



Appendix C

Targeted Threatened Species Survey





TNG Limited

Mount Peake
Targeted Threatened Species Survey

February 2017

Executive summary

Introduction, project description and objectives of this assessment

TNG Limited is proposing to develop the Mount Peake Project (the Project) consisting of the mining of an ore body through an open-pit truck and shovel operation, processing of the ore to produce a magnetite concentrate, and road haulage of the concentrate approximately 100 km eastwards to a new railway siding and loadout facility on the Alice Springs to Darwin railway.

The mining area is located approximately 235 km north-north-west of Alice Springs and approximately 50 km west of the Stuart Highway.

Ecological assessments, including fauna surveys, were undertaken for the Project in April 2013. During these surveys a number of fauna species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were identified as being present or potentially present in the Study Area. These species included:

- Black-footed Rock-wallaby (*Petrogale lateralis lateralis*) (MacDonnell Ranges Population);
- Greater Bilby (*Macrotis lagotis*); and
- Great Desert Skink (*Liopholis kintorei*).

Based on the April 2013 survey results, fauna desktop assessment and the Terms of Reference (TOR) set by the Northern Territory Environment Protection Authority (NT EPA) for assessment of the Mount Peake Project, additional targeted threatened species survey work was required to obtain sufficient information on potential impacts of the project on the threatened species listed above. The TOR specify that the Project Environment Impact Statement (EIS) must provide a detailed assessment of Matters of National Environmental Significance (MNES), that being species and communities listed under the EPBC Act including:

- The likely presence of listed threatened species (focussing on the Greater Bilby, Black-footed Rock-wallaby and Great Desert Skink) and their habitat;
- The quality and quantity of available habitat within the vicinity of the Study Area; and
- The potential impact of the project on these species and their populations.

This report describes the methods used and results obtained from a targeted survey for threatened fauna species (focussing on the Greater Bilby, Black-footed Rock-wallaby and Great Desert Skink and their habitats) completed in November 2016, following the desktop and baseline field survey completed in April 2013. The assessed area of the 2013 baseline surveys included the proposed mine site, processing site, accommodation facility, access roads and borefield area, while the 2016 targeted survey focussed on areas of the access road alignment where the relevant species were considered most likely to occur.

Legislative context for this assessment

MNES, as defined under the EPBC Act, are known or considered likely to occur within the Study Area. A referral under the EPBC Act was submitted to the then Commonwealth Department of the Environment (DoE) in October 2013. In November 2013, the Commonwealth Minister for the Environment determined that the action (Project) is a “controlled action” and requires formal assessment and approval under the EPBC Act.

The TOR set by the NT EPA take into account formal assessment and approval under the Commonwealth EPBC Act, by way of the NT/Commonwealth bilateral environmental assessment process.

The Project is being assessed at the level of EIS under the NT *Environmental Assessment Act 1982*.

The main objective of this report is to satisfy the fauna component of the biodiversity assessment requirements of the TOR set by the NT EPA for assessment of the Mount Peake Project.

Methods used for this assessment

Information presented in this report is a synthesis of the following:

- A desktop search of government database information relating to fauna distributions, including the then DotE Protected Matters Search Tool (PMST) and the NT Department of Land Resource Management (DLRM) Fauna Atlas database, and subsequent six-day baseline fauna survey of the entire Study Area completed in April 2013. The survey used a range of trapping and non-trapping sampling techniques designed to gain as complete a description as possible of the relationships between fauna and the available habitats, and target the presence of fauna species listed as threatened/migratory under the *Territory Parks and Wildlife Conservation Act 2006* (TPWC Act) and/or the EPBC Act, and subsequently reported by GHD (2015);
- A four day targeted survey in November 2016 of the alignment of the access road, to assess fauna species listed as threatened/migratory under the TPWC Act and/or EPBC Act, with a particular focus on Greater Bilby, Great Desert Skink and Black-footed Rock-wallaby, including intensive walking transects over 25 km, and an area of 300-375 hectares;
- Assessing the regional and national significance of the fauna and its populations of threatened species; and
- Determining ways in which the proposed mining operation might impact the fauna and threatened species, proposing mitigation measures to reduce the risk of impacts, and determining residual risks to fauna including threatened species.

Results and discussion

Baseline fauna surveys

Baseline fauna surveys completed in April 2013, along with analysis of desktop database searches, are reported in GHD (2015). From all sources (PMST report, DLRM database and all fauna survey results), a total of 280 fauna species were identified for the Study Area. Of those, 268 are native to the Northern Territory (40 mammals, 145 birds, 74 reptiles and nine amphibians).

Threatened, near-threatened and migratory fauna species

The DLRM Fauna Atlas and the PMST results identified 22 threatened vertebrate fauna species (15 mammals, 6 birds and one reptile) for the Study Area. Twenty of these are listed under the EPBC Act and all are listed under NT legislation (TPWC Act). Some of the species (all mammals) are considered extinct in the Northern Territory, and others are predicted to occur but have never before been recorded within the Burt Plains Bioregion.

Sixteen threatened or near-threatened species (six mammals, six birds, three reptiles and one frog) are considered likely to occur within the Study Area, either as residents or visitors. Many of these are expected to be rare or very rare. Seven of these species were detected during the baseline fauna survey in April 2013, and three were detected during the targeted survey in November 2016. These include:

- Bilby (*Macrotis lagotis*) – Potentially recorded April 2013;
- Great Desert Skink (*Liopholis kintorei*) – Recorded November 2016;
- Brush-tailed Mulgara (*Dasycercus blythi*) – Recorded April 2013;
- Grey Falcon (*Falco hypoleucos*) – Recorded April 2013;
- Emu (*Dromaius novaehollandiae*) – Recorded April 2013 and November 2016;
- Australian Bustard (*Ardeotis australis*) – Recorded April 2013 and November 2016;
- Woma Python (*Aspidites ramsayi*) – Recorded April 2013; and
- King Brown Snake (*Pseudechis australis*) – Recorded April 2013.

Bilby were not observed at any stage despite extensive targeted searches of all areas of potentially suitable habitat along the proposed access road alignment. However, diggings were found 11km from the proposed impact areas in April 2013, and were potentially made by Bilby. Confidence in these diggings being made by Bilby was reasonably high (J. Kuiper, GHD Ecologist; pers. comm.; Formerly with Australian Wildlife Conservancy). It was therefore considered possible for Greater Bilby to be present in the broader region. This determination is made on the basis of these possible diggings and areas of potentially suitable spinifex sandplain habitat containing witchetty bush (*Acacia kempeana*) particularly along the proposed alignment, apparent intent of the diggings (i.e. targeting a food source of termites and/or shallow roots), the appearance and characteristics of the scratchings (e.g. sharp edge to scrapes, two or three obvious claws marks), and proximity to historical Bilby records.

A single Great Desert Skink (*Liopholis kintorei*) was observed fleetingly during November 2016 surveys, on the edge of an access track in open sandplain within spinifex (*Triodia spp.*) understorey, approximately 7 km from the proposed haul road. Subsequent searches of the area surrounding the sighting failed to detect any further signs of this species, such as communal burrow systems or latrines.

The Brush-tailed Mulgara was not observed, but was considered likely to be present based on indirect signs (burrows, diggings and scratchings). Our confidence in the identification of the mulgara burrow was high – the burrows were fresh and active, and showed the characteristic signs of a burrow of this species (as experienced by GHD zoologists in other surveys of the Burt Plain area of the NT, where live animals have been photographed using camera traps at potential burrows). Failure to detect a live animal at the burrow using a remote sensing camera may indicate relatively low abundance of the species at this site, but may also be explained by the species' known sensitivity to disturbance, and the likelihood that mulgaras have numerous burrow entrances that would be used preferentially in response to disturbance.

Based on the survey effort of the 2013 and 2016 assessments, observations of suitable habitat features, and advice and field assistance from local specialist ecologists from Desert Wildlife Services, the failure to detect a live Bilby or Mulgara, and observation of only a single Great Desert Skink and no burrows, suggests that none of these species is likely to be present in large numbers within the Study Area. However, arid fauna typically have breeding strategies that allow them to respond rapidly to improving conditions. Thus, future population sizes may differ greatly from current population sizes, and the value of potentially suitable habitat cannot be overstated.

All of the threatened and near-threatened species detected are species that have broad distributions across Australia. The narrowest distributions are those of the two mammal species (Bilby and Mulgara), whose distributional ranges have declined in recent decades, most likely in response to a combination of predation by feral cats, habitat disturbance and degradation due to grazing, weed invasion, and increased use of fire across the landscape.

