Bennelongia Environmental Consultants

Eastern Ridge Revised Proposal: Stygofauna Assessment

Prepared for:

BHP Billiton Iron Ore

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Final Report

Short-Range Endemics I Subterranean Fauna

Waterbirds I Wetlands

Eastern Ridge Revised Proposal: Stygofauna Assessment

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EXECUTIVE SUMMARY

Background

Eastern Ridge is approximately three kilometres northeast of Newman in the central Pilbara region of Western Australia. Eastern Ridge Revised Proposal is located on Mineral Lease 244SA and consists of four orebodies: Orebody 24 , Orebody 25 , Orebody 32 East and Orebody 25 West . Iron ore is mined using conventional open pit methods and crushed at Orebody 24 and Orebody 25 Ore Handline Plants or moveable crushers. Ore is then railed to the Newman Hub or directly to Port based on business requirements.

There are three Ministerial Statements that apply to the Eastern Ridge Revised Proposal. Orebody 25 is operated under Ministerial Statement 712, which was granted on 24 January 2006; Orebody 24 is operated under Ministerial Statement 834, which was granted on 8 July 2010; and Orebody 32 is operated under Ministerial Statement 1018, granted on 15 October 2015.

BHP Billiton Iron Ore is proposing to amalgamate the three existing Ministerial Statements and include the new Orebody 25 West mining operation to manage the Eastern Ridge mining operations with one new Ministerial Statement and a single Development Envelope.

Objective

This report provides information about the potential effects on stygofauna from proposed developments within the Eastern Ridge Development Envelope. Potential effects on stygofauna were assessed using available information on the stygofauna species present within the areas likely to be impacted by the proposal. This area includes the nearby Threatened Ecological Community that referred to as the Ethel Gorge Aquifer Stygobiont Community (hereafter Ethel Gorge TEC). The development consists of two proposed extensions to the approved mine pits at Orebody 24 and Orebody 32 East, and the development of new mine pits at Orebody 25 West. BHP Billiton Iron Ore is seeking below water table mining approval at Orebody 24 and Orebody 25 West, in addition to the currently approved below water table mining at Orebody 25.

The objectives of this assessment were:

(1) To document the stygofauna community and constituent species in any areas likely to be impacted by the proposal within the Groundwater Assessment Area (the area of additional groundwater drawdown); and

(2) To determine the future conservation status of the stygofauna species in any areas likely to be impacted by the proposal.

Outcome and Conclusion

Stygofauna surveys in the Groundwater Assessment Area and associated Reference Area were conducted in accordance with the recommendations of the Environmental Protection Authority's Environmental Assessment Guideline 12 and Guidance Statement 54A. Altogether, 178 stygofauna samples were collected from within the Groundwater Assessment Area and 615 stygofauna samples were collected from the Reference Area.

Of the 79 stygofauna species collected in the Groundwater Assessment Area and Reference Area, 49 species were recorded in the Groundwater Assessment Area. Only five of the stygofauna species collected have known ranges that may potentially lead to them being impacted by groundwater drawdown within the Groundwater Assessment Area. These are the enchytraeid worm Enchytraeidae sp. OB3, the ostracod *Pilbaracandona* `OST002`, the phreodrilid worm Phreodrilidae sp. WAM indet. 1, and two syncarids *Bathynella* sp. B12 and Bathynellidae sp. WAM indet. 1. However, based on the distributions of similar species elsewhere in the Pilbara, and the wider distribution of more abundant endemic species to the Ethel Gorge/Upper Fortescue area, the ranges of Enchytraeidae sp. OB3 and

Phreodrilidae sp. WAM indet. 1 are considered likely to extend beyond the Groundwater Assessment Area. The ranges of *Pilbaracandona* `OST002`, *Bathynella* sp. B12 and Bathynellidae sp. WAM indet. 1 are considered moderately likely to extend beyond the Groundwater Assessment.

It is unclear whether increases in salinity may affect stygofauna species as a result of the Eastern Ridge Revised Proposal. However, increases in salinity within the Groundwater Assessment Area from <2,500 mg/L to >2,500 mg/L TDS would possibly cause some local restrictions of species' ranges.

The amount of predicted additional drawdown (approximately 1-2 m) in the area previously approved for groundwater drawdown within the Ethel Gorge TEC will be small relative to drawdowns previously experienced in the TEC since the mid-1970s (fluctuations up to 15 m, but typically in the order of 5-10 m). Consequently, this additional drawdown is unlikely to pose additional threat to stygofauna species. Results of the current monitoring program suggest that the stygofauna community at the Ethel Gorge TEC is resilient to previous drawdown.

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1. INTRODUCTION

1.1. Operation Overview

Eastern Ridge is approximately three kilometres (km) northeast of Newman in the central Pilbara region of Western Australia (Figure 1). The Eastern Ridge Revised Proposal (the proposal) is located on Mineral Lease 244SA and consists of four orebodies: Orebody 24, Orebody 25, Orebody 32 East and Orebody 25 West (Figure 2). Under the proposal, iron ore from the orebodies is mined using conventional open pit methods and crushed at OB24 and OB25 Ore Handline Plants or moveable crushers. Ore is then railed to the Newman Hub or directly to Port based on business requirements.

1.2. Approvals History

Three existing Ministerial Statements apply to the Eastern Ridge Revised Proposal. Orebody 25 is operated under Ministerial Statement 712, which was granted on 24 January 2006; and Orebody 24 is operated under Ministerial Statement 834, which was granted on 8 July 2010. Orebody 32 is operated under Ministerial Statement 1018, granted on 15 October 2015.

1.3. The Proposal

BHP Billiton Iron Ore is proposing to amalgamate the three existing Ministerial Statements to manage the Eastern Ridge mining operations with one new Ministerial Statement and a single Development Envelope.

Key aspects of the proposal include:

- Extension to the approved disturbance area for Orebody 24 mining operations, including below water table mining;
- Extension to the approved disturbance area for Orebody 32 East mining operations;
- Development of a new mining operation at Orebody 25 West, including below the water table mining; and
- An area of groundwater water drawdown beyond that approved under Attachment 2 to Ministerial Statement 712.

The area predicted to experience groundwater drawdown of ≥2 m as a result from the Eastern Ridge Revised Proposal is referred to throughout this report as the Groundwater Assessment Area.

1.4. Report Objectives

This report provides information about the potential effects of the proposal on stygofauna. These effects were assessed using available information about the stygofauna species present within the Groundwater Assessment Area. Drawdown within the Groundwater Assessment Area is associated with below water table extensions to the approved mine pits at Orebody 24 and the development of new below water table mine pits at Orebody 25 West.

Some of the Groundwater Assessment Area lies within the Threatened Ecological Community referred to as the Ethel Gorge Aquifer Stygobiont Community (hereafter Ethel Gorge TEC) (Figure 3). However, groundwater drawdown has already been approved under Attachment 2 to Ministerial Statement 712 in some of the Ethel Gorge TEC.

The objectives of this assessment were:

(1) To document the stygofauna community and constituent species in any areas likely to be impacted by the proposal within the Groundwater Assessment Area; and

(2) To determine the future conservation status of the stygofauna species in any areas likely to be impacted by the proposal.

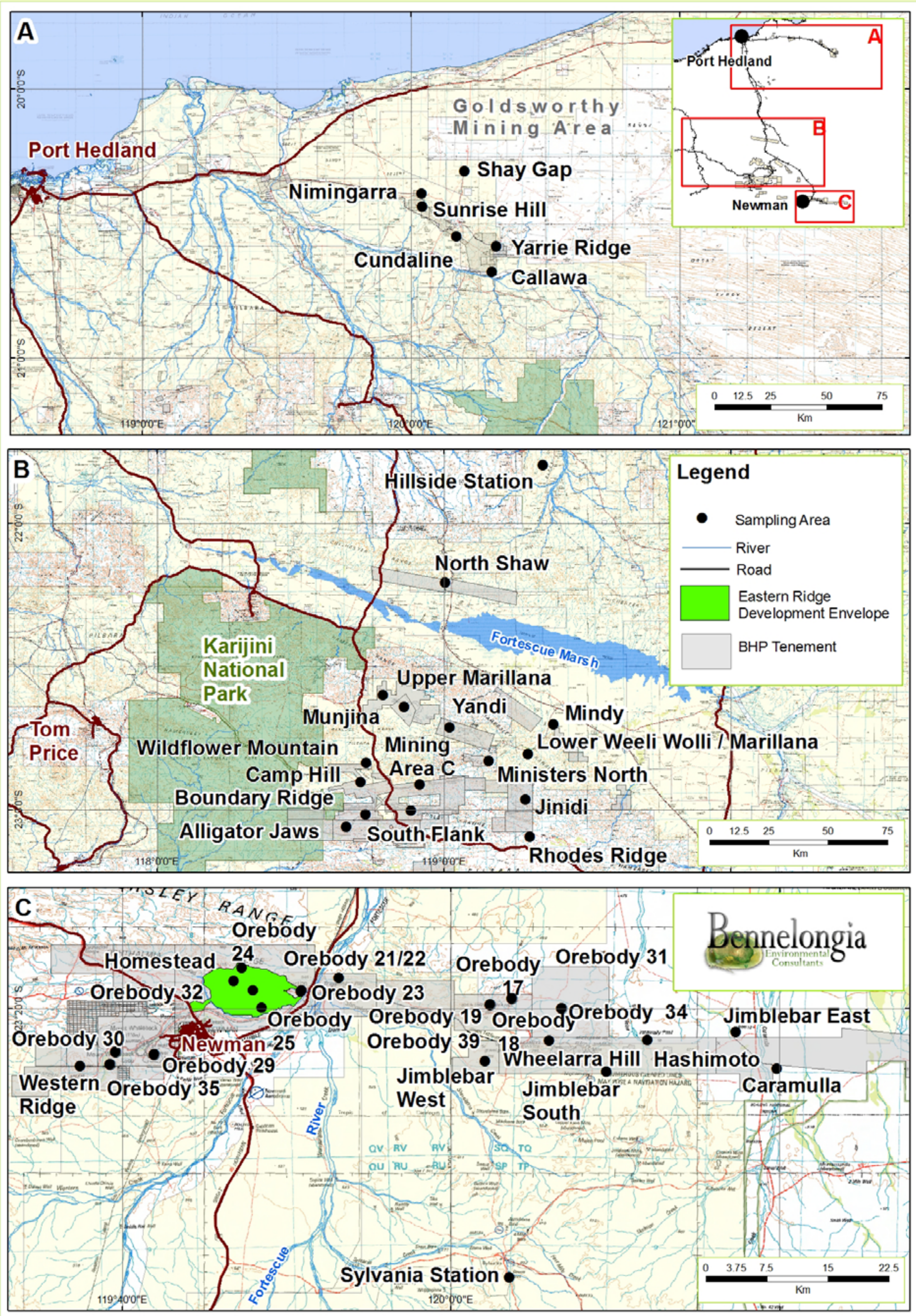

Figure 1. Eastern Ridge in relation to other locations sampled during the Regional Survey.

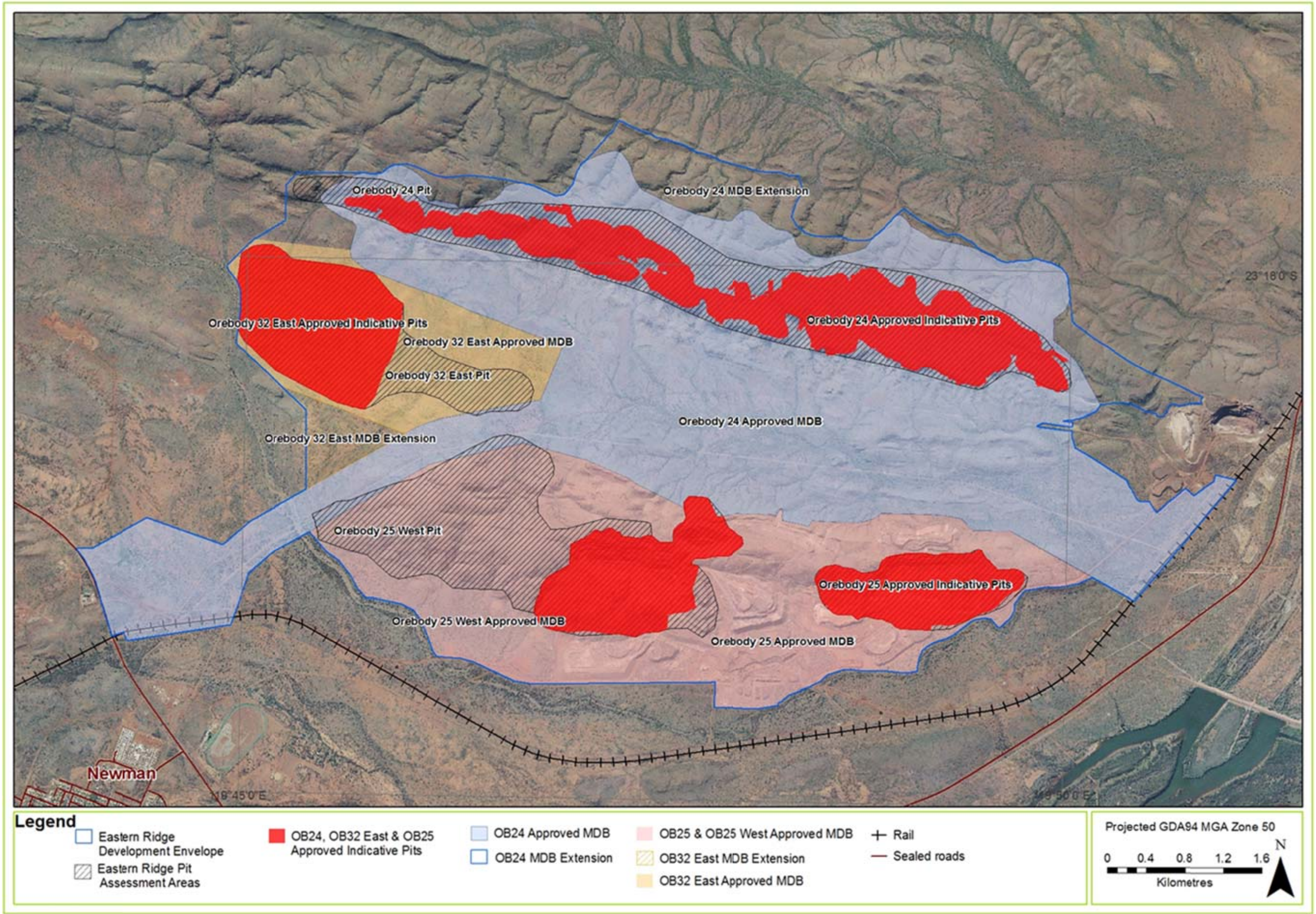

Figure 2. Key components and site layout of the Eastern Ridge Revised Proposal.

1.5. Stygofauna Survey Program

The stygofauna surveys undertaken at Eastern Ridge, on which this report is based, have been part of a broad-scale subterranean fauna survey known as the Regional Subterranean Fauna Sampling Program (the Regional Survey) that began in November 2007. To date, the Regional Survey has resulted in sampling of more than 30 mining and exploration areas across the Pilbara (Figure 1).

2. BACKGOUND

2.1. Stygofauna of the Pilbara

Stygofauna are aquatic animals that live in groundwater. They are predominantly crustaceans, although stygofaunal worms, snails and water mites also exist. In addition, groundwater contains nematodes, bdelloid rotifers and some other groups with taxonomy so poorly resolved that stygal species cannot be reliably distinguished from surface forms. In general, stygofauna are characterised by the loss of eyes and skin pigmentation and the development of a vermiform body shape and more elongated appendages than surface relatives, although some species retain reduced eyes and not all have a vermiform shape.

Stygofauna species are a focus of environmental assessment because a high proportion of them have restricted distributions (Gibert and Deharveng 2002). According to Eberhard *et al*. (2009), about 70% of Pilbara stygofauna species are likely to be short range endemics (SREs) as defined by Harvey (2002), with many of them having much smaller ranges than Harvey's criterion of 10,000 km^2. Species with restricted ranges are vulnerable to extinction following habitat destruction or environmental changes (Ponder and Colgan 2002; Fontaine *et al*. 2007).

Studies to date suggest that the Pilbara region contains the richest stygofauna communities in Australia, with up to 54 species collected from individual bores and a total of about 350 species known from the region (Halse *et al*. 2014). New species are constantly being discovered (Finston *et al*. 2008; Karanovic and Hancock 2009) and it has been estimated that 500-550 species of stygofauna will eventually be found (Eberhard *et al*. 2009). Thus, the Pilbara is not only rich in stygofauna at an Australian level; it also has outstanding richness by global standards (Halse *et al*. 2014).

2.1.1. Habitat Requirements

Stygofauna occur in an array of different groundwater habitats including porous, karstic and fractured-rock aquifers, springs and the hyporheos of streams (Eberhard *et al*. 2005). Calcrete and alluvium are typically considered to be productive habitats for stygofauna, although mafic volcanics support rich stygofauna communities compared with the moderate abundance of communities in banded iron formation (Halse *et al*. 2014). Both lateral and vertical connectivity of fissures and voids are important for the occurrence of stygofauna. Lateral connectivity enables animals to move about underground, while vertical connectivity through to the surface enables recharge of carbon and nutrients to the stygofauna community. There is a clear correlation between transmissivity of an aquifer and its suitability for stygofauna.

Stygofauna have mostly been recorded in fresh to brackish groundwater but may occur in salinities (expressed as conductivity) of up to 55,000 µS/cm (Watts and Humphreys 2006; Schulz *et al*. 2013). Apart from salinity, the physicochemical tolerance of stygofauna to different groundwater parameters, especially in the Pilbara, has been poorly defined (see Halse *et al*. 2014).

