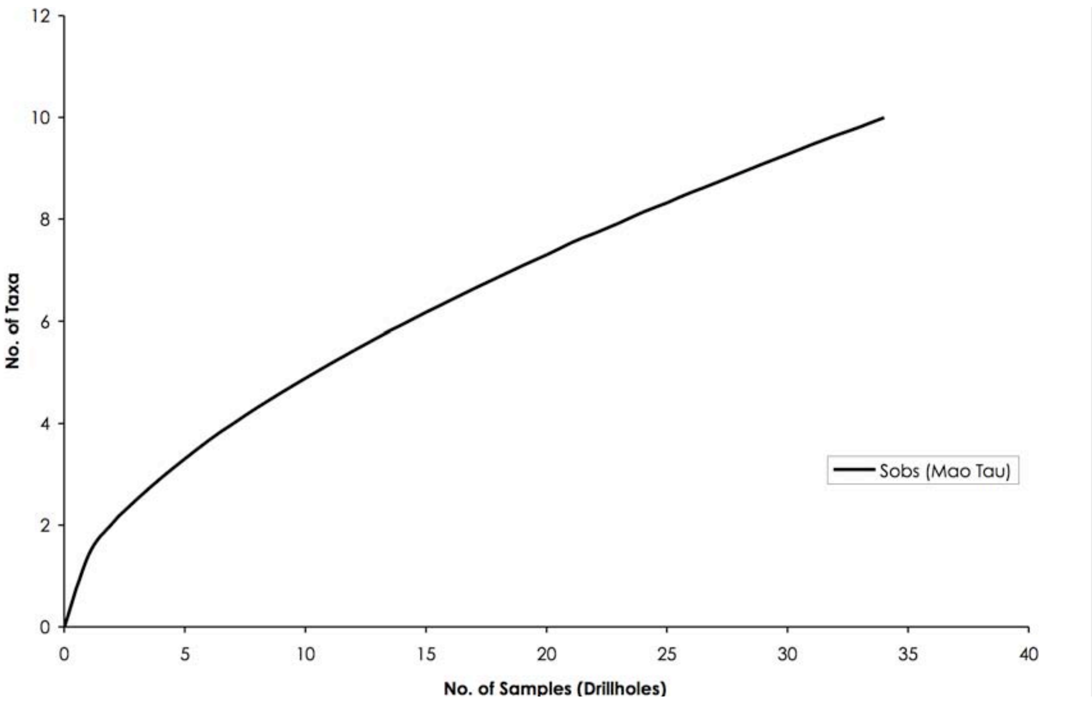


Figure 4.12: Sample-based rarefaction curve for troglobitic fauna collected at Mesa K (rarefaction curve generated with EstimateS (Colwell 2005).

Inspection of the rarefaction curves indicates that the species accumulation is still continuing and does not appear to be approaching an asymptote at this point in time. This leads to the question of estimating the point on the accumulation curve at which the data set currently sits.

There is a high frequency of singletons in the data from Mesa K (five of the 10 taxa; 50%), plus one doubleton. While it is a common ecological pattern that sampling datasets contain a few abundant species and many that are uncommon (Lindenmayer and Burgman 2005), this appears to be particularly exaggerated in troglobitic communities (Biota 2002 and 2006a).

Predicted total troglobitic species richness for Mesa K was calculated using EstimateS (Colwell 2005), utilising several different estimators (see Table 4.11).

Table 4.11: Observed and estimated troglobitic species richness at Mesa K, based on four different non-parametric estimators (calculated using EstimateS (Colwell 2005) and estimator names follow that terminology).

Actual Observed	10
Species Richness Estimator	**Estimated S_{max}**
ACE Mean	19.8
ICE Mean	26.7
Chao 2 Mean	28.0
Jacknife Mean 2	20.5

Based on the existing data, these estimators calculate that the total troglobitic species richness for Mesa K could range from 20 to 28 species (with a mean S_{max} estimate of 23.7 ± 2.1 species; Table 4.12). These estimates then suggest that the current known fauna represents between 36% and 50% of the total predicted assemblage, which is consistent with the trajectory of the rarefaction curves shown in Figure 4.11 and Figure 4.12.

These total species richness estimates should be viewed with caution, as sampling issues can affect the estimators expressions (Colwell and Coddington 1994). In the case of Mesa K (and Mesa A; Biota 2006a), it is possible that these represent either over-estimates or under-estimates. Examples in the literature indicate that estimates made early in a sampling regime, and based on few individuals, more commonly underestimate total richness (Colwell and Coddington 1994). In the current study however, considerable sampling effort has now been expended and hundreds of individuals collected. As the richness estimates are derived from frequency of singletons and doubletons, the recording of one or two more individuals of singleton taxa in later sampling phases results in lower estimates of S_{max}. If these taxa are difficult to collect, as is the case here, then the estimates may be high due to these types of sampling effects.

S_{max} estimates for Mesa K were compared with those for Mesa A based on four phases of sampling at the latter study area (Biota 2006b) (
Table 4.12). This shows that the richness is estimated as similar for both sites based on four phases of data. A fifth sampling phase has now been completed at Mesa A and S_{max} estimates were updated based on this additional data. This showed a reduction in S_{max} from 21.9 to 18.7 (Table 4.12). This was due to the collection of a pseudoscorpion and a coleopteran that had previously been singletons at that site, highlighting the sensitivity of these indices to low frequency species.

Table 4.12: Total observed and estimated troglobitic species richness from Mesa K, compared to observed and estimated richness at Mesa A.

Survey Site	Survey Area Observed Species Richness	Survey Area Estimated Species Richness (S_{max})
Mesa K	10	23.7 ± 2.1
Mesa A *	14	21.9 ± 0.8
Mesa A revised **	15	18.7 ± 0.8

* Sourced from Biota (2006b).
** Updated based on outcomes of Phase V sampling at Mesa A, completed subsequent to Biota (2006b).

This suggests that the current S_{max} predictions for Mesa K may be more likely to be slight overestimates rather than underestimates.

5.0 Conclusions and Management

5.1 Consolidation of Findings

The key component for this assessment relates to the potential for any of the taxa recorded to be restricted in distribution to the areas within Mesa K that would be impacted by the remnant mining proposal. A summary of the troglofauna survey findings in this context is presented in Table 5.1.

Table 5.1: Summary of troglobitic taxa collected from locations on Mesa K, with comments on their status and distribution (n = number of specimens; see Section 4.2 for more detail on taxa).

Taxa	Sites Inside proposed re-mining areas	Sites Outside planned re-mining areas	Status and wider distribution
Schizomida			
Draculoides sp. 'Mesa K'	MEK1456, MEK1458, MEK1474, MEK1482, MEK1524, MEK1529, MEK1551, MEK1553, MEK1556, MEK1570, MEK1685A, MEK1689, MEK1694, MEK1696, MEK1757 (n=69)	K0607, K0672, K0740, K1328, MEK1685, MEK1712, MEK1718, MEK1721, MEK1724, MEK1728, MEK1731, MEK1732, MEK1735 (n=39)	Not recorded from outside Mesa K. Collected from 28 locations on Mesa K, covering a minimum range of 169 ha.
Pseudoscorpionida			
Lagynochthonius sp. nov.	MEK1689 (n=1 or 2)	-	To date, this genus remains unrepresented at other Mesas in the Robe River valley.
Indohya sp. nov.	MEK1696 (n=1)	-	To date, this genus remains unrepresented at other Mesas in the Robe River valley.
Ideoblothrus sp. nov.	-	MEK1721 (n=1)	Other members of this genus collected from Mesas A and B, but it is unconfirmed if they represent the same taxon. Currently only known from one site on Mesa K.
Olpiidae sp. nov.	-	K0502 (n=1)	To date, this genus remains unrepresented at other Mesas in the Robe River valley. The first global troglobitic record for the family Olpiidae.
Scolopendrida			
Cryptops sp. 1	MEK1570 (n=1)	-	Others members of this genus collected from Mesas A, B and G, but it is unconfirmed if they represent the same taxon.
Polydesmida			
Polydesmidae sp. indet.	-	K0740, K1315, K0948 (n=6)	Specimens of the family Haplodesmidae have also been collected from Mesa A. Records span an area of 91 ha.
Polyxenida			
Polyxenida sp. indet.	MEK1551, MEK1556 (n=3)	-	Potentially troglobitic. Polyxenid specimens have also been collected from Mesa A.
Coleoptera			
Coleoptera sp. 1	MEK1701, K0607, K1302, MEK1728, MEK1731, MEK1735, MEK1478 (n=33)	MEK1694, MEK1718 (n=21)	Troglobitic coleopterans were also collected from Mesa A, but it is unconfirmed if they represent the same taxon. Records span an area of 128 ha.

Taxa	Sites Inside proposed re-mining areas	Sites Outside planned re-mining areas	Status and wider distribution
Diplura			
Heterojapyx sp. nov.	MEK1478 (n=1)	-	Others members of this family collected from Mesa B, but it is unconfirmed if they represent the same taxon.

From this review there are at least 10 troglobitic taxa now documented from Mesa K (Table 5.1). Based on the available data, none of these occur outside of Mesa K (although troglobitic members of the same higher order taxa are more widely distributed in most cases). This means that it cannot currently be demonstrated that any of the taxa occurring in Mesa K occur in the other mesas sampled during earlier work (Biota 2006a), and the precautionary principle suggests they should be treated as endemic to Mesa K.

At the "within mesa" scale context, seven species have been recorded from inside of proposed re-mining areas. Two of these, the schizomid species *Draculoides* sp. 'Mesa K' and the troglobitic beetle Coleoptera sp. 1 have been demonstrated to also occur beyond the areas proposed for re-mining. These are also the two best-collected taxa and it is noteworthy that four of the five remaining taxa are singletons (Table 5.1). Experience from this site shows that species that were singletons in earlier phases have subsequently been recorded further afield. The troglobitic coleopterans provide a striking example, where these were recorded from only a single individual in the re-mining area in Phase II (as five other taxa still are at present) (see Table 4.2). An additional 41 individuals from six other sites, including outside of re-mining areas, were then recorded during Phase III (Table 4.2). This is also consistent with the updated findings from Mesa A, where taxa that were previously singletons or doubletons were recorded from other sites in a later phase (see Section 4.4).

