Bennelongia Environmental Consultants

Fortescue Metals Group

Christmas Creek Project Water Management Scheme: Stygofauna Assessment

Final Report

Prepared for Fortescue Metals Group Ltd by Bennelongia Pty Ltd

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Christmas Creek Project Water Management Scheme: Stygofauna Assessment

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Cover photo: Chichester Range

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EXECUTIVE SUMMARY

Fortescue Metals Group Ltd is developing the Pilbara Iron Ore and Infrastructure Project, which includes a series of iron ore mines in the Pilbara region of Western Australia and rail and port infrastructure for export of iron ore via Port Hedland. One of the mines within the Pilbara Iron Ore and Infrastructure Project is the Christmas Creek Project, on the footslopes of the Chichester Range in the central Pilbara region of Western Australia. Fortescue is currently mining 10 million tonnes per annum of iron ore at the Christmas Creek mine and, as it increases production to the approved 45 million tonnes per annum approved in Ministerial Statement 707, will have different water requirements. The changes necessary to manage water at the Project are known as the '*Christmas Creek Project Water Management Scheme'*.

Original approval for the Christmas Creek Project under Ministerial Statement 707 was based on only 1.15 gigalites per annum of mine dewatering to assist with supply for processing and dust suppression and a total Project water requirement of 11.4 gigalitres per annum. Approval was contingent on Fortescue carrying out surveys for subterranean fauna within the Project area in accordance with an approved sampling plan (Condition 10.1). This *Stygofauna Survey Plan*, which was approved by the Department of Environment and Conservation, identified stygofauna as the subterranean fauna group likely to be at risk from mining activities. It was subsequently concluded, on the basis of stygofauna surveys, that the risk to subterranean fauna species from mining at Christmas Creek was acceptably low.

As part of the Christmas Creek Project Water Management Scheme, it is proposed to increase the extent of dewatering to a maximum of 50 gigalites per annum to facilitate access to iron ore below the water table. All abstracted groundwater not required for processing or dust suppression will be injected into aquifers near the mine site.

The area that may be impacted as a result of the Christmas Creek Project Water Management Scheme was sampled for stygofauna during previous assessment surveys. The 29 samples collected are considered sufficient to characterize this relatively depauperate community, although they represent less sampling effort than recommended for developments located in rich stygofauna communities. Six stygofauna species were recorded in the impact area of the Water Management Scheme, all of which occur outside this zone (nematode Nematoda sp. 1, worm *Enchytraeus* Pilbara sp. 2, and copepods *Diacyclops humphreysi* s. str. X *unispinosus*, *D. h. spinosus*, *Fierscyclops supersensus*, *Parastenocaris jane*).

Given the wider distribution of the six species occurring in the impact zone, neither dewatering nor groundwater injection (the two impacts associated with the Water Management Scheme) are likely to affect the conservation status of these species. Consequently, it is considered unlikely that the Christmas Creek Project Water Management Scheme will have any significant impact on stygofauna.

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1. INTRODUCTION

Fortescue Metals Group Ltd (Fortescue) is developing the Pilbara Iron Ore and Infrastructure Project, which includes a series of iron ore mines in the Pilbara region of Western Australia and rail and port infrastructure for export of iron ore via Port Hedland. One of the mines within the Pilbara Iron Ore and Infrastructure Project is the Christmas Creek Project, on the footslopes of the Chichester Range in the central Pilbara region of Western Australia. Fortescue is currently mining 10 million tonnes per annum of iron ore at the Christmas Creek mine and, as it increases production to the approved 45 million tonnes per annum approved in Ministerial Statement 707, will have different water requirements. The changes necessary to manage water at the Project are known as the '*Christmas Creek Project Water Management Scheme*'.

The Christmas Creek Project was approved under Ministerial Statement 707 (Pilbara Iron Ore and Infrastructure Project: East-West Railway and Mine Sites, Stage B), which required Fortescue to carry out surveys for subterranean fauna within the Project area in accordance with an approved sampling plan (Condition 10.1). This *Stygofauna Survey Plan* (Ecologia 2006), which was approved by the Department of Environment and Conservation, identified stygofauna as the subterranean fauna group likely to be at risk from mining activities at the Christmas Creek Project. However, an assessment of stygofauna occurrence, according to the above sampling plan, concluded that the risk to long-term survival of stygofauna species as a result of mine development was acceptable (Bennelongia 2008a).

