Bennelongia Environmental Consultants

Iron Ore Holdings Ltd

Iron Valley Project: Subterranean Fauna Assessment

Final Report

Prepared for Iron Ore Holdings Ltd
by Bennelongia Pty Ltd

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Iron Valley Project: Subterranean Fauna Assessment

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EXECUTIVE SUMMARY

Iron Ore Holdings Ltd (IOH) is planning to mine iron ore at the Iron Valley Project within IOH's Central Pilbara tenements. The Iron Valley Project is 86 km north-northwest of Newman in the Pilbara region of Western Australia (WA).

This subterranean fauna report presents results of troglofauna and stygofauna surveys conducted in 2009 and 2011 (the latter sampling at the request of the Department of Environment and Conservation) and provides an assessment of the likely impacts of mining on subterranean fauna at the Iron Valley Project. The sampling effort completed meets the requirements laid out in Environmental Protection Authority (EPA) Guidance Statement No. 54a, with a total of 98 troglofauna and 84 stygofauna samples being collected from bores inside the impact zone of the proposed mine.

The troglofauna sampling yielded 112 troglofaunal animals, representing seven Classes, 11 Orders and 16 species. Two arachnid Orders were recorded: Pseudoscorpionida (1 species) and Schizomida (1 species). The only crustacean Order collected was Isopoda (3 species). Chilopoda were represented by one species of an unknown Order (a partial and damaged specimen prevented identification based on morphology). Diplopoda were represented by Polyxenida (1 species) and Symphyla by Cephalostigmata (1 species). There were five Orders of hexapods (Entognatha/Insecta): Diplura (2 species), Blattodea (2 species), Hemiptera (2 species), Coleoptera (1 species) and Diptera (1 species).

Eleven of the 16 troglofauna species recorded at the Iron Valley Project were recorded within the proposed mine pits. Of these 11 species, 10 species are known to occur in reference areas outside the mine pits or at deposits elsewhere in the Pilbara. One species of troglofauna (Chilopoda sp.) is currently known only from within the proposed mine pits at the Iron Valley Project. Chilopoda sp. was recorded as a singleton. The conservation status of this species is very difficult to quantify because it was damaged and its identification could not be taken further and, therefore, its range could not be determined. Based on the geology of the Iron Valley Project and the distribution of other Chilopoda in the Pilbara, it is expected that this species occurs beyond the Iron Valley mine pits.

Stygofauna sampling yielded 2,153 specimens consisting of at least 23 species of at least eight Orders, including Tubificida (3 species), Hydracarina (1 species), Ostracoda (3 species), Copepoda (4 species), Syncarida (3 species), Amphipoda (7 species), Isopoda (1 species) and nematodes of unknown order/s. Copepods were the numerically dominant group at the Iron Valley Project, with species of oligochaetes, amphipods and syncarids also relatively abundant.

Twenty-two of the 23 stygofauna species recorded at Iron Valley were recorded from within the proposed drawdown cone, importantly all but two of these species are known from elsewhere. The remaining two species potentially have more localised ranges. These species, the ostracod *Meridiescandona* sp. BOS 171 and, to a lesser extent, the syncarid *Bathynella* sp. may be potentially threatened by drawdown. *Meridiescandona* sp. BOS 171 was collected from five drill holes within the Iron Valley Project, while *Bathynella* sp. was collected from a single hole. However, it is likely that both species exploit the habitat connectivity between the Project and surrounding areas in the same way as demonstrated by most of the stygofauna species at Iron Valley.

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1. INTRODUCTION

Iron Ore Holdings Ltd (IOH) is planning to mine iron ore at the Iron Valley Project within IOH's Central Pilbara tenements. The Iron Valley Project is 86 km north-northwest of Newman in the Pilbara region of Western Australia (WA) (Figure 1.1). The Iron Valley Project encompasses the following tenements: Exploration Licence E 47/1385 and M47/1439. IOH proposes to commence construction in Quarter 3, 2013, with operations commencing in Quarter 1, 2014. The life of the Project is expected to be approximately seven years. Decommissioning and closure is expected to occur between years 2021 and 2023, and closure would continue for a further 10 years until 2033.

Key mining components and activities of the proposed Project include:

- Mining of the ore deposit by conventional open pit methods over a 7 year mine life. Mining will only take place above the water table. This will involve drilling and blasting, digging and loading using hydraulic excavators and front-end loaders, and transport by haul trucks.
- Processing of ore on-site, with waste dumps located outside of the pit;
- Supporting infrastructure including an accommodation village, mine site offices and utilities; and
- Water supply borefield for potable and non-potable water.

The proposed area of mine pits at the Iron Valley Project is expected to total approximately 245 ha with a maximum depth of 70 m (depending on the water table). The watertable lies at approximately 6-18 m below ground surface to the south of the dyke and up to 70 m north of the dyke. Although the area of impact is small relative to the ranges of most restricted species, the pit excavation and drawdown (for water supply) proposed for the Iron Valley Project may potentially threaten highly restricted species of subterranean fauna, if they occur within the vicinity of the Project.

A high proportion of subterranean species are short-range endemics (SREs – defined by Harvey 2002 as species with ranges of <10,000 km^2). Consequently, the Environmental Protection Authority (EPA) usually require that the risks to subterranean fauna are considered when assessing proposed mine developments where subterranean fauna are likely to occur (EPA 2003). The very limited ranges of subterranean fauna species means they are particularly vulnerable to extinction as a result of anthropogenic activities and, therefore, they are a focus of conservation policy. About 70% of stygofauna in the Pilbara meet the criterion for being an SRE species (Eberhard *et al*. 2009) and the proportion of troglofauna that are SREs is likely to be even higher (see Lamoreux 2004).

The specific aims of the troglofauna survey at the Iron Valley Project were to:

1. Document the subterranean fauna communities of the Project area and their constituent species.
2. Determine the likely impact of the Iron Valley Project on the subterranean fauna community.

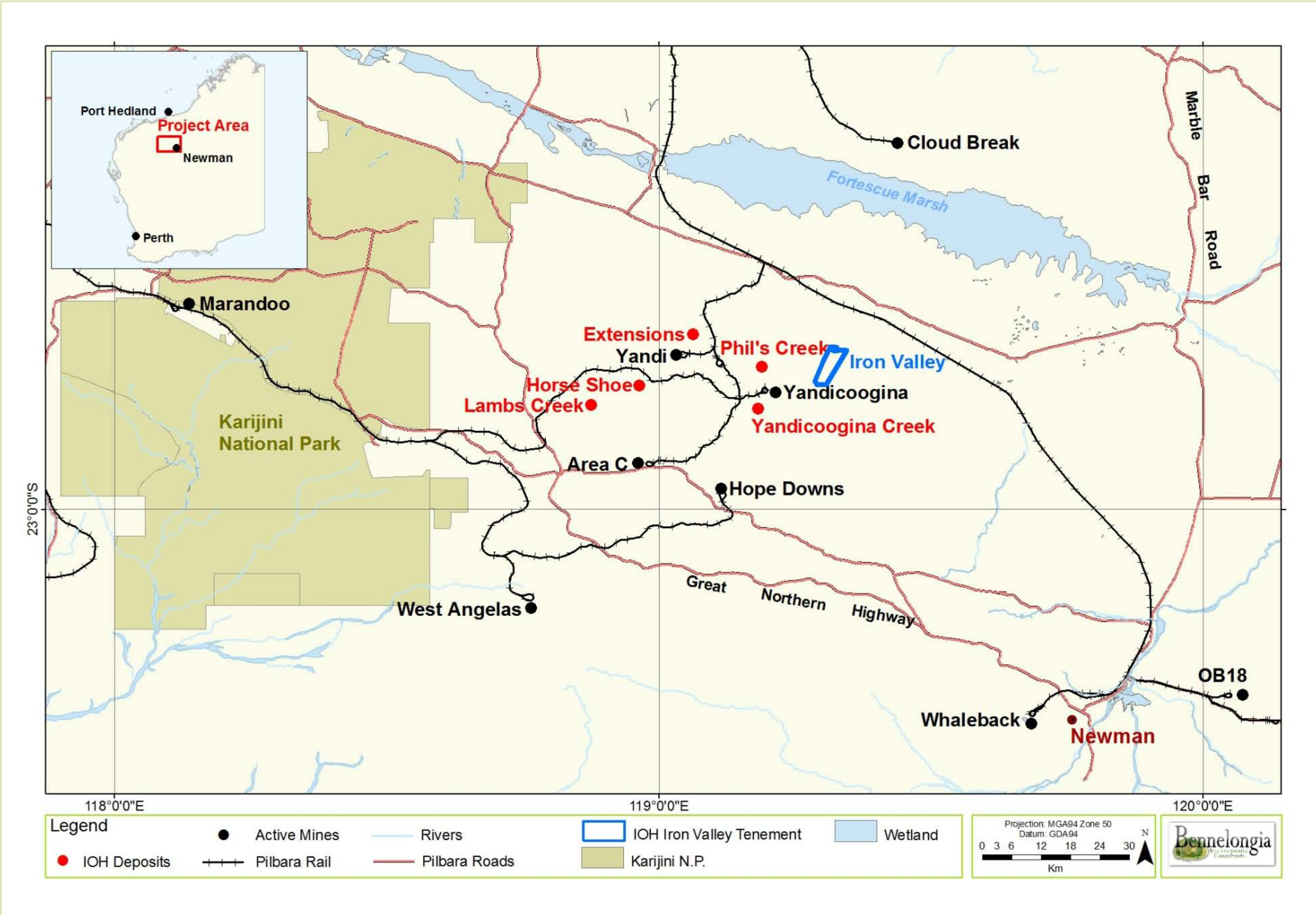

Figure 1.1. Location of the Iron Valley Project.

2. HYDROGEOLOGY

The iron ore deposit proposed to be mined by the Iron Valley Project is located in a southwards-inclined anticline of Brockman Iron Formation in the Hamersley Range (Appendix 1). Most of the mineralisation is on the eastern side of this anticline and is confined to the Upper Joffre Member. However, additional mineralisation occurs within the core of the anticline in the Dales Gorge Member. Much of the mineralisation is overlain with Quaternary Detritals (alluvium and colluvium). Although not fully characterised, existing data suggest in broad terms that geology is similar both inside and outside the proposed mine pits of the Iron Valley Project and the proposed pit boundaries reflect the extent of economic grade ore rather than prospective subterranean fauna habitat.

The local aquifer system at the Iron Valley Project extents to a depth of at least 170 m and the system comprises three main aquifers:

- Alluvium, colluvium and Tertiary detritals
- Weathered and fractured bedrock of the Brockman Iron Formation and Weeli Wolli Formation
- Mineralised zones that comprise the orebody within the Brockman Iron Formation

Hydrology of the Iron Valley Project is complex. The Project lies on the western side of a valley containing Weeli Wolli Creek. Groundwater levels typically reflect surface elevation and so are higher in the scarp to the west than in the valley and creek line. However, the Iron Valley deposit is bisected by a dolerite dyke, which runs east/west. The dyke is part of a regional feature approximately 150 km in length (Appendix 2) and interrupts the northwards flow of groundwater towards the mouth of Weeli Wolli Creek. The interruption of flow appears to be a localised feature, with the watertable being approximately 40 m higher to the south of the dyke than downstream on the northern side (Appendix 3). Around the dyke, gradients are affected by local topography and creek lines. Thus, it is likely that the southern pit, and much of the Iron Valley deposit, is separated from the regional aquifer. In contrast, the northern pit and northern section of the deposit are probably linked to the regional aquifer.

3. EXISTING INFORMATION ON SUBTERRANEAN FAUNA

There are two kinds of subterranean fauna: stygofauna and troglofauna. Stygofauna are aquatic and occur in groundwater. Troglofauna are air-breathing and occur in underground cavities, fissures and interstitial spaces above the watertable. Nearly all subterranean fauna are invertebrates, although both stygofaunal fish and troglofaunal reptiles have been recorded in WA (Whitely 1945; Aplin 1998).

The Pilbara is recognised as a global hotspot for stygofauna (Eberhard *et al*. 2009) and emerging evidence suggests the same is true for troglofauna (see Biota 2005a, 2006; Subterranean Ecology 2007; Bennelongia 2008a, b, c, 2009a, b).

3.1. Troglofauna

While the earliest work on troglofauna was focussed on their occurrence in caves, surveys during the past five years have shown that troglofauna are widespread in the landscape matrix of the Pilbara and are represented by many invertebrate groups, including isopods, palpigrads, spiders, schizomids, pseudoscorpions, harvestmen, millipedes, centipedes, pauropods, symphylans, diplurans, silverfish, cockroaches, bugs, beetles and fungus-gnats. Although abundance and diversity of troglofauna appear to be greatest in the Pilbara, at a regional scale troglofauna are ubiquitous in WA outside caves and have been recorded from the Kimberley (Harvey 2001), Cape Range (Harvey *et al*. 1993), Barrow Island (Biota 2005b), Mid-West (Ecologia 2008) and Yilgarn (Bennelongia 2009c), and South-West (Biota 2005a).