These observations suggest that it is likely that five taxa currently only known from preliminary pit areas are more widely distributed within Mesa K, and probably occur outside of the proposed re-mining areas. It is also worth noting that the majority of these five taxa were also recorded from areas subject to considerable historical mining disturbance (see Section 4.3.2).

5.2 Conservation Significance

The troglobitic fauna documented in this study represents a previously unrecorded component of the subterranean fauna of Western Australia. Other similar subterranean fauna communities occur in other mesas within the Robe River valley (Biota 2006a), in addition to Cape Range and Barrow Island, both of which are within the conservation estate. Some of the troglobitic species occurring at Cape Range and on Barrow Island are formally listed as Threatened Fauna (Biota 2006a).

With the available data, most of the troglobitic taxa documented in this study would probably be considered 'data deficient' in terms of a definitive determination of conservation status. The *Draculoides* species detailed in this study is perhaps the exception to this, given their relatively good sample size and that genetic studies and detailed morphological work have been completed. A precautionary approach should therefore be adopted in considering the conservation significance of the other less thoroughly studied and less well collected troglobitic taxa. The distribution and phylogeography of the schizomids can be used as a guide to the likely distribution of taxa in the other core troglobitic groups (Pseudoscorpionida, Scolopendrida, Polydesmida, Coleoptera, and Diplura).

The fauna recorded at Mesa K have the following attributes of relevance to assessing the conservation significance of the subterranean species and fauna assemblages recorded:

- species with very short range distributions based on available data; each species currently appears to be restricted to Mesa K;

- relictual fauna representative of very old lineages; the lineages from which the contemporary troglofauna arose were present in subterranean habitats since the late Miocene (at least the last 10 million years);
- higher tiers of biodiversity involved; the species present are the only known representatives of orders and families in the Pilbara bioregion and in some cases the only known troglobitic representatives of families; and
- it is probable that other, currently uncollected species occur in Mesa K which also have restricted distributions.

With these attributes, it is likely that the troglobitic species occurring in Mesa K could be assigned a similar conservation status to the other, previously described troglobitic species endemic to Cape Range (Biota 2006a).

5.3 Conclusions

Molecular and morphological investigations completed for this study have demonstrated that the Mesa K schizomids are a distinct taxon with very low intraspecific genetic divergence. This genetic homogeneity within Mesa K may be attributed to the schizomids mobile nature, in combination with the physical characteristics of the mesa itself. That is, vugs, fissures and mesocaverns present in the formation allow schizomids to move freely throughout the mesa with no effective barrier to gene flow. This is supported further by the fact that schizomids are distributed widely throughout Mesa K, and that a similar pattern was documented for this genus at Mesa A (Biota 2006a). Troglobitic coleopterans were also collected from across the extent of Mesa K and confirmed as the same taxon by the Western Australian Museum.

Importantly, four troglobitic taxa have been recorded from bores solely within the proposed nominal future pit outlines. There are currently four troglobitic taxa known only from records within preliminary mining areas (plus the potentially troglobitic polyxenids; Table 5.1). Two species of pseudoscorpion (families Cthoniidae and Hyidae) were each recorded from single bores within the proposed Central Pit area (MEK1689 and MEK1696 respectively; Table 5.1). Similarly, the scolopendrid *Cryptops* sp. was recorded from drillhole MEK1570 at the northern boundary of Gully Pit and the thysanuran *Heterojapyx* sp. nov. was only recorded at MEK1478. Given the low frequency of the collection of these taxa, it is uncertain whether additional sampling will yield further records of these species.

Based on habitat characteristics of Mesa K, and in combination with sampling and molecular results of schizomids and coleopterans, inferences could be drawn in relation to distribution and genetic homogeneity of the less well-collected taxa recorded at Mesa K. Due to the small number of representatives sampled from these latter taxa, their wider distribution within Mesa K cannot currently be demonstrated and their genetic homogeneity remains untested. It is possible that individual life histories and behaviour in these taxa may be such that their dispersal within Mesa K is more limited, and that local scale genetic subdivision could have occurred. However, given the results for the schizomids and the coleopterans, and recognising that these two groups vary significantly in ecology and life history, it seems likely that the four troglobitic taxa recorded only from re-mining areas are also more widely distributed. Further studies are required to resolve this.

A range of troglobitic animals were recorded both inside and outside historical pit areas, indicating that small-scale pit construction does not render the subterranean habitat adjoining and underlying the pit floor uninhabitable to this species in the short term. However, long term effects such as altered hydrology, microclimate, and organic inputs are more difficult to assess. In addition, the statistical power required to effectively compare observed schizomid abundance inside and outside existing pit areas is lacking, due to the high variability in distribution and abundance data for this fauna. Given the uncertainties with the four confirmed troglobitic taxa known only from proposed re-mining areas, it is prudent to assume that pit construction will have an adverse affect on the troglofauna that live within the proposed impact areas. As a minimum, direct habitat removal will result in the loss of individuals present in the mined ore body. With the locations of these records, it would appear that some minor amendments to pit outlines could be sufficient to modify the Mesa K remnant mining project such that no species of troglobite is at risk of extinction.

A broader question that arises from impact of the remnant mining proposal is the viability of the remaining populations of the troglobitic fauna species endemic to Mesa K. This is likely to be a function of the extent, configuration and intactness of the portions of the mesa formation left undisturbed by future mining activities. The ongoing suitability of habitat to support troglofauna in areas adjacent to mining operations is also linked to the maintenance of core biophysical conditions and processes (see Biota 2006a for a discussion). A central component of the Mesa K project includes the retention of approximately 40% of the mesa structure to provide for the preservation of the troglobitic species currently only known from that mesa.

Further sampling of Mesa K has now confirmed that a diverse troglofauna community occurs within the mesa, both in intact portions and in portions subject to historical mining. Species accumulation analysis suggests that further sampling may result in the discovery of additional taxa inhabiting Mesa K, thereby building on our knowledge of the Mesa K troglobitic community and adding to information on this fauna in the locality.

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Glossary of Terms

Allopatry	Occurring in geographically separate areas; see also sympatry and parapatry.
Autotroph	An organism that produces organic compounds from carbon dioxide as a carbon source, using either light or reactions of inorganic chemical compounds, as a source of energy. An autotroph is known as a producer in a food chain.
Base	The DNA is a chain of nucleotide units; each unit consists of a backbone made of a sugar and a phosphate group, with a nitrogenous base attached. The base unit is one of adenine (A), guanine (G), cytosine (C), or thymine (T). In RNA, uracil (U) is used instead of thymine. A and G belong to the chemical class called purines; C, T, and U are pyrimidines.
Coalescence	The evolutionary process viewed backward through time, so that allelic diversity is traced back through mutations to ancestral alleles. Coalescent theory can be used to make predictions about effective population sizes, ages and frequencies of alleles, selection, rates of mutation, or time to common ancestry of a set of alleles.
Cryptic	Tending to conceal or camouflage.
Edaphobite	Deep soil inhabitant (Wilkens *et al* 2000).
Endemic	Native to or confined to a certain region.
Epigean	The surface environment as opposed to the subsurface (subterranean, hypogean) Environment (Wilkens et al 2000).
Haplotype	A group of alleles of different genes on a single chromosome that are closely enough linked to be inherited usually as a unit.
Karst	Soluble-rock landscape; terrain with distinctive hydrology and landforms arising from a combination of high rock solubility and well-developed secondary porosity (Wilkens et al 2000).
Lineage	Direct descent from a particular ancestor; ancestry. The descendants of a common ancestor considered to be the founder of the line.
Mesocaverns	Underground voids in the size range 0.1 – 20cm, especially in karst and volcanic Substrates (Wilkens et al 2000).
Nonparametric Bootstrapping	A statistical method based on repeated random sampling with replacement from an original sample to provide a collection of new pseudoreplicate samples, from which sampling variance can be estimated.
Nucleotide	Unit building block of DNA and RNA; a nucleotide consists of a sugar and phosphate backbone with a base attached.
Oligonucleotide	A short chain of nucleotides, often produced in the laboratory.
Parametric Bootstrapping	A method for producing independent pseudoreplicates of a data set by estimating parameters from the observed data, using the estimates to produce a model, and using the model to simulate replicate data sets.
Parapatry	Adjacent but non-overlapping distributions; see also sympatry and allopatry.
Phylogenetic	Relating to or based on evolutionary development or history.
Phylogeny	The historical relationships among lineages of organisms or their parts (eg. genes).
Pisolite	Rock composed of pisoliths.
Pisolith	A small rounded accretionary mass, usually of calcium carbonate.
Primers	Oligonucleotides used to initiate synthesis of DNA by a DNA polymerase or reverse transcriptase. A primer anneals to a complementary sequence in a single-stranded DNA or RNA template, and the polymerase then extends the complementary sequence from the primer.
Pseudogene	A sequence of nucleotides in the DNA that resembles a gene but is non-functional for some reason.
Pseudoreplication	The use of inferential statistics to test for treatment effects with data from experiments where either treatments are not replicated (though samples may be) or experimental units are not statistically independent.
Purine	A kind of base; in the DNA, adenine (A) and guanine (G) are purines.
Putative	Thought, assumed, or alleged to be such or to exist.
Pyrimidine	A kind of base; in the DNA, cytosine (C) and thymine (T), and in RNA, cytosine (C) and uracil (U) are pyrimidines.