Five of the seven threatened species detected are ground-dwelling species (reptiles, non-volant mammals, flightless birds) that have limited mobility across the landscape. These species are perhaps most at risk from localised habitat changes that may result from construction and operation of a mine in the Study Area.

Impact assessment, mitigation and monitoring

The Study Area has the potential to support a range of threatened fauna species, including eight listed as *vulnerable* or *endangered* under the EPBC Act. Collectively, these species are likely to occupy the full range of available fauna habitats within the Project area, but the sandplain spinifex habitat has the potential to support more threatened species than other habitats. Following the initial impact assessment (GHD 2015), the threatened fauna relevant to the Project and re-assessed following additional targeted surveys in November 2016 can be categorised as follows:

- Ground-dwelling sandplain fauna with limited mobility (Greater Bilby, *Macrotis lagotis*; Great Desert Skink, *Liopholis kintorei*; Brush-tailed Mulgara, *Dasycercus blythi*); and
- Fauna in rocky habitat (Black-footed Rock-wallaby (MacDonnell Ranges race), *Petrogale lateralis*).

The Project poses a range of potential impacts on some of these threatened fauna species. Before mitigation, a small number of impacts have the potential to be medium or high risk. The main sources of impact on fauna are expected to be from:

- Clearing of vegetation, particularly for construction of the 100 km access road;
- Unplanned wildfire, if inadvertently started by mine construction or operation;
- Collisions between fauna and traffic during construction and operation, particularly in spinifex sandplain habitat and particularly at night;
- Introduction and/or spread of weeds (particularly through inadequate site reinstatement); and
- Increase in population size of native and non-native predators (particularly through inadequate management of garbage/waste, which could attract vermin, and subsequently their predators such as cats and foxes).

The extent and severity of impact that this Project has on fauna depends entirely on the level of management and mitigation effort given. There is potential for all impacts and risks to be reduced to an acceptable level (i.e. not significant) through the use of effective and appropriate management and mitigation. Inadequate management and mitigation has the potential to lead to irreversible long-term impacts on some threatened fauna species. Monitoring will be required to measure the effectiveness of mitigation and to identify where changes in effort may be required.

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1. Introduction

1.1 Project description and overview

TNG Limited (TNG) is proposing to develop the Mount Peake Project (the Project), located in the Northern Territory (NT) approximately 235 kilometres north-north-west of Alice Springs and approximately 50 km west of the Stuart Highway (Figure 1).

Project activities include construction, mining, processing, rehabilitation and decommissioning of an open-pit magnetite mine, with associated infrastructure including a haulage and site access road that runs approximately 100 km south-east and then east from the mining area to a proposed new railway siding and load-out facility on the Alice Springs to Darwin railway near Adnera.

The life of the mine is expected to be 19 years inclusive of construction (2 years), mining and production (15 years), and closure and rehabilitation (2 years).

GHD was engaged by TNG to undertake a fauna and habitat assessment of the Mount Peake Study Area, including assessment of listed threatened fauna species.

1.2 Scope

This report presents the methods and results of targeted assessments of threatened fauna species and their habitat at the Study Area, completed in November 2016. It includes a description of:

- Desktop searches of government database and literature review relating to fauna distributions, fauna survey of the Study Area using a range of sampling techniques designed to maximise the understanding of the relationships between fauna and the available habitats on site;
- Relevant findings from the baseline fauna surveys completed in April 2013 and reported in GHD (2015);
- Fauna surveys specifically targeting species listed as threatened under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* and/or *Territory Parks and Wildlife Conservation Act 2006* (TPWC Act) completed in November 2016;
- The regional and national significance of the fauna and any populations of threatened species;
- Potential impact of the Project on fauna and threatened species;
- Mitigation measures to reduce the risks to threatened fauna; and
- The residual risks to fauna including threatened species.

1.3 Objectives and assessment

The primary objective of this report is to address the terrestrial fauna component of the biodiversity values assessment, as required in the Terms of Reference (ToR) for the preparation of an environmental impact assessment issued by the Northern Territory Environment Protection Authority (NT EPA) for the Mount Peake Project.

Because fauna species listed as threatened under the EPBC Act are known, or considered likely to occur, within the Study Area, a referral under the EPBC Act was submitted to the Commonwealth Department of the Environment in October 2013. In November 2013, the Commonwealth Minister for the Environment determined that the action (Project) has the potential to have a significant impact on EPBC Act listed threatened species and communities (section 18 & section 18A), and is therefore a “controlled action” and requires formal assessment and approval under the EPBC Act. Therefore, this report also addresses Matters of National Environmental Significance (MNES), with the understanding that the project is to be assessed under the Bilateral Agreement between the NT and Commonwealth Governments.

With specific regard to biodiversity values at the Study Area, this report includes the following:

- Description and mapping of fauna and habitats in the Mount Peake Study Area including habitat that is suitable for species of conservation significance;
- Identification of threatened fauna species and/or populations listed under the EPBC Act and/or TPWC Act that are present or considered likely to occur within the study area, including, but not being limited to, fauna species identified by the Commonwealth Department of the Environment (DoE) in the EPBC referral decision;
- A detailed assessment of Matters of National Environmental Significance i.e. species and communities listed under the EPBC Act including, but not limited to:
 - Listed threatened species (focussing on the Greater Bilby (*Macrotis lagotis*), Great Desert Skink (*Liopholis kintorei*) and Black-footed Rock-wallaby (*Petrogale lateralis lateralis*) (MacDonnell Ranges population)) and their habitat;
 - The quality and quantity of available habitat (for those species) within the vicinity of the Study Area (identified and mapped);
 - The potential impact of the project on these species and their populations.
- Identification of the potential for the Project to impact on biodiversity values including ecosystems and listed threatened species including:
 - Assessing the regional and national significance of populations of threatened species
 - Determining ways in which the proposed Project might impact on threatened species
 - Assessing the levels of risk to threatened species posed by sources of potential impact
 - Proposing mitigation measures to reduce the risk of impacts that may be significant
 - Determining the residual risks to threatened species.

1.3.1 Specific objectives of the targeted threatened species survey

Specifically, the objectives of the targeted threatened species survey in November 2016 includes the following:

- Search for and document locations of Greater Bilby and Great Desert Skink burrows and Black-footed Rock-wallaby habitat along the proposed access road alignment;
- Map burrows detected along the proposed access road alignment and provide recommended alternative routes if necessary;
- Discuss the potential impacts of the mining proposal on threatened species, and in particular Greater Bilby, Great Desert Skink and Black-footed Rock-wallaby;

- Assess the likely local and regional impacts of the Project on the target species in relation to the EPBC Act 'significant impact criteria', and using a 'risk based' approach;
- Develop mitigation measures and a future monitoring framework for target species to monitor and respond to impacts; and
- Provide advice on compliance with legislation and policy.

1.4 Limitations

This report has been prepared by GHD for TNG Limited and may only be used and relied on by TNG Limited for the purpose agreed between GHD and TNG Limited as set out in Section 1.3 of this report.

GHD otherwise disclaims responsibility to any person/entity other than TNG Limited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD, and described in this report where relevant. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by TNG Limited and others (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

To some degree, investigations undertaken in respect of this report were constrained by the particular site conditions, such as the location of access tracks, services, vegetation, and topographic features. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

1.5 Definitions

For the purposes of this assessment, the following definitions are employed:

Study Area – refers to the proposed mining infrastructure, including: processing site, accommodation facility, access and haul roads, potable water pipeline, water supply pipeline and borefield area, as shown in Figure 1.

Region – the area within a 20 kilometre radius of the Study Area.

1.6 Changes to the EPBC Act threatened species lists

During the course of assessments for this project, the Commonwealth Department of the Environment and Energy changed the lists of threatened species considered under the EPBC Act. Two of these changes concern species identified for this project, as discussed below.

1.6.1 Brush-tailed Mulgara / Crest-tailed Mulgara

Up to December 2013, two species of mulgara were listed as threatened under the EPBC Act: the Brush-tailed Mulgara (*Dasycercus cristicauda*) and the Ampurta (*D. hillieri*). The distribution identified for *D. cristicauda* covered a large part of central and northern arid Australia, from western Qld, through northern SA and southern NT, across to the Pilbara region in WA. The distribution identified for *D. hillieri* covered a small area of central arid Australia, centred on the area where Qld, SA and NT meet. The distribution identified for *D. hillieri* did not include the Study Area, while the distribution identified for *D. cristicauda* did. Because its distribution included the study area, the 'Brush-tailed Mulgara' was included as a focal threatened species during the site assessments for this Project.