Much of the focus of troglofauna survey for environmental assessment has been in areas of pisolite and banded iron ore. The micro-habitats that troglofauna occupy within these lithologies are still being determined but it is inferred that they utilise the fissures and voids associated with weathering, enrichment and faulting (see Section 2.0). There is relatively little information about the occurrence of troglofauna outside mineralized habitats because mine development has been the primary reason for most of the sampling programs. However, it has been shown that troglofauna also occur in calcrete and alluvium in the Pilbara (Edward and Harvey 2008; Rio Tinto 2008), Yilgarn (Barranco and Harvey 2008; Platnick 2008; Bennelongia 2009c) and elsewhere (Biota 2005a, b).

3.2. Stygofauna

Survey of stygofauna in the Pilbara began in the 1990s (Humphreys 1999), with a rapid increase in knowledge over the last decade as a result of the systematic stygofauna sampling during the Pilbara Biological Survey (see Eberhard *et al*. 2005, 2009). It has been estimated that the Pilbara has between 500 and 550 stygofauna species, with the density of species being relatively uniform across the region (Eberhard *et al*. 2009). Alluvium and calcrete are usually considered to be the most productive habitats for stygofauna, although mafic volcanics may support rich populations and stygofauna occur in moderate abundance in banded iron formations (Halse *et al*. in prep.).

4. PROJECT IMPACTS

Activities that cause direct *habitat loss* are considered to be the primary impacts likely to lead to extinction of subterranean species. At the Iron Valley Project these primary impacts are:

1. *Pit excavation*. Removal of troglofauna habitat is likely to lead to significant risk to restricted troglofauna species.
2. *Groundwater drawdown.* Drawdown of aquifers to for potable and non-potable water supply is likely to lead to some risk to restricted stygofauna species due to loss of habitat.

The ecological impacts of activities that reduce the quality of subterranean fauna habitat have been little studied in Australia (or elsewhere) but it is considered that these impacts are more likely to reduce population size than cause species extinction (see Scarsbrook and Fenwick 2003; Masciopinto *et al*. 2006). Therefore, these impacts are considered to be of secondary importance.

Mining activities at the Iron Valley Project that may result in secondary impacts to subterranean fauna include:

1. *Groundwater drawdown below troglofauna habitat*. The impact of a lowered water table on subterranean humidity and, therefore, the quality of troglofauna habitat is poorly studied, but it may represent risk to troglofauna species in some cases. The extent to which humidity of the vadose[1] zone is affected by depth to the watertable is unclear. Given that pockets of residual water probably remain trapped throughout areas drawn-down and keep the overlying substrate saturated with water vapour, drawdown may have minimal impact on the humidity in the unsaturated zone. In addition, troglofauna may be able to avoid undesirable effects of a habitat drying out by moving deeper into the substrate if suitable habitat exists at depth. Overall,

[1] The zone between the surface and groundwater

drawdown outside the proposed mine pits is not considered to be a significant risk to troglofauna.

2. *Percussion from blasting*. Impacts on both stygofauna and troglofauna may occur through the physical effect of explosions. Blasting may also have indirect detrimental effects through altering underground structure (usually rock fragmentation and collapse of voids) and transient increases in groundwater turbidity. The effects of blasting are often referred to in grey literature but are poorly quantified and have not been related to ecological impacts. Any effects of blasting are likely to dissipate rapidly with distance from the pit and are not considered to be a significant threat to either stygofauna or troglofauna outside the proposed mine pits.
3. *Overburden stockpiles and waste dumps*. These artificial landforms may cause localised reduction in rainfall recharge and associated entry of dissolved organic matter and nutrients because water runs off stockpiles rather than infiltrating through them and into the underlying ground. The effects of reduced carbon and nutrient input are likely to be expressed over many years and are likely to be greater for troglofauna than stygofauna (because lateral movement of groundwater should bring in carbon and nutrients). The extent of impacts on troglofauna will largely depend on the importance of chemoautotrophy[2] in driving the subterranean system compared with infiltration-transported surface energy and nutrients. Stockpiles are unlikely to cause species extinctions, although population densities of species may decrease.
4. *Aquifer recharge with poor quality water*. Quality of recharge water declines during, and after, mining operations as a result of rock break up and soil disturbance (i.e. Gajowiec 1993; McAuley and Kozar 2006). Impacts can be minimised through management of surface water and installing drainage channels, sumps and pump in pits to prevent of recharge though the pit floor.
5. *Contamination of groundwater by hydrocarbons*. Any contamination is likely to be localised and may be minimised by engineering and management practices to ensure containment.

5. METHODS

5.1. Survey Rationale

The subterranean fauna survey at Iron Valley was conducted in accordance with the principles laid out in EPA Guidance Statements Nos 54 and 54a (EPA 2003, 2007).

The impact area for troglofauna, as a result of proposed mining at the Iron Valley Project, was defined as the area to be excavated for the mine pits (Figure 5.1). Reference bores, sampled to show the wider distribution of the troglofauna species collected in the mine pits, were located outside the pits but within the Iron Valley Project tenement (Figure 5.1). Troglofauna were also collected from other sampling programs at nearby IOH iron ore deposits, namely the Extension tenement (26 km west-northwest of the Iron Valley Project), Phil's Creek tenement (12 km west) and Horse Shoe tenement (34 km west-southwest) to show wider distribution of species (Figure 1.1).

The impact area for stygofauna, as a result of proposed mining at the Iron Valley Project, is defined as the area which would be drawn-down for potable and non-potable water supply and was set as groundwater drawdown of greater than 2 m. This is above the natural seasonal variation of about 2 m (Johnson and Wright 2001) has typically been accepted as beginning to have the potential to impact on stygofauna in the Pilbara. It should be noted that the groundwater drawdown at the Iron Valley Project is expected to have a maximum depth of only 8 m.

[2] Microbial oxidation of inorganic compounds as an energy source

5.2. Troglofauna

5.2.1. Sampling Effort

A total of 86 impact and 82 reference samples were collected during three sampling rounds from 115 drill holes within the Iron Valley Project (Table 5.1, Figure 5.1). Round 1 sampling was conducted from 13 to 18 May 2009 (scraping and setting traps) and on 8 and 9 July 2009 (retrieving traps). Round 2 sampling was conducted from 3 to 6 November 2009 (scraping and setting traps) and between 11 and 13 January 2010 (retrieving traps). Round 3 sampling was conducted at the request of the Department of Environment and Conservation (DEC) on the 11 October 2011 (scraping and setting traps). Traps were retrieved on 6 December 2011. The purpose of the sampling was to make further efforts to collect species previously known only from within the mine pit. A list of bores sampled is given in Appendix 4.

Table 5.1. Numbers of troglofauna samples collected from Iron Valley.

Round 1	**Impact**	**Reference**
Scrape	47	27
S Trap	32	20
D Trap	14	7
Samples	*47**	*27*
Round 2		
Scrape	38	22
S Trap	25	17
D Trap	14	5
Samples	*39**	*22*
Round 3		
Scrape		33
S Trap		25
D Trap		8
Samples		*33*
Total Samples	**86**	**82**

Samples consisted of a scrape and trapping event with one or two traps, S trap, one trap; D trap, two traps (shallow and deep). *In two cases, either a trap or scrap was not collected owing to sampling difficulties. Calculation of total sampling effort is based on all sampling (i.e. scrape alone or a scrape with trap/s) during a visit to a site being considered as one sample.

5.2.2. Sampling Methods

In nearly all cases, each troglofauna sample was collected using two separate techniques that provided separate subsamples. The two techniques were trapping and scraping.

1. *Trapping*. Custom made cylindrical PVC traps (270 x 70 mm, entrance holes side and top) were used for trapping. Traps were baited with moist leaf litter (sterilised by microwaving) and lowered on nylon cord to within a few metres of the watertable or end of the drill hole. In every fourth hole, a second trap was set mid-way down the hole. Drill holes were sealed while traps were set to minimise the ingress of surface invertebrates. Traps were retrieved seven or eight weeks later and their contents (bait and captured fauna) were emptied into a zip-lock bag and road freighted to the laboratory in Perth.
2. *Scraping*. Prior to setting traps, holes were scraped. This was done by lowering a troglofauna net (weighted net, 150 µm mesh with variable aperture according to diameter) to the bottom of the drill hole, or to the watertable, and scraping back to the surface along the walls of the hole. Each scrape comprised four drop and retrieve sequences with the aim of scraping any troglofauna on the walls into the net. After each scrape, the contents of the net were transferred to a 125 ml vial and preserved in 100% ethanol.

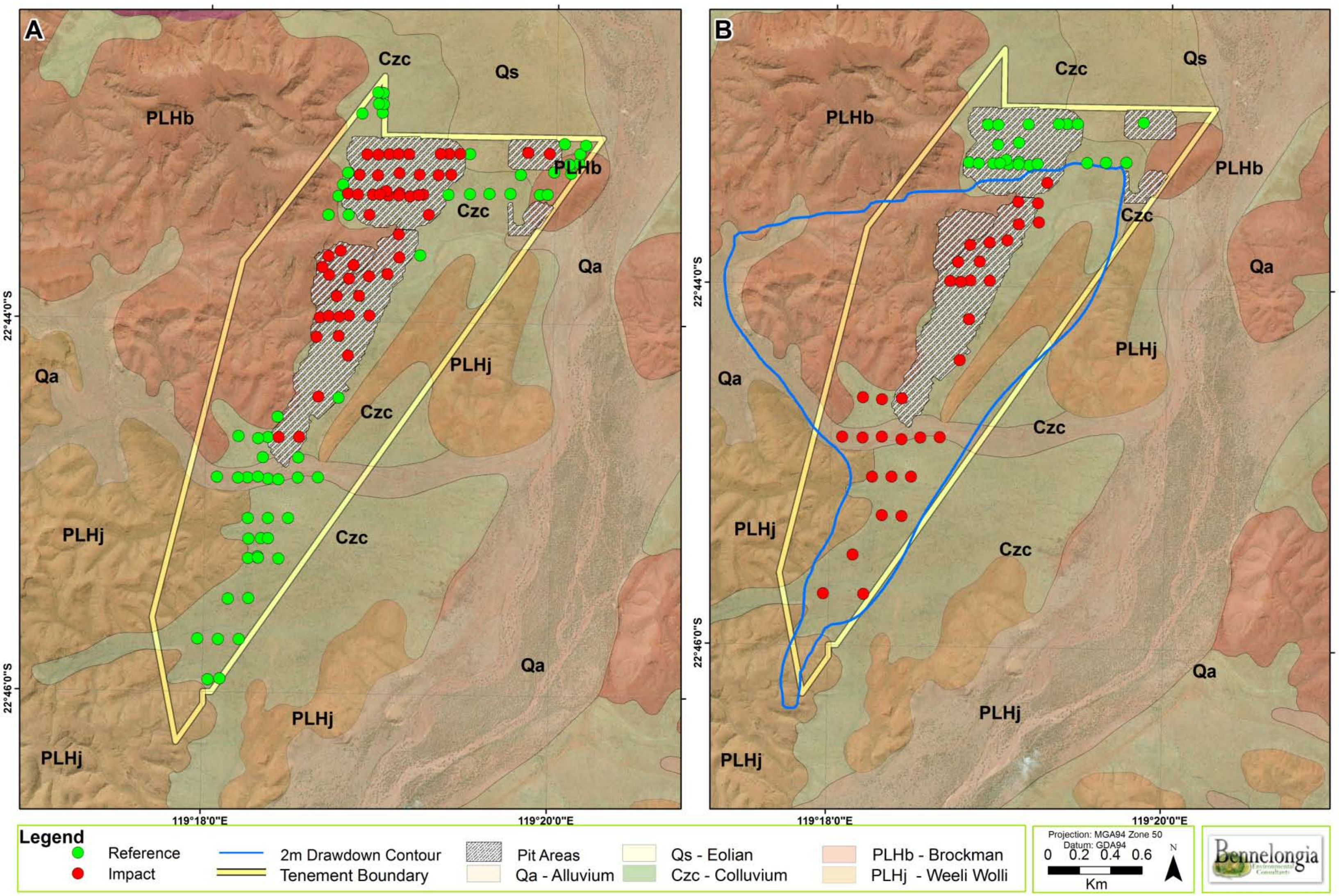

Figure 5.1. Locations of drill holes sampled for troglofauna (A) and stygofauna (B) at the Iron Valley Project.