Reproductive Isolation	Two populations, or individuals of opposite sex, are reproductively isolated from one another if they cannot together produce fertile offspring.
Short Range Endemic (SRE)	A species that has a naturally small distribution and is often characterised by having poor dispersal capabilities, confinement to disjunct habitats and low fecundity.
Stop Codon	Any of three codons (UAA, UAG, or UGA) that signal the termination of the synthesis of a protein. Also called "chain termination codon".
Stygofauna	Fauna inhabiting the various types of groundwater (Wilkens et al 2000).
Sympatry	The occurrence of organisms in overlapping geographical areas, but without interbreeding; see also allopatry and parapatry.
Systematics	A near synonym of taxonomy.
Taxonomy	Theory and practice of biological classification.
Transition	The substitution of a purine for another purine, or the substitution of a pyrimidine for another pyrimidine.
Transversion	The substitution of all types of nucleotide substitutions other than transitions.
Troglo-	(Prefix) For subterranean terrestrial systems.
Troglobite	Species which do not exist outside caves. They may, however, occur in the superficial underground compartment or in the upper hypogean zone (Wilkens et al 2000).
Troglophile	Species able to live a reproduce underground as well as in the epigean environment (Wilkens et al 2000).
Variance	A measure of the variability within a set of numbers. The more variable the numbers, the higher the variance.
Vug	A small cavity in a rock or vein, often with a mineral lining of different composition from that of the surrounding rock.

Appendix 1

Details of Boreholes Sampled During this Study

Phase	Bore	Easting	Northing	No. traps	Trap depths (m)	Bore depth (m)	Comments
1	MEK1701	423664	7598029	4	10, 20, 30, 40	40	Dry
1	MEK1712	423664	7597931	4	10, 20, 30, 40	51	45
1	MEK1704	423865	7598030	0	–	–	Blocked, not sampled
1	MEK1694	423907	7598080	4	10, 20, 30, 40	43	40
1	MEK1689	423965	7598128	4	10, 20, 30, 40	49	38
1	MEK1690	423772	7597973	0	–	–	Blocked, not sampled
1	MEK1685	423964	7598179	3	10, 20, 30	38	38
1	MEK1728	423964	7598331	3	10, 20, 30	40	Dry
1	MEK1718	424013	7598329	4	10, 20, 30, 40	46	43
1	MEK1724	424212	7598483	4	10, 20, 30, 40	45	42
1	MEK1721	424062	7598486	3	10, 20, 30	37	35
1	MEK1735	423710	7598193	3	5, 10, 15	18	Dry
2	MEK1458	423464	7597230	3	13, 19, 27	38	Cavities: 12-14, 18-20, 26-28
2	MEK1439	423511	97529	3	10, 20, 30	–	
2	MEK1449	423513	7597381	2	8, 16	20	
2	MEK1456	423563	7597231	2	8, 16	18	
2	MEK1464	423564	7597078	3	10, 20, 28	38	Cavities 26-30m
2	MEK1474	423164	7597181	2	8, 16	19	
2	MEK1478	423209	7597079	1	10	22	
2	MEK1482	423413	7597079	2	8, 16	–	
2	MEK1524	422753	7597735	3	10, 20, 33	48	Cavity: 32-34m
2	MEK1526	422863	7597777	3	10, 20, 27	42	Cavity: 26-28m
2	MEK1529	422913	7597829	3	10, 25, 38	42	Cavity: 24-28m, 38-40m
2	MEK1551	423065	7597866	3	10, 27, 35	45	Cavity 26 - 28m
2	MEK1552	423065	7597827	3	10, 20, 30	35	
2	MEK1553	423114	7597829	3	10, 15, 25	33	Damp at 24-26m
2	MEK1556	423253	7597832	3	10, 15, 25	31	Damp at 24-26m
2	MEK1570	423163	7597877	3	10, 20, 30	–	
2	MEK1628	424063	7598029	2	8, 16	18	
2	MEK1667	424214	7598432	2	8, 16	21	
2	MEK1685	423964	7598179	3	10, 20, 30	34	Cavity 36-40m
2	MEK1685A	423823	7598023	3	10, 20, 30	38	38
2	MEK1689	423622	7597973	4	10, 20, 30, 40	49	38
2	MEK1694	423769	7597923	4	10, 20, 30, 40	43	40
2	MEK1696	423812	7598079	3	10, 20, 33	36	Cavity 32-36m
2	MEK1701	423454	7597892	4	10, 20, 30, 40	40	Dry
2	MEK1712	423521	7597774	4	10, 20, 30, 40	51	45
2	MEK1721	423931	7598327	3	10, 20, 30	37	35
2	MEK1724	424071	7598330	4	10, 20, 30, 40	45	42
2	MEK1724A	424210	7598484	3	10, 18, 30	37	Damp @ 18m
2	MEK1731	423862	7598280	3	10, 20, 30	34	
2	MEK1732	423764	7598231	3	10, 15, 25	28	
2	MEK1735	423568	7598037	3	5, 10, 15	18	Dry
2	MEK1749	423616	7597777	3	10, 20, 30	46	Water @ 41m
2	MEK1757	423817	7597881	3	6, 15, 30	33	Damp @ 6m
2	MEK1770	423661	7597729	2	8, 16	20	
3	K0502	424627	7599164	3	10, 15, 25		
3	K0546	423675	7596968	0	–		Blocked, not sampled
3	K0557	424535	7599059	3	10, 15, 25		
3	K0607	424435	7599063	3	10, 15, 25		
3	K0672	423735	7597344	3	10, 15, 25		
3	K0739	422440	7597656	3	10, 15, 25		
3	K0740	422343	7597654	2	5, 15		
3	K0873	424385	7598906	3	10, 15, 25		
3	K0948	423826	7598258	3	10, 15, 25		
3	K0968	423443	7598359	3	10, 15, 25		
3	K0989	423185	7598206	3	10, 15, 25		

Phase	Bore	Easting	Northing	No. traps	Trap depths (m)	Bore depth (m)	Comments
3	K0996	423147	7598108	3	10, 15, 25		
3	K1000	423832	7598193	3	10, 15, 25		
3	K1066	424234	7598646	3	10, 15, 25		
3	K1068	424241	7598698	3	10, 15, 25		
3	K1074	424216	7598505	3	10, 15, 25		
3	K1302	422437	7597806	3	10, 15, 25		
3	K1317	423590	7596902	3	10, 15, 25		
3	K1315	423639	7596952	3	10, 15, 25		
3	K1328	423143	7598311	3	10, 15, 25		
3	K1337	422891	7598158	3	10, 15, 25		
3	MEK1449	423514	7597380	3	10, 20, 30	20	
3	MEK1456	423563	7597231	2	8, 16	18	
3	MEK1458	423464	7597231	2	6, 14	38	hit bottom/ blockage
3	MEK1474	423165	7597181	2	8, 16	19	
3	MEK1478	423208	7597078	2	8, 16	22	
3	MEK1482	423413	7597079	3	10, 15, 25	-	bottom trap in water
3	MEK1524	422752	7597735	3	10, 20, 33	48	
3	MEK1529	422912	7597830	3	10, 25, 38	42	
3	MEK1551	423065	7597865	3	10, 27, 35	45	
3	MEK1553	423113	7597829	3	10, 15, 25	33	
3	MEK1556	423253	7597831	3	10, 15, 25	31	
3	MEK1570	423163	7597877	3	10, 15, 25	–	
3	MEK1685	423963	7598180	3	10, 20, 30	34	
3	MEK1689	423965	7598128	4	10, 20, 30, 40	49	
3	MEK1694	423907	7598080	3	10, 20, 30	43	
3	MEK1696	423812	7598079	3	10, 20, 30	36	
3	MEK1712	423664	7597931	4	10, 20, 30, 40	51	
3	MEK1718	424013	7598329	3	10, 20, 30		old traps still intact
3	MEK1721	424062	7598486	3	10, 20, 30	37	
3	MEK1724	424212	7598483	3	10, 18, 30	45	
3	MEK1728	423964	7598331	3	10, 20, 30		
3	MEK1731	423861	7598281	3	10, 20, 30	34	
3	MEK1735	423711	7598193	3	5, 10, 15	18	
3	MEK1757	423816	7597882	3	6, 15, 30	33	
4	k0502	424627	7599164	3	10, 15, 25		
4	k0557	424535	7599059	3	10, 15, 25		
4	k0607	424435	7599063	3	10, 15, 25		
4	k0672	423735	7597344	3	10, 15, 25		
4	k0739	422440	7597656	3	10, 15, 25		
4	k0740	422343	7597654	2	5, 15		
4	k0873	424385	7598906	3	10, 15, 25		
4	k0948	423826	7598258	3	10, 15, 25		
4	k0968	423443	7598359	3	10, 15, 25		
4	k0989	423185	7598206	3	10, 15, 25		
4	k0996	423147	7598108	3	10, 15, 25		
4	k1000	423832	7598193	3	10, 15, 25		
4	k1066	424234	7598646	3	10, 15, 25		
4	k1068	424241	7598698	3	10, 15, 25		
4	k1074	424216	7598505	3	10, 15, 25		
4	k1302	422437	7597806	3	10, 15, 25		
4	k1317	423590	7596902	3	10, 15, 25		
4	k1315	423639	7596952	3	10, 15, 25		
4	k1328	423143	7598311	3	10, 15, 25		
4	k1337	422891	7598158	3	10, 15, 25		
4	MEK1449	423514	7597380	3	10, 20, 30	20	T3 in water
4	MEK1456	423563	7597231	2	8, 16	18	
4	MEK1458	423464	7597231	2	6, 14	38	hit bottom/ blockage
4	MEK1474	423165	7597181	2	8, 16	19	
4	MEK1478	423208	7597078	2	8, 16	22	