The originally approved Christmas Creek Project required only 1.15 gigalites (GL) per annum of mine dewatering to assist with supply for processing and dust suppression, within a total water requirement of 11.4 GL per annum. Subsequent improved knowledge of groundwater characteristics and changes to pit configuration at the mine has resulted in the predicted rate of dewatering increasing to as much as 50 GL per annum in order to provide access the ore below the water table. All abstracted groundwater not required for processing or dust suppression will be injected into aquifers near the mine site.

This desktop review provides an assessment of the possible impacts on stygofauna of the additional dewatering and groundwater injection that is proposed as part of the Christmas Creek Project Water Management Scheme. The specific aims of the assessment are:

1. To identify any species of stygofauna restricted to the areas affected by dewatering and injection;
2. To determine whether dewatering and injection are likely to have an impact on the restricted species; and
3. To assess the threat to persistence of stygofauna species resulting from the Christmas Creek Project Expansion.

2. GEOLOGY AND HYDROLOGY

Three major aquifer types have been identified in the Christmas Creek area (Figure 2):

1. An alluvium/detrital aquifer within a Quaternary/Tertiary sequence;
2. An aquifer in the upper portion of the Marra Mamba Formation where it is either mineralised or laterised; and
3. An aquifer in the Oakover Formation.

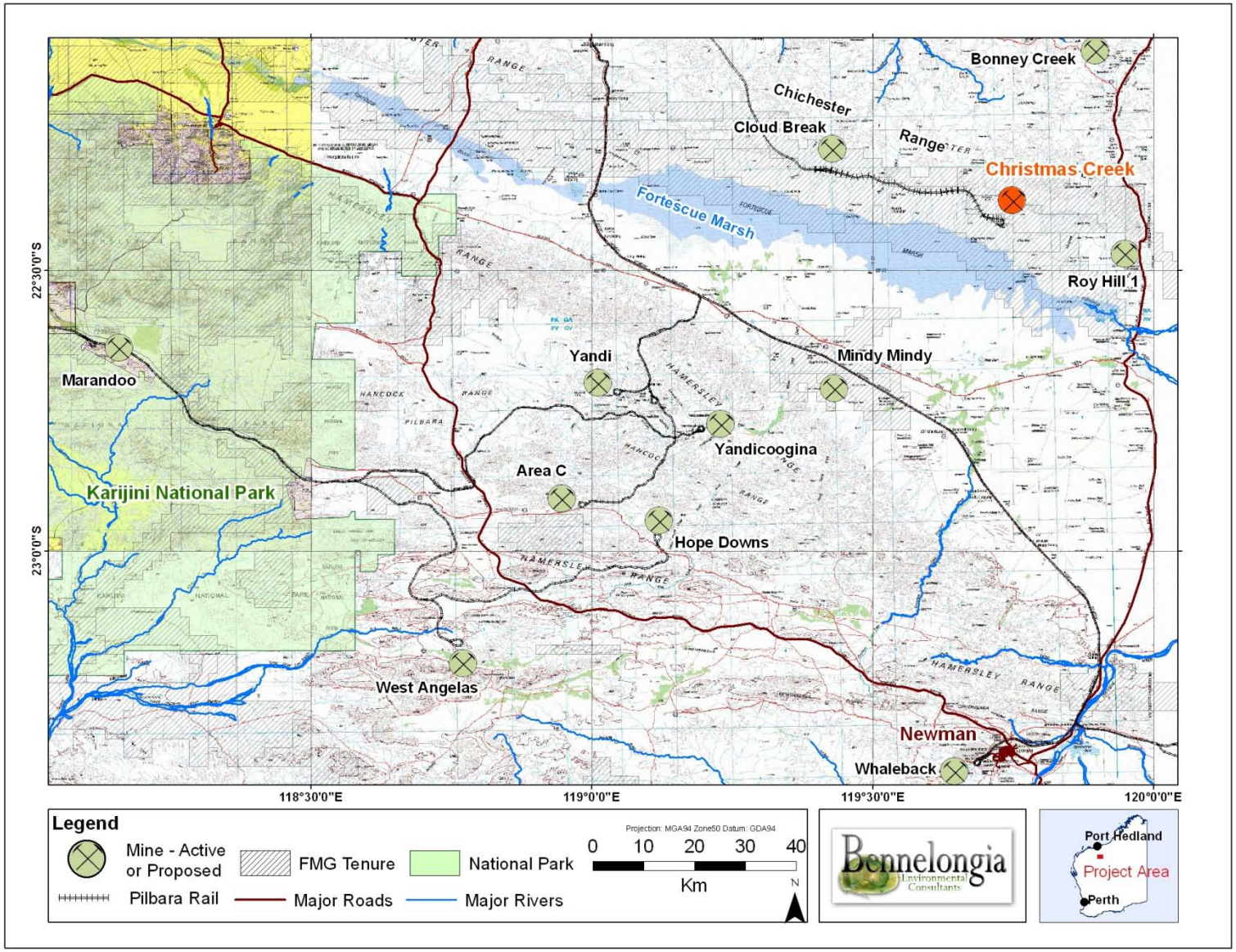

Figure 2. Location of the Christmas Creek Project in relation to other existing and proposed mine sites.