5.2.3. Sample Sorting and Species Identification

Troglofauna caught in traps were extracted from the leaf litter using Berlese funnels under halogen lamps. Light drives troglofauna and soil invertebrates out of the litter into the base of the funnel containing 100% ethanol (EPA 2007). After about 72 hours, the ethanol and its contents were removed and sorted under a dissecting microscope. Litter from each funnel was also examined under a microscope for any remaining live or dead animals.

Preserved scrapes were elutriated to separate animals from heavier sediment and sieved into size fractions (250, 90 and 53 µm) to remove debris and improve searching efficiency. Samples were then sorted under a dissecting microscope.

All fauna picked from samples were examined for troglomorphic characteristics (lack of eyes and pigmentation, well developed sensory organs, elongate appendages, vermiform body shape). Surface and soil-dwelling species were identified only to Order level. Troglofauna were identified to species or morphospecies level, unless damaged, juvenile or the wrong sex for identification (EPA 2007). Identifications were made under dissecting and/or compound microscope, with specimens being dissected as necessary. Unpublished and informal taxonomic keys were used to assist identification of taxa for which no published keys exist.

Representative animals will be lodged with the WA Museum after the assessment process has been completed.

5.3. Stygofauna

5.3.1. Sampling Effort

A total of 49 impact and 35 reference samples were collected from within the Iron Valley Project (Table 5.2, Figure 5.1). Round 1 sampling was conducted from 13 to 15 May 2009 and Round 2 sampling was conducted between 3 and 6 November 2009. A complete list of bores sampled is given in Appendix 5. To comply with DEC's request that further stygofauna sampling should be conducted outside the expected extent of groundwater drawdown, a further 27 bores were sampled at IOH's Yandicoogina, Boundary and Phil's Creek deposits in the Weeli Wolli catchment between 10 and 13 October 2011. These deposits are 15, 44 and 12 km from Iron Valley (Figure 1.1). Sampling details are not provided because no relevant stygofauna species were collected and the sampling occurred in tenements that are not the subject of this assessment. The purpose of the sampling was to demonstrate wider distribution of stygofauna species currently known only from Iron Valley. A list of bores sampled is given in Appendix 5.

Table 5.2. Numbers of stygofauna samples collected from Iron Valley.

	Impact	Reference
Round 1	21	20
Round 2	28	15
Total Samples	**49**	**35**

5.3.2. Sampling Methods

Stygofauna sampling followed the methods outlined in Eberhard *et al*. (2005) and recommended by the EPA (2007). At each bore, six net hauls were collected using a weighted plankton net. After the net was lowered to the bottom of the bore it was jerked up and down briefly to agitate benthic and epibenthic stygofauna into the water column prior to a slow retrieve of the net. Contents of the net were transferred to a 125 ml polycarbonate vial after each haul and the contents were preserved in 100% ethanol. Nets were washed between bores to minimise contamination between sites. Three hauls were taken using a 50 µm mesh net and three with a 150 µm mesh net.

Electrical conductivity (used to infer salinity), pH, and temperature were measured at each bore using a Yeo-Cal water quality analyser.

5.3.3. Species Sorting and Identification

In the laboratory, samples were elutriated to separate out heavy sediment particles and sieved into size fractions using 250, 90 and 53 µm screens. All samples were sorted under a dissecting microscope. Sorted animals were identified to species or morphospecies using available keys and species descriptions. When necessary, animals were dissected and examined under a compound microscope. Morphospecies determinations were based on characters used in species keys.

5.4. Compiling Species Lists

Identifications of animals that could not be identified to species/morphospecies level (i.e. family level identification of a specimen that was immature or damaged) were included in calculations of species richness only if the specimens could not belong to species already recorded. For example, specimens of *Draculoides* sp. and *Draculoides* sp. B04 were treated as a single species because it was likely that the animals identified to genus *Draculoides* were, in fact, those already recorded as *Draculoides* sp. B04. The purpose of this criterion was to prevent higher level identifications falsely inflating species richness.

5.5. Personnel

Fieldwork was undertaken by Sean Bennett, Jim Cocking, Mike Scanlon, Dean Main and Andrew Trotter. Sample sorting was done by Jane McRae, Lucy Gibson, Jeremy Quartermaine, Sean Bennett, Mike Scanlon, Jim Cocking, Heather McLetchie, Grant Pearson, Dean Main and Andrew Trotter. Identifications were made by Jane McRae, Mike Scanlon and Stuart Halse.

5.6. Other Sampling

Both troglofauna captured as by-catch from stygofauna sampling and stygofauna captured during troglofauna sampling are included in species lists and interpretations of species distributions.

6. RESULTS

6.1. Troglofauna

6.1.1. Troglofauna Occurrence and Abundance

Sampling at Iron Valley yielded 112 troglofaunal animals, representing seven Classes, 11 Orders and 16 species (Table 6.1, Table 6.2). Two arachnid Orders were recorded: Pseudoscorpionida (1 species) and Schizomida (1 species). The only crustacean Order collected was Isopoda (3 species). Chilopoda were represented by one species of an unknown Order (the damaged specimen could not be further identified morphologically). Diplopoda were represented by Polyxenida (1 species) and Symphyla by Cephalostigmata (1 species). There were five Orders of hexapods (Entognatha/Insecta): Diplura (2 species), Blattodea (2 species), Hemiptera (2 species), Coleoptera (1 species) and Diptera (1 species). (Table 6.1, Figure 6.1).

Table 6.1. Troglofauna species recorded at the Iron Valley Project with known distribution indicated.

Higher Groups		Species	Number of individuals		Known from outside impact area
			Impact	Reference	
Arachnida					
	Pseudoscorpionida				
		Lagynochthonius sp. B02	1		Yes, known from IOH Yandicoogina tenement; and elsewhere in the Hamersley Range[1,2]
	Schizomida				
		Draculoides sp. B04	2	1	Yes
Crustacea					
	Isopoda				
		Armadillidae sp. B04	1		Yes, known elsewhere in the Hamersley Range[2]
		Troglarmadillo sp. B26	5		Yes, known elsewhere in the Hamersley Range[2]
		nr *Andricophiloscia* sp. B03		1	Yes, from reference bores only
Chilopoda					
		Chilopoda sp.	1		Uncertain
Diplopoda					
	Polyxenida				
		Lophoproctidae sp. B01	3		Yes - very widespread species[1]
Symphyla					
	Cephalostigmata				
		Symphyella sp. B05		1	Yes, from reference bore and from Phil's Creek[2]
Entognatha					
	Diplura				
		Projapygidae sp. B02		1	Yes, from reference bore only
		Japygidae sp. B04	1		Yes - very widespread species[1]
Insecta					
	Blattodea				
		Nocticola sp. B01	3		Yes - very widespread species[1]
		Nocticola sp. B09	2	1	Yes
	Hemiptera				
		Meenoplidae sp.		6	Probably - one of two widespread species[1]
		Hemiptera sp. B01	1		Yes - very widespread species[1]
	Coleoptera				
		Staphyliinidae sp. B01		43	Yes, from reference bores only
	Diptera				
		Sciaridae sp. B01	8	22	Yes - very widespread species[1]

[1]Bennelongia 2009a; [2]Bennelongia unpublished data.

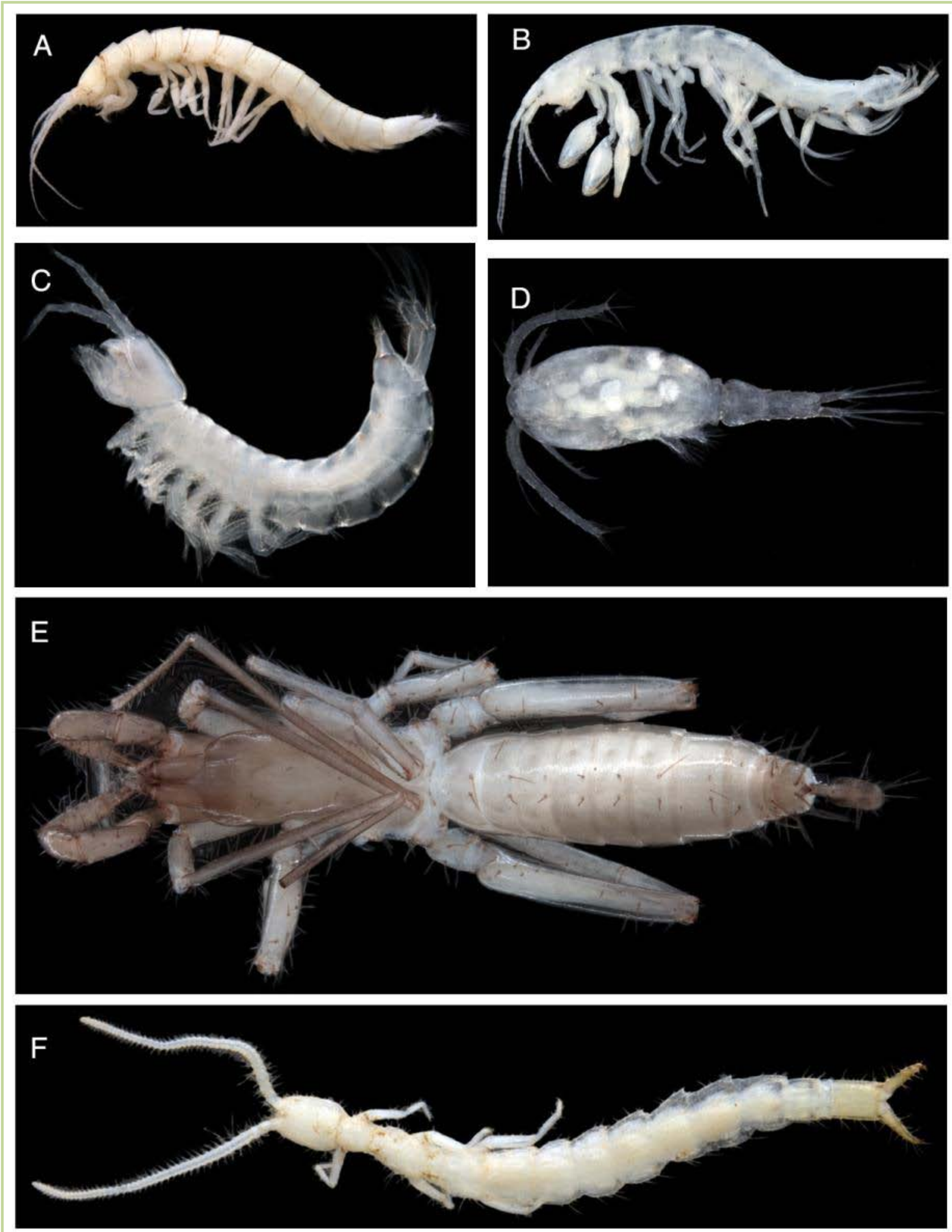

Figure 6.1. Stygofauna (A-D) and troglofauna photographs (E-F).
(A) *Pygolabis* sp. B06 (B) *Maarrka weeliwollii* (C) nr *Billibathynella* sp. B01 (D) *Thermocyclops aberrans* (E) *Draculoides* sp. B04 (F) Japygidae sp. B04.

Table 6.2. Higher level identifications (immature or incomplete specimens).

Higher Groups		Taxa	Number of individuals		Probable species
			Impact	Reference	
Arachnida					
	Schizomida				
		Draculoides sp.		2	*Draculoides* sp. B04
Entognatha					
	Diplura				
		Diplura sp.	1		Projapygidae sp. B02 or Japygidae sp. B04
Insecta					
	Blattodea				
		Nocticola sp.	2	3	*Nocticola* sp. B01 or *Nocticola* sp. B09

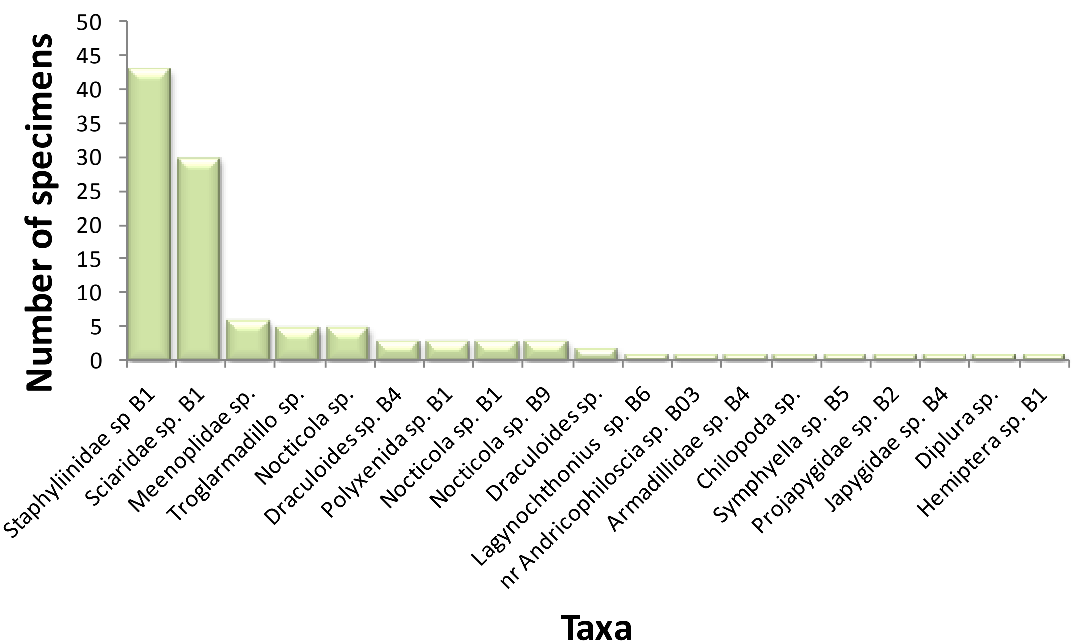

Figure 6.2. Capture abundance of each troglofauna species at the Iron Valley Project.