2.1.2. Principal Impacts of Mining on Stygofauna

Only impacts causing direct habitat loss are likely to threaten the persistence of stygofauna species. Two activities lead to most of the stygofauna habitat loss associated with mining. These are:

(1) *Groundwater drawdown*. Drawdown of aquifers from dewatering of mine pits or the abstraction of groundwater for ore processing is likely to threaten the persistence of any stygofauna species restricted to the area of drawdown.

(2) *Pit excavation*. Removal of stygofauna habitat when excavating mine pits is likely to threaten the persistence of any stygofauna species restricted to the mine pit. This impact can be assessed when considering groundwater drawdown because the mine pits are contained within the area of drawdown.

Identifying the amount of drawdown required to threaten the persistence of a stygofauna species is potentially a complex process. Natural annual drawdowns in hard rock aquifers are likely to usually be >1 m (Worley Parsons 2012), while annual changes in alluvial aquifers along the Pilbara coast outside of the flow paths of rivers are mostly about 2 m with very occasional larger changes (data from Department of Water, Water Information Reporting).

The threshold drawdown at which stygofauna species are likely to be threatened is likely to be less in shallow or stratified aquifers than in deep uniform ones. However, in most stygofauna assessments in the Pilbara the threshold has been set more or less independently of the depth of the aquifer and its characteristics. Modelled groundwater drawdowns interpreted as likely to cause impact in the Pilbara have mostly been from ≥1 to ≥5 m over and above natural groundwater fluctuations (Biota 2008a, 2010; Bennelongia 2013; MWH 2014). If appropriately applied, such thresholds represent about twice the level of natural fluctuations in Pilbara groundwater levels, so that any drawdown exceeding the threshold is reducing stygofauna habitat in a way that rarely occurs naturally. Most of the area of groundwater impact will, of course, experience more drawdown than the assessment threshold.

2.1.3. Other Impacts of Mining on Stygofauna

There has been little research into the impact of reduced habitat quality, rather than direct habitat removal, on stygofauna. Factors potentially reducing habitat quality include water quality changes, changed habitat structure, reduced energy sources. Spills of petroleum products (see Humphreys 2009). It is considered that, with the possible exception of water quality changes, reduced habitat quality is more likely to reduce animal densities than to threaten species persistence. Possible consequences of some factors reducing habitat quality are summarised below:

(1) *Water quality changes*. In most situations, water quality changes occupy relatively small areas (Rosner 1998; Zhu *et al*. 2001), although increases in groundwater salinity as a result of evapoconcentration in mine void lakes, injection of more saline water into groundwater, and various sources of recharge may be more extensive (Commander *et al*. 1994; Sharma and Al-Busaidi 2001). Salinity changes may potentially threaten some species in the Pilbara because stygofauna occur mostly in fresh water (<1,000 mg/L). Based on surface studies in south-western Australia and elsewhere, overall stygofauna species richness is likely to decline significantly if groundwater salinity reaches c. 2,500 mg/L (Pinder *et al*. 2005). Changes of this magnitude have been observed in parts of the Pilbara as a result of mining (Commander *et al*. 1994). Water quality issues in relation to the Groundwater Assessment Area are discussed further in Section 4.3.

Quality of recharged water within mine sites is often poor because of rock break-up and soil disturbance (e.g. Gajowiec 1993; McAuley and Kozar 2006). Impacts will be minimised through management of surface water on site.

(1) *Percussion from blasting and changed habitat structure*. Blasting may have a direct effect on stygofauna through percussion and indirect detrimental effects through altering underground structure (usually rock fragmentation and collapse of voids) and causing transient increases in groundwater turbidity. No quantified information on the likely effects of blasting on

subterranean fauna is available but Siskind *et al*. (1989) found the maximum distances at which structural damage would occur to houses as a result of coal mine blasting in North America varied from 30-500 m, depending on blasting charge and site characteristics. Troglofaunal cockroaches have been collected approximately 100 m from regular blasting at Mining Area C in the Pilbara (Bennelongia unpublished data). This hole was the closest available to blasting and it is likely that troglofauna persist much nearer to blasting in many situations.

(2) *Overburden stockpiles and waste dumps and reduced energy stores*. 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 unlikely to significantly impact on stygofauna as lateral movement of groundwater should bring in carbon and nutrients.

(3) *Contamination of subsurface habitats and groundwater by hydrocarbons*. Any contamination is likely to be localised and will be minimised by engineering and management practices to ensure the containment of hydrocarbon products.

2.2. Ethel Gorge Aquifer Stygobiont Community

The presence of a significant stygofauna community within the Ethel Gorge TEC first became apparent following survey work done in 1997 by Eberhard and Humphreys (1999). The initial findings of this survey were reported to the Environmental Protection Authority (EPA) by Dr Humphreys as part of the Consultative Environmental Review for mining below the water table at the Orebody 23 Mine (EPA 1998). Approval to mine Orebody 23 was given on 5 June 1998 in Ministerial Statement 478, subject to Proponent Commitment 8 regarding subterranean fauna. To meet this commitment, additional stygofauna survey was undertaken by Eberhard and Humphreys (1999) to complement the sampling in 1997, which led to the description of multiple species of the amphipod genus *Chydaekata* at Orebody 23 (Bradbury 2000). These descriptions led to the Threatened Ecological Communities Scientific Committee recommending that the Department of Parks and Wildlife (DPaW) list Ethel Gorge as containing a TEC (DEC 2010). The currently recognized extent of the TEC is outlined in Figure 3.

Recent work has documented 82 stygofauna species in the Ethel Gorge aquifer and/or adjacent local groundwaters in the Newman area, most of which occur in the TEC. About 40 species have been recorded only from the Ethel Gorge aquifer and/or adjacent local groundwater (Subterranean Ecology 2013). While this level of endemicity would be regarded as high for surface fauna, it is not unusual for subterranean fauna (Halse *et al*. 2014).

2.2.1. Legislative Framework

Legislative protection of species and communities in Western Australia is provided at both state and federal levels. At the state level, protection is under the *Wildlife Conservation Act 1950* (WC Act), while at the federal level it is under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Ethel Gorge Aquifer Stygobiont Community is not listed under the EPBC Act, nor are any of the stygofauna species occurring there (http://www.environment.gov.au/epbc/).

No stygofauna species from the Ethel Gorge TEC are listed under the WC Act (http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities). Unlike the EPBC Act, the WC Act does not provide for the listing of ecological communities. Instead, formal recognition of TECs is achieved through the Minister for the Environment annually endorsing the list of TECs prepared by DPaW on advice from the Threatened Ecological Communities Scientific Committee (http://www.dpaw.wa.gov.au/images/plants-animals/threatened-species/threatened_ecological_communities_endorsed_by_the_minister_for_the_environment_june_2015.pdf). The Ethel Gorge Aquifer TEC is listed as Endangered by DPaW and this listing is endorsed by the Minister for Environment.

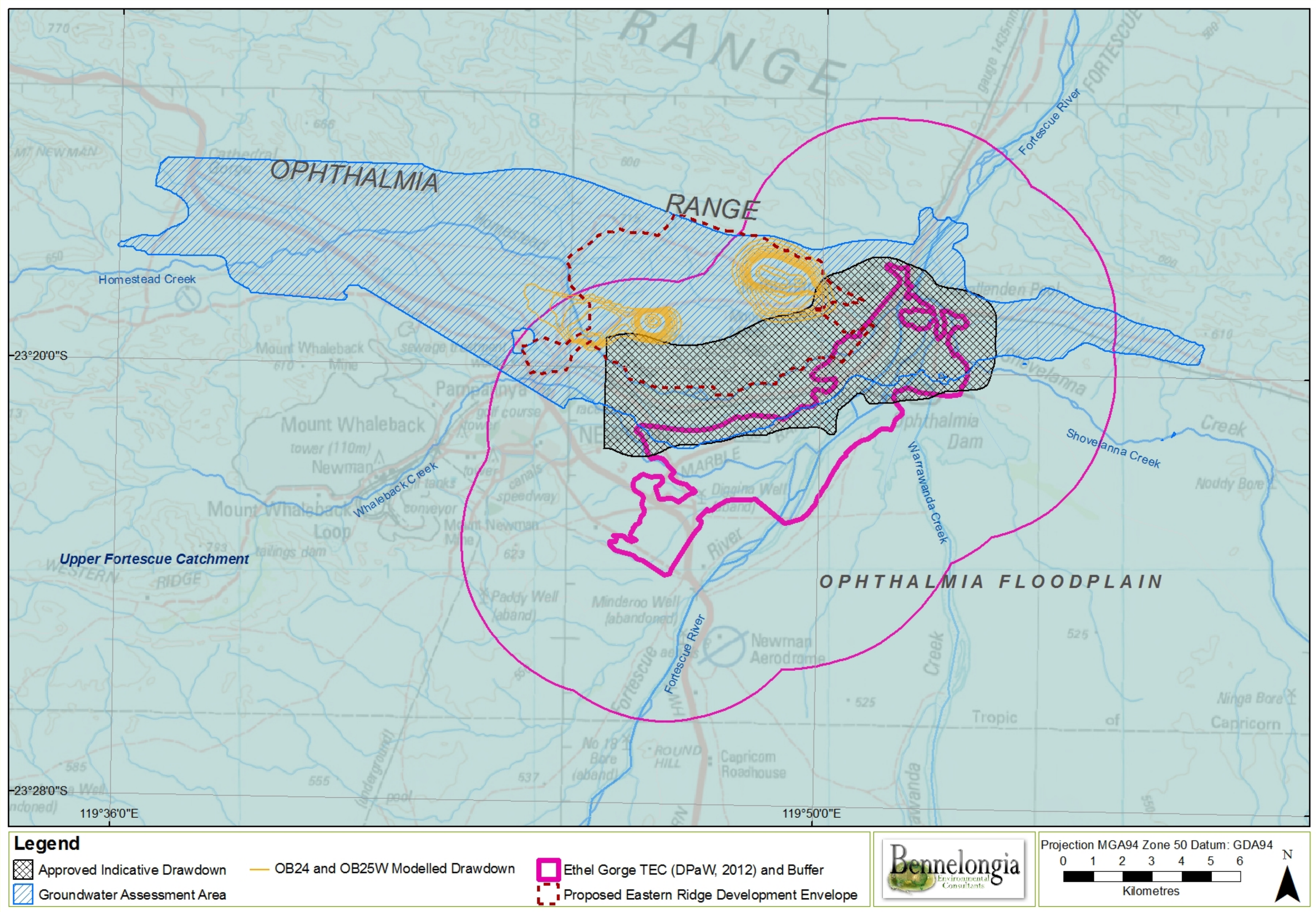

Figure 3. The Eastern Ridge Revised Proposal in relation to the Ethel Gorge TEC.

2.3. Hydrogeology

The Eastern Ridge Revised Proposal is set in the Ophthalmia Range and within the catchment of the Upper Fortescue River (Figure 3). The hydrogeology is dominated by the Fortescue River and its main tributaries (Homestead, Whaleback, Shovelanna and Warrawanda), which all join the river before cutting through the Ophthalmia Range via the 400 m-wide Ethel Gorge (Johnson and Wright 2001).

The drainage channels of the upper Fortescue in the vicinity of Ethel Gorge contain extensive gravel deposits and other coarse-grained alluvium and colluvium interspersed with calcrete, particularly on the Ophthalmia floodplain where the Warrawanda and Shovelanna creeks join the Fortescue River above Ethel Gorge. Calcretes in the area are mostly associated with the Fortescue River itself, with smaller calcretes on Warrawanda Creek. The palaeovalleys containing these creek systems are up to 90 m deep and have been eroded into basement rocks of the Wittenoom Dolomite, Brockman Iron Formation, Mount Sylvia Shale and Mount McRae Shale. Groundwater flows north through Ethel Gorge to the Fortescue Marshes (Johnson and Wright 2001).

There are transmissive aquifers in the calcrete and underlying alluvium and colluvium, where sand and gravel units are in some locations separated by a sequence of clays that act as confining layers. In addition, local perched aquifers can develop when shallow alluvium in the streambeds is saturated during seasonal flows. Basement rocks may also form localised aquifers as a result of the mineralisation and structurally induced development of secondary permeability, as well as karst development in the Wittenoom Dolomite (Johnson and Wright 2001). Adjacent to the Eastern Ridge Revised Proposal, these 'alluvial' aquifers are mostly about 1 km wide but they are up to 8 km wide in some areas on the Ophthalmia floodplain (BHPBIO 2015).

2.4. Existing Groundwater Drawdown

The existing mining operations and associated de-watering at Eastern Ridge have led to a considerable amount of approved groundwater drawdown (Figure 3). This approved drawdown is located within Eastern Ridge Revised Proposal and also the Ophthalmia Floodplain, which includes the Ethel Gorge TEC (Figure 3). Approval to mine below the water table at Orebody 23 was granted in 1998 (Ministerial Statement 478) and at Orebody 25 in 2006 (Ministerial Statement 712). Conditions were set under both Ministerial Statement 478 and Ministerial Statement 712 to monitor stygofauna. The current spatial extent of the groundwater drawdown associated with de-watering at Eastern Ridge was approved under Attachment 2 to Ministerial Statement 712.

2.5. Proposed Groundwater Drawdown

In order to assess the potential impacts of the Eastern Ridge Revised Proposal, two scenarios for changes in groundwater levels were modelled. The first examined operations at Orebody 24 and Orebody 25 West in isolation, and the second examined the potential cumulative impacts of Orebody 24 and Orebody 25 West operating in conjunction with approved mining at Orebody 23 and Orebody 25 and operating water supply borefields at Ophthalmia and Homestead.

2.5.1. Orebody 24

Based on groundwater modelling of the operation of Orebody 24 and Orebody 25 West in isolation (BHPBIO 2015), groundwater levels at Orebody 24 are expected to be lowered by up to 35 m as a result of proposed dewatering, with the 1 m drawdown contour extending radially for about 2 km from the base of the pit. This relatively small spatial extent of drawdown is the result of strata with low permeability surrounding Orebody 24, as well as the relatively small magnitude of drawdown that is required. The proposed maximum depth of drawdown at Orebody 24 will be half that at Orebody 23 and only one-third of that at Orebody 25 (Figure 3).

2.5.2. Orebody 25 West

Based on modelling at Orebody 24 and Orebody 25 West in isolation, groundwater levels at Orebody 25 West are expected to be lowered by up to 45 m as a result of dewatering. In general the zone of drawdown will be confined to a radius of about 1 km from the base of the pit with the exception of the westerly direction where the model indicates drawdown may extend out 4 km. This is the result of drawdown propagating outwards within the relatively high permeability Wittenoom Formation (Figure 3).

2.5.3. Cumulative Drawdown and Defining the Groundwater Assessment Area

In the cumulative groundwater modelling for the proposal, the area of groundwater drawdown associated with the Eastern Ridge Revised Proposal overlaps much of the 45 km^2 area of approved groundwater drawdown under Ministerial Statement 478 and Ministerial Statement 712.

The additional area predicted to experience groundwater drawdown of ≥2 m as a result of the Eastern Ridge Revised Proposal is called the Groundwater Assessment Area. It represents the maximum spatial extent of modelled groundwater drawdown of at least 2 m during the proposed life of mine operations and covers an area of 122 km^2 (Figure 3). Together, the Groundwater Assessment Area and area of approved groundwater drawdown comprise the cumulative groundwater drawdown associated with mining operations at Eastern Ridge. Only 8.1 ha of the Groundwater Assessment Area lies within the core of the Ethel Gorge TEC as defined by DPaW (2012), although a substantial proportion of the Groundwater Assessment Area lies within the buffer of the TEC (Figure 3).

This report will now focus on the assessment of the potential impacts of the Proposal on the Groundwater Assessment Area.

3. STYGOFAUNA SURVEYS

3.1. Sample effort under Regional Survey

Sampling completed across the Eastern Ridge Revised Proposal was conducted according to the general principles laid out for subterranean fauna sampling in Environmental Assessment Guidance 12 and Guidance Statement 54A (EPA 2007, 2013).

A total of 178 stygofauna samples have been collected in the Groundwater Assessment Area under the Regional Survey (Table 1 and Figure 4). A further 615 samples have been collected from the Reference Area covering parts of the surrounding Upper Fortescue Catchment (Table 1 and Figure 4). These reference samples provide information on the wider distribution of stygofauna outside the Groundwater Assessment Area.

Table 1. Stygofauna sampling in the Groundwater Assessment Area and the Reference Area.

Year	Groundwater Assessment Area	Reference Area	Total
2007	8	11	19
2008	34	192	226
2009	9	124	133
2010	6	74	80
2011	4	5	9
2012	8	39	47
2013	84	132	216
2014	16	26	42
2015	9	12	21
Total	**178**	**615**	**793**

Details of sampling methodology and a complete list of bores sampled (with coordinates) within the Groundwater Assessment Area and the Reference Area are provided in Appendix 1. Additional information on species ranges was obtained from other Regional Survey sampling in the Pilbara, previous surveys in the vicinity of Ethel Gorge by Eberhard and Humphreys (1999), Biota (2001a, b, 2004, 2008b), Halse *et al*. (2014), other published literature, and unpublished data from the Bennelongia database.

3.1.1. Other sampling

Troglofauna sampling was sometimes undertaken at locations sampled for stygofauna by Subterranean Ecology or Bennelongia. All stygofauna collected as by-catch during troglofauna sampling are included in species lists and interpretations of species distributions and diversity.