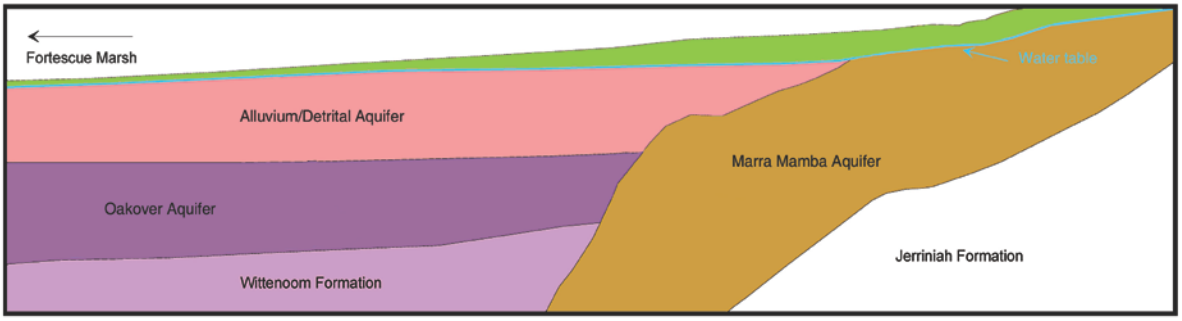

Figure 3. Schematic depiction of the relationship between the three major aquifer types at Christmas Creek (see text).

The Oakover Formation underlies the alluvial and detrital sequence in areas close to the Fortescue Marsh. Both the Oakover Formation and the mineralised/weathered Marra Mamba Formation have been identified as brackish to saline aquifers. Salinity levels in the Oakover Formation aquifer increase markedly in proximity to the Fortescue Marsh, where it has a conductivity of 100,000 microSiemens per centimetre (µS cm^{-1}). This represents a salinity of approximately 100,000 milligrams per litre Total Dissolved Solids (mg L^{-1} TDS).

Depth to groundwater in the Christmas Creek area varies from 6-30 m (Bennelongia 2008a), with groundwater salinity varying from about 1000 to >150000 mg L^{-1} TDS (FMG 2009). Previous stygofauna sampling has shown salinities of 1000-34,000 mg L^{-1} TDS in the top metre of groundwater in the vicinity of Christmas Creek (Bennelongia 2008a).

There are four key lithological units within the aquifer units that contribute to high transmissivities and provide potential habitat for stygofauna:

1. Pebble layers within the alluvium of the unconfined/semi-confined alluvium/detrital aquifer (fresh to brackish, depending on permeability);
2. Cemented and loose gravel in the detrital layer of the semi-confined alluvium/detrital aquifer (fresh to brackish);
3. Marra Mamba Formation within that aquifer, particularly areas of lateritic hardcap and where vugs and pisolitic structures are preserved (fresh to saline dependent on proximity to Chichester Range or Fortescue Marsh); and
4. Oakover Formation within that aquifer, particularly where silica replacement results in vuggy areas of higher transmissivity (saline to hypersaline).

3. PROJECT DESCRIPTION

The Christmas Creek Project is mining Marra Mamba Formation iron ore by surface scraping. After processing, ore is transported by rail to Port Hedland for shipping.

The estimated resource to be mined at Christmas Creek is 1000 million tonnes of Marra Mamba ore. The approved rate of production under Ministerial Statement 707 is 45 million tonnes per annum, which will be beneficiated at the Christmas Creek mine. The approved total area of disturbance at Christmas Creek is 10,135.5 hectares, with an average pit depth of 60 metres (Ministerial Statement 707).

It was anticipated that, during the first three years of activity at Christmas Creek, mining would be mainly above the watertable, with limited dewatering of the orebody required. Thereafter, a small amount of dewatering of the alluvial and Marra Mamba aquifers was expected to be needed in the southern pits closest to the Marsh. Maximum drawdown was not expected to extend more than 4 m below existing levels and the volume of dewatering was predicted to be only 1.15 GL per annum.