Seven animals were collected that did not appear to represent additional species, but which could not be properly identified to species level because they were damaged, juvenile or the wrong sex (Table 6.2). All are likely to belong to species in Table 6.1.

Staphyliinidae sp. B01 and Sciaridae sp. B01 were the numerically dominant species within the Iron Valley Project (Table 6.1, Figure 6.2). Nearly all other species were collected in low abundance (≤6 specimens) and eight species were recorded as singletons, i.e. only one animal of that species was collected during the study (Table 6.1; excluding unidentifiable specimens). Three of these singleton species (Japygidae sp. B04, *Symphyella* sp. B05 and Hemiptera sp. B01) have been previously recorded elsewhere in the central Pilbara (Table 6.1, Bennelongia 2009a, b, unpublished data).

The number of troglofaunal specimens collected per sample was about three times higher from reference bores than impact bores (Table 6.3). However, the number of species per sample was essentially the same for reference and impact bores (Table 6.3). The number of species collected within the mine pit (11) was higher than in the reference area (8) (Table 6.3).

Table 6.3. Summary statistics of troglofauna sampling at the Iron Valley Project.

Bore type	No. of Samples	Total Specimens	Mean specimens per sample	No. of Species	Mean species per sample
Impact	86	31	0.36	11	0.20 ± 0.06
Reference	82	81	0.99	8	0.20 ± 0.02

6.1.2. Troglofauna Species of the Proposed Mine Pits

Eleven of the 16 species recorded at the Iron Valley Project were recorded within the proposed mine pits (i.e. the impact area) (Table 6.1). Of these 11 species, 10 species are known to occur in reference areas outside the mine pits or at deposits elsewhere in the Pilbara. One species, Chilopoda sp. (recorded as a singleton based on a damaged specimen) is only known from the proposed mine pit (Figure 6.3). The taxonomy of this specimen cannot be taken further and, therefore, its range cannot be determined.

6.1.3. Troglofauna Distributions

Overall, about two-thirds of the troglofauna species collected are known from outside the Project area. Given that three species are known only from their singleton records at Iron Valley and most animals occurred in low abundance, making it likely their ranges are under-estimated; it appears that the troglofauna community of Iron Valley is not restricted to the Project area.

For example, five species (Lophoproctidae sp. B01, Japygidae sp. B04, *Nocticola* sp. B01, Hemiptera sp. B01 and Sciaridae sp. B01) are very widespread and known from many locations in the Pilbara (Table 6.1, Bennelongia 2009a, b). A sixth species, Meenoplidae sp. (represented by five nymphs from a reference hole), probably belongs to one of two species that are very widespread in the Pilbara (Table 6.1, Bennelongia 2009a). A seventh species, *Symphyella* sp. B5, is known from Phil's Creek approximately 12 km from the Iron Valley Project and an additional three species, *Lagynochthonius* sp. B02, Armadillidae sp. B04 and *Troglarmadillo* sp. B26, are known more locally in the Hamersley Range (Table 6.1).

6.1.4. Sampling Efficiency

Documenting the composition of troglofauna communities and the distribution of the species within them is difficult because a high proportion of troglofauna species occur in low abundance. At the Project site, 13% of all troglofaunal animals represented two-thirds of all species. Only two species were represented by more than five animals (Figure 6.2).

Despite the low abundance of most individual species, the average number of troglofaunal animals caught at the Iron Valley Project was 0.66 per sample, which is well above the historical capture rate of 0.25 for the Pilbara (Subterranean Ecology 2007). Capture rates were higher in the reference area than impact area (0.99 specimens per sample versus 0.36, in Table 6.3). Scraping and trapping gave similar yields but reference bores yielded better than impact bores (Figure 6.4).

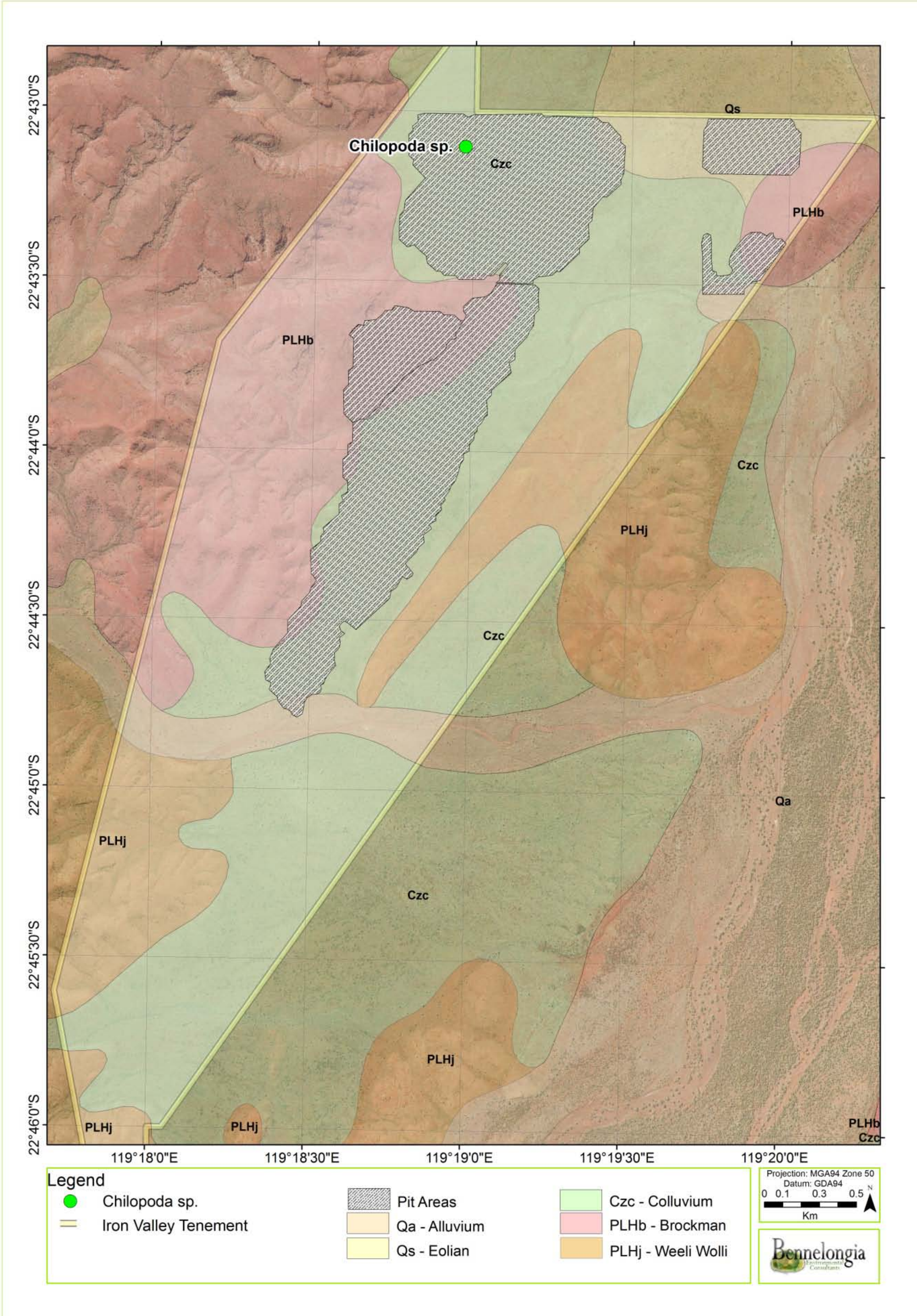

Figure 6.3. Locations of specimens of troglofauna species collected only from impact bores.

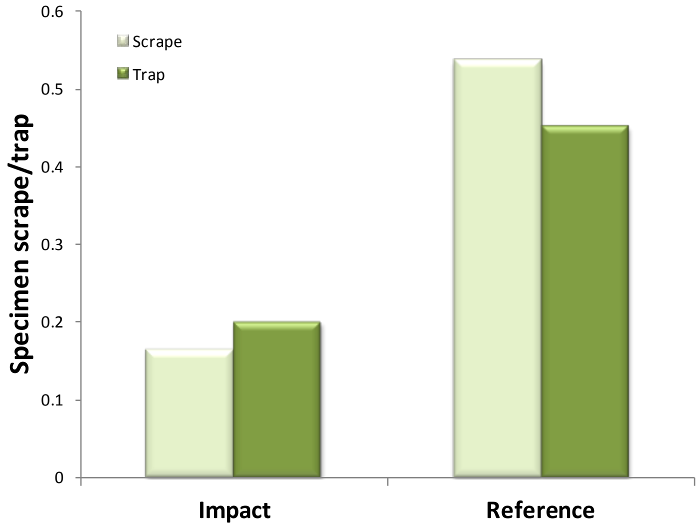

Figure 6.4. Comparison of capture rates between scraping and trapping.

6.2. Stygofauna

6.2.1. Stygofauna Occurrence and Abundance

Stygofauna sampling yielded 2,153 specimens of at least 23 species of eight Orders, including Tubificida (3 species), Hydracarina (1 species), Ostracoda (3 species), Copepoda (4 species), Syncarida (3 species), Amphipoda (7 species), Isopoda (1 species) and nematodes of unknown order/s (Table 6.4, Figure 6.1).

Copepods were the numerically dominant group within the Iron Valley Project, with species of oligochaetes, amphipods and syncarids also relatively abundant (Table 6.4, Figure 6.5). *Diacyclops humphreysi humphreysi*, *Thermocyclops aberrans* and nr *Billibathynella* sp. B01 were the most numerous species (Table 6.4, Figure 6.5). The majority of taxa were collected at low abundance with the most abundant third of the species accounting for 91% of all the animals collected and the least abundant third only 1% (Figure 6.5).

The number of stygofaunal specimens collected per sample was about three times higher from impact bores than bores reference (Table 6.6). While, the number of species per sample was about double that in impact bores compared to reference bores (Table 6.6). The number of species collected from impact bores (22) was higher than that from reference bores (13) (Table 6.6).

6.2.2. Species Identification Issues

Some stygofauna could not be identified to species level (Table 6.3). It is probable that all belong to species in Table 6.4 but in most cases the animals were too juvenile or damaged for identification below Family or Order level. Table 6.4 contains one species identified only to genus level (*Bathynella* sp.).

The taxonomy of *Bathynella* in Australia is poorly resolved and Iron Valley specimens cannot be compared reliably with specimens from elsewhere in the Pilbara, although it is considered that a single species occurs at Iron Valley. The taxonomy of *Chydaekata* sp. has been the subject of considerable genetic research and it is believed a single species of *Chydaekata* in present within the Weeli Wolli/Marillana catchment (see Finston and Johnson 2004; Finston *et al*. 2007). This species has been recorded from a number of locations on Weeli Wolli Creek and the Fortescue Marsh, with the closest record to Iron Valley being 6.5 km away.

Table 6.4. Stygofauna species recorded from the Iron Valley Project.
All specimens collected from impact area. Number of animals and whether species are known from outside impact area are shown.