3.2. Stygofauna Occurrence and Abundance

A total of 23,264 specimens of stygofauna were collected during dedicated stygofauna surveys or as by-catch from troglofauna surveys in the Groundwater Assessment Area and the Reference Area (Table 2 and Table 3). At least 79 species of stygofauna have been recorded within the Groundwater Assessment Area and the Reference Area. The species belong to 12 higher level groups: Platyhelminthes (1 species), Nematoda (treated as 1 species, but potentially more), Rotifera (1 species), Aphanoneura (2 species), Enchytraeida (6 species), Haplotaxida (10 species), Trombidiformes (1 species), Ostracoda (20 species), Maxillopoda (copepods) (19 species), Syncarida (9 species), Amphipoda (8 species) and Isopoda (1 species) (Table 2).

The numerically dominant groups and species were copepods (*Diacyclops humphreysi humphreysi*, *Archinitocrella newmanensis* and *Parastenocaris jane*), rotifers (Bdelloidea sp. 2:2), ostracods (mostly *Notacandona gratia*) and amphipods (mostly *Chydaekata acuminata*). All of these species were represented by more than 500 specimens. Nineteen species were represented by fewer than 20 specimens (Table 2).

Of the 79 stygofauna species collected in the Groundwater Assessment Area and Reference Area, 49 species were recorded in the Groundwater Assessment Area and 67 species were recorded in the Reference Area. Twelve species were recorded only in the Groundwater Assessment Area during sampling (although most of these species have been recorded more widely beyond the Reference Area in other sampling programs, including the Regional Survey: see Table 2). Thirty species were recorded in the Reference Area but not in the Groundwater Assessment Area.

3.3. Species Known only from the Groundwater Assessment Area

Five of the 12 species recorded only in the Groundwater Assessment Area are currently known only from that area, or from the Groundwater Assessment Area and the approved drawdown (Table 2, Figure 5). The five species are the enchytraeid worm Enchytraeidae sp. OB3 represented by two specimens from one drill hole, the phreodrilid worm Phreodrilidae sp. WAM indet. 1 represented by a single specimen, the ostracod *Pilbaracandona* `OST002` represented by a single animal in the Groundwater Assessment Area and 14 specimens collected from three drill-holes approximately 11 km away in the approved drawdown, and two syncarids: *Bathynella* sp. B12 represented by four specimens collected from one drill hole, and Bathynellidae sp. WAM indet. 1 represented by seven specimens collected from two drill-holes 8.5 km apart (Table 2, Figure 5).

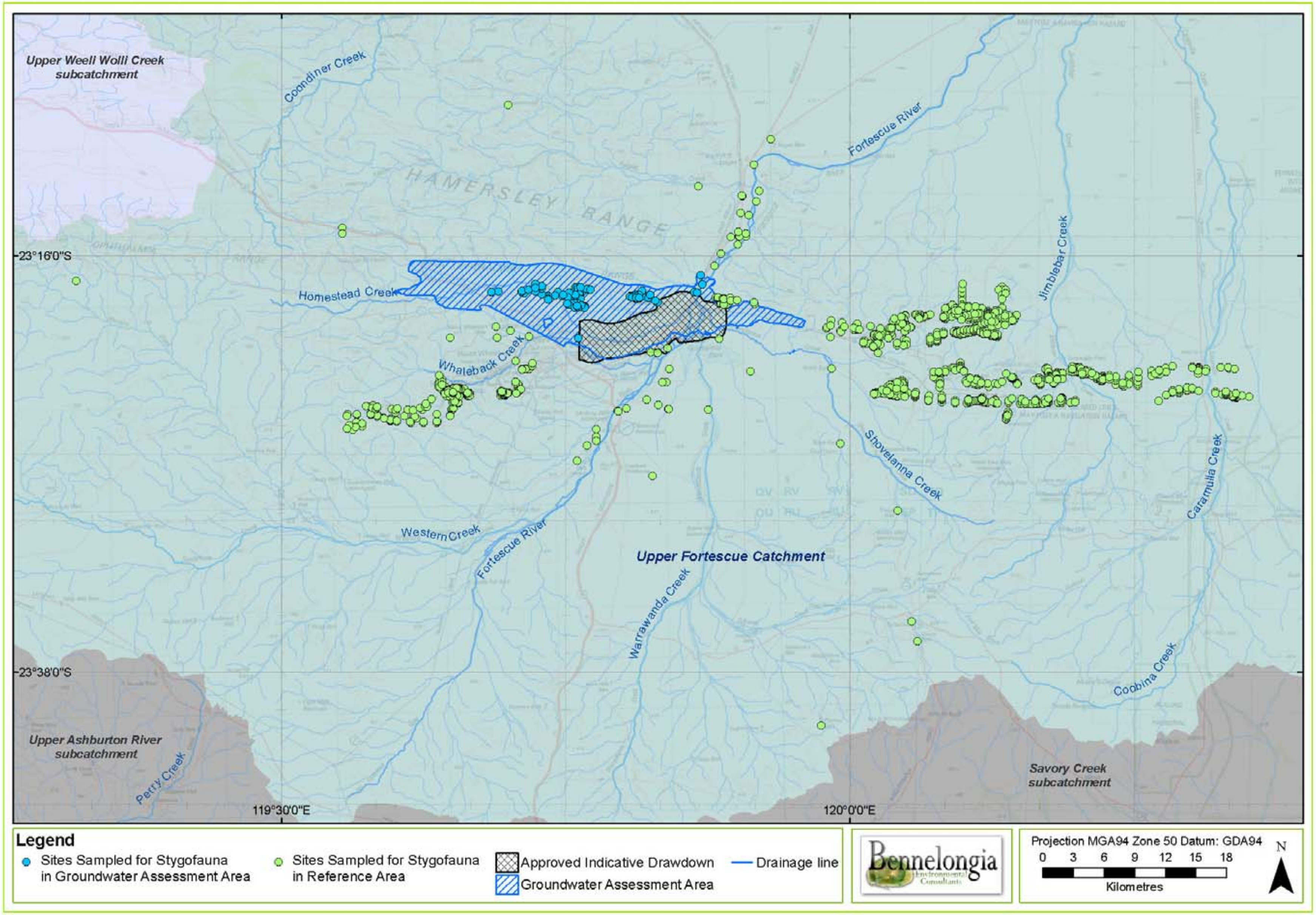

Figure 4. Drill holes sampled for stygofauna in the Groundwater Assessment Area and the Reference Area.

Table 2. Stygofauna species collected within the Groundwater Assessment Area and Reference Area.
Note: Includes specimens collected as by-catch during troglofauna sampling.

Taxonomy	Groundwater Assessment Area	Reference Area	Recorded Outside of the Cumulative Drawdown Cone	Other Occurrences, Comments
Platyhelminthes				
Turbellaria sp.		33	Not assessed in EIAs[1]	Probably widespread[2]
Nematoda				
Nematoda sp.	27	115	Not assessed in EIAs[1]	Probably widespread[2]
Rotifera				
Bdelloidea				
Bdelloidea sp. 2:2	111	1179	Not assessed in EIAs[1]	Probably widespread[2]
Annelida				
Aphanoneura				
Aeolosoma sp. 1 (PSS)		1	Yes	Pilbara-wide[2,3]
Aeolosoma sp. OB		5	Yes	Also known from approved drawdown
Clitellata				
Enchytraeida				
Enchytraeidae sp. OB2		1	Yes	Known only from this record
Enchytraeidae sp. OB3	2		No	Known only from these records
Enchytraeus sp. Ench1	75		Yes	Yandi
Enchytraeus sp. Ench2		14	Yes	Known only from these records
Enchytraeus sp. Ench3		11	Yes	Known only from these records
Enchytraeus sp. Ench6 (=OB_MC)	5	111	Yes	Also known from approved drawdown, Mindy Coondiner[4]
Haplotaxida				
Insulodrilus sp. OB1		6	Yes	Known only from these records
Phreodrilidae sp. OB3		59	Yes	Known only from these records
Phreodrilidae sp. ?Phre1 (=OP1)		11	Yes	Also known from approved drawdown
Phreodrilidae sp. Phre1 (=OP1)	7	61	Yes	Also known from approved drawdown

Taxonomy	Groundwater Assessment Area	Reference Area	Recorded Outside of the Cumulative Drawdown Cone	Other Occurrences, Comments
Phreodrilidae sp. WAM indet. 1	1		No	Known only from this record
Pristina aequiseta		3	Yes	Cosmopolitan[5]
Pristina longiseta	7		Yes	Cosmopolitan[5]
Pristina sp. OB	89	9	Yes	Also known from approved drawdown
Tubificoid Naididae stygo type 1A	121	3	Yes	Pilbara-wide and beyond[6]
Tubificoid Naididae stygo type 5		4	Yes	Pilbara-wide[2,3]
Arthropoda				
Arachnida				
Trombidiformes				
Peza `ACA001`	9	5	Yes	Also known from approved drawdown
Crustacea				
Ostracoda				
Popocopida				
Riocypris fitzroyi	2	5	Yes	Kimberley, Pilbara[6,7]
Cypretta seurati	1		Yes	Cosmopolitan[8,9]
Stenocypris malcolmsoni		1	Yes	Cosmopolitan[9]
Sarscypridopsis ochracea		2	Yes	Cosmopolitan[9,10]
Candonopsis tenuis	3		Yes	Cosmopolitan[9]
Cypridopsis vidua		28	Yes	Cosmopolitan[9]
Gomphodella hirsuta	62	11	Yes	Pilbara-wide[2,11]
Areacandona mulgae		101	Yes	Described from West Strelley River[12]
Meridiescandona cf. *facies*		2	Yes	Range uncertain due to taxonomic resolution
Notacandona gratia	2	592	Yes	Also known from approved drawdown, Also known from approved drawdown[13]
Origocandona grommike		58	Yes	Ashburton[3,13]
Origocandona inanitas	24	10	Yes	Also known from approved drawdown, Ashburton[13]
Origocandona sp. BOS099	1	46	Yes	Also known from approved drawdown
Pilbaracandona `OST002`	1		No	Also known from approved drawdown
Pilbaracandona `OST001`	3	2	Yes	Also known from approved drawdown

Taxonomy	Groundwater Assessment Area	Reference Area	Recorded Outside of the Cumulative Drawdown Cone	Other Occurrences, Comments
Pilbaracandona colonia	10	5	Yes	Asburton[14]
Pilbaracandona eberhardi	61	197	Yes	Also known from approved drawdown[14]
Pilbaracandona kosmos	36	25	Yes	Also known from approved drawdown[13]
Pilbaracandona temporaria	2		Yes	Also known from approved drawdown, and elsewhere in the Pilbara[6,14]
Vestalenula marmonieri		1	Yes	Pacific Region and Australasian Region[9]
Maxillopoda				
Cyclopoida				
Anzcyclops sp. B06		1	Yes	Known only from this record
Diacyclops cockingi	13	13	Yes	Pilbara-wide[2,15]
Diacyclops humphreysi humphreysi	2655	10663	Yes	Pilbara-wide[2,16]
Diacyclops sobeprolatus	25	248	Yes	Pilbara-wide[2,15]
Fierscyclops sp. B03 (nr *frustratio*)		6	Yes	Fortescue Catchment[3]
Mesocyclops brooksi	9	1	Yes	Central/Eastern Pilbara[2,15]
Mesocyclops notius	6	4	Yes	Australia[17]
Metacyclops pilbaricus	5	57	Yes	Central Pilbara[3,15]
Microcyclops varicans	1	5	Yes	Cosmopolitan[18]
Orbuscyclops westaustraliensis		120	Yes	Robe[15]
Pilbaracyclops supersensus	8		Yes	Also known from approved drawdown, and downstream towards the Fortescue Marsh[6]
Thermocyclops decipiens	9		Yes	Cosmopolitan[19]
Harpacticoida				
Archinitocrella newmanensis	12	1292	Yes	Also known from approved drawdown, Asburton[15]
Megastygonitocrella bispinosa		1	Yes	Pilbara-wide[2,15]
Nitocrella `COP003`	1	258	Yes	Also known from approved drawdown
Nitocrella `ophthalmia`	1	104	Yes	Known only from these records
Parastenocaris `COP001`	15	283	Yes	Also known from approved drawdown
Parastenocaris cf. *jane*		60	Yes	Taxonomy uncertain
Parastenocaris jane	17	613	Yes	Pilbara-wide[2,15]
Malacostraca				

Taxonomy	Groundwater Assessment Area	Reference Area	Recorded Outside of the Cumulative Drawdown Cone	Other Occurrences, Comments
Syncarida				
Atopobathynella sp. B18	1	1	Yes	Known only from these records
Bathynella sp. B03		4	Yes	Known only from these records
Bathynella sp. B11	45	3	Yes	Known only from these records
Bathynella sp. B12	4		No	Known only from these records
Bathynellidae sp. OB1		17	Yes	Also known from approved drawdown
Bathynellidae sp. OB3		27	Yes	Known only from these records
Billibathynella cassidis		8	Yes	Also known from approved drawdown[20]
Brevisomabathynella pilbaraensis		17	Yes	Known only from these records[21]
Bathynellidae sp. WAM indet. 1	7		No	Known only from these records
Amphipoda				
Chydaekata `AMP005`	5	55	Yes	Also known from approved drawdown
Chydaekata acuminata	173	329	Yes	Also known from approved drawdown
Kruptus `AMP004`	2	63	Yes	Known only from these records
Maarrka etheli	1	1	Yes	Also known from approved drawdown, and downstream towards the Fortescue Marsh[6,22]
Paramelitidae gen. nov. 1 `AMP001`	100	9	Yes	Also known from approved drawdown
Paramelitidae gen. nov. 1 `AMP002`		4	Yes	Also known from approved drawdown
Paramelitidae gen. nov. 1 `AMP003`	17	16	Yes	Also known from approved drawdown
Paramelitidae sp. B34		1	Yes	Known only from this record
Isopoda				
Pygolabis humphreysi	153	39		Also known from approved drawdown, and downstream towards the Fortescue Marsh[6,23]

[1] Some invertebrate groups are excluded from assessment because of poor taxonomic framework (EPA (2007); [2]Halse *et al.* (2014); [3]Regional Subterranean Fauna Sampling Program; [4]Helix (2014); [5]Pinder (2010); [6]Bennelongia unpublished data; [7]McKenzie (1966); [8]Okubo 1973; [9]Martens and Savatenalinton (2011); [10]Karanovic (2012); [11]Karanovic (2006a); [12]Karanovic (2005); [13]Karanovic (2007); [14]Karanovic and Marmonier (2003); [15]Karanovic (2006b); [16]Pesce and De Laurentiis (1996); [17]Holynska *et al.* (2003); [18]Sars (1863); [19]Kiefer (1929); [20]Hong and Cho (2009); [21]Cho and Humphreys (2010); [22]Finston *et al.* (2011); [23]Keable and Wilson (2006).

Table 3. Stygofauna identified only to higher levels (immature or damaged specimens).
Note: Includes specimens collected as by-catch during troglofauna sampling.

Taxonomy	Groundwater Assessment Area	Reference Area
Annelida		
Aphanoneura		
Aeolosoma sp.		29
Clitellata		
Enchytraeida		
Enchytraeidae PST1		135
Enchytraeidae sp.	48	143
Enchytraeus sp.	13	155
Enchytraeus sp. 1 (PSS) Pilbara		1
Enchytraeus sp. 2 (PSS) Pilbara	8	471
Haplotaxida		
Insulodrilus sp.	1	1
Insulodrilus WA31	1	70
Naididae sp.	10	1
Phreodrilidae sp.	33	38
Phreodrilidae with dissimilar ventral chaetae		6
Phreodrilus sp.		345
Oligochaeta sp.		9
Arthropoda		
Crustacea		
Malacostraca		
Amphipoda		
Chydaekata sp.	14	64
Paramelitidae sp.	92	75
Paramelitidae sp.		1
Paramelitidae sp. OB1/OB2	1	3
Amphipoda sp.	1	21
Isopoda		
Pygolabis sp.		1

Taxonomy	Groundwater Assessment Area	Reference Area
Syncarida		
Bathynella sp.		3
Bathynellidae sp.	9	151
Brevisomabathynella sp.		1
Bathynellidae sp.	1	
Maxillopoda		
Cyclopoida		
Diacyclops sp.	2	14
Mesocyclops sp.		1
Thermocyclops sp.		8
Cyclopoida sp.		10
Harpacticoida		
Parastenocaris sp.	11	73
Harpacticoida sp.		12
Copepoda sp.		1
Ostracoda		
Popocopida		
Candonidae sp.		17
Candoninae sp.	2	17
Cyprididae sp.		4
Cyprinopsinae sp.		1
Pilbaracandona sp.		14
Ostracoda sp. unident.	5	129

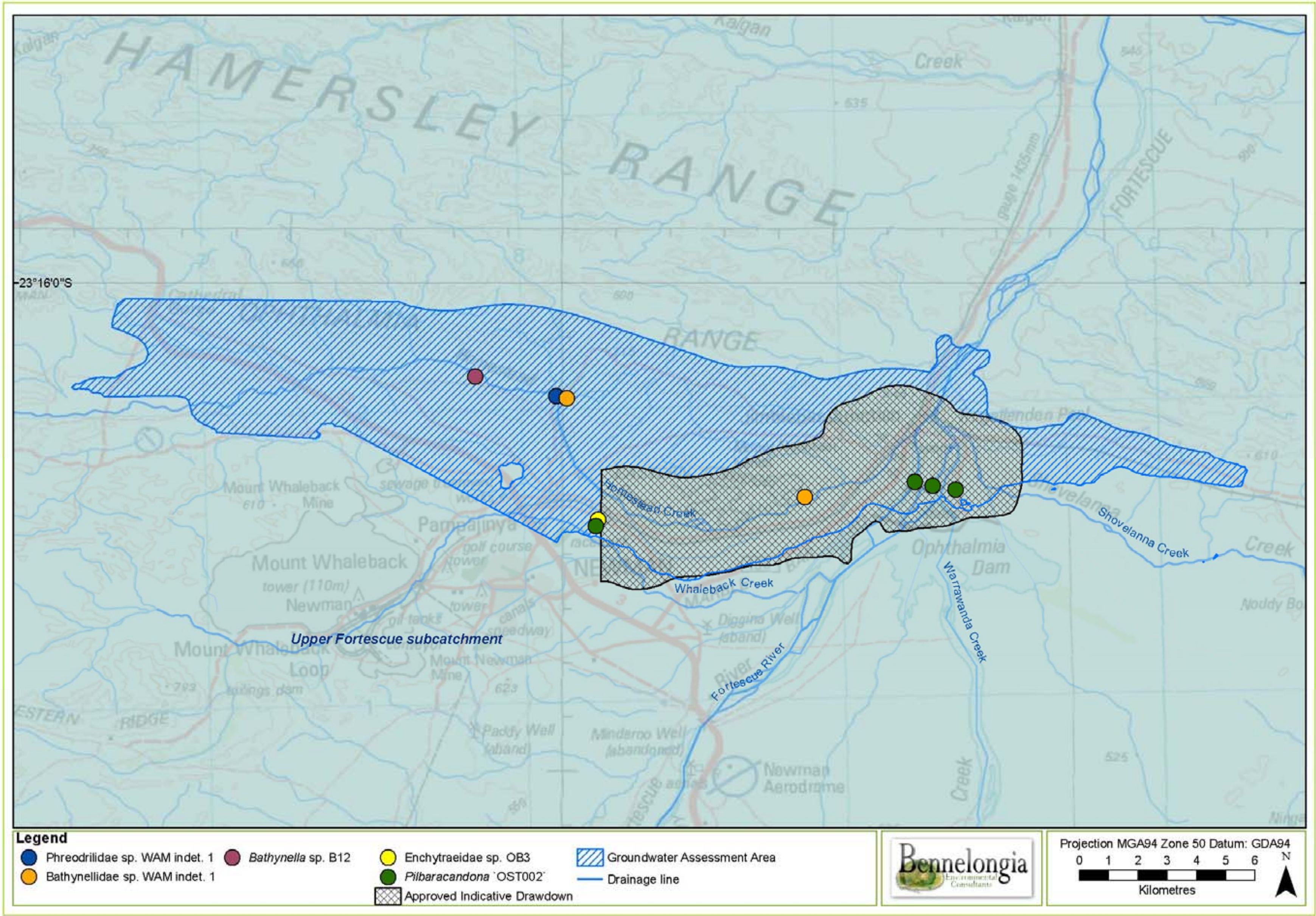

Figure 5. Stygofauna species currently known only from the Groundwater Assessment Area.