As a result of improved understanding of groundwater characteristics, and planned changes to pit configuration, it is now estimated that up to 50 GL per annum of groundwater abstraction will be required to enable access to the ore below the watertable. Dewatering will be achieved by a network of production bores in Flinders and Windich pits (Figure 3). The quantity of groundwater abstracted will be in excess of requirements for ore processing and dust suppression and unused groundwater will be injected into underlying aquifers. Brackish groundwater from the Marra Mamba Formation will injected to the east and west of the active mine pits, resulting in the consequent development of 2 m high groundwater mounds. During mine life, as the active pits are deepened, a higher proportion of the abstracted groundwater will be derived from the Oakover Formation aquifer. This hypersaline groundwater will be injected into the Oakover Formation via saline injection bores near Fortescue Marsh, resulting in a 1 m high groundwater mound on the fringe of the Marsh.

4. SUBTERRANEAN FAUNA IN THE REGION

Subterranean fauna spend all, or most, of their lifecycle underground and are typically possess adaptations to life underground. Commonly, these adaptations include pallid colouration, reduction or loss of eyes, elongate body, long slender appendages and well developed sensory setae. Subterranean fauna consists of both aquatic (stygofauna) and terrestrial (troglofauna) species. Stygofauna occur in groundwater and troglofauna occur in subterranean cavities above the watertable. Nearly all subterranean animals are invertebrates, however both stygofaunal fish and troglofaunal reptiles occur in Western Australia (i.e. Whitely 1945, Aplin 1998).

Subterranean fauna have significant scientific value and a high proportion of subterranean species are short-range endemics (SREs), defined by Harvey (2002) as species with ranges of <10,000 km^2. The very limited ranges of SRE species means they are particularly vulnerable to extinction as a result of anthropogenic activities and, therefore, are a focus for conservation. Consequently, the Environmental Protection Authority (EPA) usually requires that the risks to both stygofauna and troglofauna are considered when assessing proposed mine developments where dewatering is proposed (EPA 2003).

4.1. Stygofauna

Stygofauna studies in the Pilbara began in the 1990s (Humphreys 1999), with a considerable increase in knowledge over the last decade resulting from the systematic sampling during the Pilbara Biological Survey (see Eberhard et al. 2005, 2009). The Pilbara is estimated to have between 500 and 550 stygofauna species, with the density of species being relatively uniform across the region. About 70% of stygofauna in the Pilbara are SREs (Eberhard et al. 2009).

Alluvium and calcrete are typically thought to be the most productive habitats for stygofauna, although mafic volcanics also support rich communities and stygofauna may occur in moderate abundance in banded iron formations and related geologies (Halse et al. in preparation).