Higher Groups		Species	Impact	Reference	Known from outside of impact
Nematoda					
		Nematoda sp.	15		Not assessed in EIAs, widespread in the Pilbara
Oligochaeta	Tubificida				
		Phreodrilid with dissimilar ventral chaetae	27		Yes, Pilbara-wide[1]
		Phreodrilid with similar ventral chaetae	23		Yes, Pilbara-wide[1]
		Enchytraeus Pilbara sp. 1	126	6	Yes, Pilbara-wide[1]
Acariformes					
	Hydracarina				
		Recifella sp. P1 (nr *umala*)	1		Yes, central Pilbara[1]
Crustacea	Ostracoda				
		Humphreyscandona 'janeae'		3	Reference are only, and widespread in the Fortescue catchment[1]
		Meridiescandona lucerna	9	31	Yes, and also more widely in the Fortescue catchment[1]
		Meridiescandona sp. BOS 171	47		No
	Copepoda				
		Microcyclops varicans	158		Yes, Pilbara-wide and beyond[2]
		Diacyclops cockingi	1	33	Yes, Pilbara-wide[3]
		Diacyclops humphreysi humphreysi	617	178	Yes, Pilbara-wide and beyond[4]
		Thermocyclops aberrans	223	100	Yes, central Pilbara[5]
	Syncarida				
		Bathynella sp.	3		Uncertain
		nr *Billibathynella* sp. B01	298		Yes, known from lower Weeli Wolli and Marillana Creeks[6]
		Atopobathynella sp. B07	2		Yes, known from Marillana Creek[6]
	Amphipoda				
		Maarrka weeliwollii	2	1	Yes, widespread in Weeli Wolli/Marillana catchment[6,7]
		Chydaekata sp. E	9	1	Yes, widespread in Weeli Wolli/Marillana catchment[6,8]
		Paramelitidae Genus 2 sp. B01	87	6	Yes, lower Weeli Wolli Creek[2]
		Paramelitidae Genus 2 sp. B02	30	7	Yes, widespread in Weeli Wolli/Marillana catchment[6]
		Paramelitidae sp. B16	44	1	Yes, known from lower Weeli Wolli and Marillana Creeks[6]
		Paramelitidae sp. B03	2	1	Yes, widespread in Weeli Wolli/Marillana catchment[6]
		Paramelitidae sp. B26	3	10	Yes, known from southern floodplain of the Fortescue Marsh[6]
	Isopoda				
		Pygolabis sp. B06	11		Yes, known from lower Weeli Wolli and Marillana Creeks[6]

[1]Halse *et al*. unpublished data; [2]Sars (1863); [3]Karanovic (2006); [4]Pesce and De Laurentiis (1996); [5]Lindberg (1952); [6]Bennelongia unpublished data; [7]Finston *et al*. (2011); [8]Finston *et al*. (2009).

Table 6.5. Higher level stygofauna identifications (immature or incomplete specimens).
Number of animals collected and probable species is shown.

Higher Groups	Taxa	Impact	Reference	Probable species
Oligochaeta				
Tubificida				
	Enchytraeidae sp.	12	1	*Enchytraeus* Pilbara sp. 1
Crustacea				
Ostracoda	Ostracoda sp.	2		One of the three ostracods in Table 6.4
Copepoda				
	Diacyclops sp.		2	*Diacyclops humphreysi humphreysi* or *Diacyclops cockingi*
	Thermocyclops sp.	2		*Thermocyclops aberrans*
Amphipoda				
	Amphipoda sp.	1	3	One of the amphipods in Table 6.4
	Paramelitidae sp.	10	3	One of the paramelitid in Table 6.4
Isopoda				
	Pygolabis sp.	1		*Pygolabis* sp. B06

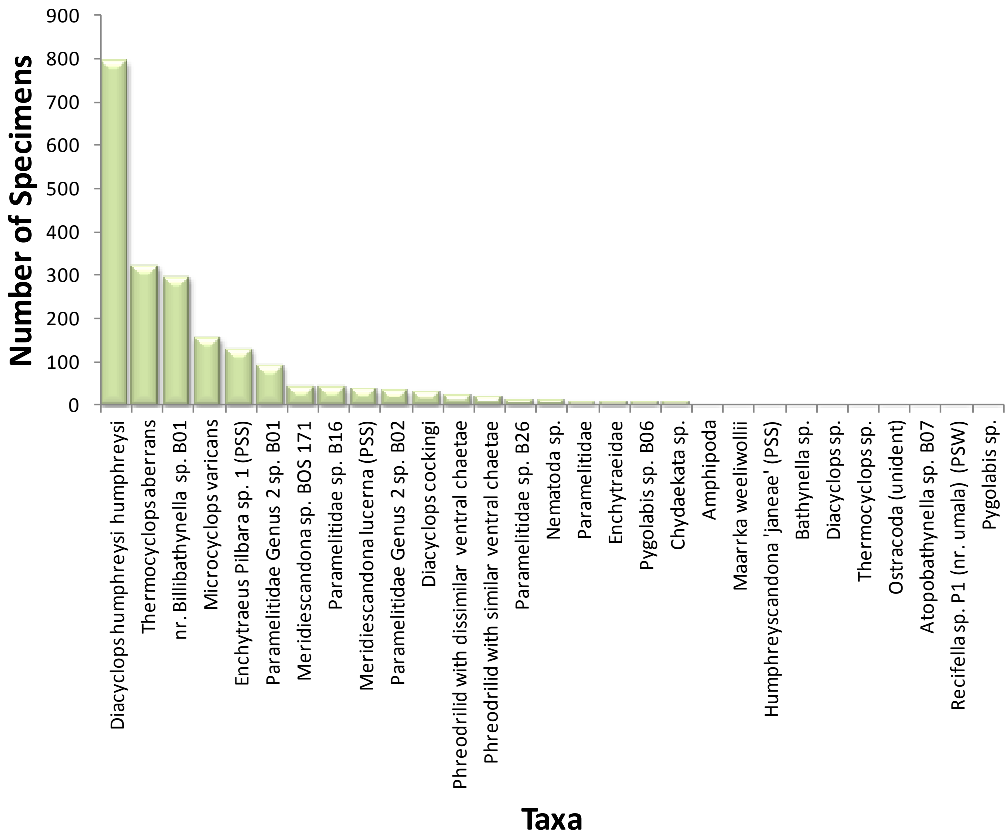

Figure 6.5. Capture abundance of each stygofauna species at the Iron Valley Project.

Table 6.6. Summary statistics of stygofauna sampling at the Iron Valley Project.

Bore type	No. of Samples	Total Specimens	Mean specimens per sample	No. of Species	Mean species per sample
Impact	49	1764	36	22	1.77 ± 0.27
Reference	35	389	11.1	13	0.71 ± 0.12

6.2.3. Stygofauna Species of the Proposed Drawdown Cone

Twenty-two stygofauna species were recorded from within the proposed drawdown cone and all but two of these species are known from elsewhere (Table 6.4). The remaining two species potentially have more localised ranges (Figure 6.6). The ostracod *Meridiescandona* sp. BOS 171 has to date been collected only from the area that will be impacted by groundwater drawdown, where it has been found in five drill holes. The syncarid *Bathynella* sp. has also been collected only from the area that will be impacted by groundwater drawdown (twice at bore WW010). However, it is uncertain if *Bathynella* sp. is a new species (due to the genus level identification) and these specimens may be conspecific with specimens of *Bathynella* that have been previously collected about seven kilometres south-west of the Iron Valley Project (Figure 6.7).

6.2.4. Stygofauna Distributions

Seven of the stygofauna species collected at the Iron Valley Project are very widespread, either known from throughout the Pilbara or beyond (Table 6.4). Four species are known to have relatively extensive ranges in the central Pilbara/Fortescue catchment. Ten species are known from either the Weeli Wolli/Marillana catchment or the southern floodplain of the Fortescue Marsh (Table 6.4).

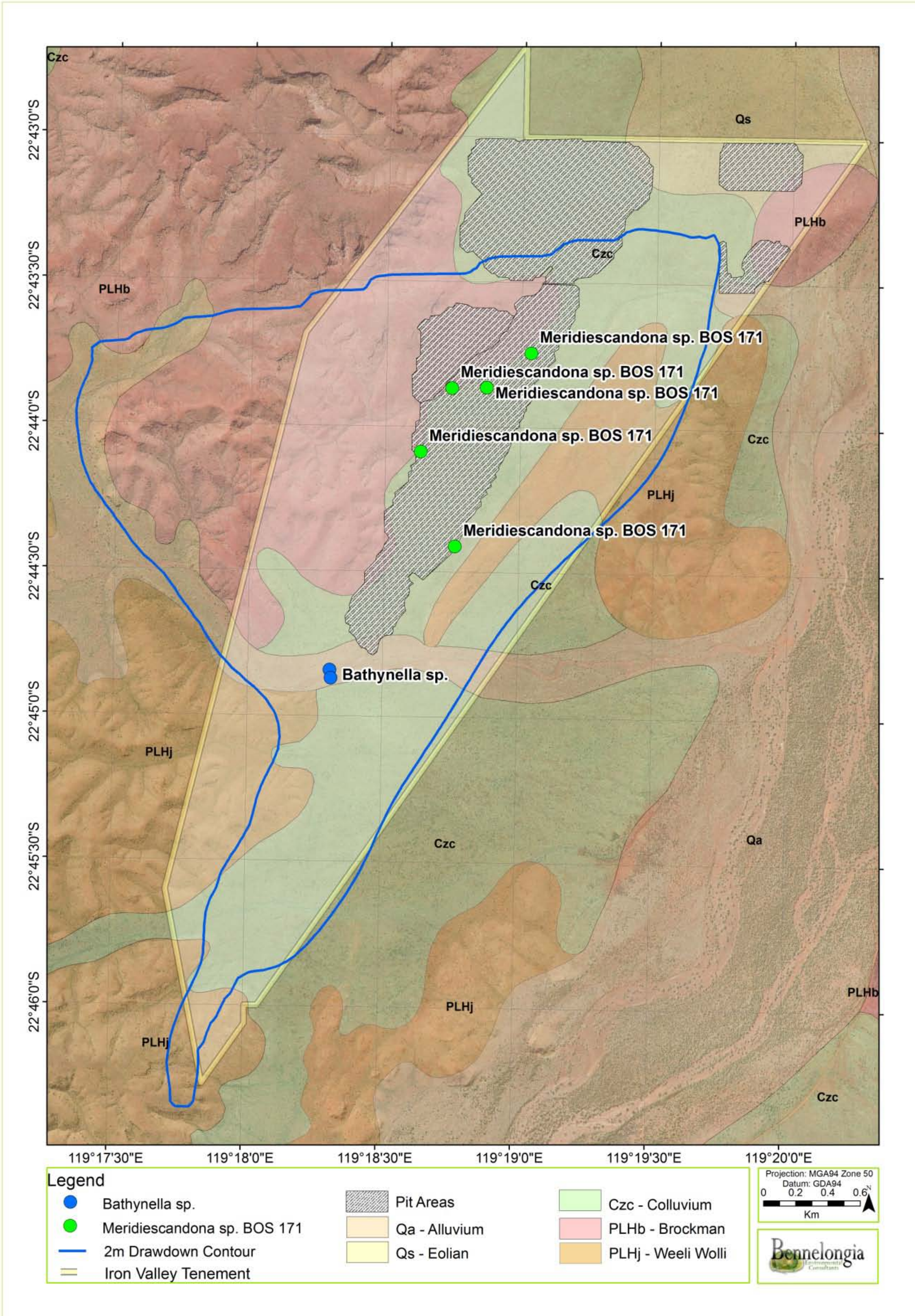

Figure 6.6. Locations of stygofauna species collected only from bores at the Iron Valley Project.
Drawdown cones are expected to extend beyond all of the bores indicated.