4. IMPACT EVALUATION

4.1. The Groundwater Assessment Area

4.1.1. Habitat Connectivity and Species

The considerable extent and habitat connectivity of the alluvial aquifers (and to a lesser extent the calcrete deposits) of the Tertiary Detrital valley-fill successions in the Upper Fortescue River and the associated tributaries probably allow easy dispersal of stygofauna species between the Groundwater Drawdown Area and surrounding aquifers. For example, species apparently endemic to the Ethel Gorge/Upper Fortescue area, such as the amphipods *Chydaekata acuminata* (linear range of 27 km), Paramelitidae gen. nov. 1 \`AMP001\` (49 km) and the copepod *Parastenocaris* \`COP001\` (40 km), occur in both the Groundwater Assessment Area and surrounding areas. The syncarids Bathynellidae sp. OB1 (8 km) and *Brevisomabathynella pilbaraensis* (24 km) are also relatively widespread in the local area (Figure 6). This suggests there are few, if any, physical barriers to prevent species occurring in the Groundwater Assessment Area from extending into the surrounds beyond the impact of mining. In fact, based on survey results, almost 92% of the species known from the Groundwater Assessment Area are also known from the surrounding area or further beyond.

4.1.2. Future Conservation Status of Stygofauna Species

Only five of the stygofauna species collected have known ranges that make them potentially vulnerable to groundwater drawdown within the Groundwater Assessment Area. These are the enchytraeid worm Enchytraeidae sp. OB3, the ostracod *Pilbaracandona* \`OST002\`, the phreodrilid worm Phreodrilidae sp. WAM indet. 1, and two syncarids *Bathynella* sp. B12 and Bathynellidae sp. WAM indet. 1 (Figure 5).

In assessing whether groundwater drawdown is likely to threaten persistence of the five species, it should be recognised that the ranges of all five are likely to have been underestimated because of the low numbers of animals collected. It usually requires at least 25 positive samples to define the full range of a species, even when environmental data are used to assist in delimiting the range (Hernandez *et al*. 2006; Wisz *et al*. 2008).

Three of the five species have been collected from only one site (Enchytraeidae sp. OB3, Phreodrilidae sp. WAM indet. 1 and *Bathynella* sp. B12), one species was recorded from two sites (Bathynellidae sp. WAM indet. 1), while *Pilbaracandona* \`OST002\` has been recorded from four sites (Figure 5). A further constraint on fully documenting the ranges of the five species is that large parts of their potential ranges outside the Groundwater Assessment Area could not be sampled owing to lack of drill holes (Figure 4). Details of the likely distributions of each of the five species are discussed below:

Enchytraeidae sp. OB3

Enchytraeidae sp. OB3 was recorded as two specimens collected by Subterranean Ecology from one drill hole (Figure 5). The identification was based on morphology (by Adrian Pinder of DPaW) and genetics (by Dr Remko Leijs of the South Australian Museum) (Subterranean Ecology 2013). It is expected that eventual comparisons with additional specimens in the Newman area and perhaps beyond will demonstrate that Enchytraeidae sp. OB3 is more widely distributed, as has been observed for *Enchytraeus* sp. Ench6 (=OB_MC) which has been recorded from within the Groundwater Assessment Area and also approximately 73 km away at Mindy Coondiner (Table 2). This follows the general trend for enchytraeid species to be relatively wide-ranging (Helix 2014). Therefore, it is considered likely that Enchytraeidae sp. OB3 occurs beyond the Groundwater Assessment Area and is unlikely to be threatened by the proposed Eastern Ridge Revised Proposal.

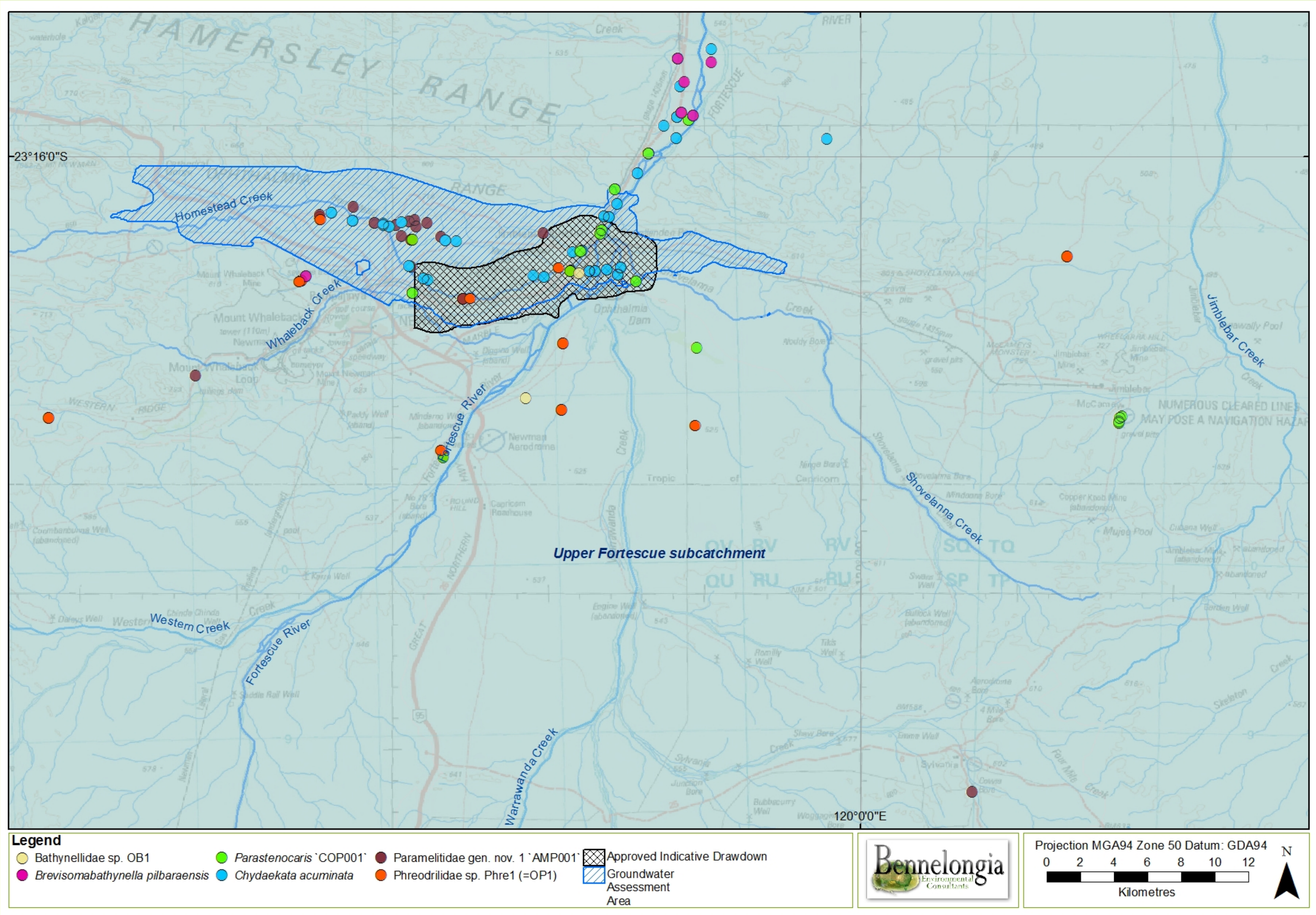

Figure 6. Distributions of some more abundant stygofauna species, which are considered endemic to the local area.

Phreodrilidae sp. WAM indet. 1

Phreodrilidae sp. WAM indet. 1 is represented by a single specimen identified by the Western Australian Museum using DNA (WAM 2015). Little can be said about the likely range of this species based on the single specimen but another phreodrilid (Phreodrilidae sp. Phre1 {=OP1}) collected from Ethel Gorge and surrounds has been found to have linear range of approximately 56 km (confirmed by DNA) with specimens collected from 10 sites (Figure 6). Phreodrilidae sp. WAM indet. 1 probably has a range closer to that of Phreodrilidae sp. Phre1 (=OP1) than the current scenario of it being restricted to Homestead Creek. Hence, it is considered unlikely that Phreodrilidae sp. WAM indet. 1 would be threatened by the Eastern Ridge Revised Proposal.

Pilbaracandona `OST002`

Pilbaracandona `OST002` was represented by a single animal in the Groundwater Assessment Area and 14 specimens collected from three drill-holes approximately 11 km away in the approved drawdown (Figure 5). While *Pilbaracandona rosa* appears to have a range of 150 km on the Pilbara coastal plain (Stuart Halse and Ivana Karanovic unpublished data), other species of *Pilbaracandona* appear to have relatively restricted distributions (<15 km). It is quite possible that the four bores in which *Pilbaracandona* `OST002` was collected at Whaleback Creek and Ethel Gorge over a distance of 11 km (Figure 5) cover most of the east-west range of the species. These existing records are, however, only 0.6 km (western site) and 1.2-1.6 km (eastern sites) from the southern boundary of the Groundwater Assessment Area.

While there is some uncertainty about the range of *Pilbaracandona* `OST002`, given the relatively short north-south extent of the cumulative groundwater drawdown area compared with the species' known east-west range and the known ranges of other *Pilbaracandona* species from the area, it is considered moderately likely *Pilbaracandona* `OST002` will extend into undisturbed areas and that the species will not be threatened by the Eastern Ridge Revised Proposal.

Bathynella sp. B12

Bathynella sp. B12 was recorded from only one site and it has some potential to be localised within the Homestead Creek area because stygofaunal syncarids are known to have small ranges (Guzik *et al*. 2008; Asmyhr *et al*. 2014). Conversely there is also evidence that syncarid ranges are often underestimated and, thus, increase with sampling effort (Camecho and Valdecasas 2008). Two other syncarids occurring in the same general area, the parabathynellid *Brevisomabathynella pilbaraensis* and bathynellid Bathynellidae sp. OB1, are known to occur more widely. The range of *Brevisomabathynella pilbaraensis* extends from south to north of the Groundwater Assessment Area with a range of at least 27 km (Figure 6). The range of Bathynellidae sp. OB1 extends from the Groundwater Assessment Area farther south, with a range of 8 km (Figure 6). Two syncarids occurring in the Groundwater Assessment Area (Bathynella sp. B11 and Atopobathynella sp. B18) have ranges extending into the Reference Area (Table 2).

The range of *Bathynella* sp. B12, which is currently known only from the Homestead Creek catchment, may extend farther upstream in that catchment or it may have a wider distribution in the same way as the four syncarid species discussed in the previous paragraph. While there is uncertainty about the range of *Bathynella* sp. B12, given the known wider range of some other syncarids occurring in the area and the connected nature of the local subterranean habitat, it is considered moderately likely that the range of *Bathynella* sp. B12 will extend beyond the Groundwater Assessment Area and that the species will not be threatened by the Eastern Ridge Revised Proposal.

Bathynellidae sp. WAM indet. 1

The syncarid Bathynellidae sp. WAM indet. 1 is represented by seven specimens collected from two drill-holes 8.5 km apart (Figure 5). The information presented above for *Bathynella* sp. B12 is also applicable to determining the likely distribution of Bathynellidae sp. WAM indet. 1. As Bathynellidae sp. WAM indet. 1 occurs only 2.5 km from the south limit of the Groundwater Assessment Area, it is considered probable that it also occurs in undisturbed areas to the south. Hence, although there is uncertainty in the assessment, it is considered unlikely that Bathynellidae sp. WAM indet. 1 would be threatened by the Eastern Ridge Revised Proposal.

4.2. Impacts on the Ethel Gorge Aquifer Stygobiont Community

4.2.1. Historical Impacts

Approval to mine below the water table at Orebody 23 was granted in 1998 (Ministerial Statement 478) and at Orebody 25 in 2006 (Ministerial Statement 712). The existing mining operations and associated de-watering at Eastern Ridge have led to a considerable amount of approved groundwater drawdown in the vicinity, including within the Ethel Gorge TEC (Figure 3). Conditions were set under both Ministerial Statement 478 and Ministerial Statement 712 to monitor the stygofauna species within the TEC.

Water level data collected since the mid-1970s show the aquifers containing the Ethel Gorge TEC are highly responsive and groundwater levels are affected by both recharge from Ophthalmia Dam and abstraction from the Ophthalmia water supply borefield. Changes in groundwater levels of up to 15 m, but typically in the order of 5-10 m, have occurred historically with the lowest water levels being in the early 1980s prior to the construction of Ophthalmia Dam, and the highest water levels occurring in the early 2000s after a period of significant rainfall and prior to dewatering activities at Orebody 23 and Orebody 25 Pit 3 (BHPBIO 2015). This range of groundwater levels is considerably greater than the 'average' seasonal fluctuations expected for Pilbara groundwater levels away from river channels. Stygofauna monitoring at the Ethel Gorge TEC and surrounds undertaken over the last five years has not detected any adverse impact on the stygofauna community as a result of approved mining activities and associated groundwater changes (Subterranean Ecology 2011, 2012, 2014, MWH 2015).

4.2.2. Potential Additional Impacts from the Eastern Ridge Revised Proposal

Within Approved Drawdown Area

It is expected that there will be minimal additional drawdown (approximately 1-2 m) in the area previously approved for groundwater drawdown in the Ethel Gorge TEC as a result of the Eastern Ridge Revised Proposal. This additional groundwater drawdown is very small relative to the changes documented in the area since the mid-1970s and is considered unlikely to pose additional threat to stygofauna species; given the monitoring program suggests the stygofauna community is resilient to drawdowns of larger magnitude (Subterranean Ecology 2011, 2012, 2014, MWH 2015).

Outside Approved Drawdown Area

The additional 8.1 ha of the TEC modelled to be included in the Groundwater Assessment Area is very small compared with the 2077 ha that will remain un-impacted by the groundwater drawdown (Figure 3). It is unlikely that stygofauna conservation values will be impacted by this slight spatial increase in drawdown.

4.3. Other Impacts

Groundwater salinities vary across the Groundwater Assessment Area, from c. 500 mg/L TDS in Homestead Creek to the west to c. 4,000 mg/L in Shovelanna Creek to the east. Higher salinities (c. 6,000 mg/L) have been recorded north of Ophthalmia Dam (Parsons Binckerhoff 2015). Some of the data in Parsons Binckerhoff (2015) suggest that salinities may have increased in the central and eastern parts of the Groundwater Assessment Area over the past 30-40 years, although 90% of the recent salinity recordings made by Subterranean Ecology (2014) in the Groundwater Assessment Area and surrounds were <2,000 mg/L TDS.

The salinity tolerances of stygofauna species occurring in the Groundwater Assessment Area are not well documented, although Subterranean Ecology (2012) used records from different areas to provide information on salinity tolerances of three species. The amphipod Paramelitidae gen. nov. 1 `AMP001` has a documented salinity range of 334-1,715 mg/L, the copepod *Parastenocaris* `COP001` has a documented range of 1,048-3,066 mg/L and the worm Phreodrilidae sp. Phre1 has a documented range of 334-2,662 mg/L. These values fit moderately well with the management trigger threshold value for salinity in the Ethel Gorge TEC, which is 2,500 mg/L TDS (BHPBIO 2015). This threshold value reflects the findings of Pinder *at al*. (2005) that species richness of freshwater invertebrates begins to decline at salinities >2,500 mg/L TDS.