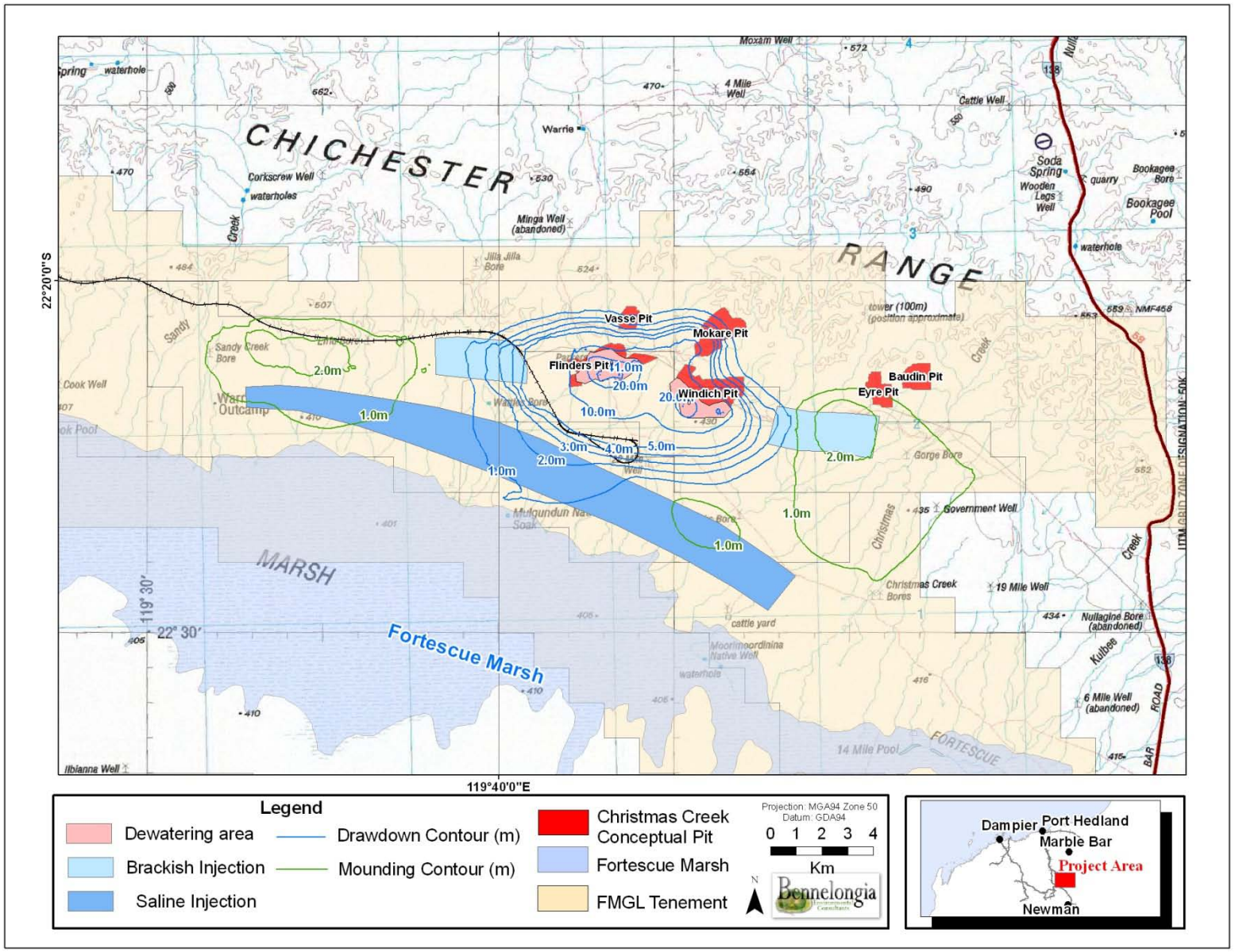

Figure 4. Location of borefields at Christmas Creek and modelled groundwater abstraction/injection (mounding) contours.

5. STYGOFAUNA OF THE CHRISTMAS CREEK PROJECT AREA

At least seven stygofauna surveys have been conducted in the vicinity of the Christmas Creek Project (21.97-22.76°S, 119.3-120.23°E). These comprise five surveys undertaken for environmental assessment of mines within the Pilbara Iron Ore and Infrastructure Project (Knott and Goater 2007; Ecowise 2007; Bennelongia 2007, 2008a,b), one to assess a mine at Bonney Downs (Bennelongia 2008c), and some of the sampling undertaken for the Pilbara-wide survey by the Department of Environment and Conservation (Halse et al. in prep).

A moderately rich stygofauna community occurs in the vicinity of Christmas Creek with 68 species belonging to 13 higher taxonomic groups having been recorded (Table 1). These include turbellarians, nematodes, rotifers, gastropods, oligochaetes, polychaetes, mites, ostracods, copepods, spelaeogriphacids, syncarids, amphipods and isopods. In addition, two rotifer species of the genus *Filina*, which may represent stygofauna, were collected. The community around Christmas Creek is characterised by widespread species, with only 10 of the 68 species (15%) potentially having restricted distributions. These include the described speleogriphacid *Mangkurtu kutjarra* and ostracods *Pilbaracandona colonia and P. rhabdote*, all of which occur east of the Marsh (with varying distributions larger than the Water Management Scheme area, Table 1). In addition, there are six species known from single bores that may reflect either restricted distributions or low abundance and infrequent collection. These species are the copepods *Goniocyclops* sp. B2 and *Parapseudoleptomesochra* sp. B1 from near the Cloudbreak mine site, the amphipods '*Maarrka*' sp. ms (Finston et al. submitted) from near Cloudbreak and Paramelitidae cf. sp. 10 (PSS) from east of the injection area at Christmas Creek, the ostracod *Notocandona 'whitecliffi'* ms from north of Christmas Creek in the Shaw River headwaters, and the syncarid *Bathynella* sp. B2 from east of the injection area at Christmas Creek. In addition, the copepod *Abnitrocella* sp., which occurs east of the Marsh, may be restricted.