Phase	Bore	Easting	Northing	No. traps	Trap depths (m)	Bore depth (m)	Comments
4	MEK1482	423413	7597079	3	10, 15, 25	-	bottom trap in water
4	MEK1524	422752	7597735	3	10, 20, 33	48	
4	MEK1529	422912	7597830	3	10, 25, 38	42	
4	MEK1551	423065	7597865	3	10, 27, 35	45	
4	MEK1553	423113	7597829	3	10, 15, 25	33	
4	MEK1556	423253	7597831	3	10, 15, 25	31	
4	MEK1570	423163	7597877	3	10, 15, 25	–	
4	MEK1685	423963	7598180	3	10, 20, 30	34	
4	MEK1685A	423823	7598024	3	10, 15, 25	49	
4	MEK1689	423965	7598128	4	10, 20, 30, 40	43	
4	MEK1694	423907	7598080	3	10, 20, 30	36	
4	MEK1696	423812	7598079	3	10, 20, 30	51	
4	MEK1712	423664	7597931	4	10, 20, 30, 40		
4	MEK1721	424062	7598486	3	10, 20, 30	37	
4	MEK1724	424212	7598483	3	10, 18, 30	45	
4	MEK1728	423964	7598331	3	10, 20, 30		
4	MEK1731	423861	7598281	3	10, 20, 30	34	
4	MEK1735	423711	7598193	3	5, 10, 15	18	
4	MEK1757	423816	7597882	3	6, 15, 30	33	

Appendix 2

Schizomid DNA Extractions/Specimens

DNA Extraction Code	Sample ID	Museum ID	Sampling Phase	Inside Project Area?	Successful PCR Reaction?	Sex	Status	Cap No.	No. legs
S01	MEK1456T2-12	T78190	II	Y	Y	F	J	187	2
S02	MEK1482T1-10	T78191	II	Y	Y		J	206	2
S03	MEK1685AT2-17	T78204	II	N	Y		J	28	2
S04	MEK1685AT3-13	T78205	II	N	Y		J	24	4
S05	MEK1724T1-11	T78214	II	N	Y		J	165	4
S06	MEK1757T1-11	T78217	II	Y	Y		J	136	4
S07	MEK1757T3-18	T78218	II	Y	Y		J	142	2
S08	K0607 P3 T2-3		III	N	Y		J	475	3
S09	KO672 P3 T2-2		III	N	Y		A	451	3
S10	KO740 P3 T2-1		III	N	Y		A	541	1
S18	K1328 P3 T3-2		III	N	Y			632	3
S12	MEK1474 P3 T2-1		III	Y	Y			327	4
S13	MEK1570 P3 T1-2		III	Y	Y			361	2
S14	MEK1529 P3 T1-3		III	Y	Y		J	442	3
S15	MEK1529 P3 T2-2		III	Y	Y		J	444	3
S16	MEK1529 P3 T3-2		III	Y	Y		J	447	4
S17	MEK1551 P3 T3-4		III	Y	Y			625	4
S11	MEK1553 P3 T2-1		III	Y	Y		J	511	3
S19	MEK1689T1-20	T78206	II	Y	Y		J	44	3
S20	MEK1570 P3 T3-2		III	Y	Y			366	3
S21	MEK1685 P3 T2-4		III	Y	Y			405	3
S22	MEK1696 P3 T1-1		III	Y	N		A	609	1
S23	MEK1712 P3 T1-2		III	N	Y			518	3
S24	MEK1721 P3 T1-1		III	N	N			495	3
S25	MEK1721 P3 T2-3		III	N	Y			501	3
S27	MEK1728 P3 T2-1		III	N	Y			372	
S28	MEK1731 P3 T1-2		III	N	Y			553	
S29	MEK1694 P3 T1-3		III	Y	Y			351	
S30	MEK1694 P3 T2-2		III	Y	Y			353	
S26	MEK1731 T1-11		III	N	N			154	
S31	MEK1689T2-15	T78207	II	Y	N			39	
S32	MEK1731T2-13	T78216	II	N	Y			156	
S33	MEK1696T1-11	T78210	II	Y	N			199	
S34	MEK1529T1-12	T78196	II	Y	N			102	
S35	MEK1570T2-14	T78202	II	Y	Y			150	
S36	MEK1721T3-12	T78212	II	N	Y			215	
S37	MEK1696T2-13	T78211	II	Y	N			201	
S38	MEK1553T2-12	T78201	II	Y	N			162	

DNA Extraction Code	Sample ID	Museum ID	Sampling Phase	Inside Project Area?	Successful PCR Reaction?	Sex	Status	Cap No.	No. legs
S39	MEK1757T2-16	T76908	II	Y	N			140	
S40	MEK1529T2-14	T78197	II	Y	N			104	
S41	MEK1529T3-17	T78198	II	Y	Y			107	
S42	MEK1694T3-13	T78209	II	Y	N			212	

Appendix 3

Details of Troglobitic Specimens Collected During the Study

Phase	Date	Borehole	Easting	Northing	Class: Order	n	Sample ID
1	28/7/05	MEK1685	423964	7598179	Arachnida: Schizomida	1	MEK1685 T1-2
1	28/7/05	MEK1685	423964	7598179	Arachnida: Schizomida	1	MEK1685 T1-3
1	28/7/05	MEK1685	423964	7598179	Arachnida: Schizomida	2	MEK1685 T2-4
1	28/7/05	MEK1689	423965	7598128	Arachnida: Schizomida	1	MEK1689 T2-2
1	28/7/05	MEK1694	423769	7597923	Arachnida: Schizomida	1	MEK1694 T1-2
1	28/7/05	MEK1694	423769	7597923	Arachnida: Schizomida	3	MEK1694 T2-5
1	28/7/05	MEK1721	423931	7598327	Arachnida: Schizomida	1	MEK1721 T2-2
1	28/7/05	MEK1721	423931	7598327	Arachnida: Schizomida	1	MEK1721 T3-3
1	28/7/05	MEK1728	423964	7598331	Arachnida: Schizomida	1	MEK1728 T1-2
2	3/8/06	MEK1689	423963	7598128	Arachnida Pseudoscorpionida	1	MEK1689 T1-19
2	3/8/06	MEK1689	423963	7598128	Arachnida Pseudoscorpionida	1	MEK1689 T2-16
2	3/8/06	MEK1696	423812	7598079	Arachnida: Pseudoscorpionida	1	MEK1696 T1-12
2	3/8/06	MEK1456	423563	7597231	Arachnida: Schizomida	2	MEK1456 T2-12
2	3/8/06	MEK1458	423464	7597230	Arachnida: Schizomida	1	MEK1458 T1-11
2	3/8/06	MEK1458	423464	7597230	Arachnida: Schizomida	1	MEK1458 T1-12
2	3/8/06	MEK1482	423413	7597080	Arachnida: Schizomida	1	MEK1482 T1-10
2	3/8/06	MEK1524	422753	7597735	Arachnida: Schizomida	2	MEK1524 T2-12
2	3/8/06	MEK1524	422753	7597735	Arachnida: Schizomida	4	MEK1524 T3-17
2	3/8/06	MEK1529	422913	7597829	Arachnida: Schizomida	3	MEK1529 T1-12
2	3/8/06	MEK1529	422913	7597829	Arachnida: Schizomida	3	MEK1529 T2-14
2	3/8/06	MEK1529	422913	7597829	Arachnida: Schizomida	2	MEK1529 T3-17
2	3/8/06	MEK1551	423065	7597866	Arachnida: Schizomida	2	MEK1551 T3-14
2	3/8/06	MEK1553	423114	7597829	Arachnida: Schizomida	2	MEK1553 T1-11
2	3/8/06	MEK1553	423114	7597829	Arachnida: Schizomida	1	MEK1553 T2-12
2	3/8/06	MEK1556	423253	7597832	Arachnida: Schizomida	1	MEK1556 T2-16
2	3/8/06	MEK1556	423253	7597832	Arachnida: Schizomida	1	MEK1556 T3-14
2	3/8/06	MEK1570	423164	7597877	Arachnida: Schizomida	1	MEK1570 T2-14
2	3/8/06	MEK1685	423964	7598179	Arachnida: Schizomida	1	MEK1685 T2-11
2	3/8/06	MEK1685A	423823	7598024	Arachnida: Schizomida	1	MEK1685A T1-21
2	3/8/06	MEK1685A	423823	7598024	Arachnida: Schizomida	1	MEK1685A T2-17
2	3/8/06	MEK1685A	423823	7598024	Arachnida: Schizomida	1	MEK1685A T3-13
2	3/8/06	MEK1689	423963	7598128	Arachnida: Schizomida	3	MEK1689 T1-20

Phase	Date	Borehole	Easting	Northing	Class: Order	n	Sample ID
2	3/8/06	MEK1689	423963	7598128	Arachnida: Schizomida	1	MEK1689 T2-15
2	3/8/06	MEK1694	423909	7598079	Arachnida: Schizomida	1	MEK1694 T1-10
2	3/8/06	MEK1694	423909	7598079	Arachnida: Schizomida	1	MEK1694 T2-11
2	3/8/06	MEK1694	423909	7598079	Arachnida: Schizomida	1	MEK1694 T3-13
2	3/8/06	MEK1696	423812	7598079	Arachnida: Schizomida	2	MEK1696 T1-11
2	3/8/06	MEK1696	423812	7598079	Arachnida: Schizomida	1	MEK1696 T2-13
2	3/8/06	MEK1696	423812	7598079	Arachnida: Schizomida	1	MRK1696 tullgren
2	3/8/06	MEK1712	423663	7597929	Arachnida: Schizomida	1	MEK1712 T1-17
2	3/8/06	MEK1721	424063	7598482	Arachnida: Schizomida	3	MEK1721 T3-12
2	3/8/06	MEK1721	424063	7598482	Arachnida: Schizomida	1	MEK1721 T3-14
2	3/8/06	MEK1724	424071	7598330	Arachnida: Schizomida	1	MEK1724 T1-11
2	3/8/06	MEK1731	423862	7598280	Arachnida: Schizomida	1	MEK1731 T1-11
2	3/8/06	MEK1731	423862	7598280	Arachnida: Schizomida	1	MEK1731 T2-13
2	3/8/06	MEK1732	423764	7598231	Arachnida: Schizomida	1	MEK1732 T1-13
2	3/8/06	MEK1732	423764	7598231	Arachnida: Schizomida	2	MEK1732 T2-16
2	3/8/06	MEK1732	423764	7598231	Arachnida: Schizomida	1	MEK1732 T3-18
2	3/8/06	MEK1735	423710	7598193	Arachnida: Schizomida	1	MEK1735 T3-11
2	3/8/06	MEK1757	423817	7597881	Arachnida: Schizomida	1	MEK1757 T1-11
2	3/8/06	MEK1757	423817	7597881	Arachnida: Schizomida	1	MEK1757 T2-14
2	3/8/06	MEK1757	423817	7597881	Arachnida: Schizomida	1	MEK1757 T2-16
2	3/8/06	MEK1757	423817	7597881	Arachnida: Schizomida	2	MEK1757 T3-18
2	3/8/06	MEK1478	423208	7597078	Diplura: Diplura	1	MEK1478 T1-11
2	3/8/06	MEK1701	423661	7598029	Insecta: Coleoptera	1	MEK1701 T3-12
3	15/11/06	MEK1721	424062	7598486	Arachnida: Pseudoscorpionida	1	MEK1721 P3 T1-2
3	15/11/06	K0607	424435	7599063	Arachnida: Schizomida	2	K0607 P3 T2-3
3	15/11/06	K0672	423735	7597344	Arachnida: Schizomida	1	K0672 P3 T2-2
3	15/11/06	K0740	422343	7597654	Arachnida: Schizomida	1	K0740 P3 T2-1
3	15/11/06	K1328	423143	7598311	Arachnida: Schizomida	1	K1328 P3 T3-2
3	15/11/06	MEK1474	423165	7597181	Arachnida: Schizomida	1	MEK1474 P3 T2-1
3	15/11/06	MEK1524	422752	7597735	Arachnida: Schizomida	1	MEK1524 P3 T1-1
3	15/11/06	MEK1529	422912	7597830	Arachnida: Schizomida	2	MEK1529 P3 T1-3
3	15/11/06	MEK1529	422912	7597830	Arachnida: Schizomida	1	MEK1529 P3 T2-2
3	15/11/06	MEK1529	422912	7597830	Arachnida: Schizomida	1	MEK1529 P3 T3-2