While there is uncertainty regarding the tolerance of stygofauna species within the Groundwater Assessment Area, it is possible that increases in salinity as a result of the Eastern Ridge Revised Proposal may restrict the ranges of some species. In particular, to be precautionary it should be assumed that increases in salinities may result in some local restrictions of species' ranges if areas currently <2,500 mg/L develop salinities of >2,500 mg/L TDS.

CONCLUSION

Stygofauna surveys in the Groundwater Assessment Area and associated Reference Area were conducted in accordance with the recommendations of EPA Environmental Assessment Guideline 12 and Guidance Statement 54A. Altogether, 178 stygofauna samples were collected from within the Groundwater Assessment Area and 615 stygofauna samples were collected from the Reference Area.

Of the 79 stygofauna species collected in the Groundwater Assessment Area and Reference Area, 49 species were recorded in the Groundwater Assessment Area. Only five of the stygofauna species collected have known ranges that may potentially lead to them being impacted by groundwater drawdown within the Groundwater Assessment Area. These are the enchytraeid worm Enchytraeidae sp. OB3, the ostracod *Pilbaracandona* `OST002`, the phreodrilid worm Phreodrilidae sp. WAM indet. 1, and two syncarids *Bathynella* sp. B12 and Bathynellidae sp. WAM indet. 1. However, based on the distributions of similar species elsewhere in the Pilbara, and the wider distribution of more abundant endemic species in the Ethel Gorge/Upper Fortescue area, the ranges of Enchytraeidae sp. OB3 and Phreodrilidae sp. WAM indet. 1 are considered likely to extend beyond the Groundwater Assessment Area. The ranges of *Pilbaracandona* `OST002`, *Bathynella* sp. B12 and Bathynellidae sp. WAM indet. 1 are considered moderately likely to extend beyond the Groundwater Assessment.

It is unclear whether increases in salinity that affect stygofauna species may occur as a result of the Eastern Ridge Revised Proposal. However, increases in salinity within the Groundwater Assessment Area from <2,500 mg/L to >2,500 mg/L TDS may possibly cause some local restrictions of species' ranges.

The amount of predicted additional drawdown (approximately 1-2 m) in the area previously approved for groundwater drawdown within the Ethel Gorge TEC will be small relative to drawdowns previously experienced in the TEC since the mid-1970s (fluctuations up to 15 m, but typically in the order of 5-10 m). Consequently, this additional drawdown is unlikely to pose additional threat to stygofauna species. Results of the current monitoring program suggest that the stygofauna community at Ethel Gorge TEC is resilient to previous drawdown.

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6. APPENDICES

Appendix 1 – Field and Laboratory Methods and Sites Sampled for Stygofauna

Sampling Technique

Stygofauna sampling followed the methods recommended by EPA (2007). At each drill hole, six net hauls were made using a weighted plankton net (three hauls with a 50 µm mesh net and three with a 150 µm mesh net). During each net haul, the net was lowered gently to the bottom of the drill hole, agitated briefly to stir benthic and epibenthic stygofauna into the water column, then retrieved slowly. 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 when moving from one drill hole to the next to prevent contamination between sites.

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. Stygofauna 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.

Reference

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Holes Sampled for Stygofauna within the Groundwater Assessment and the Reference Area

Groundwater Assessment Area		
Drill Hole Code	Latitude	Longitude
EA0002RT	-23.306287	119.817
EA0015RT	-23.306537	119.81461
EA0028RT	-23.303863	119.81458
EA0029RT	-23.303535	119.814566
EA0030RT	-23.303224	119.814599
EA0031RT	-23.304059	119.814526
EA0032RT	-23.304662	119.814597
EA0042RT	-23.302567	119.812228
EA0044RT	-23.303273	119.812213
EA0046RT	-23.303779	119.812215
EA0047RT	-23.304069	119.812185
EA0048RT	-23.304318	119.812144
EA0051RT	-23.301571	119.817013
EA0052RT	-23.301029	119.817033
EA0053RT	-23.302247	119.817081
EA0054RT	-23.302763	119.817058
EA0055RT	-23.302925	119.816982
EA0056RT	-23.30334	119.817071
EA0057RT	-23.303632	119.81697
EA0060RT	-23.304332	119.816981
EA0065RT	-23.302073	119.814636
EA0080RT	-23.304925	119.812185
EA0086RT	-23.309355	119.830664
EA0093RT	-23.303838	119.810995
EA0095RT	-23.302659	119.803962
EA0110RT	-23.294626	119.764545
EA0112RT	-23.296855	119.774028
EA0113RT	-23.296377	119.769438
EA0114RT	-23.29581	119.777538
EA0118RT	-23.296744	119.786101
EA0130RT	-23.295354	119.766996
EA0131RT	-23.295032	119.761205
EA0132RT	-23.296297	119.764732
EA0145DT	-23.294604	119.762281
EA0147R	-23.29421732	119.7765108
EA0148R	-23.295721	119.775287
EA0149R	-23.295347	119.774303
EA0150R	-23.29478	119.774354
EA0151R	-23.295308	119.775365
EA0152R	-23.296562	119.770498
EA0153R	-23.296391	119.772772
EA0154R	-23.296381	119.772826
EA0155R	-23.296112	119.770637
EA0156R	-23.295739	119.768853
EA0157R	-23.29631	119.768573
EA0158R	-23.296321	119.768573
EA0159R	-23.29693	119.766799
EA0160R	-23.296555	119.765814
EA0161R	-23.296189	119.763388
EA0162R	-23.2943455	119.7658527
EA0163R	-23.29397244	119.7657666
EA0164R	-23.294601	119.763344
EA0165R	-23.294103	119.763713
EA0166R	-23.294117	119.763712
EA0168R	-23.295687	119.76095
EA0169R	-23.295678	119.760949
EA0170R	-23.294723	119.758453
EA0171R	-23.294799	119.75989
EA0172R	-23.294928	119.766669
EA0177R	-23.301777	119.804446
EA0178R	-23.301156	119.805765
EA0179R	-23.300693	119.805595
EA0183R	-23.303088	119.804593
EA0186R	-23.302303	119.80695
EA0188R	-23.302601	119.805833
EA0192R	-23.302562	119.80809
EA0194R	-23.303438	119.80805
EA0200R	-23.306209	119.808019

Groundwater Assessment Area		
Drill Hole Code	Latitude	Longitude
EA0206R	-23.30516	119.803351
EA0212R	-23.305201	119.802092
EA0218R	-23.304306	119.799604
EA0224R	-23.303553	119.804584
EA0230R	-23.303193	119.79733
EA0236R	-23.301607	119.794981
EA0254R	-23.303168	119.793835
EA0260R	-23.301825	119.7913
EA0263R	-23.297105	119.791992
EA0264R	-23.301733	119.806183
EA0266R	-23.302722	119.815756
EA0267R	-23.30298	119.818237
EA0268R	-23.303995	119.822859
EA0270R	-23.302118	119.800317
EA0275R	-23.302401	119.820593
EA0276R	-23.302479	119.821735
EA0277R	-23.301574	119.821081
EA0278R	-23.301982	119.821733
EA0279R	-23.305873	119.82859
EA0280R	-23.302773	119.815846
EA0284R	-23.307792	119.830691
EA0290R	-23.293604	119.783595
EA0291R	-23.294646	119.783936
EA0302R	-23.302385	119.796211
EA0304R	-23.298252	119.792098
EA0305R	-23.304141	119.813367
EA0307R	-23.303486	119.81325
EA0308R	-23.302787	119.806301
EA0310R	-23.302744	119.797309
EA0313R	-23.300815	119.805157
EA0314R	-23.301323	119.80759
EA0315R	-23.30123	119.808332
EA0316R	-23.301285	119.808712
EA0317R	-23.305739	119.827695
EA0318R	-23.300465	119.816937
EA0319R	-23.297585	119.817217
EA0320R	-23.301161	119.824256
EA0472R	-23.29697169	119.7902911
EA0585R	-23.300742	119.77363
EA0588R	-23.29879	119.764612
EA0589R	-23.298067	119.77067
EA0591R	-23.29502122	119.7851748
EA0593R	-23.300987	119.76251
EA0834R	-23.29757852	119.7688355
EA0835RG	-23.2976332	119.7695278
EA0836R	-23.29791433	119.7700301
EA0855R	-23.29503105	119.7759106
EA0862R	-23.29564292	119.7782204
EA0893R	-23.29739726	119.7904775
EA0900R	-23.29472486	119.7590648
EA0902R	-23.29649	119.765262
EA1000R	-23.29452833	119.7752742
EA1118R	-23.29352914	119.7637618
EA1119R	-23.29332265	119.7630808
EA1132R	-23.29306691	119.761474
EA1134R	-23.2933744	119.7601548
EA1136R	-23.29317404	119.7597179
EA1137R	-23.29261109	119.7595913
EA1145R	-23.2953447	119.7731553
EA1156R	-23.29390379	119.7765046
EA1206RG	-23.295689	119.760725
EA1207R	-23.295798	119.761924
EA1212RG	-23.295386	119.758354
EA1215R	-23.294249	119.758893
EA1225R	-23.29799972	119.7695933
EA1272R	-23.29267137	119.7695117
EA1273R	-23.29483155	119.7705947
EA1274R	-23.29284568	119.7736538

Groundwater Assessment Area		
Drill Hole Code	Latitude	Longitude
EAP0007	-23.302183	119.817018
EAP0008	-23.301091	119.817013
EAP0013	-23.302075	119.802709
EAP0028	-23.301039	119.812251
EAP0038	-23.302221	119.821786
EAP0048	-23.302163	119.814626
EAP0052	-23.301068	119.814638
EAP0069	-23.303295	119.819375
EAP0102	-23.29689	119.771767
EAP0103	-23.296339	119.771771
EAP0104	-23.29641	119.774155
EAP0105	-23.295807	119.774175
EAP0110	-23.303866	119.821756
EAP0114	-23.294359	119.76466
EAP0115	-23.302766	119.821777
EAP0116	-23.293808	119.764644
EAP0121	-23.294065	119.762258
EAP0129	-23.30667	119.828871
EAP0130	-23.307077	119.828868
EAP0139	-23.310489	119.824088
EAP0141	-23.302679	119.809854
EAP0144	-23.302128	119.809859
EAP0151	-23.303854	119.819346
EAP0155	-23.302722	119.816989
EAP0156	-23.301628	119.817002
EAP0161	-23.303822	119.814612
EAP0176	-23.301613	119.814625
EAP0196	-23.294625	119.759869
EAP0203	-23.297411	119.774095
EAP0217	-23.29799	119.771757
EAP0233	-23.310213	119.824091
EAP0243	-23.302403	119.809856
EAP0253	-23.30322	119.808658
EAP0272	-23.301888	119.814628
EAP0280	-23.304081	119.814597
EAP0283	-23.302995	119.816993
EAP0301	-23.303858	119.820571
EAP0303	-23.304426	119.82056
EAP0338	-23.306946	119.828887
EAP0342	-23.304022	119.812193
EAP0399	-23.309415	119.82767
EAP0400	-23.309136	119.827672
EAP0473	-23.29911	119.787132
EAP0475	-23.298425	119.787161
EAP0476	-23.298729	119.787146
EAP0509	-23.298106	119.789626
EAP0528	-23.2999	119.794359
EAP0540	-23.296036	119.783704
EAP0541	-23.295813	119.783748
EAP0542	-23.296242	119.782435
EAP0547	-23.29551	119.78004
EAP0548	-23.29507	119.780135
EAP0550	-23.294183	119.780141
EAP0553	-23.295029	119.778964
EAP0555	-23.293993	119.778948
EAP0556	-23.295236	119.777797
EAP0557	-23.294624	119.777865
EAP0558	-23.294104	119.777877
EAP0560	-23.294231	119.778948
EAP0569	-23.295942	119.782506
EAP0594	-23.301729	119.795558
EAP0707	-23.309371	119.825217
EAP0721	-23.303032	119.820616
EAP0722	-23.303571	119.818175
EC0685R	-23.3205828	119.7747718
EC0805DT	-23.31940658	119.7775899
EC0842R	-23.31760584	119.7766449
EC0970R	-23.31934872	119.7761416
EC0985R	-23.32163755	119.7780463
EC1206DT	-23.31898741	119.776144

Groundwater Assessment Area		
Drill Hole Code	Latitude	Longitude
EC1223DT	-23.32027534	119.7771559
EC1225DG	-23.3197317	119.77848
EC1240DG	-23.32063515	119.7788069
EC1310R	-23.31842858	119.7785427
EC1314R	-23.31982649	119.7795802
EC1470R	-23.31937125	119.775235
ECP0057	-23.325495	119.759972
ECP0058	-23.326408	119.759952
ECP0067	-23.325902	119.759955
ECP0470	-23.32423313	119.7925335
ECP0471	-23.32443278	119.7930206
ECP0512	-23.325313	119.758947
ECP0513	-23.326097	119.759033
ECP0612	-23.325621	119.783091
ECP0614	-23.32359875	119.7830805
ECP0615	-23.32400619	119.7846001
ECP0619	-23.323404	119.79097
ECP0679	-23.32160488	119.7706032
ECP0680	-23.322318	119.770573
EEX0038	-23.301773	119.815532
EEX0236	-23.313863	119.775665
EEX0560	-23.298034	119.711349
EEX0561	-23.298942	119.711337
EEX0572	-23.304531	119.734726
EEX0573	-23.305445	119.734723
EEX0574	-23.302239	119.728904
EFP0015	-23.307086	119.906827
EMP0038	-23.303728	119.74648
EMP0042	-23.301855	119.740643
EMP0049	-23.299105	119.734793
EMP0050	-23.30183	119.734765
EMP0054	-23.297276	119.728954
EMP0059	-23.29808	119.717218
EMP0061	-23.296299	119.71724
EMP0068	-23.298536	119.717216
EMP0070	-23.296726	119.717231
EMP0086	-23.302275	119.73476
EMP0097	-23.310247	119.772826
EMP0098	-23.30935725	119.7728337
EMP0115	-23.309209	119.755239
EMP0127	-23.312512	119.775752
EMP0130	-23.311624	119.775747
EMP0139	-23.300889	119.728923
EMR0021	-23.30422146	119.749104
EMR0022	-23.302825	119.746488
EMR0024	-23.300899	119.734775
EMR0041	-23.298538	119.690637
EXR0520	-23.307023	119.906725
EXR0527	-23.30149	119.876606
EXS0038	-23.303271	119.766076
GRAV0117	-23.321701	119.766753
GRAV0118	-23.319583	119.776466
HEOP0317	-23.339503	119.760878
HEOP0391	-23.299062	119.684661
HEOP0395	-23.298839	119.74315
HEOP0504	-23.299183	119.865786
HEOP0572	-23.291981	119.869989
HHS0010	-23.299889	119.713479
HHS0017	-23.298159	119.723081
HHS0019	-23.302123	119.740499
HHS0020	-23.302183	119.746535
HHS0029	-23.29911	119.753006
HHS0032	-23.295375	119.723097
HHS0035	-23.293671	119.729144
HHS0037	-23.291721	119.723321
HHS0043	-23.295563	119.729014
HNPIOP0030	-23.299182	119.86559
HST0004R	-23.313921	119.781328
HST0007R	-23.312077	119.784217
HST0008R	-23.312771	119.784107