In December 2013, the EPBC species listings for mulgaras were revised to align with taxonomic work on the mulgara species by Woolley (2005). Woolley concluded that there were indeed two species of mulgara, but that those species did not align with the existing species identification.

Woolley concluded that *D. hillieri* is a synonym of *D. cristicauda* (i.e. they are the same species), and that species is now classified as the Crest-tailed Mulgara (*D. cristicauda*). The Crest-tailed Mulgara (*D. cristicauda*) is listed as Vulnerable under both the EPBC Act and TPWC Act. The Crest-tailed Mulgara (*D. cristicauda*) is now reported to occupy an area of central Australia, centred on and extending west from the area where Qld, SA and NT meet. It occurs in sand dunes that have a sparse cover of Sandhill Canegrass (*Zygochloa paradoxa*). This habitat does not occur within the Study Area. The Crest-tailed Mulgara (*D. cristicauda*) was not identified by the PMST search for this Project, and is considered unlikely to occur within the Study Area.

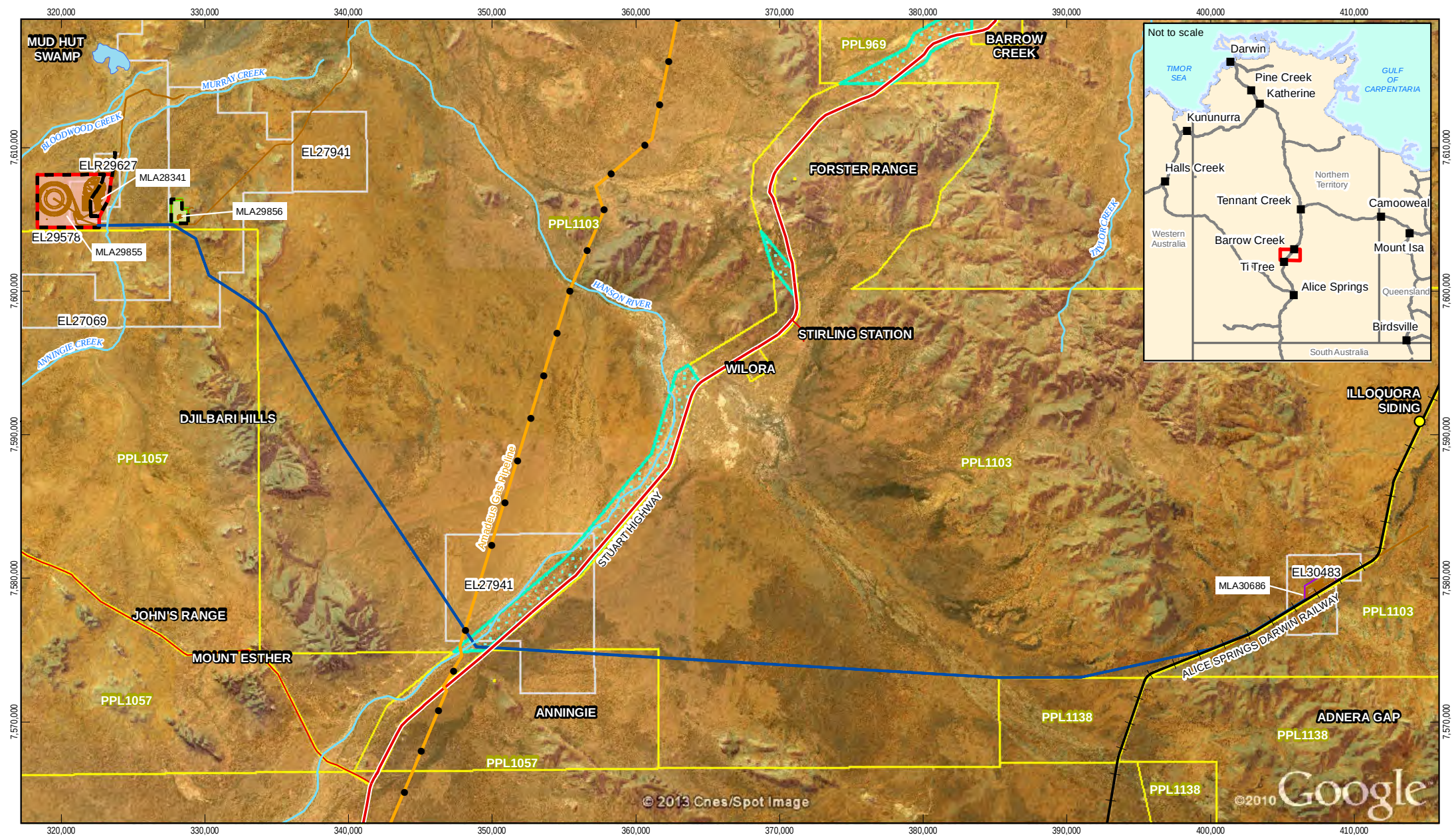
Woolley concluded also that the mulgara species originally (i.e., pre-2013) referred to as Brush-tailed Mulgara (*D. cristicauda*) is really the Brush-tailed Mulgara (*D. blythi*). This species is not currently listed as threatened under the EPBC Act, but it is listed as Vulnerable under the TPWC Act and therefore is considered in this study. This species is reported to occupy sandplain habitats across a large part of central Australia, from western Qld, through northern SA and southern NT, across to the Pilbara region in WA. This species occurs within the Study Area.

The name *D. hillieri* has been removed from the EPBC Act threatened species list (December 2013). The name Ampurta was used for mulgaras by Aboriginal people (Woolley 2005), and Woolley notes that it is impossible to tell which species was known as Ampurta.

1.6.2 Southern Marsupial Mole

The Southern Marsupial Mole (*Notoryctes typhlops*) was listed as Endangered under the EPBC Act up to December 2015. In December 2015, an approved [Commonwealth Listing Advice](#) for the species resulted in the species being de-listed from the EPBC Act threatened species list. The species is still listed as Vulnerable under the TPWC Act.

This species was not recorded during baseline or targeted surveys and no historical records exist for the Study Area; however it is a poorly known species and rarely seen/reported because of its subterranean habits. This species was originally included in the assessment as a focal threatened species due to its conservation status under the EPBC Act. Since the species was de-listed from the EPBC Act, it has been excluded from the short list of threatened fauna species considered in detail for this assessment. The sandplain habitat in the west of the Study Area is potentially suitable for this species, but provides only marginal quality habitat.

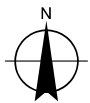


Paper Size A4

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53



LEGEND

- | | | |
|--------------------|------------------------------|-------------------------------|
| Illoquora Siding | Amadeus Gas Pipeline | Crown Land |
| Principal Road | Mine Site Facilities | Mount Peake Granted Tenements |
| Minor Road | Mud Hut Swamp | Mount Peake Mineral Leases |
| Major Watercourses | Rail Siding Loading Facility | Cadastral Boundaries |
| Railway | Mount Peake Mining Area | Access Road |
| | Camp Facilities | |



TNG Ltd
Mount Peake EIS

Project Location
Mount Peake Project Area

Job Number 61-29057
Revision A
Date 23 Oct 2015

Figure 1

G:\61\29057\11 GISMaps\MXD\6129057_001_Fig1ProjectLocation.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

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Data source: TNG - Gas / Slurry Pipeline Study Corridor, Camp Facilities, Transport Study Corridor, Mount Peake Mining Area, Mount Peake Granted Tenements (2015). Geoscience Australia - Waterways, mainland, placename, road (2008). Google Earth Pro - Imagery (Date extracted: 13/02/2014). Created by: RB

2. Mount Peake Study Area

2.1 Location and area

The Mount Peake Study Area (Study Area) is located in central Northern Territory, approximately 235 km north-north-west of Alice Springs (Figure 1).

The Study Area is located in the Central Desert Shire and within the Burt Plain Bioregion.

The Study Area spans a large area; the proposed mine area is approximately 50 km west of the Stuart Highway, while the proposed load-out facility at the existing Alice Springs to Darwin railway is approximately 50 km east of the highway. The Study Area is primarily located on the Stirling pastoral station with a small stretch of the proposed access road located on Anningie pastoral station. The closest town is Barrow Creek, approximately 60 km north east of the mining area. The main site access road is proposed to intersect the Stuart Highway approximately 20 km south of Wilora.