Phase	Date	Borehole	Easting	Northing	Class: Order	n	Sample ID
3	15/11/06	MEK1551	423065	7597865	Arachnida: Schizomida	3	MEK1551 P3 T3-4
3	15/11/06	MEK1553	423113	7597829	Arachnida: Schizomida	1	MEK1553 P3 T2-1
3	15/11/06	MEK1570	423163	7597877	Arachnida: Schizomida	2	MEK1570 P3 T1-2
3	15/11/06	MEK1570	423163	7597877	Arachnida: Schizomida	2	MEK1570 P3 T3-2
3	15/11/06	MEK1685	423963	7598180	Arachnida: Schizomida	1	MEK1685 P3 T2-4
3	15/11/06	MEK1694	423907	7598080	Arachnida: Schizomida	2	MEK1694 P3 T1-3
3	15/11/06	MEK1694	423907	7598080	Arachnida: Schizomida	1	MEK1694 P3 T2-2
3	15/11/06	MEK1696	423812	7598079	Arachnida: Schizomida	1	MEK1696 P3 T1-1
3	15/11/06	MEK1712	423664	7597931	Arachnida: Schizomida	1	MEK1712 P3 T1-2
3	15/11/06	MEK1718	424013	7598329	Arachnida: Schizomida	2	MEK1718 P3 T1-1
3	15/11/06	MEK1718	424013	7598329	Arachnida: Schizomida	1	MEK1718 P3 T2-3
3	15/11/06	MEK1718	424013	7598329	Arachnida: Schizomida	2	MEK1718 P3 T3-2
3	15/11/06	MEK1721	424062	7598486	Arachnida: Schizomida	1	MEK1721 P3 T1-1
3	15/11/06	MEK1721	424062	7598486	Arachnida: Schizomida	1	MEK1721 P3 T2-3
3	15/11/06	MEK1728	424062	7598486	Arachnida: Schizomida	1	MEK1728 P3 T1-2
3	15/11/06	MEK1728	424062	7598486	Arachnida: Schizomida	1	MEK1728 P3 T2-1
3	15/11/06	MEK1731	423861	7598281	Arachnida: Schizomida	1	MEK1731 P3 T1-2
3	15/11/06	MEK1570	423163	7597877	Chilopoda: Scolopendrida	1	MEK1570 P3 T3-1
3	15/11/06	K0740	422343	7597654	Diplopoda: Polydesmida	1	K0740 P3 T2-2
3	15/11/06	K1315	423639	7596952	Diplopoda: Polydesmida	2	K1315 P3 T2-1
3	15/11/06	K1315	423639	7596952	Diplopoda: Polydesmida	2	K1315 P3 T3-1
3	15/11/06	MEK1551	423065	7597865	Diplopoda: Polyxenida	1	MEK1551 P3 T3-3
3	15/11/06	K0607	424435	7599063	Insecta: Coleoptera	1	K0607 P3 T2-4
3	15/11/06	K0607	424435	7599063	Insecta: Coleoptera	1	K0607 P3 T3-3
3	15/11/06	K1302	422437	7597806	Insecta: Coleoptera	1	K1302 P3 T1-4
3	15/11/06	MEK1694	423907	7598080	Insecta: Coleoptera	2	MEK1694 P3 T2-4
3	15/11/06	MEK1694	423907	7598080	Insecta: Coleoptera	8	MEK1694 P3 T3-1
3	15/11/06	MEK1718	424013	7598329	Insecta: Coleoptera	20	MEK1718 P3 T2-1
3	15/11/06	MEK1728	423964	7598331	Insecta: Coleoptera	3	MEK1728 P3 T1-4
3	15/11/06	MEK1731	423861	7598281	Insecta: Coleoptera	1	MEK1731 P3 T2-2
3	15/11/06	MEK1731	423861	7598281	Insecta: Coleoptera	2	MEK1731 P3 T3-3
3	15/11/06	MEK1735	423711	7598193	Insecta: Coleoptera	2	MEK1735 P3 T2-2

Phase	Date	Borehole	Easting	Northing	Class: Order	n	Sample ID
3	15/11/06	MEK1735	423711	7598193	Insecta: Coleoptera	1	MEK1735 P3 T3-2
4	12/1/07	MEK1728	423964	7598331	Arachnida: Schizomida	1	MEK1728 P4 T3-1
4	12/1/07	K0502	424627	7599164	Archnida: Pseudoscorpionida	1	K0502 P4 T2-4
4	12/1/07	K0948	423826	7598258	Diplopoda: Polydesmida	1	K0948 P4 T3-1
4	12/1/07	MEK1551	423065	7597865	Diplopoda: Polyxenida	1	MEK1551 P4 T1-2
4	12/1/07	MEK1556	423253	7597831	Diplopoda: Polyxenida	1	MEK1556 P4 T3-2
4	12/1/07	MEK1478	423208	7597078	Insecta: Coleoptera	3	MEK1478 P4T1-4
4	12/1/07	MEK1478	423208	7597078	Insecta: Coleoptera	8	MEK1478P 4T2-1