Despite the occurrence of a moderately rich community in the vicinity, only six species of stygofauna have been collected from within the impact area of the Water Management Scheme (i.e. mine footprint and the spatial extent of dewatering and re-injection) from a total of 29 samples at 13 bores. All six species of stygofauna within the impact area (the nematode Nematoda sp. 1, the worm *Enchytraeus* Pilbara sp. 2, and the copepods *Diacyclops humphreysi* s. str. X *unispinosus*, *D .h. spinosus*, *Fierscyclops supersensus*, *Parastenocaris jane*) are widespread species that are known to occur beyond the vicinity of the Project area (Table 1).

The sampling effort within the impact area of the Christmas Creek Project Expansion has been only 72% of the effort recommended by EPA (2007) for areas likely to support a significant stygofauna community. Nevertheless, with only six widespread species recorded at a capture rate of 0.70 species per sample, it is appears that the impact area does not support a stygofauna community of high conservation significance. At least 85% of the species in the stygofauna community of the Christmas Creek area, and all the species collected within the species-poor impact area of the Water Management Scheme, are widespread.

6. POTENTIAL THREATS TO STYGOFAUNA

The Christmas Creek Project Water Management Scheme appears likely to have minimal impact on stygofauna species persistence, irrespective of any habitat changes that may occur, because all species recorded from Project area are widespread and most of their populations will occur outside the impact zone of Project.