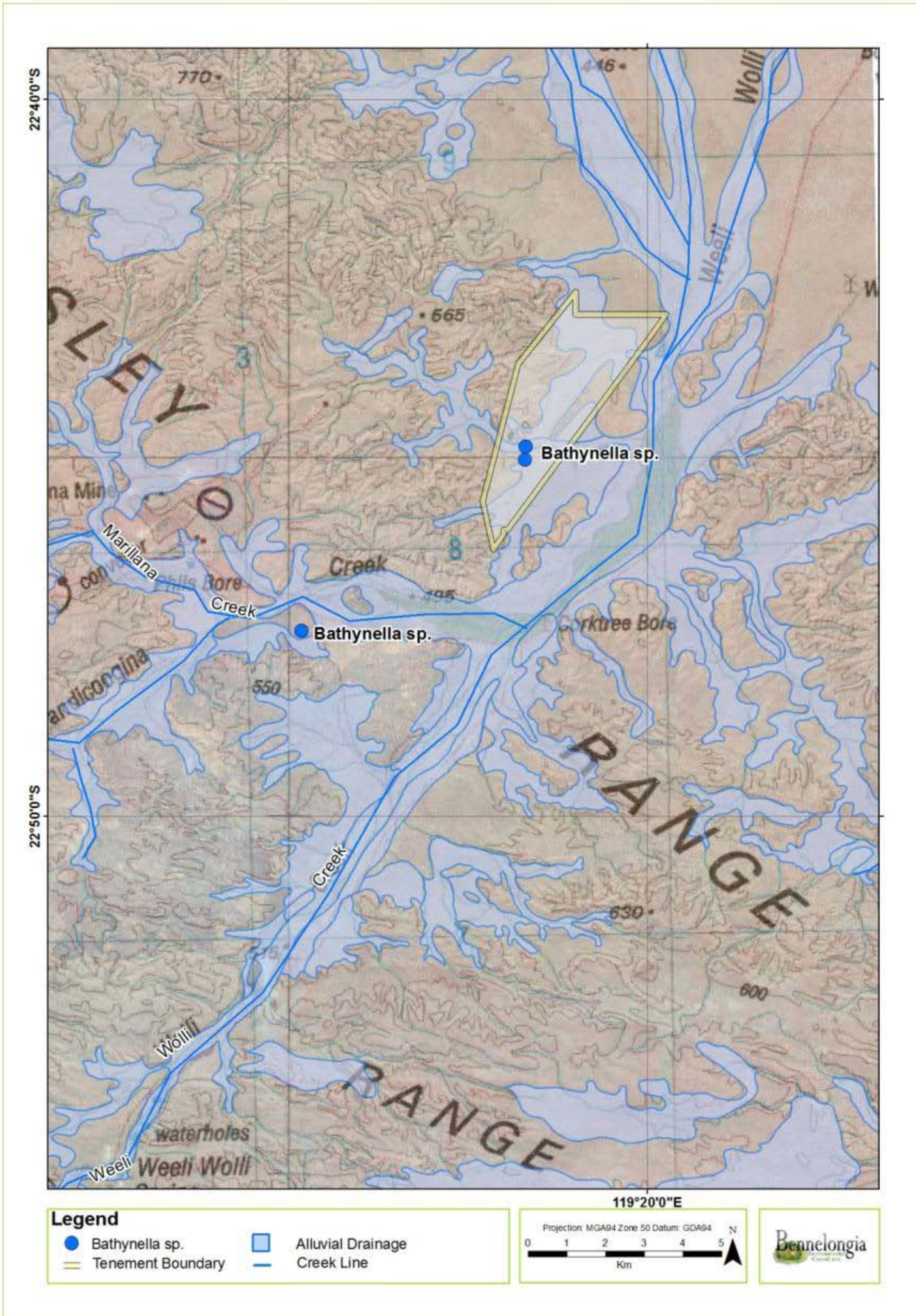

Figure 6.7. Locations of *Bathynella* specimens in the vicinity of the Iron Valley Project.
Specimens from outside the Iron Valley Project were collected during the Pilbara Stygofauna Survey (Halse *et al*. in prep.). Species level relationships are uncertain.

7. DISCUSSION

7.1. Troglofauna

7.1.1. Troglofauna Distributions and Conservation Risks for Species

The range characteristics of different troglofaunal groups in WA are not yet fully described. Troglofauna survey and research has typically focussed on taxonomy and, for the purpose of conservation, the presence or absence of species at particular localities. Little focus has been placed on documenting distributions and the most comprehensive studies to date have been on schizomids, where quite variable (although mostly small) ranges have been identified). Harvey *et al*. (2008) reported that six species of schizomid in the Robe Valley were each tightly restricted to single mesas (the largest only 989 ha), whereas one species (*Draculoides vinei*) in the Cape Range had a linear range of about 50 km.

Many of the troglofauna collected at Iron Valley are known more widely in the Pilbara (Table 6.1). Extensive distributions suggest that species have moderately high dispersal ability, either through possessing a surface dispersal phase in their life cycles or because they inhabit well connected subterranean habitats. Whether very widely dispersed species are obligate troglofauna is sometimes questioned and many such species probably have a surface dispersal phase. However, there seems little doubt that the arachnid species *Draculoides* sp. B04 is a troglobiont. *Draculoides* sp. B04 was found in both impact and reference bores at Iron Valley, suggesting that subterranean habitats within the impact and reference areas are connected. In fact, the true range of *Draculoides* sp. B04 may be considerably greater than demonstrated, owing to the confined distribution of the sampling at the Iron Valley Project and subterranean habitat connections may extend well outside the Iron Valley Project into surrounding areas (see Section 7.1.3).

One species of troglofauna (Chilopoda sp.) is currently known only from within the proposed mine pits at the Iron Valley Project. Chilopoda sp. was recorded as a singleton. The conservation status of this species cannot be quantified because the specimen was too damaged for species identification. It should be noted, however, that:

- All species of Chilopoda collected by Bennelongia in the Pilbara have been collected at very low abundance (110 specimens from over 10,000 troglofauna samples), which makes determination of range very difficult.
- In the rare cases where multiple records for a Chilopoda species exist, they have indicated the species have relatively wide ranges for troglofauna. *Cryptops* sp. B7 and *Cryptops* sp. B10 have been shown to have linear ranges of at least 27 and 90 km, respectively (Bennelongia unpublished data).

7.1.2. Habitat Characterisation

The occurrence of troglofauna is dependent on geology and, if no fissures or voids are present in the strata, no troglofauna will occur. If subterranean spaces are present, the pattern of their occurrence will largely determine the density and distribution of troglofauna. Vertical connectivity with the surface is important for supplying carbon and nutrients to maintain populations of different species (plant roots are an important surface connection), while lateral connectivity of voids is crucial to underground dispersal. Geological features such as major faults and dykes may block off the continuity of habitat and act as barriers to dispersal leading to species having highly restricted ranges.

Although not fully characterised, existing data suggest that, in broad terms, geology is similar both inside and outside the proposed mine pits of the Iron Valley Project. The proposed pit boundaries reflect the extent of economic grade ore rather than prospective subterranean fauna habitat (see Section 2, Appendix 1). The dolerite dyke that transects the Project trending in an east/west direction does not appear to represent a barrier to troglofauna because four species recorded at the Project site are known from both sides of the dyke (Appendix 6). Two of these species are very widespread (Lophoproctidae sp. B01 and Sciaridae sp. B1) and may not be obligate troglofauna but *Nocticola* sp. B09 and *Draculoides* sp. B04 are troglobites.

7.1.3. Iron Valley Troglofauna Community

The 16 species collected from 168 troglofauna samples indicate that the Iron Valley troglofauna community is moderately species rich by Pilbara standards. Large areas such as the Jirrpalpur and Packsaddle Ranges are substantially richer, having about 80 species in total; the larger Cape Preston area is also richer with at least 29 species; while the similar sized Bonnie Creek area south of Nullagine has comparable richness (18 species). The Pardoo area (12 species) and a section of the Chichester Ranges (9 species) seem to have fewer species (Subterranean Ecology 2007; Bennelongia 2008d, 2009a, b).

Abundance at the Iron Valley Project (0.66 animals per sample, impact and reference data combined) was similar to that observed for many areas of the Pilbara. Some previous rates of collection are 0.64 specimens per sample at Ore Body 24 in the Opthalmia Range, 0.70 in the Jirrpalpur Range, 0.87 at the Packsaddle Range, 0.95 at Phil's Creek and 1.1 in the Bonnie Creek area south of Nullagine (Bennelongia 2008b, c, 2009a, c).

Abundance was considerably greater in reference than impact holes within the Iron Valley Project (Table 6.3). This appears to suggest that surrounding habitat at the Iron Valley Project is more favourable for troglofauna than the commercial grade ore of the pit areas, but reference hole abundance was boosted by high capture of two species (Staphyliinidae sp. B01 and Sciaridae sp. B01).

7.2. Stygofauna

7.2.1. Stygofauna Distributions and Conservation Risk for Species

Most of the stygofauna species collected are known to, or probably, occur beyond the Iron Valley Project. On the basis of existing data, one species appears to be possibly threatened by Project development (the ostracod *Meridiescandona* sp. BOS 171), while the status of syncarid species identified only to genus (*Bathynella* sp.) is unclear and it is must also be regarded as potentially impacted. Existing information about the likely ranges and conservation significance of both species is discussed below:

1. *Meridiescandona* sp. BOS 171 is known only from the Iron Valley Project (Figure 6.6), which lies within the small area where *Meridiescandona* has radiated (see Karanovic 2007; Reeves *et al*. 2007). *Meridiescandona* sp. BOS 171 was collected from five bores within the Iron Valley Project. The presence of large stygofauna such as *Maarrka weeliwollii* and *Pygolabis* sp. B06 (the largest Pilbara stygofauna species), both in the Project impact area and more widely in Weeli Wolli/Marillana Creek, suggests that considerable habitat continuity exists in the alluvial drainage channels around the Project (see Appendix 7). It is likely that the much smaller *Meridiescandona* sp. BOS 171 makes use of such habitat connectivity and is not restricted to the Project area, although it is yet to be collected outside the Project area.

2. *Bathynella* sp. represents a genus level identification because of the absence of a satisfactory taxonomic foundation for recognizing boundaries of Australian species. Whether *Bathynella* sp. is known only from the Project area is unclear. The occurrence of larger stygofauna species such as *Maarrka weeliwollii* and *Pygolabis* sp. B06 more widely in the Marillana/Weeli Wolli Creek catchment (see Appendix 7) suggests it is unlikely that the small *Bathynella* sp. would be restricted to the Project area. Therefore, *Bathynella* sp. found at Iron Valley may be the same as the *Bathynella* species that was collected seven kilometres away in previous surveys (Figure 6.7). The only evidence suggesting that the species may be different is that two-thirds of known syncarid species have linear ranges of <10 km (Camacho and Valdecasas 2008).

When the 8 m drawdown cone is put into context of the total depth of the local aquifer system (at least 170 m deep, see Section 2 and Appendix 3), drawdown probably does not represent a significant threat to stygofauna species, unless such species are further restricted to particular units of the local aquifer system.

7.2.2. Habitat Characterisation

The dolerite dyke that transects the Project trending in an east/ west direction would appear to be a potential barrier to stygofauna movements because of the hydraulic discontinuity it represents (groundwater level is about 40 m lower on the northern side of the dyke). However, the distribution of stygofauna species suggests the dyke is not a barrier with three amphipods, a copepod and an ostracod found on both sides of the dyke (Paramelitidae Genus 2 sp. B01, Paramelitidae sp. B16, Paramelitidae sp. B26, *Diacyclops humphreysi humphreysi* and *Meridiescandona lucerna*) (Appendix 6).

7.2.3. Iron Valley Stygofauna Community

The number of stygofauna species collected from the Iron Valley Project (22 species from 84 samples) is relatively modest by Pilbara standards. For example, 34 species from 17 samples were recorded in the upper Fortescue area near Newman (Ethel Gorge community, Halse *et al*. unpublished data) and the wider Fortescue marsh area yielded 55 species in an extensive sampling program (Bennelongia 2007).

8. CONCLUSION

8.1. Troglofauna

The 168 samples on which this report was based met EPA guidelines for troglofauna assessment and the following conclusions can be drawn:

- The troglofauna community at the Iron Valley Project consists of 11 Orders and 16 species. Two arachnid Orders were recorded: Pseudoscorpionida (1 species) and Schizomida (1 species). The only crustacean Order collected was Isopoda (3 species). Chilopoda were represented by one species of an unknown Order (a partial and damaged specimen prevented identification based on morphology). Diplopoda were represented by Polyxenida (1 species) and Symphyla by Cephalostigmata (1 species). There were five Orders of hexapods (Entognatha/Insecta): Diplura (2 species), Blattodea (2 species), Hemiptera (2 species), Coleoptera (1 species) and Diptera (1 species).
- Eleven of the 16 species recorded at the Iron Valley Project were recorded within the proposed mine pits (i.e. the impact area) (Table 6.1). Of these 11 species, 10 species are known to occur in reference areas outside the mine pits or at deposits elsewhere in the Pilbara.

- One species of troglofauna (Chilopoda sp.) is currently known only from within the proposed mine pits at the Iron Valley Project. Chilopoda sp. was recorded as a singleton. The conservation status of this species cannot be quantified because the specimen was too damaged for species identification.

8.2. Stygofauna

The 84 samples on which this report was based meet the EPA requirement for stygofauna assessment. The following conclusions are drawn from the survey:

- Stygofauna sampling yielded 2,153 specimens consisting of at least 23 species of at least eight Orders, including Tubificida (3 species), Hydracarina (1 species), Ostracoda (3 species), Copepoda (4 species), Syncarida (3 species), Amphipoda (7 species), Isopoda (1 species) and nematodes of unknown order/s.
- Many species of stygofauna collected in the Iron Valley Project area (including the largest species *Pygolabis* sp. B01) are known to occur in surrounding areas of the Weeli Wolli/Marillana Creek drainage channel and, therefore, it is inferred that habitat connections exist between Iron Valley and these areas.
- To date the ostracod *Meridiescandona* sp. BOS 171 and, possibly, the syncarid *Bathynella* sp. have been collected only from the Iron Valley Project impact footprint.
- Consequently, the ostracod *Meridiescandona* sp. BOS 171 and, to lesser extent, the syncarid *Bathynella* sp. are possibly threatened by Project development. However, it is likely that both species exploit the habitat connectivity between the Project and surrounding areas in the same way as demonstrated by most of the stygofauna species at Iron Valley.