Appendix 4

Genetic Distance Table

		Robe Valley - Warramboo	Cape Range	Robe Valley East			Robe Valley – Mesa A											Robe Valley – Mesa B			Queensland
		WB66234_1	D_sp_65506	MRobe63337	MRobe63373	MRobe63374	A63306	A63325	A63332	A63336	A63339	A66228	A66229	A66232_1	A66315	A66316	A66317_1	B63341	B63366	B63367_2	Bamazomus
Robe Valley - Warramboo	WB66234_1																				
Cape Range	D_sp_65506	0.1320																			
Robe Valley East	MRobe63337	0.1820	0.1440																		
	MRobe63373	0.1790	0.1400	0.0030																	
	MRobe63374	0.1790	0.1370	0.0050	0.0030																
Robe Valley – Mesa A	A63306	0.0900	0.1600	0.1880	0.1850	0.1850															
	A63325	0.0990	0.1570	0.1920	0.1880	0.1880	0.0080														
	A63332	0.0900	0.1600	0.1880	0.1850	0.1850	0.0000	0.0080													
	A63336	0.0930	0.1570	0.1920	0.1880	0.1880	0.0030	0.0050	0.0030												
	A63339	0.0960	0.1600	0.1950	0.1920	0.1920	0.0050	0.0080	0.0050	0.0030											
	A66228	0.0900	0.1630	0.1950	0.1920	0.1920	0.0050	0.0130	0.0050	0.0080	0.0100										
	A66229	0.0930	0.1570	0.1920	0.1880	0.1880	0.0030	0.0050	0.0030	0.0000	0.0030	0.0080									
	A66232_1	0.0870	0.1600	0.1990	0.1950	0.1950	0.0080	0.0160	0.0080	0.0100	0.0130	0.0030	0.0100								
	A66315	0.0910	0.1320	0.1660	0.1630	0.1630	0.0590	0.0670	0.0590	0.0620	0.0640	0.0590	0.0620	0.0560							
	A66316	0.0930	0.1630	0.1920	0.1880	0.1880	0.0030	0.0050	0.0030	0.0050	0.0080	0.0080	0.0050	0.0100	0.0620						
	A66317_1	0.0940	0.1280	0.1690	0.1660	0.1660	0.0620	0.0650	0.0620	0.0590	0.0620	0.0620	0.0590	0.0590	0.0030	0.0650					
Robe Valley – Mesa B	B63341	0.1020	0.1570	0.1990	0.1960	0.1960	0.1270	0.1370	0.1270	0.1300	0.1330	0.1270	0.1300	0.1240	0.1050	0.1300	0.1080				
	B63366	0.1050	0.1600	0.2030	0.1990	0.1990	0.1300	0.1400	0.1300	0.1340	0.1370	0.1240	0.1340	0.1210	0.1080	0.1340	0.1120	0.0030			
	B63367_2	0.1050	0.1600	0.2030	0.1990	0.1990	0.1300	0.1400	0.1300	0.1340	0.1370	0.1240	0.1340	0.1210	0.1080	0.1340	0.1120	0.0030	0.0000		
Queensland	Bamazomus	0.1630	0.1310	0.1660	0.1630	0.1590	0.1920	0.2030	0.1920	0.1960	0.1990	0.1990	0.1960	0.1990	0.1660	0.1960	0.1700	0.1660	0.1690	0.1690	
Barrow Island	Barrow_B11	0.1900	0.1440	0.1630	0.1590	0.1560	0.1660	0.1770	0.1660	0.1700	0.1730	0.1700	0.1700	0.1730	0.1660	0.1700	0.1690	0.2100	0.2140	0.2140	0.1880
	Barrow_B27	0.1900	0.1440	0.1630	0.1590	0.1560	0.1660	0.1770	0.1660	0.1700	0.1730	0.1700	0.1700	0.1730	0.1660	0.1700	0.1690	0.2100	0.2140	0.2140	0.1880
	Barrow_BMW	0.1600	0.1320	0.1560	0.1530	0.1500	0.1700	0.1800	0.1700	0.1730	0.1760	0.1730	0.1730	0.1700	0.1600	0.1730	0.1630	0.1860	0.1890	0.1890	0.1750
	Barrow_MW1	0.1600	0.1290	0.1660	0.1630	0.1590	0.1670	0.1770	0.1670	0.1700	0.1730	0.1700	0.1700	0.1670	0.1630	0.1700	0.1660	0.1860	0.1900	0.1900	0.1750
	Barrow_S2	0.1730	0.1440	0.1560	0.1600	0.1560	0.1540	0.1640	0.1540	0.1570	0.1600	0.1570	0.1570	0.1540	0.1530	0.1570	0.1560	0.2060	0.2100	0.2100	0.1990
	Barrow_S4	0.1870	0.1410	0.1600	0.1560	0.1530	0.1870	0.1970	0.1870	0.1900	0.1930	0.1900	0.1900	0.1940	0.1800	0.1900	0.1830	0.2030	0.2070	0.2070	0.1820
	Barrow_S7	0.1600	0.1380	0.1630	0.1600	0.1560	0.1800	0.1900	0.1800	0.1830	0.1860	0.1830	0.1830	0.1800	0.1630	0.1830	0.1660	0.1790	0.1820	0.1820	0.1690
Queensland	Brignolizo	0.1950	0.1990	0.2150	0.2190	0.2150	0.2150	0.2190	0.2150	0.2120	0.2150	0.2220	0.2120	0.2190	0.2150	0.2190	0.2120	0.2290	0.2330	0.2330	0.2050
Robe Valley – Mesa C	C63343	0.0960	0.1500	0.1960	0.1920	0.1920	0.1210	0.1300	0.1210	0.1240	0.1270	0.1210	0.1240	0.1180	0.1050	0.1240	0.1080	0.0100	0.0130	0.0130	0.1590
	C63344	0.0960	0.1500	0.1960	0.1920	0.1920	0.1210	0.1300	0.1210	0.1240	0.1270	0.1210	0.1240	0.1180	0.1050	0.1240	0.1080	0.0100	0.0130	0.0130	0.1590
Cape Range	D_juliane1	0.1380	0.0260	0.1530	0.1500	0.1470	0.1640	0.1600	0.1640	0.1600	0.1630	0.1600	0.1600	0.1570	0.1350	0.1670	0.1320	0.1600	0.1570	0.1570	0.1410
	D_juliane2	0.1380	0.0260	0.1530	0.1500	0.1470	0.1640	0.1600	0.1640	0.1600	0.1630	0.1600	0.1600	0.1570	0.1350	0.1670	0.1320	0.1600	0.1570	0.1570	0.1410
	D_juliane3	0.1380	0.0260	0.1530	0.1500	0.1470	0.1640	0.1600	0.1640	0.1600	0.1630	0.1600	0.1600	0.1570	0.1350	0.1670	0.1320	0.1600	0.1570	0.1570	0.1410
	D_vinei_3	0.1250	0.0420	0.1690	0.1660	0.1630	0.1380	0.1410	0.1380	0.1350	0.1380	0.1410	0.1350	0.1380	0.1350	0.1410	0.1320	0.1500	0.1540	0.1540	0.1380
	D_vinei_4	0.1250	0.0480	0.1860	0.1820	0.1790	0.1510	0.1540	0.1510	0.1480	0.1510	0.1540	0.1480	0.1510	0.1380	0.1540	0.1350	0.1500	0.1530	0.1530	0.1410
Robe Valley – Mesa K	S01	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S02	0.1140	0.1560	0.1890	0.1860	0.1860	0.1360	0.1460	0.1360	0.1390	0.1420	0.1430	0.1390	0.1390	0.0960	0.1390	0.0990	0.1250	0.1280	0.1280	0.1620
	S03	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S04	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S05	0.1210	0.1560	0.1830	0.1790	0.1790	0.1430	0.1520	0.1430	0.1460	0.1490	0.1490	0.1460	0.1460	0.1020	0.1460	0.1050	0.1250	0.1280	0.1280	0.1620
	S06	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S07	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S08	0.1140	0.1560	0.1890	0.1860	0.1860	0.1430	0.1520	0.1430	0.1460	0.1490	0.1490	0.1460	0.1460	0.1020	0.1460	0.1050	0.1310	0.1340	0.1340	0.1690
	S10	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S09	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S11	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S12	0.1210	0.1560	0.1860	0.1830	0.1830	0.1430	0.1520	0.1430	0.1460	0.1490	0.1490	0.1460	0.1460	0.1020	0.1460	0.1050	0.1250	0.1280	0.1280	0.1690
	S13	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S14	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S15	0.1140	0.1500	0.1830	0.1790	0.1790	0.1430	0.1520	0.1430	0.1460	0.1490	0.1490	0.1460	0.1460	0.1020	0.1460	0.1050	0.1250	0.1280	0.1280	0.1620
	S16	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S17	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S18	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S23	0.1200	0.1560	0.1890	0.1860	0.1860	0.1420	0.1520	0.1420	0.1460	0.1490	0.1490	0.1460	0.1460	0.1020	0.1460	0.1050	0.1310	0.1340	0.1340	0.1690
	S27	0.1140	0.1560	0.1890	0.1860	0.1860	0.1360	0.1460	0.1360	0.1390	0.1420	0.1430	0.1390	0.1390	0.0960	0.1390	0.0990	0.1250	0.1280	0.1280	0.1620
Cape Range	D_sp_65505	0.1320	0.0000	0.1440	0.1400	0.1370	0.1600	0.1570	0.1600	0.1570	0.1600	0.1630	0.1570	0.1600	0.1320	0.1630	0.1280	0.1570	0.1600	0.1600	0.1310
	D_vinei_1	0.1290	0.0510	0.1660	0.1630	0.1590	0.1410	0.1440	0.1410	0.1380	0.1410	0.1440	0.1380	0.1410	0.1260	0.1440	0.1230	0.1540	0.1570	0.1570	0.1410
	D_vinei_2	0.1320	0.0420	0.1660	0.1630	0.1590	0.1440	0.1470	0.1440	0.1410	0.1440	0.1470	0.1410	0.1440	0.1410	0.1470	0.1380	0.1500	0.1540	0.1540	0.1380
	D_vinei_65	0.1260	0.0420	0.1630	0.1590	0.1560	0.1510	0.1540	0.1510	0.1480	0.1510	0.1540	0.1480	0.1510	0.1350	0.1540	0.1320	0.1500	0.1540	0.1540	0.1370
Robe Valley – Mesa G	G63313	0.1070	0.1370	0.1860	0.1820	0.1820	0.1480	0.1580	0.1480	0.1510	0.1540	0.1480	0.1510	0.1450	0.1450	0.1510	0.1480	0.1140	0.1170	0.1170	0.1440
	G63314	0.1070	0.1370	0.1860	0.1820	0.1820	0.1480	0.1580	0.1480	0.1510	0.1540	0.1480	0.1510	0.1450	0.1450	0.1510	0.1480	0.1140	0.1170	0.1170	0.1440
	G63315	0.1100	0.1400	0.1860	0.1820	0.1820	0.1580	0.1680	0.1580	0.1610	0.1640	0.1580	0.1610	0.1550	0.1450	0.1610	0.1480	0.1110	0.1140	0.1140	0.1340
	G63345	0.1040	0.1310	0.1790	0.1760	0.1760	0.1450	0.1540	0.1450	0.1480	0.1510	0.1380	0.1480	0.1350	0.1290	0.1480	0.1320	0.1170	0.1140	0.1140	0.1530
	G63371	0.0980	0.1310	0.1790	0.1760	0.1760	0.1510	0.1610	0.1510	0.1540	0.1580	0.1450	0.1540	0.1410	0.1290	0.1540	0.1320	0.1110	0.1080	0.1080	0.1470
Robe Valley – Mesa K	K65795	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	K65797	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
Robe Valley East	MRobe63333	0.1820	0.1430	0.0050	0.0030	0.0050	0.1880	0.1880	0.1880	0.1920	0.1950	0.1950	0.1920	0.1990	0.1660	0.1880	0.1690	0.1990	0.2020	0.2020	0.1660
	MRobe63334	0.1760	0.1440	0.0050	0.0030	0.0050	0.1880	0.1920	0.1880	0.1920	0.1950	0.1950	0.1920	0.1990	0.1660	0.1920	0.1690	0.1920	0.1960	0.1960	0.1590
	MRobe63335	0.1790	0.1400	0.0030	0.0000	0.0030	0.1850	0.1880	0.1850	0.1880	0.1920	0.1920	0.1880	0.1950	0.1630	0.1880	0.1660	0.1960	0.1990	0.1990	0.1630
Robe Valley – Mesa K	S41	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S20	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S21	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S23	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S25	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S28	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S29	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S32	0.1200	0.1560	0.1890	0.1860	0.1860	0.1420	0.1520	0.1420	0.1460	0.1490	0.1490	0.1460	0.1460	0.1020	0.1460	0.1050	0.1310	0.1340	0.1340	0.1690
	S35	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S36	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S27	0.1140	0.1560	0.1890	0.1860	0.1860	0.1360	0.1460	0.1360	0.1390	0.1420	0.1430	0.1390	0.1390	0.0960	0.1390	0.0990	0.1250	0.1280	0.1280	0.1620
	S30	0.1170	0.1530	0.1860	0.1830	0.1830	0.1390	0.1490	0.1390	0.1430	0.1460	0.1460	0.1430	0.1430	0.0990	0.1430	0.1020	0.1280	0.1310	0.1310	0.1660
	S19	0.1240	0.1600	0.1860	0.1830	0.1830	0.1460	0.1560	0.1460	0.1490	0.1520	0.1520	0.1490	0.1490	0.1050	0.1490	0.1080	0.1280	0.1310	0.1310	0.1720