2.2 Climate

The Study Area experiences hot and arid conditions. The hottest months are November to February, with the monthly mean of daily maximum temperatures above 35°C, and monthly mean of daily minimum temperatures not dropping below 18°C (Table 1). The coolest months are May to August, with the monthly mean of daily maximum temperatures remaining at or below 25.3°C, and monthly mean of daily minimum temperatures not rising above 10°C.

The mean annual rainfall is approximately 319 mm, with a strong seasonal pattern of summer dominated rainfall. Average monthly rainfall totals range from 4.6 mm in July to 68.0 mm in February (Table 1). Average three-monthly rainfall totals range from 18.8 mm in June/July/August to 171.8 mm in December/January/February. However, rainfall is extremely variable and any month can receive relatively large rainfall totals, or little to no rain at all.

Table 1 Rainfall and temperature statistics (BoM 2013; Territory Grape Farm NT 1987-2012)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)												
Highest	280.4	342.2	109.2	151.7	136.3	53.8	34.2	39.4	96.6	56.8	119.2	115.7
95 th %ile	154.7	255.0	97.7	93.2	100.4	49.5	21.6	27.9	41.8	52.5	82.8	96.6
Mean	57.2	68.0	21.9	17.7	23.7	9.3	4.6	5.0	10.9	16.5	31.9	46.6
5 th %ile	3.7	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.2	8.6
Lowest	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
Temp (°C)												
Maximum ¹	37.5	36.2	33.9	30.4	25.3	22.2	22.5	25.2	30.2	33.0	35.4	36.3
Minimum ²	21.8	21.7	19.5	14.4	9.2	6.0	5.1	7.0	12.0	15.6	18.6	21.0

Notes: ¹ Monthly mean maximum temperature is the average of the available daily maxima for a month.

² Monthly mean minimum temperature is the average of the available daily minima for a month.

2.3 Burt Plain Bioregion

The Study Area occurs entirely within the Burt Plain Bioregion, which is characterised by the following:

- The bioregion is broadly characterised by plains of Acacia shrubland, tussock and hummock grasslands, Acacia and Eucalyptus woodlands, and mountain ranges in the east, north and west of the bioregion. More than 80% of the bioregion is devoted to pastoralism;
- The bioregion supports some of Australia's best developed and most extensive mulga woodlands;
- As with other central Australian bioregions, the overall condition of the Burt Plain Bioregion is masked by a very strong rainfall effect, with degradation sometimes difficult to detect following a series of good seasons;
- Much of the bioregion has been impacted by a range of pervasive factors such as grazing by livestock and/or feral animals, feral predators and weed infestations;
- The bioregion has suffered substantial losses of its mammal fauna over the last century and there are ongoing declines of some bird and mammal populations. Exotic predators are widespread and there are fifteen declared weed species currently listed under the *Northern Territory Weeds Management Act 2001* known to occur in the Burt Plain Bioregion. Other exotic plant species, most notably buffel and couch grass, also pose significant threats to some habitats; and
- Many fauna species have been lost from this bioregion over the last 150 years. Of those that persist, 13 species are currently listed as threatened at the National and/or Territory level.

2.4 Vegetation communities representing habitat types in the Study Area

Existing vegetation mapping for the Study Area and surrounding bioregions is limited due to the lack of previous detailed vegetation survey. Vegetation mapping that does exist for the site includes vegetation mapping that has been completed for the whole Territory at 1:1,000,000 scale (Wilson *et al.* 1990). This mapping was used to help determine locations for fauna sites and targeted surveys across the Study Area, and is shown as the base layer for Figure 2 and Figure 3.

A flora assessment of the Study Area (conducted by GHD concurrently with the baseline fauna survey in April 2013) identified eight vegetation communities in the Study Area, these are all described in detail in GHD (2015). The eight vegetation communities provide five broad habitat types for fauna, and these are presented and discussed in GHD (2015).

2.5 Current land use

More than 80% of the Burt Plain Bioregion is used for pastoralism. The Study Area lies mainly within Stirling Station which is currently used for cattle grazing.

3. Species descriptions and Study Area records of threatened species

GHD completed a baseline fauna survey of the Study Area in April 2013, prior to this targeted threatened species survey in November 2016. The current knowledge of the key threatened species in the Study Area is described below.

3.1 Greater Bilby (*Macrotis lagotis*)

3.1.1 Species description

The Greater Bilby (*Macrotis lagotis*) is known from the Burt Plain bioregion, and is considered likely to still be present in this part of the Northern Territory, albeit probably in small numbers in fragmented populations. In favourable conditions, Bilby populations can expand rapidly in abundance and occupied area (Woinarski *et al.* 2007).

The Greater Bilby is listed as vulnerable under the EPBC and TPWC Acts. Wild populations are restricted predominantly to the Tanami Desert, Northern Territory (Johnson and Southgate 1990), the Great Sandy and Gibson Deserts, Western Australia (Friend 1990), and an outlying population between Boulia and Birdsville in south-west Queensland (Gordon *et al.* 1990).

The species occupies three major vegetation types: open tussock grassland on uplands and hills; mulga woodland/shrubland growing on ridges and rises; and hummock grassland in plains and alluvial areas (Southgate 1990a). In the Tanami Desert, the Greater Bilby is less abundant on dune and sand substrate than on laterite/rock features or drainage/calcrete substrates (Southgate and Carthew 2007).

The Greater Bilby is known to consume a wide range of foods, including root-dwelling larvae, nasute termites, hypogeal fungi, bulbs, fruit and seed (Gibson 2001). Fire and the promotion of key food plants are thought to be important processes affecting bilby distribution. Fire management may present an opportunity to improve habitat suitability and the status of the bilby (Southgate and Carthew 2006). Bilbies burrow and are able to survive in habitats that have little vegetation. Southgate and Carthew (2006) found that a large part of their diet consisted of seeds from fire-promoted plants.

The Greater Bilby once occurred over 70% of mainland Australia (Southgate 1990b), but its distribution has significantly decreased since European settlement to about 20% of its former range (Southgate 1990b). Fox predation may be the primary factor associated with regional declines of the species (Abbott 2001). Feral cats have also been known to take the bilbies as prey (Southgate 1990b). Clearing of habitat for grazing and as a result of fire are potential threats (Southgate 1990b).

The most effective survey technique for bilbies is through indirect detection, conducting diurnal searches (walking along transects through areas of suitable habitat) to locate signs of activity including burrows, tracks, scats and diggings. If areas of activity are found, these can be watched closely and, for example, burrow entrances that show recent signs of activity can be targeted with motion-activated cameras for the possible emergence of animals.

3.1.2 Study Area records

Historical records of Greater Bilby for the Study Area are all from pre-1970. Two records are within 4 km of the proposed access road corridor, but are located in a Mulga community with few suitable habitat features. No location accuracy or date of the records makes these difficult to interpret with confidence.

Extensive and intensive spotlighting searches were undertaken in 2013 within potentially suitable habitat by a team of ecologists in an effort to detect active signs of this species. Potential signs of Greater Bilby digging were recorded during the 2013 surveys approximately 11 km north-east of the proposed access road, though intensive searches of the surrounding area failed to find any further evidence of the species, thereby increasing the uncertainty that the diggings were made by Greater Bilby.

Extensive targeted searches of areas considered to provide the most suitable habitat for Greater Bilby within the Study Area were completed in November 2016, and no direct or indirect evidence of the species was found. Through these surveys, evidence of the introduced European Rabbit (*Oryctolagus cuniculus*) was found in areas considered to provide the most suitable Greater Bilby habitat (Plate 1). Competition from rabbits is considered a potentially major threatening process for the bilby (Pavey 2006a).

Spinifex-dominated habitats across the Study Area provide potential habitat, including some rocky areas and areas with a low shrub cover of the favoured Witchetty Bush (*Acacia kempeana*) (Pavey 2006a).



Plate 1 Diggings beneath Witchetty Bush (*Acacia kempeana*) in part of the Study Area considered suitable habitat for Greater Bilby. These diggings were made by rabbits

3.2 Great Desert Skink (*Liopholis kintorei*)

3.2.1 Species description

The Great Desert Skink (*Liopholis kintorei*) (Plate 2) is the largest of its genus, growing up to 187 mm (snout-vent length) (Wilson and Swan 2013). This skink creates characteristic communal burrows and latrines and is predominantly nocturnal, particularly in warm and hot weather (McAlpin 2001; McAlpin *et al.* 2011).