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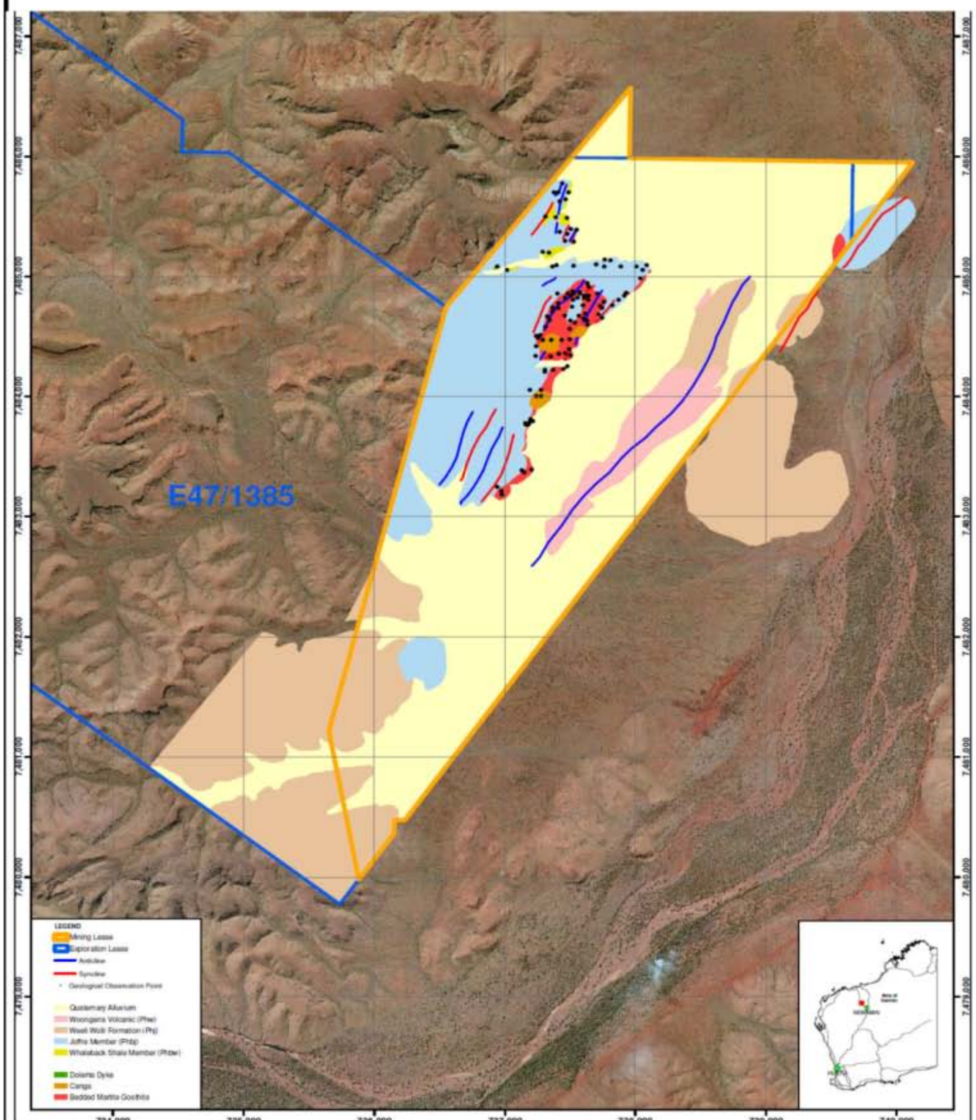
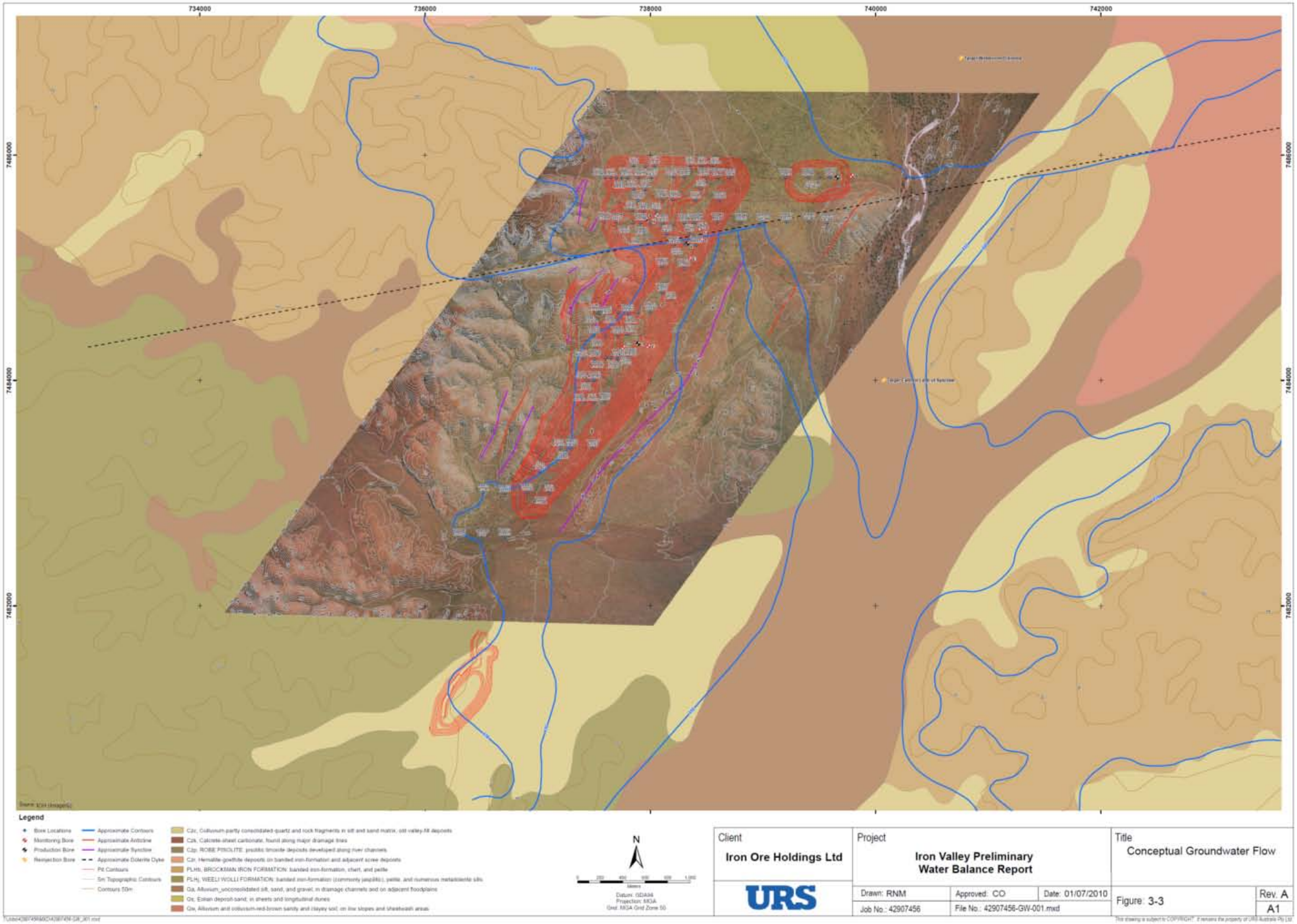
10. APPENDICES

Appendix 1: Geology of the Iron Valley Project

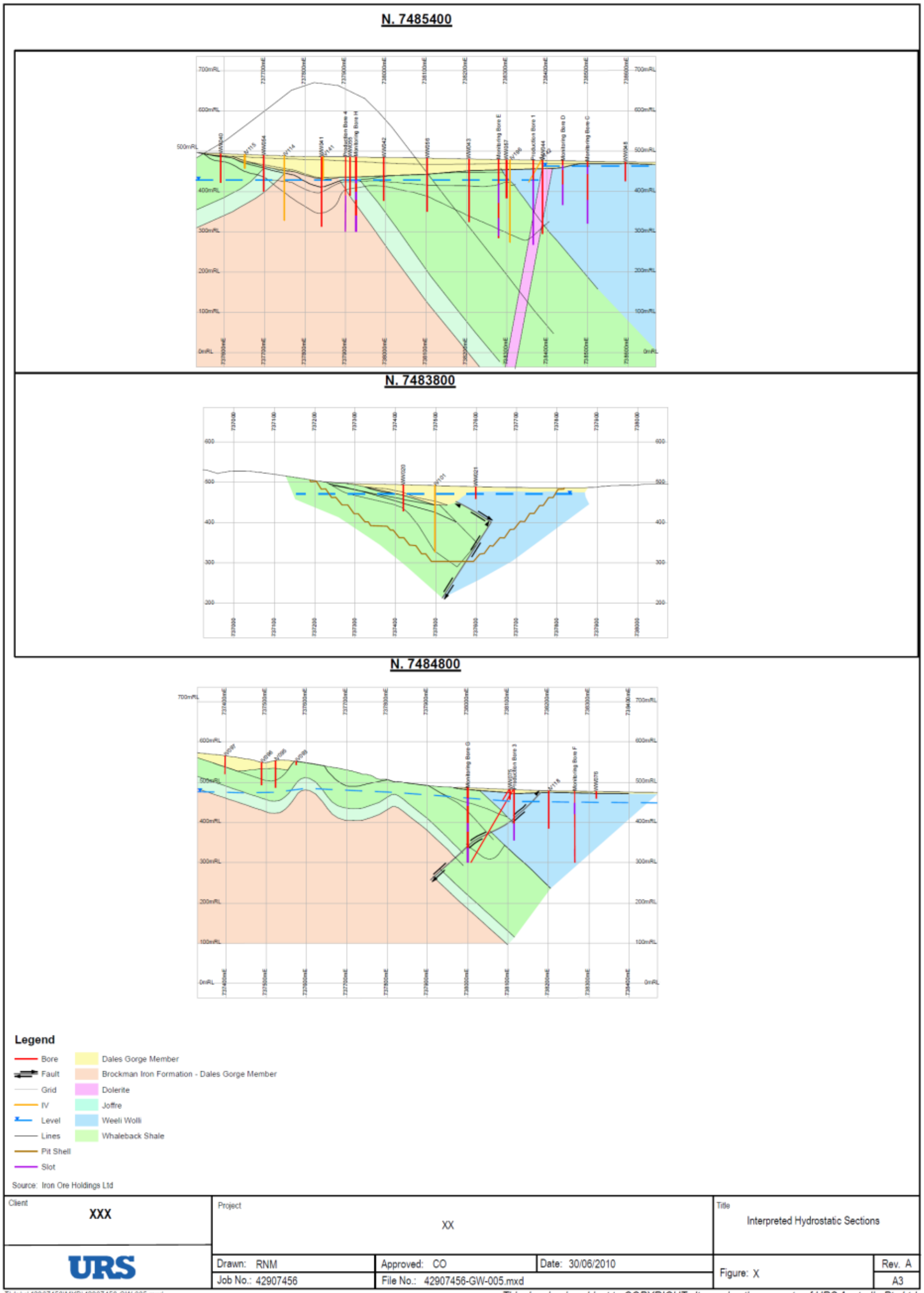


Iron Ore Holdings	Iron Valley Hydrogeological Assessment				Iron Valley Site Geology and Structures (IOH, 2010)
URS	Job No.	42907456	Chk'd By	IGB	Figure 3-2 / Rev. A
	Prep. By	CO 25 Feb '10	Revision No.	0	A4

Appendix 2: Conceptual Groundwater Flow (historical figure)



Appendix 3: Interpreted Hydrostatic Sections



Appendix 4: Co-ordinates of Bores Sampled for Troglofauna at the Iron Valley Project