		Barrow Island							Queensland	Robe Valley- Mesa C		Cape Range					Robe Valley _ Mesa K							
		Barrow_B11	Barrow_B27	Barrow_BMW	Barrow_MW1	Barrow_S2	Barrow_S4	Barrow_S7	Brignolizo	C63343	C63344	D_juliane1	D_juliane2	D_juliane3	D_vinei_3	D_vinei_4	S01	S02	S03	S04	S05	S06	S07	S08
Robe Valley - Warramboo	WB66234_1																							
Cape Range	D_sp_65506																							
Robe Valley East	MRobe63337																							
	MRobe63373																							
	MRobe63374																							
Robe Valley – Mesa A	A63306																							
	A63325																							
	A63332																							
	A63336																							
	A63339																							
	A66228																							
	A66229																							
	A66232_1																							
	A66315																							
	A66316																							
	A66317_1																							
Robe Valley – Mesa B	B63341																							
	B63366																							
	B63367_2																							
Queensland	Bamazomus																							
Barrow Island	Barrow_B11																							
	Barrow_B27	0.0000																						
	Barrow_BMW	0.0480	0.0480																					
	Barrow_MW1	0.0500	0.0500	0.0160																				
	Barrow_S2	0.0700	0.0700	0.0590	0.0670																			
	Barrow_S4	0.0240	0.0240	0.0420	0.0560	0.0700																		
	Barrow_S7	0.0560	0.0560	0.0160	0.0260	0.0650	0.0530																	
Queensland	Brignolizo	0.2360	0.2360	0.2090	0.2020	0.2120	0.2360	0.2150																
Robe Valley – Mesa C	C63343	0.2030	0.2030	0.1790	0.1800	0.1990	0.1960	0.1720	0.2220															
	C63344	0.2030	0.2030	0.1790	0.1800	0.1990	0.1960	0.1720	0.2220	0.0000														
Cape Range	D_juliane1	0.1570	0.1570	0.1380	0.1350	0.1510	0.1540	0.1440	0.1920	0.1600	0.1600													
	D_juliane2	0.1570	0.1570	0.1380	0.1350	0.1510	0.1540	0.1440	0.1920	0.1600	0.1600	0.0000												
	D_juliane3	0.1570	0.1570	0.1380	0.1350	0.1510	0.1540	0.1440	0.1920	0.1600	0.1600	0.0000	0.0000											
	D_vinei_3	0.1570	0.1570	0.1380	0.1350	0.1440	0.1470	0.1500	0.1780	0.1500	0.1500	0.0620	0.0620	0.0620										
	D_vinei_4	0.1740	0.1740	0.1540	0.1540	0.1740	0.1670	0.1600	0.1990	0.1440	0.1440	0.0670	0.0670	0.0670	0.0260									
Robe Valley – Mesa K	S01	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530								
	S02	0.1830	0.1830	0.1760	0.1800	0.1830	0.1830	0.1730	0.1950	0.1180	0.1180	0.1730	0.1730	0.1730	0.1470	0.1500	0.0030							
	S03	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030						
	S04	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000					
	S05	0.1760	0.1760	0.1700	0.1730	0.1830	0.1770	0.1660	0.1910	0.1250	0.1250	0.1660	0.1660	0.1660	0.1470	0.1560	0.0030	0.0050	0.0030	0.0030				
	S06	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030			
	S07	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000		
	S08	0.1830	0.1830	0.1760	0.1800	0.1900	0.1830	0.1730	0.1980	0.1250	0.1250	0.1730	0.1730	0.1730	0.1530	0.1560	0.0030	0.0050	0.0030	0.0030	0.0050	0.0030	0.0030	
	S10	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S09	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S11	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S12	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1980	0.1180	0.1180	0.1730	0.1730	0.1730	0.1530	0.1560	0.0030	0.0050	0.0030	0.0030	0.0050	0.0030	0.0030	0.0050
	S13	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S14	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S15	0.1830	0.1830	0.1700	0.1730	0.1830	0.1770	0.1690	0.1910	0.1180	0.1180	0.1660	0.1660	0.1660	0.1470	0.1500	0.0030	0.0050	0.0030	0.0030	0.0050	0.0030	0.0030	0.0050
	S16	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S17	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S18	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S23	0.1830	0.1830	0.1760	0.1800	0.1890	0.1830	0.1730	0.1980	0.1240	0.1240	0.1730	0.1730	0.1730	0.1530	0.1560	0.0030	0.0050	0.0030	0.0030	0.0050	0.0030	0.0030	0.0050
	S27	0.1830	0.1830	0.1760	0.1800	0.1830	0.1830	0.1730	0.1950	0.1180	0.1180	0.1730	0.1730	0.1730	0.1470	0.1500	0.0030	0.0000	0.0030	0.0030	0.0050	0.0030	0.0030	0.0050
Cape Range	D_sp_65505	0.1440	0.1440	0.1320	0.1290	0.1440	0.1410	0.1380	0.1990	0.1500	0.1500	0.0260	0.0260	0.0260	0.0420	0.0480	0.1530	0.1560	0.1530	0.1530	0.1560	0.1530	0.1530	0.1560
	D_vinei_1	0.1540	0.1540	0.1350	0.1320	0.1480	0.1440	0.1410	0.1890	0.1540	0.1540	0.0590	0.0590	0.0590	0.0240	0.0400	0.1500	0.1470	0.1500	0.1500	0.1470	0.1500	0.1500	0.1470
	D_vinei_2	0.1510	0.1510	0.1310	0.1290	0.1440	0.1410	0.1440	0.1820	0.1500	0.1500	0.0620	0.0620	0.0620	0.0050	0.0260	0.1500	0.1470	0.1500	0.1500	0.1470	0.1500	0.1500	0.1530
	D_vinei_65	0.1510	0.1510	0.1380	0.1350	0.1510	0.1410	0.1440	0.1850	0.1500	0.1500	0.0620	0.0620	0.0620	0.0160	0.0320	0.1470	0.1440	0.1470	0.1470	0.1440	0.1470	0.1470	0.1440
Robe Valley – Mesa G	G63313	0.1830	0.1830	0.1660	0.1760	0.1860	0.1630	0.1600	0.2430	0.1020	0.1020	0.1590	0.1590	0.1590	0.1440	0.1470	0.1300	0.1330	0.1300	0.1300	0.1330	0.1300	0.1300	0.1270
	G63314	0.1830	0.1830	0.1660	0.1760	0.1860	0.1630	0.1600	0.2430	0.1020	0.1020	0.1590	0.1590	0.1590	0.1440	0.1470	0.1300	0.1330	0.1300	0.1300	0.1330	0.1300	0.1300	0.1270
	G63315	0.1560	0.1560	0.1440	0.1470	0.1760	0.1500	0.1440	0.2180	0.1050	0.1050	0.1630	0.1630	0.1630	0.1410	0.1440	0.1140	0.1180	0.1140	0.1140	0.1110	0.1140	0.1140	0.1110
	G63345	0.1600	0.1600	0.1440	0.1470	0.1760	0.1540	0.1630	0.2220	0.1110	0.1110	0.1400	0.1400	0.1400	0.1190	0.1410	0.1140	0.1170	0.1140	0.1140	0.1110	0.1140	0.1140	0.1110
	G63371	0.1660	0.1660	0.1500	0.1540	0.1830	0.1600	0.1570	0.2220	0.1050	0.1050	0.1400	0.1400	0.1400	0.1250	0.1410	0.1140	0.1170	0.1140	0.1140	0.1110	0.1140	0.1140	0.1110
Robe Valley – Mesa K	K65795	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	K65797	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
Robe Valley East	MRobe63333	0.1630	0.1630	0.1560	0.1660	0.1630	0.1590	0.1630	0.2220	0.1950	0.1950	0.1530	0.1530	0.1530	0.1690	0.1860	0.1860	0.1890	0.1860	0.1860	0.1820	0.1860	0.1860	0.1890
	MRobe63334	0.1590	0.1590	0.1500	0.1590	0.1630	0.1560	0.1560	0.2150	0.1890	0.1890	0.1530	0.1530	0.1530	0.1690	0.1790	0.1860	0.1890	0.1860	0.1860	0.1830	0.1860	0.1860	0.1890
	MRobe63335	0.1590	0.1590	0.1530	0.1630	0.1600	0.1560	0.1600	0.2190	0.1920	0.1920	0.1500	0.1500	0.1500	0.1660	0.1820	0.1830	0.1860	0.1830	0.1830	0.1790	0.1830	0.1830	0.1860
Robe Valley – Mesa K	S41	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S20	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S21	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S23	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S25	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S28	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S29	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S32	0.1830	0.1830	0.1760	0.1800	0.1890	0.1830	0.1730	0.1980	0.1240	0.1240	0.1730	0.1730	0.1730	0.1530	0.1560	0.0030	0.0050	0.0030	0.0030	0.0050	0.0030	0.0030	0.0050
	S35	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S36	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S27	0.1830	0.1830	0.1760	0.1800	0.1830	0.1830	0.1730	0.1950	0.1180	0.1180	0.1730	0.1730	0.1730	0.1470	0.1500	0.0030	0.0000	0.0030	0.0030	0.0050	0.0030	0.0030	0.0050
	S30	0.1800	0.1800	0.1730	0.1760	0.1860	0.1800	0.1690	0.1950	0.1210	0.1210	0.1700	0.1700	0.1700	0.1500	0.1530	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030
	S19	0.1800	0.1800	0.1730	0.1800	0.1860	0.1800	0.1690	0.2020	0.1210	0.1210	0.1760	0.1760	0.1760	0.1570	0.1600	0.0050	0.0080	0.0050	0.0050	0.0080	0.0050	0.0050	0.0080