KeepGuard

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Plate 2 Great Desert Skink emerging from a burrow (photo taken 100 km south of the study area)

The Great Desert Skink is listed as vulnerable under the EPBC and TPWC Acts.

The species occupies a range of vegetation types, with its main habitat being sandplain and adjacent swales. Great Desert Skinks prefer a landscape that supports a mosaic of differently-aged vegetation, and typically inhabit sites that have been burnt in the previous three to fifteen years (McAlpin 2001). Vegetation usually consists of hummock grassland (*Triodia basedowii*, *T. pungens* and *T. schinzii*), with some scattered shrubs and occasional trees (e.g. *Acacia spp.*, *Eucalyptus spp.*, *Hakea spp.*, *Grevillea spp.* and *Allocasuarina decaisneana*) (Cogger *et al.* 1993; McAlpin 2001).

Great Desert Skinks construct large burrow complexes with multiple entrances spreading over an area up to 13 m diameter (McAlpin *et al.* 2011). They live in family groups and defecate at a nearby communal latrine (Pearson *et al.* 2001). Great Desert Skinks can move up to 100 m from their burrow to forage, and have been recorded moving 10 km or more to colonise new areas (McAlpin 2000).

Great Desert Skinks mainly eat termites, but also feed on other invertebrates such as beetles, spiders, grasshoppers and cockroaches as well as some leaves, flowers and fruits (Paltridge *pers. comm.*).

Threats to the species include intense large-scale fires, predation by foxes and cats, and rabbits digging up burrow systems.

The most effective survey technique is to locate burrow systems by walking along transects through suitable habitat, and then, using motion-activated camera traps, watching those burrow entrances that show recent signs of activity (active latrine site, recently dug soil at entrances) for the possible emergence of animals (Plate 3). Great Desert Skinks are likely to be more active in warmer weather. Thus, watching burrow entrances is likely to be more successful in warmer months than in cooler months. McAlpin (2001) reports the optimum time of year for monitoring burrows as late summer and early autumn, before the lizards enter hibernation, at which time the maximum number of individuals are likely to inhabit the burrow systems.



Plate 3 Remote camera set up on Great Desert Skink burrows 100 km south of the study area

3.2.2 Study Area records

One Great Desert Skink was observed on a sandy rise alongside a vehicular track in spinifex sandplain habitat during the 2016 targeted fauna survey approximately 7 km north of the proposed access road. Further searches by five ecologists and five Anmatyerr Rangers of the area surrounding this observation failed to find a burrow system or subsequent sightings of the skink. It was in habitat that appeared not to have been burnt very recently when compared to much of the rest of the Study Area, but had been burnt recently enough that the spinifex tussocks were large but not very large (perhaps burnt within the past 5-6 years).

The NT Fauna Atlas (DLRM) results (June 2015) indicate that the species has not been recorded previously in the Study Area, with all previous records to the south and west of the Mount Peake Study Area. Previous surveys by GHD ecologists near the Napperby Access Road approximately 100 km south-west of the Mount Peake Study Area in 2015 found one active Great Desert Skink burrow system (as shown in Plate 2 and Plate 3 above), which was potentially the most north-easterly records of this species known at the time. While much of the Study Area that comprises spinifex-dominated sandplain provides potentially suitable habitat for this species, it is considered to be at the very edge of its distribution and therefore unlikely to provide core habitat.

3.3 Black-footed Rock-wallaby (*Petrogale lateralis lateralis*)

3.3.1 Species description

The Black-footed Rock-wallaby (*Petrogale lateralis lateralis*) (Plate 4) is a moderately sized macropod found in rocky arid areas of central Australia. This species is a habitat specialist (rocky ranges and slopes) and is likely to occur in any suitable habitat throughout the region. They feed on grass, with some herbs, leaves and fruits eaten also. Both spearbush (*Pandorea doratoxylon*) and fig (*Ficus brachypoda*) are important food plants for rock-wallabies (Geelen 1999), along with a range of grasses and forbs, such as *Cymbopogon ambiguus*, *Digitaria brownii* and *Enneapogon polyphyllus* (Geelen 1999). Though occasionally drinking when water is present, rock-wallabies can survive extended periods without water. Water requirements are reduced by wallabies sheltering during the day in caves and under boulders, where relative humidity is higher and air temperatures cooler, usually emerging in the late afternoon or early evening to feed. In cooler months, animals may bask in the sun during the early morning following a cold night (Pavey 2006).



Plate 4 Black-footed Rock-wallaby (Photo taken at Finke Gorge National Park, NT)

The Black-footed Rock-wallaby is listed as vulnerable under the EPBC Act and near threatened under the TPWC Act. Northern Territory animals belong to a currently undescribed subspecies (MacDonnell Ranges subspecies) which is centred on the MacDonnell Ranges bioregion of the southern Northern Territory. In the Northern Territory its range extends north to the Davenport and Murchinson Ranges, east to the Jervois Range, west to the Western Australian border and south to the South Australian border (Pavey 2006). Major threats faced by isolated populations in Western Australia and South Australia and parts of the Northern Territory include predation by introduced predators (Red Fox, Cat) and native predators (Wedge-tailed Eagle, Dingo), and habitat degradation caused by changed fire regimes and grazing by introduced herbivores (Pavey 2006; Read and Ward 2011). With their specific habitat requirements, Black-footed Rock-wallabies can be limited in their ability to disperse.

3.3.2 Study Area records

Low densities of Black-footed Rock-wallabies can be difficult to detect using ground-based diurnal or spotlighting surveys. Searching for scats is considered a reliable and repeatable technique for detecting low density populations (Sharp 1999). The desktop assessment found two recent records of Black-footed Rock-wallaby approximately 7 km east of the proposed camp facilities.

In April 2013, diurnal surveys were undertaken by ecologists looking for the presence of suitable habitat for the Black-footed Rock-wallaby in and around the Mount Peake Mine Lease area. The main activities undertaken were investigating areas of potential rock-wallaby habitat and collecting potential rock-wallaby scat. Surveys concentrated on rocky outcrops and included assessment of crevices, caves and boulder piles where rock-wallabies typically shelter (Ward *et al.* 2011) and vegetated parts of hills and escarpments, particularly grassy areas, where rock-wallabies potentially forage (Ward *et al.* 2011).

The species was not detected within the Study Area during the GHD April 2013 or November 2016 fauna surveys, but its presence in nearby Dgilbari Hills range was confirmed by a GHD ecologist during a helicopter flight for vegetation mapping.

3.4 Brush-tailed Mulgara (*Dasycercus blythi*)

3.4.1 Species description

The Brush-tailed Mulgara (*Dasycercus blythi*) is likely to occur within the Study Area. It is listed as vulnerable under the TPWC Act, and was recently removed from the EPBC Act threatened species list, before which it was included as vulnerable (see section 1.6.1).

The Brush-tailed Mulgara occupies spinifex (*Triodia spp.*) grasslands, and burrows in flats between sand dunes. It is generally a solitary species that hunts at night, although it is not strictly nocturnal (Woolley 2008).

The Brush-tailed Mulgara has a relatively patchy distribution and sedentary lifestyle with home ranges of males (25.5 ha) significantly larger than those of females (10.8 ha) (Kortner *et al.* 2007). Its diet consists of insects, other arthropods and small vertebrates (Menkhorst and Knight 2011). Populations fluctuate with quality of seasons (Menkhorst and Knight 2011).

The Brush-tailed Mulgara has declined over 50–90% of its historical range (Maxwell *et al.* 1996). Its habitat has been adversely affected by the grazing of introduced species (e.g. camels, rabbits, cattle), and changes to the fire regime. Studies have shown that the abundance of Brush-tailed Mulgara is greater in areas of high *Triodia* cover compared with recently burnt areas with low *Triodia* cover (Masters 1993; Baker 1996).

Fire appears to have an impact on population size, with fewer animals found in the years after a burn (Masters 1993). Alteration of fire regimes following European settlement and inappropriate use of fire management are potentially significant conservation issues. Predation by introduced feral cats and foxes may threaten this species. Climate change may pose a threat to this species in the future (Woolley 2008).

All spinifex-dominated areas on the sand plains within the Study Area have the potential to support this species, likely in low densities. Age of spinifex will likely have an influence also – patches of older, more established spinifex, and patches that have not been burnt recently, may have a higher chance of supporting the species. Rocky areas are unlikely to be suitable.