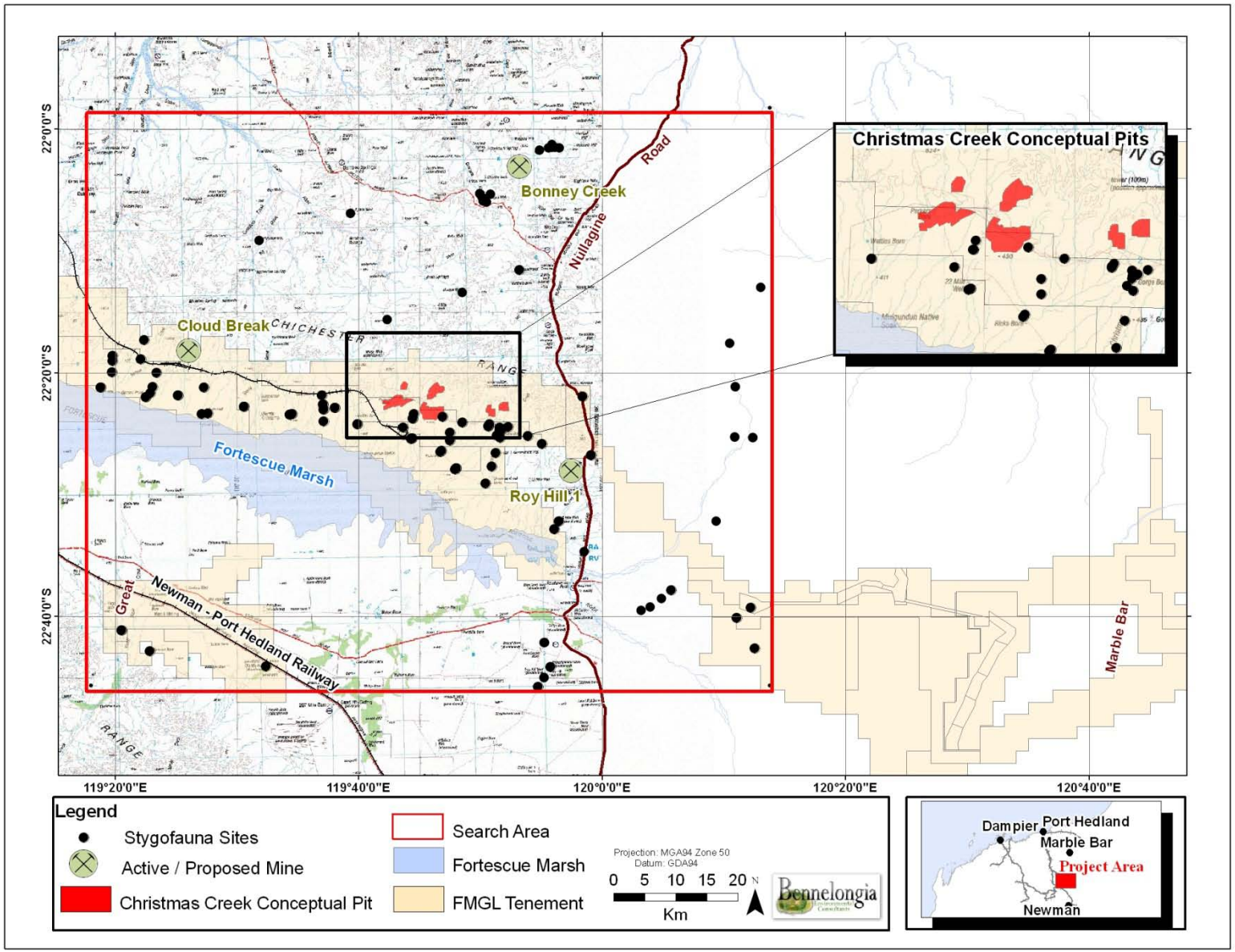

Figure 5. Christmas Creek search area (21.97-22.76 S, 119.3-120.23 E) and locations of bores sampled.

Table 1. Stygofauna known from the area surrounding the Christmas Creek Water Management Scheme (defined by a rectangle: 21.97-22.76°S, 119.3-120.23°E), with comments on their distribution. Species in the impact area of the Water Management Scheme are highlighted in grey. Animals identified only at higher taxonomic levels (e.g. Order or Family), and unlikely to represent additional species, excluded from list.

Higher Groups	Species	Comments	Source
Turbellaria	Turbellaria sp.	Widespread	
Nematoda	Nematoda sp. 1 (PSS)	Widespread, not assessed in EIAs	Halse et al. in prep.
	Nematoda sp. 19 (PSS)	Widespread, not assessed in EIAs	Halse et al. in prep.
Rotifera	Bdelloidea sp. 2:2	Widespread, not assessed in EIAs	Halse et al. in prep.
	Dissotrocha sp.	Widespread, not assessed in EIAs	Halse et al. in prep.
	Filinia australiensis	Widespread, stygofauna status unclear, not assessed in EIAs	Halse et al. in prep.
	Filinia longiseta	Widespread, stygofauna status unclear, not assessed in EIAs	Halse et al. in prep.
Gastropoda	Planorbidae sp.	Southern Pilbara (considered to be one species)	Bennelongia unpubl. data
Oligochaeta	*Enchytraeus* Pilbara sp. 1 (PSS)	Pilbara-wide	Halse et al. in prep.
	Enchytraeus Pilbara sp. 2 (PSS)	Pilbara	Halse et al. in prep.
	Insulodrilus sp.	Pilbara	Halse et al. in prep.
	Monopylephorus n. sp. WA29 (ex *Pristina* WA3) (PSS)	Pilbara	Halse et al. in prep.
	Phreodrilid with dissimilar ventral chaetae	Pilbara	Halse et al. in prep.
	Phreodrilid with similar ventral chaetae	Pilbara	Halse et al. in prep.
	Phreodrilus peniculus	Pilbara	Halse et al. in prep.
	Pristina aequiseta	Widespread	Halse et al. in prep.
	Pristina longiseta	Cosmopolitan	Pinder 1994
	Tubificidae stygo morphotype 2 (PSS)	Pilbara	Halse et al. in prep.
	Tubificidae stygo type 4	Pilbara	Halse et al. in prep.
	Tubificidae stygo type 5	Pilbara	Halse et al. in prep.
Polychaeta	*Namanereis* sp.	North-eastern Pilbara	Bennelongia unpubl. data
Acariformes	*Guineaxonopsis* sp.	Pilbara-wide	Halse et al. in prep.
	Halacaridae sp.	Species of this family appear to be widespread in Pilbara	Halse et al. in prep.
	Oribatida group 4 (PSS)	Pilbara	Halse et al. in prep.
Ostracoda	*Areacandona* sp.	Distribution cannot be determined	-
	Candonopsis tenuis	Australia	I. Karanovic, 2007