Groundwater Assessment Area		
Drill Hole Code	Latitude	Longitude
HST0013R	-23.312818	119.757838
HST0031R	-23.3060738	119.7737015
HST0032R	-23.300803	119.76189
HST0033R	-23.303468	119.764925
HST0034R	-23.30614963	119.7679625
HST0035R	-23.30854081	119.7767855
HST0037R	-23.302829	119.760528
HST0040R	-23.303759	119.760529
HST0042R	-23.303527	119.757363
HST0044R	-23.305508	119.757787
HST0045R	-23.30125	119.751805
HST0047RD	-23.303658	119.752016
HST0056R	-23.312688	119.766547
HST0062R	-23.309231	119.754895
HST0063R	-23.310005	119.757817
HST0067RD	-23.31175608	119.7665607
HST0068R	-23.31155259	119.7783248
HST0069R	-23.31246006	119.7783562
HST0071R	-23.311845	119.76368
HST0075R	-23.31164	119.772462
HST0083RD	-23.312387	119.775431
HST0084RD	-23.31339	119.775425
HST0096R	-23.30303	119.757665
HST0098R	-23.30509	119.757708
HST0122R	-23.306824	119.760665
HST0125RE	-23.301467	119.760471
HST0130R	-23.301972	119.754777
HST0131R	-23.30251	119.751753
HST0132R	-23.301726	119.751769
HST0133R	-23.303359	119.751783
HST0137R	-23.307767	119.760664
HST0152R	-23.311135	119.769511
HST0175R	-23.31218239	119.7665264
HST0180R	-23.307278	119.763603
HST0185R	-23.310413	119.76078
HST0186R	-23.311237	119.760742
HST0205D	-23.310876	119.766586
HST0211DT	-23.305556	119.757687
HST0212D	-23.311287	119.763678
HST0213D	-23.308639	119.760652
HST0215DT	-23.307388	119.754659
HST0216D	-23.303687	119.760584
HST0217D	-23.312818	119.757842
HST0219D	-23.303394	119.764945
HST0221D	-23.305556	119.757687
HST0222DM	-23.310572	119.763863
HST0225DM	-23.310491	119.766618
HST0227DM	-23.310906	119.76964
HST0229DM	-23.312612	119.77544
HST0230DM	-23.312783	119.772732
HST0231DM	-23.313678	119.778563
HST0233DG	-23.311885	119.760739
HST0241D	-23.29930829	119.7552062
HST0242D	-23.309589	119.764892
HST0244D	-23.302655	119.745115
HST0310R	-23.302401	119.756712
HST0325R	-23.306488	119.756744
HST0329R	-23.307285	119.756837
HST0332R	-23.308602	119.756864
HST0350R	-23.303853	119.759151
HST0353R	-23.305146	119.75917
HST0354R	-23.302525	119.758522
HST0355R	-23.301618	119.75862
HST0380R	-23.304644	119.75425
HST0396R	-23.301055	119.76263
HST0398R	-23.303205	119.768539
HST0399R	-23.302355	119.768506
HST0420R	-23.305414	119.7553
HST0423R	-23.304317	119.762647
HST0425R	-23.303958	119.763002
HST0427R	-23.304728	119.763031
HST0428R	-23.306031	119.764069
HST0442R	-23.301609	119.756788
HST0448R	-23.301674	119.75814
HST0449RD	-23.29979251	119.7549704
HST0454R	-23.309469	119.759757
HST0473R	-23.303061	119.75229
HST0480R	-23.303043	119.755027
HST0529R	-23.29667606	119.7479938
HST0530R	-23.29832711	119.7505427
HST0532R	-23.29843984	119.748106
HST0544R	-23.29854018	119.7566353
HST0545R	-23.29930786	119.7565833
HST0546R	-23.30015859	119.7566449
HST0704R	-23.309896	119.752945
HST0705R	-23.306685	119.747932
HST0706R	-23.305886	119.748116
HST0707R	-23.305094	119.748132
HST0708R	-23.304023	119.748097
HST0720R	-23.30333285	119.7491033
HST0723R	-23.301494	119.747972
HST0769R	-23.309022	119.751567
HST0800R	-23.303284	119.771423
HST0801R	-23.30517	119.771532
HST0810R	-23.29886943	119.7549502
HST0811R	-23.29805897	119.755019
HST0813R	-23.30012713	119.7575805
HST0814R	-23.29925097	119.7575626
HST0817R	-23.30263243	119.7656309
HST0835R	-23.30331528	119.7450182
HST0836R	-23.30375689	119.7450619
HST0838R	-23.30188666	119.7449788
HST0907R	-23.311314	119.759791
HST0910R	-23.3090403	119.7727908
HST0911R	-23.30816709	119.7727724
HST0912R	-23.3098127	119.7757598
HST0913R	-23.31074458	119.7757454
MKCFOR2	-23.32256278	119.7722925
MKCFOR4	-23.29577778	119.7786389
MKCFOR6	-23.28388889	119.6583333
MKCFOR7	-23.29574028	119.7786944
OB25WUNK10	-23.32438162	119.7930056
T0399	-23.284253	119.868595
T0401	-23.298805	119.863041

Reference Area		
Drill Hole Code	Latitude	Longitude
18-ERT	-23.34379611	120.0478742
C Wall Composite	-23.34027778	119.8847222
Cowra Bore	-23.60608333	120.0593611
EB0001R	-23.315892	120.0867
EB0003R	-23.314098	120.086763
EB0004R	-23.312395	120.08677
EB0006R	-23.317961	120.092494
EB0009R	-23.315108	120.092642
EB0010R	-23.314221	120.092653
EB0011R	-23.313322	120.092665
EB0012R	-23.312417	120.092677
EB0017R	-23.320364	120.082078
EB0018R	-23.32084	120.082342
EB0019R	-23.32146	120.082191
EB0020R	-23.32172	120.08218
EB0021R	-23.320928	120.083594
EB0022R	-23.319944	120.083785
EB0024R	-23.31579	120.08386
EB0027R	-23.313093	120.083711
EB0028R	-23.318793	120.095399
EB0029R	-23.319696	120.095403
EB0030R	-23.317752	120.095429

Reference Area		
Drill Hole Code	**Latitude**	**Longitude**
EB0033R	-23.315182	120.095515
EB0034R	-23.314277	120.09553
EB0036R	-23.317478	120.121812
EB0037R	-23.318404	120.121807
EB0038R	-23.319301	120.121781
EB0039R	-23.320218	120.121755
EB0044R	-23.325561	120.121719
EB0048R	-23.31961	120.112937
EB0050R	-23.317747	120.113036
EB0053R	-23.320697	120.098354
EB0058R	-23.313445	120.098447
EB0060R	-23.311635	120.098516
EB0063R	-23.317299	120.08957
EB0065R	-23.315518	120.089604
EB0067R	-23.31372	120.08966
EB0069R	-23.31201	120.089708
EB0070R	-23.321837	120.110112
EB0072R	-23.320056	120.110136
EB0079R	-23.311825	120.110226
EB0080R	-23.32578	120.127516
EB0081R	-23.324898	120.12756
EB0083R	-23.323107	120.127573
EB0088R	-23.318589	120.127672
EB0090R	-23.316788	120.127692
EB0091R	-23.314992	120.127736
EB0092R	-23.325668	120.124616
EB0093R	-23.32476	120.124633
EB0094R	-23.314034	120.1043
EB0095R	-23.312212	120.104349
EB0102R	-23.321229	120.104141
EB0111R	-23.325884	120.133469
EB0113R	-23.32395	120.133303
EB0116R	-23.321188	120.1335
EB0118R	-23.319591	120.133485
EB0122R	-23.325657	120.130463
EB0127R	-23.321225	120.130578
EB0133R	-23.315752	120.130629
EB0137R	-23.321057	120.118886
EB0145R	-23.325669	120.118751
EB0146R	-23.32328	120.136367
EB0147R	-23.322468	120.136593
EB0148R	-23.321346	120.13618
EB0149R	-23.320598	120.136418
EB0156DT	-23.319443	120.104286
EB0164R	-23.313222	120.113134
EB0168R	-23.321161	120.124724
EB0169R	-23.320147	120.124766
EB0172RE	-23.317635	120.1248
EB0174R	-23.321689	120.101279
EB0176R	-23.319889	120.101311
EB0177R	-23.318898	120.101309
EB0179R	-23.316217	120.101335
EB0180R	-23.296697	120.133939
EB0181R	-23.294358	120.134065
EB0183R	-23.2967	120.136991
EB0184R	-23.296787	120.130999
EB0185R	-23.299832	120.136835
EB0186R	-23.30157	120.133876
EB0188R	-23.314396	120.101393
EB0189R	-23.311582	120.101474
EB0190R	-23.322222	120.107071
EB0195R	-23.318641	120.107141
EB0196R	-23.317733	120.107146
EB0198R	-23.315936	120.107184
EB0200R	-23.314201	120.107243
EB0201R	-23.31965	120.136454
EB0202R	-23.318031	120.136431
EB0203R	-23.319355	120.139406
EB0204R	-23.322363	120.142275
EB0205R	-23.320544	120.142271

Reference Area		
Drill Hole Code	**Latitude**	**Longitude**
EB0207R	-23.3157	120.121835
EB0208R	-23.316611	120.121806
EB0209R	-23.312883	120.116076
EB0211R	-23.327049	120.115797
EB0214R	-23.324168	120.112872
EB0215R	-23.324458	120.109937
EB0216R	-23.322826	120.110015
EB0223R	-23.317967	120.098401
EB0224R	-23.318151	120.110095
EB0230R	-23.321752	120.08364
EB0236R	-23.318846	120.11593
EB0238R	-23.324593	120.139265
EB0239R	-23.312337	120.133626
EB0241R	-23.325616	120.136365
EB0243R	-23.3242	120.142207
EB0245R	-23.319069	120.146424
EB0246R	-23.321534	120.145138
EB0253R	-23.309928	120.098536
EB0254R	-23.306364	120.098642
EB0255R	-23.322644	120.083627
EB0259R	-23.320935	120.089504
EB0262R	-23.323473	120.098241
EB0266R	-23.3231	120.104099
EB0267R	-23.310877	120.104396
EB0268R	-23.31298	120.107504
EB0270R	-23.305184	120.133833
EB0271R	-23.323776	120.14415
EB0273R	-23.327854	120.136288
EB0274R	-23.327786	120.130391
EB0276R	-23.302721	120.098709
EB0277R	-23.299092	120.098733
EB0278R	-23.295514	120.098855
EB0279R	-23.291916	120.098914
EB0286R	-23.329292	120.124472
EB0291DTM	-23.318665	120.104314
EB0305RDTM	-23.323926	120.124587
EB0321R	-23.310219	120.089741
EB0444R	-23.326666	120.127543
EB0446R	-23.322346	120.111413
EB0453R	-23.323565	120.143237
EB0484R	-23.321489	120.114391
EB0485R	-23.319695	120.11442
EB0486R	-23.317883	120.114469
EBP0056	-23.335396	120.10015
EBP0069	-23.334071	120.106019
EBP0075	-23.333198	120.111892
EBP0086	-23.319716	120.108851
EBR0003	-23.332234	120.100165
EBR0004	-23.332898	120.100161
EBR0008	-23.334916	120.094278
EBR0011	-23.333174	120.10602
EBR0017	-23.334583	120.11775
EBR0019	-23.334398	120.082553
EBR0021	-23.33401	120.094284
EBR0023	-23.335977	120.082544
EBR0037	-23.333928	120.117749
EBR0054	-23.320372	120.108846
EEG0077	-23.386481	119.706611
EEG0080	-23.384691	119.708584
EEG0082	-23.381527	119.708125
EEG0083	-23.381079	119.708618
EEG0113	-23.38334	119.709086
EEG0544	-23.379337	119.705847
EEG0798	-23.386645	119.694611
EEG0818	-23.386139	119.693146
EEG0819	-23.386401	119.693864
EEG0822	-23.386809	119.694381
EEG0823	-23.386895	119.695288
EEG0824	-23.387163	119.695058
EEG0832	-23.387353	119.694796

Reference Area		
Drill Hole Code	**Latitude**	**Longitude**
EEG0833	-23.38709	119.696072
EEX0295	-23.387318	119.695864
EEX0296	-23.386376	119.692898
EEX0318	-23.366234	119.714628
EEX0322	-23.361314	119.720538
EEX0324	-23.364025	119.720515
EEX0345	-23.387329	119.699747
EEX0346	-23.388216	119.698762
EEX0387	-23.389136	119.697774
EEX0388	-23.388179	119.694855
EEX0389	-23.389083	119.693866
EEX0395	-23.389991	119.692897
EEX0396	-23.389885	119.696942
EEX0402	-23.3667	119.717561
EEX0406	-23.367103	119.711682
EEX0433	-23.384704	119.710526
EEX0434	-23.385594	119.709539
EEX0435	-23.386493	119.708555
EEX0436	-23.387384	119.707584
EEX0437	-23.388289	119.706592
EEX0444	-23.386871	119.696359
EEX0518	-23.38864	119.694377
EEX0519	-23.3877	119.695458
EEX0520	-23.389567	119.697291
EEX0521	-23.388662	119.698275
EEX0522	-23.387779	119.69928
EEX0540	-23.382802	119.708692
EEX0542	-23.37972	119.708149
EEX0543	-23.377886	119.706199
EEX0680	-23.328396	119.982889
EEX0731	-23.33169	120.006316
EEX0739	-23.308387	119.889162
EEX0751	-23.310208	119.889264
EEX0794	-23.309355	119.89208
EEX0795	-23.31015	119.892031
EEX0796	-23.308442	119.886308
EEX0797	-23.309276	119.886227
EEX0909	-23.337751	120.023796
EFD0003	-23.304541	119.888051
EFD0004	-23.303171	119.882114
EFP0003	-23.303807	119.883347
EFP0008	-23.304772	119.889199
EFP0009	-23.30657	119.894975
EFP0010	-23.304814	119.895065
EFP0013	-23.305754	119.900914
EFR0008	-23.305715	119.89506
EH0007R	-23.318934	120.07078
EH0010R	-23.320372	120.064841
EH0015R	-23.318584	120.062021
EH0016R	-23.321153	120.064831
EH0025DTM	-23.319807	120.067894
EJ0003R	-23.330151	120.053743
EJ0004R	-23.329726	120.053253
EJ0017R	-23.32926	120.051768
EJ0034R	-23.332442	120.049812
EJ0039R	-23.333246	120.048357
EJ0044R	-23.330598	120.049859
EJ0045R	-23.330181	120.049883
EJ0047R	-23.329611	120.050029
EJ0053R	-23.335516	120.032231
EJ0055R	-23.328723	120.044495
EJ0073R	-23.328303	120.044432
EJ0085R	-23.334578	120.034135
EJ0097R	-23.331002	120.048872
EJ0116R	-23.335115	120.036146
EJ0117R	-23.335024	120.03515
EJ0149R	-23.318911	120.057234
EJ0165R	-23.322105	120.061106
EJ0218R	-23.333636	120.032718
EJ0234R	-23.329707	120.04836

Reference Area		
Drill Hole Code	**Latitude**	**Longitude**
EJ0239R	-23.328501	120.050083
EJ0245R	-23.327393	120.049821
EJ0278RT	-23.333617	120.035606
EJ0288R	-23.334932	120.028358
EJ0337R	-23.319301	120.048875
EJ0339R	-23.328525	120.044846
EJ0349R	-23.338428	120.023896
EJ0350R	-23.337119	120.02406
EJ0351R	-23.337988	120.020881
EJ0352R	-23.335958	120.020923
EJ0353R	-23.33675	120.021881
EJ0354R	-23.337495	120.022759
EJ0355R	-23.335844	120.02296
EJ0356R	-23.337208	120.024803
EJ0357R	-23.336357	120.024829
EJ0358R	-23.337392	120.025777
EJ0368R	-23.33695	120.037086
EJ0371R	-23.3397	120.033745
EJ0379R	-23.319983	120.048585
EJ0380R	-23.321883	120.047151
EJ0381R	-23.323203	120.047388
EJ0382R	-23.323482	120.047429
EJ0384R	-23.329567	120.04369
EJ0391R	-23.335937	120.025641
EJ0399R	-23.324609	120.039794
EJ0400R	-23.324326	120.037784
EJ0402R	-23.329785	120.036974
EJ0413R	-23.321644	120.060178
EJ0414R	-23.318515	120.061171
EJ0433R	-23.320276	120.061188
EJ0434R	-23.321186	120.061102
EJ0475R	-23.33814	120.027256
EJ0477R	-23.336767	120.027298
EJ0478R	-23.336479	120.027006
EJ0482R	-23.336798	120.03109
EJ0492R	-23.335955	120.033914
EJ0500R	-23.327989	120.048933
EJP0003	-23.324224	120.046443
EJP0039	-23.331425	120.036529
EJP0060	-23.330541	120.036545
EJR0001	-23.379692	120.245508
EJR0002	-23.377974	120.245554
EJR0003	-23.376082	120.245584
EJR0004	-23.374333	120.245604
EJR0005	-23.38042	120.23988
EJR0006	-23.37868	120.239667
EJR0013	-23.375772	120.227993
EJR0014	-23.373968	120.22803
EJR0015	-23.372163	120.228068
EJR0016	-23.380387	120.233763
EJR0018	-23.376778	120.233838
EJR0019	-23.374974	120.233876
EJR0022	-23.372474	120.24566
EJR0023	-23.378025	120.253367
EJR0024	-23.374416	120.253442
EJR0027	-23.369003	120.253553
EJR0028	-23.37983	120.25333
EJR0029	-23.381634	120.253293
EJR0032	-23.37011	120.265263
EJR0033	-23.368306	120.2653
EJR0034	-23.372817	120.265207
EJR0035	-23.373169	120.233913
EJR0201	-23.323933	120.045277
EJR0202	-23.324731	120.045431
EJR0203	-23.326528	120.045955
EJR0205	-23.326559	120.046786
EJR0208	-23.322902	120.046446
EJR0212	-23.326578	120.046339
EJR0215	-23.326771	120.045865
EJR0219	-23.325635	120.046403

Reference Area		
Drill Hole Code	Latitude	Longitude
EJR0232	-23.330384	120.03492
EJR0233	-23.33081	120.026535
EJR0234	-23.330916	120.026652
EJR0235	-23.322105	120.03893
EJR0236	-23.324378	120.040547
EJR0237	-23.320771	120.044913
EJR0243	-23.321202	120.060193
EJR0247	-23.3185	120.058155
EK0006R	-23.386855	119.644991
EK0009R	-23.388624	119.645358
EK0020R	-23.383264	119.650869
EK0034R	-23.383744	119.654776
EK0045R	-23.390785	119.654723
EK0050R	-23.390851	119.645444
EK0058R	-23.384186	119.650853
EK0065R	-23.390347	119.647521
EK0070R	-23.383296	119.65384
EK0073R	-23.384628	119.655839
EK0079R	-23.385244	119.660666
EK0081R	-23.383331	119.655765
EK0086R	-23.385115	119.657678
EK0088R	-23.387556	119.663681
EK0090R	-23.384225	119.660713
EK0094R	-23.384549	119.656706
EK0097R	-23.383246	119.656897
EK0099R	-23.384258	119.657745
EK0103R	-23.390072	119.654731
EK0145R	-23.375949	119.641176
EK0146R	-23.377743	119.641174
EK0151R	-23.390837	119.647357
EK0153R	-23.376816	119.639181
EK0154R	-23.37866	119.639161
EK0156R	-23.382276	119.639136
EK0178R	-23.388674	119.643587
EK0223R	-23.390571	119.655743
EK0228R	-23.384528	119.652778
EK0252R	-23.380498	119.641143
EK0273R	-23.387807	119.643428
EKP0002	-23.385162	119.655764
EKP0003	-23.386062	119.655763
EKP0009	-23.385999	119.649886
EKP0015	-23.385102	119.649894
EKP0022	-23.382357	119.644055
EKP0023	-23.386874	119.644009
EKP0024	-23.382302	119.638187
EKP0040	-23.387019	119.661609
EKP0042	-23.386994	119.658678
EKP0052	-23.386043	119.652784
EKP0055	-23.38689	119.646946
EKP0056	-23.387804	119.646944
EKP0058	-23.388721	119.646927
EKP0059	-23.385095	119.646962
EKP0064	-23.381424	119.64113
EKP0066	-23.38504	119.641092
EKP0068	-23.389728	119.66451
EKP0071	-23.387945	119.664536
EKP0072	-23.379597	119.638211
EKP0078	-23.389737	119.663544
EKP0080	-23.387964	119.665514
EKP0082	-23.388401	119.664517
EKP0083	-23.388883	119.665508
EKP0085	-23.389764	119.665409
EKP0086	-23.390207	119.66554
EKP0089	-23.39021	119.664518
EKP0093	-23.389287	119.662565
EKP0096	-23.387958	119.662582
EKP0098	-23.386986	119.66257
EKP0103	-23.388361	119.661658
EKP0105	-23.387911	119.660626
EKP0106	-23.387451	119.660625