Bore Code	Site type	Latitude	Longitude
WW022	Reference	-22.7619	119.2994
WW023	Reference	-22.7619	119.3014
WW024	Reference	-22.7619	119.3034
WW026	Reference	-22.7583	119.3043
WW025	Reference	-22.7583	119.3023
WW028	Reference	-22.7547	119.3071
WW027	Reference	-22.7546	119.3051
WW013	Reference	-22.751	119.308
WW011	Reference	-22.7511	119.3041
WW012	Reference	-22.7511	119.306
WW007	Reference	-22.7473	119.3108
WW006	Reference	-22.7474	119.3088
WW005	Reference	-22.7476	119.307
WW010	Reference	-22.7474	119.305
WW009	Reference	-22.7475	119.3031
WW004	Reference	-22.7474	119.3011
WW014	Reference	-22.7438	119.3031
WW015	Reference	-22.7439	119.305
WW016	Impact	-22.7438	119.3069
WW017	Impact	-22.7438	119.3089
WW019	Reference	-22.7402	119.3126
WW018	Impact	-22.7401	119.3107
WW021	Impact	-22.7364	119.3135
WW082	Impact	-22.7347	119.3126
WW081	Impact	-22.7348	119.3104
WW001	Impact	-22.7329	119.3116
WW029	Impact	-22.7329	119.3126
WW002	Impact	-22.7328	119.3136
WW051	Impact	-22.7295	119.3135
WW052	Impact	-22.7293	119.3154
WW080	Impact	-22.7311	119.3145
WW079	Impact	-22.7311	119.3123
WW077	Impact	-22.7255	119.3182
WW003	Impact	-22.7328	119.3155
WW053	Impact	-22.7291	119.3172
WW076	Reference	-22.7274	119.3203
WW075	Impact	-22.7276	119.3183
WW068	Impact	-22.7237	119.3211
WW048	Reference	-22.7219	119.3229
WW044	Impact	-22.7219	119.3205
WW074	Impact	-22.7201	119.3232
WW073	Impact	-22.7201	119.322
WW036	Reference	-22.7182	119.325
WW062	Impact	-22.7182	119.324
WW045	Impact	-22.7218	119.3182
WW046	Impact	-22.7216	119.3169
WW047	Reference	-22.7217	119.3289

Bore Code	Site type	Latitude	Longitude
WW050	Reference	-22.7218	119.3269
WW049	Reference	-22.7218	119.325
WW037	Impact	-22.7181	119.3326
WW038	Impact	-22.718	119.3306
WW039	Impact	-22.718	119.3306
WW061	Impact	-22.7183	119.3221
WW033	Impact	-22.7183	119.3191
WW059	Impact	-22.7183	119.3181
WW035	Impact	-22.7182	119.323
WW032	Impact	-22.7183	119.3172
WW058	Impact	-22.7184	119.3161
WW031	Impact	-22.7184	119.3151
WW069	Impact	-22.7202	119.3144
WW070	Impact	-22.7202	119.3161
WW071	Impact	-22.72	119.3182
WW072	Impact	-22.7201	119.3201
WW057	Impact	-22.7219	119.3201
WW043	Impact	-22.7221	119.3193
WW056	Impact	-22.722	119.3182
WW042	Impact	-22.722	119.3172
WW055	Impact	-22.7219	119.3163
WW041	Impact	-22.722	119.3157
WW054	Impact	-22.722	119.3142
WW040	Impact	-22.7219	119.3133
WW065	Impact	-22.7238	119.3154
WW063	Reference	-22.7238	119.3114
WW064	Reference	-22.7238	119.3134
IV135	Impact	-22.733	119.3107
IV095	Impact	-22.727	119.3126
IV097	Impact	-22.7275	119.3115
IV098	Impact	-22.7283	119.3139
IV100	Impact	-22.7285	119.3109
IV099	Impact	-22.7292	119.3116
IV182	Reference	-22.7221	119.3123
IV209	Reference	-22.7218	119.3318
IVUNK01	Reference	-22.7218	119.3325
IV207	Reference	-22.72	119.3299
IV208	Reference	-22.72	119.3299
IV204	Reference	-22.7198	119.3331
IV453	Reference	-22.7198	119.3348
IV454	Reference	-22.7189	119.3355
IV464	Reference	-22.719	119.3346
IV460	Reference	-22.7181	119.3356
IV452	Reference	-22.7172	119.3341
IV463	Reference	-22.7173	119.3361
IV444	Reference	-22.7146	119.3165
IV448	Reference	-22.7147	119.3145
IV445	Reference	-22.7139	119.3166
IV449	Reference	-22.7138	119.3161

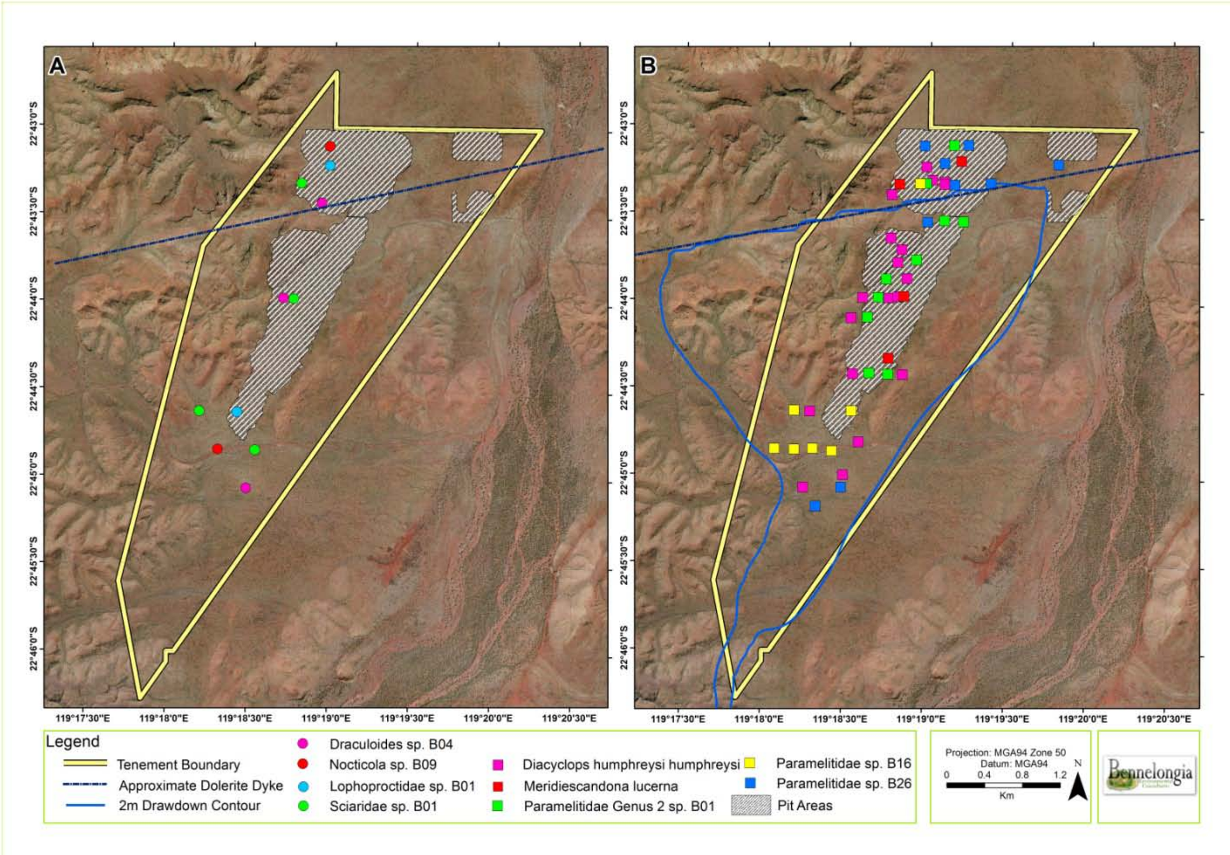
Bore Code	Site type	Latitude	Longitude
IV446	Reference	-22.7129	119.3165
IV450	Reference	-22.7128	119.316
IV109	Reference	-22.7201	119.3133
IV367	Reference	-22.7211	119.3128
IV344	Reference	-22.742	119.3068
IV338	Reference	-22.7438	119.3059
IV247	Reference	-22.7656	119.3004
IV248	Reference	-22.7655	119.3016
IV223	Reference	-22.7546	119.3051
IV273	Reference	-22.7547	119.3042
IV276	Reference	-22.7529	119.3061
IV275	Reference	-22.7529	119.3054
IV274	Reference	-22.7529	119.3042
IV244	Reference	-22.7475	119.306
IV242	Reference	-22.7475	119.304
IV241	Reference	-22.7456	119.3089
IV235	Reference	-22.7456	119.3054
IV239	Reference	-22.7545	119.3051

Appendix 5: Co-ordinates of Bores Sampled for Stygofauna at the Iron Valley Project

Bore code	Site type	Latitude	Longitude
WW024	Impact	-22.7619	119.3034
WW025	Impact	-22.7583	119.3023
WW028	Impact	-22.7547	119.3071
WW027	Impact	-22.7546	119.3051
WW013	Impact	-22.751	119.308
WW011	Impact	-22.7511	119.3041
WW012	Impact	-22.7511	119.306
WW007	Impact	-22.7473	119.3108
WW006	Impact	-22.7474	119.3088
WW005	Impact	-22.7476	119.307
WW010	Impact	-22.7474	119.305
WW009	Impact	-22.7475	119.3031
WW004	Impact	-22.7474	119.3011
WW001	Impact	-22.7329	119.3116
WW029	Impact	-22.7329	119.3126
WW002	Impact	-22.7328	119.3136
WW051	Impact	-22.7295	119.3135
WW052	Impact	-22.7293	119.3154
WW080	Impact	-22.7311	119.3145
WW079	Impact	-22.7311	119.3123
WW077	Impact	-22.7255	119.3182
WW045	Reference	-22.7218	119.3182
WW046	Reference	-22.7216	119.3169
WW047	Reference	-22.7217	119.3289
WW050	Reference	-22.7218	119.3269
WW049	Reference	-22.7218	119.325
WW038	Reference	-22.718	119.3306
WW061	Reference	-22.7183	119.3221
WW033	Reference	-22.7183	119.3191
WW035	Reference	-22.7182	119.323
WW058	Reference	-22.7184	119.3161
WW070	Reference	-22.7202	119.3161
WW057	Reference	-22.7219	119.3201
WW043	Reference	-22.7221	119.3193
WW056	Reference	-22.722	119.3182
WW042	Reference	-22.722	119.3172
WW055	Reference	-22.7219	119.3163
WW054	Reference	-22.722	119.3142
WW040	Reference	-22.7219	119.3133
WW031	Reference	-22.7184	119.3151
WW071	Reference	-22.72	119.3182
WW022	Impact	-22.7619	119.2994
WW024	Impact	-22.7619	119.3034
WW025	Impact	-22.7583	119.3023
WW013	Impact	-22.751	119.308
WW011	Impact	-22.7511	119.3041
WW007	Impact	-22.7473	119.3108

Bore code	Site type	Latitude	Longitude
WW005	Impact	-22.7476	119.307
WW010	Impact	-22.7474	119.305
WW004	Impact	-22.7474	119.3011
WW014	Impact	-22.7438	119.3031
WW015	Impact	-22.7439	119.305
WW016	Impact	-22.7438	119.3069
WW019	Impact	-22.7402	119.3126
WW021	Impact	-22.7364	119.3135
WW001	Impact	-22.7329	119.3116
WW029	Impact	-22.7329	119.3126
WW002	Impact	-22.7328	119.3136
WW080	Impact	-22.7311	119.3145
WW079	Impact	-22.7311	119.3123
WW003	Impact	-22.7328	119.3155
WW053	Impact	-22.7291	119.3172
WW052	Impact	-22.7293	119.3154
WW051	Impact	-22.7295	119.3135
WW077	Impact	-22.7255	119.3182
WW076	Impact	-22.7274	119.3203
WW075	Impact	-22.7276	119.3183
WW068	Impact	-22.7237	119.3211
WW045	Reference	-22.7218	119.3182
WW046	Reference	-22.7216	119.3169
WW057	Reference	-22.7219	119.3201
WW043	Reference	-22.7221	119.3193
WW042	Reference	-22.722	119.3172
WW055	Reference	-22.7219	119.3163
WW041	Reference	-22.722	119.3157
WW054	Reference	-22.722	119.3142
WW040	Reference	-22.7219	119.3133
WW070	Reference	-22.7202	119.3161
WW078	Impact	-22.7256	119.3202
WW062	Reference	-22.7182	119.324
WW061	Reference	-22.7183	119.3221
WW058	Reference	-22.7184	119.3161
WW033	Reference	-22.7183	119.3191
WW035	Reference	-22.7182	119.323

Appendix 6: Locations of Troglofauna (A) and Stygofauna (B) Species in Relation the Dolerite Dyke that Transects the Iron Valley Project



Appendix 7: Locations of Isopods and Amphipods

Pygolabis spp., *Chydakata* sp. and *Maarrka weeliwollii* specimens collected at the Iron Valley Project (outlined in black) and nearby. Source of data outside the Project: *Pygolabis* sp. = *Pygolabis* sp. B06 (Finston *et al*. 2009); *Maarrka weeliwollii* (Halse *et al*. unpublished data); *Chydaekata* sp. (Halse *et al*. unpublished data, Bennelongia unpublished data).