Higher Groups	Species	Comments	Source
	Cypretta seurati	Cosmopolitan on current taxonomy	Okubo 1973
	Humphreyscandona akaina	Southern Pilbara	I. Karanovic 2007
	Kencandona harleyi	North-eastern Pilbara	I. Karanovic 2007
	Meridiescandona facies	Pilbara-wide	I. Karanovic 2007
	Notacandona 'whitecliff' (PSS)	Shaw River headwaters	Halse et al. in prep.
	Pilbaracandona colonia	Newman area	I. Karanovic 2007
	Pilbaracandona rhabdote	East and north of Fortescue Marsh.	Bennelongia unpubl. data
	Stenocypris bolieki	Cosmopolitan	Ferguson 1968
	Vestalenula matildae	Pilbara	Martens and Rosetti 2002
Copepoda	*Abnitocrella* sp.	Unknown, possibly restricted to east of Fortescue Marsh	-
	Australocamptus sp. 5 (SAP)	Widespread	Halse et al. in prep
	Diacyclops humphreysi humphreysi	Western Australia	Pesce and De Laurentiis 1996
	Diacyclops humphreysi s. str X unispinosus	Pilbara	Karanovic 2006
	Diacyclops humphreysi unispinosus	Pilbara	Karanovic 2006
	Diacyclops sobeprolatus	Pilbara	T. Karanovic 2006
	Elaphoidella humphreysi	Pilbara	T. Karanovic 2006
	Elaphoidella sp. B1 (PIL)	Southern Pilbara	Bennelongia unpubl. data
	Fierscyclops (Pilbaracyclops) supersensus	Western Pilbara	T. Karanovic 2006
	Goniocyclops sp. B2	Near Cloudbreak	Bennelongia 2007
	Mesocyclops brooksi	Australia	Holynska et al. 2003
	Mesocyclops notius	Australia	Holynska et al. 2003
	Microcyclops varicans	Cosmopolitan	Sars 1863
	Parapseudoleptomesochra sp B1	Near Cloudbreak	Bennelongia 2007
	Parastenocaris jane	Cosmopolitan	T. Karanovic 2006
	Parastenocaris n. sp. B2	Eastern Pilbara	Bennelongia unpubl. data
	Parastenocaris sp. B1 (PIL)	Fortescue Valley	T. Kananovic pers. comm.
	Pseudectinosoma galassiae	Pilbara	T. Karanovic 2006
	Stygonitocrella bispinosa	Pilbara	T. Karanovic 2006
	Stygonitocrella trispinosa	Pilbara	T. Karanovic 2006

Higher Groups	Species	Comments	Source
	Stygonitocrella unispinosa	Pilbara	T. Karanovic 2006
Spelaeogriphacea	*Mangkurtu kutjarra*	East of Fortescue Marsh	Poore and Humphreys 2003
Syncarida	*Atopobathynella* sp.	Unknown	-
	Bathynella sp. B2 (Christmas Creek)	Christmas Creek (east of re-injection)	Bennelongia 2008a
	Notobathynella sp.	Unknown, possibly restricted	-
Amphipoda	*Chydaekata* sp.	Upper Fortescue	Bradbury 2000
	'Maarrka' sp. ms	Near Cloudbreak	Bennelongia 2007
	Paramelitidae cf. sp. 10 (PSS)	Christmas Creek (south-east of brackish re-injection)	Bennelongia 2008a
	Paramelitidae sp. 2 (PSS)	Southern Pilbara (species complex?)	Halse et al. in prep.
	Paramelitidae sp. 6 (PSS)	Northern Pilbara	Halse et al. in prep.
	Paramelitidae sp. 7 (PSS)	Northern Pilbara	Halse et al. in prep.
	Pilbarus millsi	Middle Fortescue	Bradbury and Wiliams 1997
Isopoda	Microcerberidae sp.	Unknown	-
	Pygolabis sp.	Unknown (undescribed species)	-

Two significant threats to stygofauna at the individual animal, rather than species, scale can be identified in relation to the Christmas Creek Project Water Management Scheme. These are the loss, or very substantial disturbance, of habitat through dewatering or injection of groundwater. Dewatering will reduce the amount of groundwater habitat in the Project area and injection may change groundwater chemistry, especially salinity, although an attempt will be made to minimize impact by injecting brackish water into the Marra Mamba aquifer (which is brackish) and hypersaline water into the Oakover aquifer (which is hypersaline)

The extent of habitat loss and disturbance are not considered further in this review because of the perceived lack of threat to stygofauna species.

7. CONCLUSION

The impact area of the Christmas Creek Project Water Management Scheme has been sampled for stygofauna with an effort that is considered to be sufficient to characterize this relatively depauperate community. Despite the surrounding area being moderately rich in stygofauna, the impact area of the Water Management Scheme area contains few stygofauna species. Only six species have been recorded in this area, all of which occur more widely (the nematode Nematoda sp. 1, the worm *Enchytraeus* Pilbara sp. 2, and the copepods *Diacyclops humphreysi* s. str. X *unispinosus*, *D. h. spinosus*, *Fierscyclops supersensus*, *Parastenocaris jane*).

Neither dewatering nor groundwater injection (the two impacts associated with the Water Management Scheme) are likely to affect the conservation status of any of the six species. Consequently, it is considered unlikely that the Christmas Creek Project Water Management Scheme will have any significant impact on stygofauna.

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