Reference Area		
Drill Hole Code	Latitude	Longitude
EKP0115	-23.386554	119.659662
EKP0116	-23.386107	119.659667
EKP0118	-23.386519	119.658682
EKP0122	-23.385307	119.656678
EKP0123	-23.385626	119.656725
EKP0124	-23.385605	119.655744
EKP0134	-23.385532	119.6548
EKP0152	-23.391012	119.655701
EKP0153	-23.391483	119.655652
EKP0170	-23.388267	119.648874
EKP0176	-23.390064	119.649848
EKP0184	-23.387362	119.646924
EKP0185	-23.386442	119.646949
EKP0186	-23.385581	119.646956
EKP0187	-23.384623	119.646958
EKP0189	-23.38648	119.649874
EKP0196	-23.384695	119.644975
EKP0197	-23.38415	119.645021
EKP0198	-23.383726	119.645034
EKP0199	-23.384179	119.645995
EKP0205	-23.386888	119.645924
EKP0206	-23.384584	119.64794
EKP0216	-23.38556	119.648906
EKP0217	-23.38601	119.648903
EKP0218	-23.386468	119.648905
EKP0219	-23.386915	119.64889
EKP0220	-23.387364	119.648878
EKP0221	-23.387829	119.648861
EKP0225	-23.386965	119.650854
EKP0226	-23.387378	119.650843
EKP0227	-23.387833	119.650847
EKP0252	-23.390585	119.65668
EKP0257	-23.385637	119.657704
EKP0263	-23.386481	119.649859
EKP0271	-23.385105	119.64697
EKP0290	-23.387391	119.661101
EKP0292	-23.387873	119.661025
EKP0293	-23.387389	119.660141
EKP0307	-23.390155	119.662968
EKP0308	-23.389715	119.663
EKP0310	-23.39056	119.663994
EKP0311	-23.390171	119.664017
EKP0312	-23.389713	119.664033
EKP0318	-23.386043	119.655319
EKP0321	-23.385624	119.657241
EMS0244	-23.375678	120.167349
EMS0259	-23.3791	120.17918
EMS0260	-23.379637	120.179168
EMS0390	-23.376892	120.164417
EMS0398	-23.374218	120.166427
EMS0424	-23.38244	120.122288
EMS0461	-23.378156	120.110615
EMS0572	-23.382973	120.078732
ETP0005	-23.343809	120.070761
EXD0050	-23.366676	119.714618
EXD0058	-23.366658	119.711686
EXP0011	-23.370568	120.305959
EXP0012	-23.386	120.296618
EXP0013	-23.385098	120.296637
EXP0015	-23.368365	120.305933
EXP0016	-23.366437	120.313218
EXP0018	-23.382842	120.296683
EXP0026	-23.397378	119.626871
EXP0038	-23.36561	120.27787
EXP0039	-23.364011	120.283673
EXP0093	-23.407933	119.557513
EXP0094	-23.406557	119.558271
EXP0098	-23.401791	119.583004
EXP0102	-23.408163	119.608306
EXP0179	-23.419058	119.557595

Reference Area		
Drill Hole Code	**Latitude**	**Longitude**
EXP0182	-23.419588	119.562476
EXP0183	-23.41999	119.562555
EXR0106	-23.387585	120.045199
EXR0107	-23.388303	120.044987
EXR0228	-23.338786	119.982799
EXR0283	-23.369447	120.278055
EXR0293	-23.396005	119.655654
EXR0294	-23.396905	119.655653
EXR0298	-23.391894	119.649832
EXR0347	-23.407889	119.616195
EXR0348	-23.407902	119.616214
EXR0349	-23.40852	119.61745
EXR0350	-23.409818	119.618588
EXR0353	-23.406562	119.636756
EXR0360	-23.399111	119.574424
EXR0361	-23.398974	119.580305
EXR0388	-23.370688	120.272206
EXR0389	-23.371439	120.27227
EXR0421	-23.38812	120.030534
EXR0422	-23.388607	120.030415
EXR0423	-23.367721	120.305958
EXR0424	-23.366919	120.306145
EXR0425	-23.366187	120.306268
EXR0426	-23.365591	120.306483
EXR0427	-23.367413	120.312737
EXR0429	-23.387482	120.026588
EXR0447	-23.402441	119.611385
EXR0448	-23.401058	119.621729
EXR0449	-23.393296	119.631915
EXR0518	-23.303746	119.894681
EXR0521	-23.308013	119.915612
EXR0522	-23.309302	119.915958
EXR0524	-23.303506	119.883845
EXR0525	-23.304415	119.889232
EXR0572	-23.366454	120.338421
EXR0579	-23.369633	120.272244
EXR0580	-23.368731	120.272129
EXR0585	-23.367493	120.272143
EXR0626	-23.366047	120.333101
EXR0627	-23.364956	120.332634
EXR0628	-23.368682	120.313005
EXR0632	-23.365795	120.301295
EXR0633	-23.364794	120.301228
EXR0639	-23.389027	120.035314
EXR0641	-23.389541	120.03537
EXR0644	-23.383156	120.03545
EXR0647	-23.412205	119.601681
EXR0648	-23.409672	119.58998
EXR0779	-23.413165	119.601684
EXR0780	-23.410146	119.590036
EXR0781	-23.405964	119.578373
EXR0782	-23.406414	119.578425
EXR0783	-23.406925	119.578398
EXR0784	-23.406833	119.566504
EXR0785	-23.406213	119.56641
EXR0786	-23.413425	119.613514
EXR0787	-23.414291	119.613628
EXR0789	-23.386131	120.032777
EXR0791	-23.387583	120.03197
EXR0792	-23.387222	120.032761
EXR0793	-23.387681	120.03307
EXR0794	-23.38828	120.033091
EXR0795	-23.388745	120.033139
EXR0797	-23.365107	120.306601
EXR0798	-23.385737	120.289251
EXR0799	-23.387018	120.289176
EXR0800	-23.3847	120.289301
EXR0801	-23.384273	120.301152
EXR0803	-23.383371	120.30117
EXR0811	-23.385618	120.283963

Reference Area		
Drill Hole Code	**Latitude**	**Longitude**
EXR0978	-23.388153	120.020943
EXR0979	-23.388568	120.021022
EXR0980	-23.389035	120.02167
EXR0981	-23.387246	120.02367
EXR0982	-23.387751	120.023853
EXR0983	-23.38822	120.023944
EXR0984	-23.388626	120.023877
EXR0986	-23.388014	120.028444
EXR0988	-23.388927	120.038619
EXR0989	-23.412858	119.613379
EXR0990	-23.413848	119.613545
EXR0992	-23.414107	119.624994
EXR0993	-23.413252	119.624899
EXR0994	-23.41294	119.636933
EXR0995	-23.412293	119.636802
EXR0996	-23.413826	119.636862
EXR0997	-23.407486	119.648287
EXR0998	-23.407938	119.648247
EXR1010	-23.388465	120.03864
EXR1012	-23.389873	120.041623
EXR1013	-23.389344	120.04152
EXR1014	-23.388941	120.041189
EXR1015	-23.390415	120.041512
EXR1016	-23.390027	120.048022
EXR1017	-23.389511	120.0482
EXR1018	-23.390524	120.048014
EXR1019	-23.389942	120.045249
EXR1080	-23.401427	119.60175
EXR1082	-23.402146	119.649159
EXR1083	-23.402302	119.65058
EXR1084	-23.400902	119.650601
EXR1085	-23.400893	119.651188
EXR1086	-23.395296	119.651223
EXR1087	-23.395185	119.652443
EXR1088	-23.395534	119.650445
EXR1089	-23.379969	120.038573
EXR1090	-23.380874	120.0387
EXR1091	-23.379171	120.041719
EXR1092	-23.380735	120.042239
EXR1093	-23.381416	120.045814
EXR1094	-23.381275	120.0448
EXR1095	-23.38151	120.046318
EXR1108	-23.388302	120.330748
EXR1164	-23.399844	119.627793
EXR1165	-23.399958	119.626377
EXR1180	-23.364935	120.326132
EXR1240	-23.402117	119.624121
EXR1241	-23.402663	119.61577
EXR1343	-23.401971	119.596646
EXR1346	-23.403012	119.600315
EXR1354	-23.388181	120.321598
EXR1356	-23.386745	120.321539
EXR1357	-23.387761	120.330808
EXR1358	-23.389899	120.344993
EXR1361	-23.38731	120.330817
EXR1411	-23.289304	119.319491
EXR1433R	-23.400742	119.57989
EXR1446R	-23.404998	119.600213
EXR1447R	-23.389719	120.277905
EXR1448RT	-23.38702	120.283573
EXR1449R	-23.387802	120.28342
EXR1458R	-23.386398	120.330796
EXR1461R	-23.388038	120.339114
EXR1462R	-23.39105534	120.3509258
EXR1541R	-23.389355	120.038552
EXR1542R	-23.389889	120.038473
EXR1543R	-23.390946	120.041597
EXR1544R	-23.391025	120.048
EXR1549R	-23.399794	119.578037
EXR1550R	-23.400978	119.584067

Reference Area		
Drill Hole Code	Latitude	Longitude
EXR1551R	-23.39992	119.584177
EXR1555R	-23.394454	120.271357
EXR1562R	-23.388086	120.289226
EXR1563R	-23.386222	120.306689
EXR1566R	-23.389169	120.327468
EXR1567R	-23.389413	120.330651
EXR1568R	-23.388861	120.330584
EXR1569R	-23.388909	120.33337
EXR1571R	-23.389243	120.333373
EXR1639R	-23.378376	120.04766
EXR1640R	-23.380167	120.047628
EXR1641R	-23.382048	120.047555
EXR1642R	-23.384168	120.047564
EXR1659R	-23.412673	119.59603
EXR1660R	-23.412215	119.595957
EXR1661R	-23.40839	119.584254
EXR1662R	-23.407506	119.584263
EXR1663R	-23.406945	119.584312
EXR1664R	-23.406573	119.584273
EXR1666R	-23.410734	119.596023
EXR1668R	-23.411655	119.595934
EXR1676R	-23.38516	120.035435
EXR1677R	-23.385085	120.028267
EXR1678R	-23.385927	120.041114
EXR1679R	-23.383844	120.041151
	-23.38384371	120.0411507
EXR1680R	-23.380325	120.045641
EXR1681R	-23.378353	120.045737
EXS0023	-23.33315	119.991804
EXS0024	-23.334245	119.99208
EXS0025	-23.32976	119.979854
EXS0026	-23.330966	119.979565
FG0557	-23.374271	120.141881
FG0560	-23.374202	120.143436
FG0632	-23.374944	120.142298
FG0633	-23.374328	120.142304
FG0673	-23.377731	120.133897
FG0678	-23.375404	120.143365
FG0679	-23.374847	120.142912
FG0984	-23.374139	120.141609
FG0985	-23.373803	120.142441
FG1085	-23.378309	120.146333
FG1089	-23.379276	120.147782
FG1090	-23.379716	120.147292
FG1093	-23.373813	120.143501
FG1100	-23.3744	120.142987
FG1101	-23.374786	120.143416
FG1284	-23.37443	120.104857
FG1303	-23.375407	120.104841
FG1304	-23.374877	120.105796
FG1310	-23.377156	120.103836
FG1311	-23.378055	120.10385
FG1312	-23.378884	120.103794
FG1318	-23.378121	120.109637
FG1322	-23.377247	120.110646
FG1323	-23.379987	120.108598
FG1343	-23.37617	120.104856
FG1359	-23.376361	120.11073
FG1363	-23.375449	120.111599
FG1616R	-23.377206	120.102817
FG1618R	-23.379034	120.102763
FG1697R	-23.375711	120.076521
FG1701R	-23.370309	120.076565
FG1717R	-23.373951	120.073506
FG1718R	-23.369358	120.073588
FG1762R	-23.376384	120.162553
FG1771R	-23.367918	120.092765
FG1786R	-23.364806	120.095736
FG1790DT	-23.366561	120.097255
FG1860R	-23.380937	120.167398

Reference Area		
Drill Hole Code	Latitude	Longitude
FG1879R	-23.369497	120.080938
FG1883R	-23.365612	120.089817
FG1885R	-23.367329	120.083945
FG1889R	-23.369077	120.083908
FG1912R	-23.369839	120.07811
FG1914R	-23.36906	120.078045
FG1921R	-23.371728	120.079491
FG1938R	-23.3685	120.100073
FG2024R	-23.376972	120.079352
FG2026R	-23.378805	120.079297
FG2027R	-23.379708	120.079218
FG2041R	-23.365591	120.091406
FG2060R	-23.371199	120.078
FG2100R	-23.377368	120.167387
FG2104R	-23.379183	120.167355
FG2105R	-23.374655	120.165589
FG2106R	-23.380099	120.167337
FG2109R	-23.376371	120.165416
FG2150R	-23.370937	120.137257
FG2170R	-23.379171	120.12787
FG2178R	-23.376508	120.165347
FG2180R	-23.394278	120.198298
FG2185R	-23.395587	120.17466
FG2186R	-23.394678	120.17467
FG2187R	-23.393783	120.174783
FG2188R	-23.392885	120.174816
FG2190R	-23.396913	120.151271
FG2192R	-23.395106	120.151466
FG2193R	-23.394178	120.15144
FG2194R	-23.391608	120.057519
FG2195R	-23.390677	120.057538
FG2196R	-23.389801	120.057546
FG2200R	-23.393882	120.080934
FG2201R	-23.392955	120.080963
FG2202R	-23.396097	120.104428
FG2203R	-23.395181	120.10439
FG2204R	-23.394293	120.10441
FG2205R	-23.393412	120.104433
FG2206R	-23.396504	120.127746
FG2207R	-23.396072	120.127834
FG2208R	-23.395171	120.127862
FG2211R	-23.394254	120.127809
FG2212R	-23.395666	120.104384
FG2213R	-23.394734	120.104406
FG2214R	-23.393856	120.104433
FG2216R	-23.394204	120.174744
FG2217R	-23.393306	120.174798
FG2218R	-23.396046	120.17187
FG2219R	-23.395081	120.171792
FG2220R	-23.39462	120.171815
FG2222R	-23.394662	120.151516
FG2223R	-23.390278	120.057534
FG2225R	-23.388937	120.057581
FG2226R	-23.38794	120.057584
FG2227R	-23.387119	120.057597
FG2228R	-23.3875	120.057585
FG2229R	-23.388406	120.057555
FG2231R	-23.392017	120.080988
FG2232R	-23.391169	120.081015
FG2233R	-23.390258	120.08104
FG2234R	-23.393733	120.171798
FG2236R	-23.396473	120.171859
FG2275R	-23.379954	120.130386
FG2279R	-23.379428	120.121088
FG2311R	-23.380964	120.113087
FG2312R	-23.380932	120.111891
FG2316R	-23.376339	120.113103
FG2318R	-23.379117	120.112615
FG2319R	-23.380048	120.113014
FG2322R	-23.377315	120.112507

Reference Area		
Drill Hole Code	Latitude	Longitude
FG2324R	-23.379116	120.111037
FG2325R	-23.377435	120.115052
FG2327R	-23.380138	120.114891
FG2334R	-23.376586	120.112126
FG2338R	-23.378818	120.115542
FG2339R	-23.392122	120.186601
FG2340R	-23.392678	120.186659
FG2341R	-23.393138	120.18662
FG2342R	-23.39358	120.186582
FG2343R	-23.393928	120.186593
FG2344R	-23.394453	120.186535
FG2345R	-23.394933	120.186549
FG2346R	-23.393592	120.163162
FG2347R	-23.397122	120.163016
FG2348R	-23.396711	120.16309
FG2350R	-23.395797	120.163111
FG2352R	-23.394895	120.16313
FG2353R	-23.394458	120.163148
FG2356R	-23.396257	120.139561
FG2357R	-23.394887	120.139671
FG2358R	-23.396804	120.092624
FG2360R	-23.395921	120.092662
FG2361R	-23.395485	120.092638
FG2362R	-23.395013	120.092679
FG2364R	-23.394113	120.092691
FG2365R	-23.394549	120.069233
FG2366R	-23.394091	120.069215
FG2368R	-23.393199	120.069227
FG2371R	-23.391857	120.069275
FG2374R	-23.39406	120.116125
FG2375R	-23.39364	120.11613
FG2379R	-23.391826	120.116233
FG2380R	-23.39225	120.116224
FG2381R	-23.392696	120.116201
FG2382RDT	-23.395652	120.080783
FG2384RDT	-23.393811	120.127819
FG2385R	-23.393151	120.116203
FG2386R	-23.39007	120.069314
FG2469R	-23.377155	120.101927
FG2491R	-23.379081	120.109578
FG2509RDT	-23.364655	120.097118
GNHSLK1192	-23.24208333	119.5533611
HEOP0216	-23.247115	119.908231
HEOP0217	-23.245717	119.901891
HEOP0313	-23.352401	119.830848
HEOP0314	-23.352061	119.824973
HEOP0337	-23.403318	119.795934
HEOP0396	-23.36655	119.841045
HEOP0398	-23.393611	119.821274
HEOP0409	-23.378297	119.834834
HEOP0413	-23.401154	119.803436
HEOP0445	-23.460786	119.826356
HEOP0458	-23.403686	119.796059
HEOP0462	-23.264992	119.886637
HEOP0467	-23.231226	119.910955
HEOP0474	-23.426307	119.776939
HEOP0489	-23.447614	119.760197
HEOP0490	-23.433915	119.768902
HEOP0496	-23.401958	119.840094
HEOP0501	-23.40219	119.875476
HEOP0508	-23.402053	119.840368
HEOP0513	-23.398023	119.831318
HEOP0515	-23.164193	119.930375
HEOP0525	-23.186693	119.915538
HEOP0526	-23.249805	119.908191
HEOP0528	-23.20934	119.920223
HEOP0531	-23.249749	119.902286
HEOP0538	-23.249768	119.902773
HEOP0540	-23.213932	119.905276
HEOP0541	-23.205275	119.866564