Plate 5 Brush-tailed Mulgara captured on motion-sensing camera (photo taken 100 km south of the Study Area)

3.4.2 Study Area records

At least one active mulgara burrow was located within the Study Area during the April 2013 baseline survey, though no further active burrows were found during targeted surveys of extensive areas of spinifex sandplain in November 2016. Acknowledging that population size can fluctuate with the quality of season, it is considered possible that the species occurs in low densities wherever suitable habitat is present across the Study Area.

4. Methods

4.1 2013 Desktop assessment and baseline fauna survey

A baseline fauna survey of the Mount Peake Study Area was completed in April 2013 (GHD 2015). This included a desktop review of government databases relating to fauna distributions included the following:

- The then Commonwealth Department of the Environment (DotE) Protected Matters Search Tool (PMST) was used to identify matters of national environmental significance potentially occurring in the Study Area (Appendix A). The PMST only considers flora and fauna species and communities listed in one or more provisions of the EPBC Act, and is based on predicted distributions of taxa and their habitat, rather than known records. The PMST may predict the occurrence of a species or community in an area when there are no documented records from the area. The PMST was used to identify matters of national environmental significance up to a distance of 50 km beyond the Study Area. Information was downloaded in February 2013 (and re-checked in November 2015 and September 2016 for additions/revisions) in the form of an Environmental Report from the website <http://www.environment.gov.au/erin/ert/epbc/index.html> (Appendix A); and
- The DLRM Fauna Atlas database was used to identify records of all fauna species known to occur (rather than predicted to occur) in the Burt Plain bioregion (the area encompassed by Lat: -21.41213 to -22.13333; Long: 133.03458 to 134.12140).

A baseline fauna survey across the Study Area was conducted by eight GHD ecologists from the 9th to 14th April 2013. Sixteen sites in a representative range of vegetation/habitat types were surveyed in areas relevant to the proposed mining infrastructure footprint, and considered to provide higher quality habitat for fauna, based upon vegetation structure, topographic location, and habitat features (e.g. presence of rock outcrops, hollow-bearing trees, long grass, leaf litter). The choice of sites was made in an effort to maximise the likelihood of detecting fauna, including threatened species. The sixteen survey sites were established proportionately across the five main vegetation types represented in the mine leases, as follows:

- Mulga woodland (8 sites);
- Riparian woodland (2 sites);
- Rocky shrubland (3 sites);
- Spinifex grassland (2 sites); and
- Corymbia woodland (1 site).

For the most part, habitat classification was based on landscape features of note (e.g. rocks, waterway, species of dominant trees). Note, however, that while only two sites were formally categorised as spinifex grassland sites, other sites supported spinifex grasses also, particularly rocky shrubland sites and some mulga sites.

Each survey site was focussed on a 50 m x 50 m area (0.25 ha). The locations of the fauna survey sites and the vegetation types were mapped as part of GHD's flora and vegetation impact assessment (GHD 2015), which was used to help inform selection of sites.

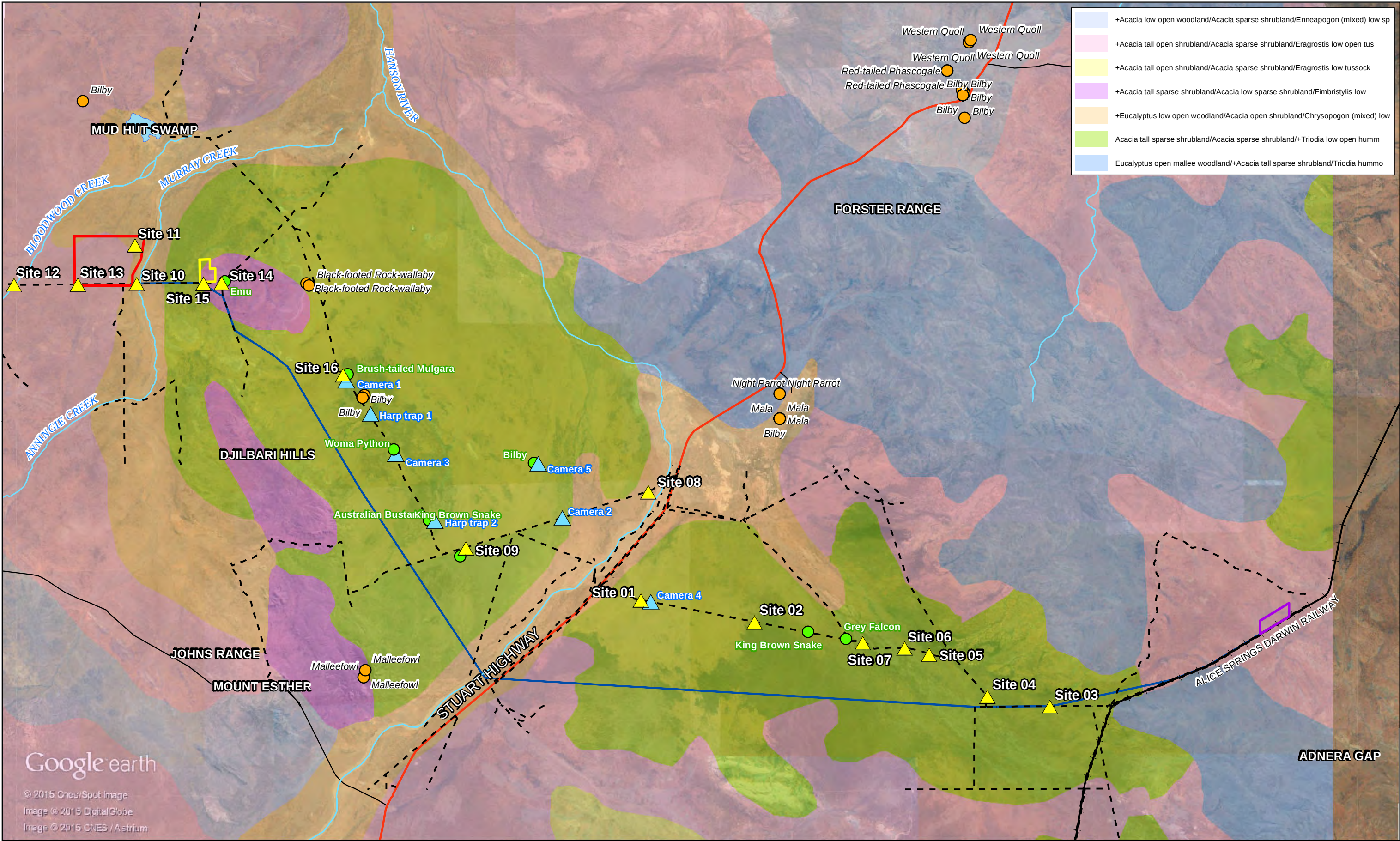
4.1.1 Baseline survey techniques

Survey methods followed the *Standard terrestrial vertebrate survey methods used by the Department of Land Resource Management* (Appendix A in NT EPA 2013¹). Table 2 provides a summary of survey effort for the baseline survey in each site (focussed on a 50 m x 50 m area). More detail was provided in GHD (2015).

Table 2 Summary of fauna survey effort during baseline survey of the Study Area (April 2013)

Survey type	Survey effort
Habitat assessment	Conducted over approximately two person-hours per site, investigating quadrat area through various survey methods.
Elliot trapping	20 baited Elliot traps (type A) per site, checked twice daily for four days and nights. 1280 trap-nights in total; 80 trap-nights per site.
Cage trapping	Four baited cage traps per site, checked twice daily for four days and nights. 256 trap-nights in total; 16 trap-nights per site.
Pitfall trapping	Four 10 m pitfall traplines (each with one bucket) per site, checked twice daily for four days and nights. 256 trap-nights in total; 16 trap-nights per site.
Funnel trapping	Two 10 m traplines (each with two funnel traps) per site, checked twice daily for four days and nights; Two funnel traps on each pitfall trapline (four pitfall lines). 768 trap-nights in total; 48 trap-nights per site.
Anabat	One survey-night at each site; 16 survey-nights in total
Bird surveys	At least three 20 minute diurnal surveys at each site, incorporating 'instantaneous bird counts'. 48 bird counts in total.
Active searches	Conducted opportunistically by at least one ecologist at sites and other locations, depending on conditions.
Nocturnal searches	At least two 20-minute nocturnal searches by two ecologists at each site or at other locations. Road spotlighting through study area and along the existing gas pipeline access road. Minimum of 24 person-hours active searching in total.
Remote surveillance cameras	Five units were deployed opportunistically during the survey, for up to four days and nights each. >15 trap-nights in total.
Scat / hair / bone / skin / pellet analysis	Assessed / Collected opportunistically
Opportunistic observations	Eight ecologists over the entire survey period, including six 12-hour days during set-up and survey. Minimum of 576 person-hours of opportunistic observation.