		Robe Valley – Mesa K												Cape Range				Robe Valley – Mesa G					Robe Valley – Mesa K		Robe Valley East			Robe Valley – Mesa K					
		S10	S09	S11	S12	S13	S14	S15	S16	S17	S18	S23	S27	D_sp_65505	D_vinei_1	D_vinei_2	D_vinei_65	G63313	G63314	G63315	G63345	G63371	K65795	K65797	MRobe63333	MRobe63334	MRobe63335	S41	S20	S21	S23	S25	S2
Robe Valley - Warramboo	WB66234_1																																
Cape Range	D_sp_65506																																
Robe Valley East	MRobe63337																																
	MRobe63373																																
	MRobe63374																																
Robe Valley – Mesa A	A63306																																
	A63325																																
	A63332																																
	A63336																																
	A63339																																
	A66228																																
	A66229																																
	A66232_1																																
	A66315																																
	A66316																																
	A66317_1																																
Robe Valley – Mesa B	B63341																																
	B63366																																
	B63367_2																																
Queensland	Bamazomus																																
Barrow Island	Barrow_B11																																
	Barrow_B27																																
	Barrow_BMW																																
	Barrow_MW1																																
	Barrow_S2																																
	Barrow_S4																																
	Barrow_S7																																
Queensland	Brignolizo																																
Robe Valley – Mesa C	C63343																																
	C63344																																
Cape Range	D_juliane1																																
	D_juliane2																																
	D_juliane3																																
	D_vinei_3																																
	D_vinei_4																																
Robe Valley – Mesa K	S01																																
	S02																																
	S03																																
	S04																																
	S05																																
	S06																																
	S07																																
	S08																																
	S10																																
	S09	0.0000																															
	S11	0.0000	0.0000																														
	S12	0.0030	0.0030	0.0030																													
	S13	0.0000	0.0000	0.0000	0.0030																												
	S14	0.0000	0.0000	0.0000	0.0030	0.0000																											
	S15	0.0030	0.0030	0.0030	0.0050	0.0030	0.0030																										
	S16	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030																									
	S17	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000																								
	S18	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000																							
	S23	0.0030	0.0030	0.0030	0.0050	0.0030	0.0030	0.0050	0.0030	0.0030	0.0030																						
	S27	0.0030	0.0030	0.0030	0.0050	0.0030	0.0030	0.0050	0.0030	0.0030	0.0030	0.0050																					
Cape Range	D_sp_65505	0.1530	0.1530	0.1530	0.1560	0.1530	0.1530	0.1500	0.1530	0.1530	0.1530	0.1560	0.1560																				
	D_vinei_1	0.1500	0.1500	0.1500	0.1540	0.1500	0.1500	0.1470	0.1500	0.1500	0.1500	0.1530	0.1470	0.0510																			
	D_vinei_2	0.1500	0.1500	0.1500	0.1530	0.1500	0.1500	0.1470	0.1500	0.1500	0.1500	0.1530	0.1470	0.0420	0.0240																		
	D_vinei_65	0.1470	0.1470	0.1470	0.1500	0.1470	0.1470	0.1440	0.1470	0.1470	0.1470	0.1500	0.1440	0.0420	0.0080	0.0160																	
Robe Valley – Mesa G	G63313	0.1300	0.1300	0.1300	0.1270	0.1300	0.1300	0.1270	0.1300	0.1300	0.1300	0.1330	0.1330	0.1370	0.1600	0.1500	0.1500																
	G63314	0.1300	0.1300	0.1300	0.1270	0.1300	0.1300	0.1270	0.1300	0.1300	0.1300	0.1330	0.1330	0.1370	0.1600	0.1500	0.1500	0.0000															
	G63315	0.1140	0.1140	0.1140	0.1110	0.1140	0.1140	0.1110	0.1140	0.1140	0.1140	0.1170	0.1180	0.1400	0.1560	0.1470	0.1470	0.0320	0.0320														
	G63345	0.1140	0.1140	0.1140	0.1140	0.1140	0.1140	0.1110	0.1140	0.1140	0.1140	0.1170	0.1170	0.1310	0.1410	0.1250	0.1310	0.0540	0.0540	0.0420													
	G63371	0.1140	0.1140	0.1140	0.1140	0.1140	0.1140	0.1110	0.1140	0.1140	0.1140	0.1170	0.1170	0.1310	0.1410	0.1310	0.1310	0.0480	0.0480	0.0370	0.0050												
Robe Valley – Mesa K	K65795	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140											
	K65797	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140	0.0000										
Robe Valley East	MRobe63333	0.1860	0.1860	0.1860	0.1860	0.1860	0.1860	0.1820	0.1860	0.1860	0.1860	0.1890	0.1890	0.1430	0.1660	0.1660	0.1630	0.1850	0.1850	0.1850	0.1790	0.1790	0.1860	0.1860									
	MRobe63334	0.1860	0.1860	0.1860	0.1860	0.1860	0.1860	0.1830	0.1860	0.1860	0.1860	0.1890	0.1890	0.1440	0.1660	0.1660	0.1630	0.1860	0.1860	0.1790	0.1790	0.1790	0.1860	0.1860	0.0050								
	MRobe63335	0.1830	0.1830	0.1830	0.1830	0.1830	0.1830	0.1790	0.1830	0.1830	0.1830	0.1860	0.1860	0.1400	0.1630	0.1630	0.1590	0.1820	0.1820	0.1820	0.1760	0.1760	0.1830	0.1830	0.0030	0.0030							
Robe Valley – Mesa K	S41	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140	0.0000	0.0000	0.1860	0.1860	0.1830						
	S20	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140	0.0000	0.0000	0.1860	0.1860	0.1830	0.0000					
	S21	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140	0.0000	0.0000	0.1860	0.1860	0.1830	0.0000	0.0000				
	S23	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140	0.0000	0.0000	0.1860	0.1860	0.1830	0.0000	0.0000	0.0000			
	S25	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140	0.0000	0.0000	0.1860	0.1860	0.1830	0.0000	0.0000	0.0000	0.0000		
	S28	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140	0.0000	0.0000	0.1860	0.1860	0.1830	0.0000	0.0000	0.0000	0.0000	0.0000	
	S29	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140	0.0000	0.0000	0.1860	0.1860	0.1830	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
	S32	0.0030	0.0030	0.0030	0.0050	0.0030	0.0030	0.0050	0.0030	0.0030	0.0030	0.0050	0.0050	0.1560	0.1530	0.1530	0.1500	0.1330	0.1330	0.1170	0.1170	0.1170	0.0030	0.0030	0.1890	0.1890	0.1860	0.0030	0.0030	0.0030	0.0030	0.0030	0.0
	S35	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140	0.0000	0.0000	0.1860	0.1860	0.1830	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
	S36	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140	0.0000	0.0000	0.1860	0.1860	0.1830	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
	S27	0.0030	0.0030	0.0030	0.0050	0.0030	0.0030	0.0050	0.0030	0.0030	0.0030	0.0050	0.0000	0.1560	0.1470	0.1470	0.1440	0.1330	0.1330	0.1180	0.1170	0.1170	0.0030	0.0030	0.1890	0.1890	0.1860	0.0030	0.0030	0.0030	0.0030	0.0030	0.0
	S30	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0030	0.0030	0.1530	0.1500	0.1500	0.1470	0.1300	0.1300	0.1140	0.1140	0.1140	0.0000	0.0000	0.1860	0.1860	0.1830	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
	S19	0.0050	0.0050	0.0050	0.0030	0.0050	0.0050	0.0080	0.0050	0.0050	0.0050	0.0080	0.0080	0.1600	0.1570	0.1570	0.1540	0.1300	0.1300	0.1140	0.1170	0.1170	0.0050	0.0050	0.1860	0.1860	0.1830	0.0050	0.0050	0.0050	0.0050	0.0050	0.0

		Robe Valley – Mesa K						
		S29	S32	S35	S36	S27	S30	S19
Robe Valley - Warramboo	WB66234_1							
Cape Range	D_sp_65506							
Robe Valley East	MRobe63337							
	MRobe63373							
	MRobe63374							
Robe Valley – Mesa A	A63306							
	A63325							
	A63332							
	A63336							
	A63339							
	A66228							
	A66229							
	A66232_1							
	A66315							
	A66316							
	A66317_1							
Robe Valley – Mesa B	B63341							
	B63366							
	B63367_2							
Queensland	Bamazomus							
Barrow Island	Barrow_B11							
	Barrow_B27							
	Barrow_BMW							
	Barrow_MW1							
	Barrow_S2							
	Barrow_S4							
	Barrow_S7							
Queensland	Brignolizo							
Robe Valley – Mesa C	C63343							
	C63344							
Cape Range	D_juliane1							
	D_juliane2							
	D_juliane3							
	D_vinei_3							
	D_vinei_4							
Robe Valley – Mesa K	S01							
	S02							
	S03							
	S04							
	S05							
	S06							
	S07							
	S08							
	S10							
	S09							
	S11							
	S12							
	S13							
	S14							
	S15							
	S16							
	S17							
	S18							
	S23							
	S27							
Cape Range	D_sp_65505							
	D_vinei_1							
	D_vinei_2							
	D_vinei_65							
Robe Valley – Mesa G	G63313							
	G63314							
	G63315							
	G63345							
	G63371							
Robe Valley – Mesa K	K65795							
	K65797							
Robe Valley East	MRobe63333							
	MRobe63334							
	MRobe63335							
Robe Valley – Mesa K	S41							
	S20							
	S21							
	S23							
	S25							
	S28							
	S29							
	S32	0.0030						
	S35	0.0000	0.0030					
	S36	0.0000	0.0030	0.0000				
	S27	0.0030	0.0050	0.0030	0.0030			
	S30	0.0000	0.0030	0.0000	0.0000	0.0030		
	S19	0.0050	0.0080	0.0050	0.0050	0.0080	0.0050	