Reference Area		
Drill Hole Code	Latitude	Longitude
HEOP0543	-23.21391368	119.9049824
HEOP0556	-23.218566	119.917791
HEOP0563	-23.275749	119.880819
HEOP0799	-23.348136	119.839548
HEOP0801	-23.352327	119.829695
HEOP0809	-23.419871	119.777123
HEOP0811	-23.426461	119.776977
HEOP0812	-23.427283	119.77695
HEOP0813	-23.429747	119.77685
HEOP0814	-23.378175	119.838396
HH003	-23.367722	120.197251
HH004	-23.367827	120.198094
HH0110R	-23.37568	120.17526
HH0111R	-23.37569	120.17426
HH0114R	-23.373011	120.174274
HH0115R	-23.372221	120.175263
HH0116R	-23.372124	120.174311
HH0117R	-23.371229	120.174311
HH0118R	-23.37018	120.17447
HH0119R	-23.36939	120.174427
HH012	-23.3698	120.201116
HH0120R	-23.372206	120.180238
HH0121R	-23.369576	120.182239
HH0124R	-23.371339	120.207059
HH0125R	-23.37047	120.207103
HH0126R	-23.369536	120.207151
HH0127R	-23.36863	120.207132
HH0129R	-23.367195	120.204249
HH013	-23.368898	120.201124
HH0131R	-23.372493	120.215922
HH0132R	-23.373238	120.215871
HH0137R	-23.372909	120.213125
HH0138R	-23.371882	120.212912
HH0139R	-23.37016	120.213037
HH0140R	-23.37095	120.212959
HH0141R	-23.371216	120.210035
HH0143R	-23.36967	120.210083
HH0153R	-23.371802	120.187084
HH0154R	-23.371058	120.187038
HH0155R	-23.369996	120.18704
HH0156R	-23.370407	120.184121
HH0157R	-23.3718	120.204177
HH0158R	-23.370885	120.204283
HH0160R	-23.368976	120.204282
HH0161R	-23.368103	120.204189
HH0162R	-23.3687	120.210116
HH022	-23.367374	120.196208
HH025	-23.364416	120.196193
HH032	-23.367042	120.200236
HH033	-23.367554	120.20024
HH034	-23.36557	120.200256
HH035	-23.368364	120.195317
HH036	-23.366591	120.195277
HH037	-23.365692	120.195283
HH038	-23.364701	120.195306
HH045	-23.368818	120.196246
HH045A	-23.368726	120.196248
HH046	-23.368574	120.199136
HH049	-23.366522	120.200257
HH050	-23.366045	120.201162
HH051	-23.366947	120.201146
HH052	-23.365183	120.201184
HH062	-23.365165	120.202098
HH104	-23.369294	120.196129
HH106	-23.365327	120.198106
HMG0064	-23.340782	120.047459
HMG0102	-23.345194	120.049595
HMG0104	-23.345971	120.047216
HMG0105	-23.345744	120.041422
HMG0109	-23.343497	120.041518

Reference Area		
Drill Hole Code	Latitude	Longitude
HMG0110	-23.343964	120.049562
HMG0115	-23.34169	120.049797
HSJ0003	-23.393095	120.151362
HSJ0015	-23.395085	120.125005
HSJ0017	-23.394981	120.151379
HSJ0018	-23.405735	120.139256
HSJ0019	-23.396656	120.129632
HSJ0020	-23.392765	120.142344
HWHB0593	-23.372463	119.638634
HWHB0711	-23.338958	119.648583
JH0066R	-23.380617	120.047093
JH0067R	-23.379151	120.046314
JH0068R	-23.377758	120.045795
JH0069R	-23.376198	120.045737
JH0070R	-23.382464	120.044952
JH0074R	-23.387571	120.050479
JH0075R	-23.385366	120.04801
JH0076R	-23.38743	120.047939
JH0082R	-23.381542	120.043686
JH0084R	-23.379712	120.043787
JH0085R	-23.378382	120.041295
JH0090R	-23.380523	120.03541
JH0091R	-23.382009	120.033374
LB002	-23.375818	120.180083
LB005	-23.373142	120.180147
LB006	-23.376701	120.179088
LB008	-23.376686	120.178113
LB015	-23.373995	120.178169
LB017	-23.374856	120.179124
LB019	-23.373978	120.179131
LB022	-23.375836	120.181063
LB024	-23.375814	120.18204
LB030	-23.373144	120.183091
LB032	-23.371353	120.183133
LB033	-23.373199	120.184071
LB034	-23.372278	120.184069
LB035	-23.37138	120.184092
LB036	-23.374029	120.181099
LB040	-23.373602	120.183061
LB047	-23.37627	120.180077
LB048	-23.373014	120.175259
LB049	-23.373041	120.179206
LB052	-23.374792	120.176197
LB053	-23.373043	120.176211
LB055	-23.373905	120.175257
LB057	-23.375424	120.182036
LB066	-23.371318	120.181134
LB068	-23.370861	120.182146
LB069	-23.370865	120.181203
LB070	-23.371803	120.181147
LB084	-23.374423	120.179117
LB087	-23.377146	120.179082
LB091	-23.373525	120.178179
LB096	-23.377192	120.181034
May09unknown10	-23.40447222	120.1390278
May09unknown3	-23.40811111	120.1378889
May09unknown4	-23.40941667	120.1375556
May09unknown5	-23.41033333	120.1373333
May09unknown6	-23.41077778	120.1371667
May09unknown7	-23.41055556	120.1372778
May09unknown8	-23.409	120.1376944
May09unknown9	-23.40725	120.1381667
MCM0021	-23.374817	120.216417
MCM0023	-23.373116	120.216697
MCM0043	-23.375074	120.220723
MCM0048	-23.376184	120.222743
MCM0049	-23.375663	120.222891
MCM0058	-23.368771	120.193245
MCM0066	-23.366189	120.195288
MCM0067	-23.365226	120.195404

Reference Area		
Drill Hole Code	Latitude	Longitude
MCM0071	-23.36678	120.196186
MCM0073	-23.365292	120.196208
MCM0076	-23.36825	120.196415
MCM0106	-23.368119	120.197188
MCM0107	-23.367331	120.197171
MCM0109	-23.365377	120.197281
MCM0112	-23.368231	120.198089
MCM0114	-23.365785	120.198032
MCM0116	-23.368122	120.199127
MCM0120	-23.365319	120.199081
MCM0121	-23.369279	120.199942
MCM0132	-23.369868	120.201959
MCM0141	-23.36677	120.203141
MCM0142	-23.366029	120.203193
MCM0154	-23.370529	120.207277
MCM0157	-23.367776	120.207237
MCM0163	-23.370655	120.209279
MCM0168	-23.370805	120.210058
MCM0240	-23.367147	120.172251
MCM0241	-23.366426	120.172315
MCM0242	-23.365479	120.172335
MCM0247	-23.367091	120.174158
MCM0248	-23.366191	120.174275
MCM0256	-23.381669	120.239916
MCM0257	-23.38182	120.240793
MCM0280	-23.371347	120.270439
MCM0282	-23.370871	120.268493
MCM0307	-23.369467	120.077587
MCM0357	-23.372954	120.075829
MCM0360	-23.370385	120.075983
MCM0365	-23.370447	120.076862
MCM1529	-23.375853	120.182038
MCM1530	-23.374951	120.182058
MCM1533	-23.375729	120.175197
MCM1534	-23.374845	120.176194
MCM1535	-23.37488	120.178148
MCM1538	-23.373943	120.176213
MCM1539	-23.373129	120.181118
MCM1543	-23.371289	120.179202
MCM1545	-23.378529	120.180271
MG0022R	-23.34303	120.012165
MG0030R	-23.343035	120.012133
MG0036R	-23.33854	120.129587
MG0037R	-23.337588	120.129628
MG0041R	-23.337433	120.124232
MG0042R	-23.336918	120.124213
MG0043R	-23.335831	120.124216
MG0044R	-23.334453	120.124266
MG0045R	-23.335913	120.117686
MG0046R	-23.335042	120.117687
MG0049R	-23.333587	120.111877
MG0050R	-23.330819	120.111943
MG0051R	-23.334393	120.105972
MG0052R	-23.332708	120.105963
MG0053R	-23.331647	120.106023
MG0055R	-23.336099	120.100084
MG0056R	-23.335399	120.100045
MG0057R	-23.336299	120.094213
MG0058R	-23.335388	120.094197
MG0059R	-23.334468	120.094218
MG0060R	-23.333138	120.094259
MG0061R	-23.33659	120.082413
MG0063R	-23.335302	120.082416
MG0066R	-23.336494	120.076619
MG0070R	-23.340197	120.070749
MG0075R	-23.335242	120.091275
MG0076R	-23.334412	120.091317
MG0077R	-23.3349	120.097171
MG0079R	-23.333232	120.103085
MG0080R	-23.332849	120.108964

Reference Area		
Drill Hole Code	**Latitude**	**Longitude**
MG0081R	-23.333433	120.114816
MG0083R	-23.333533	120.120642
MG0085R	-23.33415	120.103092
MG0086R	-23.335823	120.097143
MG0087R	-23.333989	120.097214
MG0088R	-23.342723	120.076542
MG0089R	-23.341901	120.07651
MG0090R	-23.34108	120.076372
MG0103R	-23.339623	120.076608
MG0104R	-23.340515	120.076722
MG0105R	-23.338734	120.076585
MG0109R	-23.334682	120.076688
MG0112R	-23.341523	120.070662
MG0115R	-23.338783	120.070774
MG0116R	-23.334483	120.100083
MG0117R	-23.334004	120.100093
MG0119R	-23.333161	120.100083
MG0121R	-23.333926	120.082501
MG0122R	-23.333429	120.091335
MG0123R	-23.333597	120.105986
MG0124R	-23.332241	120.105998
MG0126R	-23.331758	120.111894
MG0127R	-23.331314	120.111893
MG0128R	-23.335432	120.117651
MG0130R	-23.333609	120.117855
MG0133R	-23.336949	120.129574
MG0134R	-23.336157	120.129665
MG0136R	-23.33814	120.127144
MG0137R	-23.337673	120.127122
MG0138R	-23.337164	120.127136
MG0139R	-23.336831	120.127174
MG0140R	-23.332492	120.100128
MG0141R	-23.334016	120.120632
MG0142R	-23.336208	120.120579
MG0143R	-23.33536	120.120627
MG0145R	-23.335672	120.120565
MG0146R	-23.334906	120.12058
MG0149R	-23.334313	120.114798
MG0150R	-23.333892	120.11479
MG0152R	-23.3325	120.11488
MG0153R	-23.332045	120.114927
MG0154R	-23.333772	120.108989
MG0155R	-23.333277	120.108943
MG0156R	-23.332416	120.108999
MG0157R	-23.331954	120.109001
MG0159R	-23.331103	120.109047
MG0161R	-23.33538	120.127223
MG0162R	-23.333223	120.117651
MG0163R	-23.334974	120.103042
MG0164R	-23.33456	120.103087
MG0165R	-23.333664	120.103064
MG0172R	-23.336675	120.097152
MG0181R	-23.332314	120.10308
MG0182R	-23.331789	120.103098
MG0194R	-23.344099	120.0181
MG0196R	-23.341771	120.012249
MG0198R	-23.345303	120.026649
MG0200R	-23.342578	120.07066
MG0201R	-23.337834	120.076606
MG0202R	-23.333076	120.111842
MG0222R	-23.345821	120.020823
MG0227R	-23.344253	120.014954
MG0257R	-23.336265	120.097145
MG0267R	-23.347268	120.020787
MG0268R	-23.34673	120.02078
MG0280R	-23.333548	120.097248
MG0302RDT	-23.343976	120.012169
MG0359R	-23.344186	120.023948
MKCFOR3	-23.13416667	119.6994722
MKCFOR5	-23.24719444	119.5533333

Reference Area		
Drill Hole Code	**Latitude**	**Longitude**
MS273	-23.37525	120.187
NI0005R	-23.329638	119.995345
NI0007R	-23.32895	120.018046
NI0009R	-23.326883	120.006408
NI0010R	-23.325708	119.993319
NI0011R	-23.323623	119.983529
NI0014R	-23.332067	120.006147
NI0015R	-23.331822	120.003118
NI0016R	-23.330586	120.003127
NI0132R	-23.331743	120.008528
Ninga Bore	-23.43233333	119.9913889
Noddy Bore	-23.36613889	119.9838611
Ophthalmia	-23.36886111	119.9124722
PI002	-23.37703	120.222587
PI003	-23.376124	120.222605
PI005	-23.377499	120.221594
PI007	-23.374329	120.222647
PI008	-23.375658	120.221636
PI009	-23.374755	120.221662
PI011	-23.373551	120.22265
PI012	-23.372602	120.222673
PI013	-23.373777	120.221671
PI014	-23.377504	120.22065
PI018A	-23.37535	120.219669
PI026	-23.374229	120.217768
PI027	-23.373344	120.217782
PI034	-23.375118	120.216767
PI039	-23.374223	120.216785
PI041	-23.375667	120.222639
PI042	-23.374799	120.222634
PI043	-23.37388	120.222657
PI044	-23.373002	120.222652
PI045	-23.377079	120.221585
PI059	-23.374256	120.218732
PI060	-23.375584	120.217719
PI068	-23.373535	120.216796
PP008	-23.381365	120.045247
PP023	-23.388675	120.020923
Salvania 1	-23.58880556	120.0541667
Salvania 2	-23.68097222	119.9749444
Shovelanna	-23.35227778	120.0248056
SJ0033R	-23.394715	120.114559
SJ0041R	-23.394884	120.108709
SJ0253R	-23.396069	120.174661
SJ0320R	-23.394444	120.185079
SJ0330R	-23.396304	120.183486
SJ0349R	-23.39721	120.159865
SJ0364R	-23.392651	120.185109
SJ0389R	-23.39738	120.170269
SJ0413R	-23.397143	120.156965
SJ0421R	-23.395754	120.198128
SJ0441R	-23.397105	120.149662
SJ0454R	-23.395878	120.117583
SJ0491R	-23.396548	120.102719
SJ0494R	-23.395766	120.105819
SJ0496R	-23.394901	120.110057
SJ0497R	-23.395355	120.107312
SJ0499R	-23.396368	120.193815
SJ0500R	-23.391655	120.186542
SJ0502R	-23.396384	120.120417
SJ0504R	-23.395866	120.118955
SJ0505R	-23.394977	120.115602
SJ0508R	-23.394431	120.113135
SJ0509R	-23.394819	120.111613
SJ0516R	-23.396383	120.186525
SJ0526R	-23.396374	120.174678
SJ0563R	-23.397221	120.158462
SJ0573R	-23.397116	120.154088
SJ0574R	-23.396661	120.154091
SJ0577R	-23.395319	120.15415

Reference Area		
Drill Hole Code	**Latitude**	**Longitude**
SJ0578R	-23.397081	120.155512
SJ0591R	-23.397374	120.165745
SJ0592R	-23.396946	120.165816
SJ0597R	-23.396883	120.16871
Swan Bore	-23.49177778	120.042
W262	-23.40638889	120.1383611
W2750	-23.40811111	120.1371389
WBGW0050D	-23.32927778	119.6884167
WBGW007	-23.35941667	119.7060556
WBGW010	-23.33827778	119.7176111
WBGW019D	-23.33888889	119.6895833
WBGW045D	-23.33299806	119.7014922
WH045	-23.368037	120.100062
WH049	-23.365388	120.097199
WH050	-23.362512	120.097161
WH051	-23.363535	120.097144
WH052	-23.360873	120.097188
WJR001	-23.38598	120.032096
WJR003	-23.385985	120.032628

Reference Area		
Drill Hole Code	**Latitude**	**Longitude**
WP0122	-23.25699978	119.9013124
WP126NRE	-23.25038889	119.895
WP131	-23.22919444	119.9036111
WRKRC140	-23.39063889	120.3361944
WRKRC141	-23.39075	120.3361111
WRKRC142	-23.39125	120.3361389
WRKRC143	-23.39169444	120.3371944
WRKRC144	-23.39144444	120.337
WRKRC147	-23.39083333	120.3370833
WRKRC148	-23.39166667	120.33975
WRKRC149	-23.39208333	120.3397222
WRKRC237	-23.39086111	120.338
WRKRC238	-23.39111111	120.3379722
WRKRC240	-23.39172222	120.3380556
WSR0007R	-23.415865	119.559899
WSR0009R	-23.413654	119.565642
WSR0011R	-23.41759	119.565486
WSR0014R	-23.41724	119.570987
WSR0017R	-23.414462	119.570986