¹ Guidelines for assessment of impacts on terrestrial biodiversity. Northern Territory Environment Protection Authority; April 2013, Version 1.2



4.2 2016 targeted surveys for threatened fauna species

During baseline fauna survey, and/or during review of the then Commonwealth DotE PMST data, a number of EPBC-listed fauna species were identified as being present or potentially present in the Study Area including:

- Greater Bilby (*Macrotis lagotis*);
- Great Desert Skink (*Liopholis kintorei*);
- Black-footed Rock-wallaby (*Petrogale lateralis* MacDonnell Ranges race); and
- Brush-tailed Mulgara (*Dasymercus blythi*) (but see discussion in Section 1.6.1).

These species are rare, cryptic and/or sparse, and require targeted and non-standard survey methods to maximise the chances of detection. Survey objectives and efforts for these species are described below.

4.2.1 Objectives of the targeted surveys for threatened fauna species

- Document and review all known locations of previous records of threatened species, in particular Greater Bilby, Great Desert Skink, Brush-tailed Mulgara and Black-footed Rock-wallaby in the Study Area and surrounding region;
- Review and characterise the habitats that will be impacted by the proposed mine site, access roads, bore pipeline and associated infrastructure;
- Prioritise areas of highest habitat suitability for these threatened species which occur within the Study Area to target for threatened species surveys;
- Complete targeted surveys for priority species Greater Bilby, Great Desert Skink, Brush-tailed Mulgara and Black-footed Rock-wallaby within the Study Area, following standard methods for these species as per the Commonwealth Government's survey guidelines for mammals (DSEWPaC 2011a) and reptiles (DSEWPaC 2011b), primarily walking transects along proposed infrastructure corridors, in areas of most suitable habitat;
- Discuss the potential impacts of the mining proposal on these species;
- Assess the likely local and regional impacts of the Project on the species in relation to the EPBC Act 'significant impact criteria', and using a 'risk based' approach;
- Develop mitigation measures and a future monitoring framework for this species in order to monitor potential impact; and
- Provide advice on compliance with legislation and policy.

4.2.2 Desktop Assessment

In addition to the desktop assessment process described in Section 4.1 above, the DLRM fauna database and the scientific literature were reviewed to provide background information on the biology and conservation status of each of the threatened species.

4.2.3 Field assessment – threatened species survey

Table 3 provides a summary of the level of effort applied to targeted threatened species survey at the Mount Peake Study Area in 2016. Figure 3 provides a visual representation of the targeted survey effort.

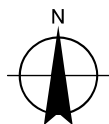
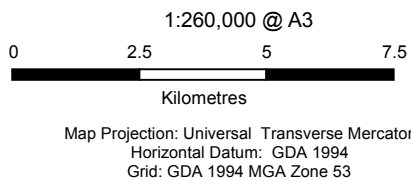
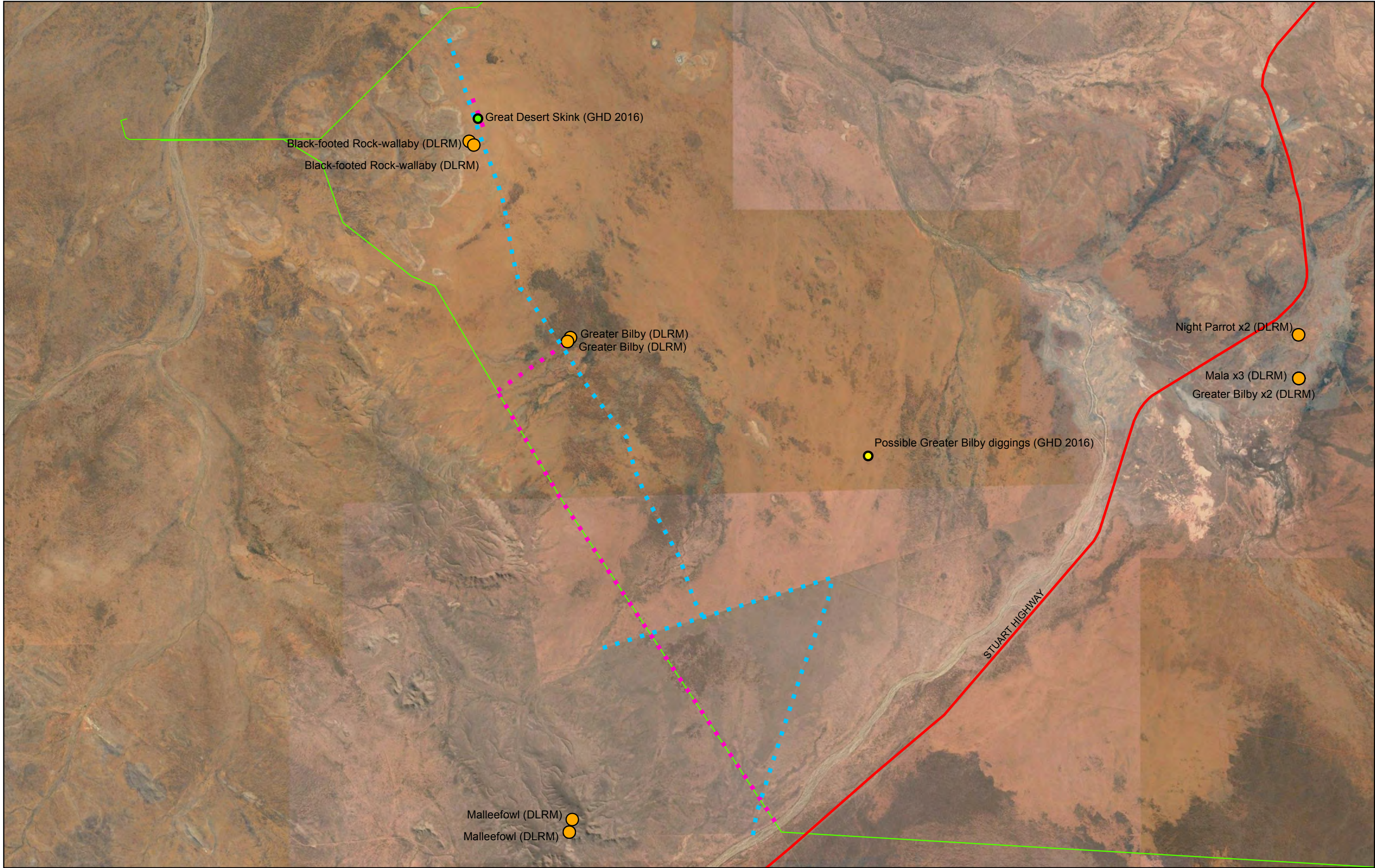
Table 3 Targeted survey schedule and brief description

Timing	Team	Extent of survey	Brief description
21 – 24 November 2016	Three to five ecologists including Steve Eldridge (Desert Wildlife Services) working with five Anmatyerr Rangers based in Ti Tree.	Survey of the access road to detect the presence of Greater Bilby, Great Desert Skink and Brush-tailed Mulgara along the proposed access road corridor, as shown in Figure 3. No specific survey efforts were made in November 2016 to detect Black-footed Rock-wallaby. Targeted searches for this species were included in April 2013, and the area surveyed in November 2016 was unsuitable rock-wallaby habitat.	Daylight surveys walking transects along the access road corridor. People walked roughly 10-20 m apart scanning the ground for signs of the threatened species such as scat, burrows, diggings and/or latrines. An eye was kept out for Black-footed Rock-wallaby habitat, but none was found within or near the surveyed area.

The survey was conducted during daylight hours, with three to five ecologists and five Anmatyerr Rangers traversing the disturbance corridor on foot, roughly 10-20 m apart and scanning the ground for signs of the threatened species such as scat, burrows, diggings and/or latrines. The total length of corridor surveyed intensively in this way was over 25 km (see Figure 3), and an area of 300-375 hectares.

Any burrows or other signs of threatened species were recorded, including GPS coordinates. The following were also recorded for the access road walk:

- Evidence of grazing;
- Fire history;
- Vegetation cover (spinifex, acacia/mulga, buffel grass); and
- Predator signs.

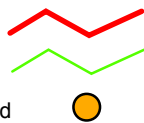


LEGEND

Major Roads

Proposed Infrastructure Alignment

DLRM Database records as labelled



2016 Survey Walking Transect

2016 Survey Driving Transect

Great Desert Skink observation 2016

Possible Greater Bilby diggings 2013

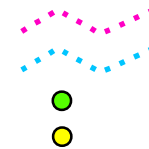


Figure 3



TNG Limited
Mount Peake EIS

Job Number 61-29057
Revision A
Date 09 Dec 2016

**Targeted Threatened Species
Fauna Surveys**

4.2.4 Survey techniques

The following section describes the specific survey techniques that were utilised in targeted searches to detect presence of EPBC listed, threatened fauna species.

*Targeted surveys for Greater Bilby (*Macrotis lagotis*)*

Recommended survey techniques include habitat assessments, searching for signs of activity (burrows, diggings), collection of predator scats and soil plot surveys (for tracks). Spotlight or camera surveys at burrow entrances may be effective following detection of signs. Spotlight surveys from a vehicle allowing large distance to be covered through suitable habitat are also effective.

Extensive and intensive nocturnal (spotlighting) searches were undertaken on foot and from slow-moving vehicles to detect active individuals of this species in 2013 and again in 2016 (although wet weather hampered nocturnal efforts in 2016). In 2016 extensive diurnal searches of the haul road corridor were also undertaken by walking transects along its entire route where suitable habitats exist (Figure 3), to locate signs of potential activity, including burrows, tracks, scats and diggings.

The targeted surveys focussed on areas of spinifex-dominated habitats within the Study Area, considered to provide the most suitable habitat and including areas with low shrub cover, including some rocky areas and areas with a low shrub cover of the favoured Witchetty Bush (*Acacia kempeana*) (Pavey 2006a).

*Targeted surveys for Great Desert Skink (*Liopholis kintorei*)*

The Great Desert Skink has a habitat preference for open sandplain within spinifex (*Triodia* spp.), which occurs extensively across the southern part of the Mount Peake site.

The most effective survey technique is to locate burrow systems by walking along transects through suitable habitat, and then checking/watching the burrow entrances that show recent signs of activity (active latrine site, recently dug soil at entrances, fresh tracks at burrow entrance) for the possible emergence of animals. Great Desert Skinks are likely to be more active in warmer weather. Thus, watching burrow entrances tends to be more successful in warmer months than in cooler months.

Watching burrows can be done through the use of motion-sensing cameras to 'watch' for longer periods, a technique which has been used successfully by GHD in previous surveys (Plate 2 and Plate 3). McAlpin (2001b) reports the optimum time of year for monitoring burrows as late summer and early autumn, before the lizards enter hibernation, at which time the maximum number of individuals are likely to inhabit the burrow systems.

*Targeted surveys for Black-footed Rock-wallaby (*Petrogale lateralis* MacDonnell Ranges race)*

Surveys for this species should be concentrated on rocky outcrops, crevices, caves and boulder piles where rock-wallabies typically shelter (Ward *et al.* 2011); and vegetated parts of hills and escarpments, particularly grassy areas, where rock-wallabies potentially forage (Ward *et al.* 2011).

Low densities of Black-footed Rock-wallabies can be difficult to detect using ground-based diurnal or spotlighting surveys. Searching for scats is considered a reliable and repeatable technique for detecting low density populations (Sharp 1999). Scats are deposited in the vegetated zones where they forage, on exposed boulders or ledges where they 'bask' and particularly in crevasses, caves or under boulder piles adjacent to secure refuges (Sharman and Maynes 2002).

In April 2013, diurnal surveys were undertaken by ecologists looking for the presence of suitable habitat for the Black-footed Rock-wallaby in and around the Mount Peake Mine Lease area. The main activities undertaken were investigating areas of potential rock-wallaby habitat and collecting potential rock-wallaby scat. As recommended, surveys concentrated on rocky outcrops, crevices, caves, boulder piles and vegetated parts of hills and escarpments.

No specific survey efforts were made in November 2016 to detect Black-footed Rock-wallaby. The area surveyed in November 2016 was unsuitable rock-wallaby habitat.

4.2.5 Weather

During the 2016 targeted threatened species survey, environmental conditions were warm to hot and humid, with afternoon thunderstorms and some heavy afternoon/evening rainfall in areas of the Study Area. Maximum daily temperatures at the nearby Territory Grape Farm weather station ranged from 31.9 to 39.6 °C and overnight minimums ranged from 19.3 to 25.9 °C (Table 4). While very little rain was recorded during the survey at the weather station, quite large falls occurred within the Study Area, and 35 mm was recorded in an unofficial rain gauge close-by (Stirling station). Thunderstorm rainfall in this area tends to be localised and patchy.

In the months prior to the survey, the area experienced mild conditions (Table 4). Very little rain fell in the area in the month prior (October 20 – November 20). Rainfall during the preceding year (from November 2015 to the end of October 2016) totalled 333.2 mm, which was 13.3 mm (4.16%) higher than the long-term (25-year) average for that period (319.9 mm).

Table 4 Weather conditions experienced prior to and during the November 2016 threatened species surveys (BOM; Territory Grape Farm NT)

Month / Day	Rainfall (mm)	Mean max. temp (°C)	Mean min. temp (°C)
August 2016	0.0	25.2	8.1
September 2016	25.8	27.0	12.7
October 2016	1.4	31.2	12.6
November 21	0.0	39.6	25.9
November 22	3.2	34.0	19.3
November 23	0.0	34.2	21.3
November 24	2.8	31.9	19.3
November 2016	6.8	36.1	18.6

5. Results

5.1 Key threatened and near-threatened species

Greater Bilby (Macrotis lagotis)

Spinifex-dominated habitats across the Study Area provide potential Greater Bilby habitat, including some rocky areas and areas with a low shrub cover of the favoured Witchetty Bush (*Acacia kempeana*) (Pavey 2006a).

Potential signs of Greater Bilby digging were recorded during the 2013 surveys approximately 11 km north-east of the proposed access road (Figure 3). Intensive searches of the surrounding area at the time failed to find any further evidence of the species.

In November 2016, extensive targeted searches within potentially suitable habitat by a team of three ecologists and five Anmatyerr Rangers included spotlighting and walking over 25 km of transects along the proposed haul road corridor (Figure 3). No direct or indirect evidence of the species was found.

These surveys did however find evidence of the introduced European Rabbit (*Oryctolagus cuniculus*) in areas considered to provide the most suitable Greater Bilby habitat (Plate 1). Competition from rabbits is considered a potentially major threatening process (Pavey 2006a), and anecdotal evidence suggests that rabbit populations may increase local predator densities to the demise of bilbies in the area. Where rabbits occur, Bilbies rarely do (Steve Eldridge, DWS, *pers. comm.*).

As a result of the baseline and targeted surveys, the Greater Bilby is considered unlikely to occur within the Study Area. If it does occur there, then its numbers are likely to be low.

Great desert skink (Liopholis kintorei)

One Great Desert Skink was observed at the edge of a track during the 2016 targeted fauna survey approximately 7 km north of the proposed access road, in spinifex sandplain habitat. Subsequent searches later that day by five ecologists and five Anmatyerr Rangers of the area surrounding this observation for at least 400 m failed to find any evidence of the typically quite obvious burrow system or of the observed individual. This was in habitat that appeared not to have been burnt very recently when compared to much of the rest of the Study Area, but had been burnt recently enough that the spinifex tussocks were large but not very large (perhaps burnt within the past 5-6 years).

The NT Fauna Atlas (DLRM) results indicate that the species has not been recorded previously in the Study Area, with all previous records well to the south and west of the Mount Peake Study Area. Previous surveys by GHD ecologists near the Napperby Access Road approximately 100 km south-west of the Mount Peake Study Area in 2015 found one active Great Desert Skink burrow system (as shown in Plate 2 and Plate 3 above), which was potentially the most north-easterly record of this species known at the time. While much of the Study Area that is spinifex-dominated sandplain provides potentially suitable habitat for this species, it appears to be at the very edge of the species' distribution and is unlikely to provide core habitat.

Black-footed Rock-wallaby MacDonnell Ranges Race (Petrogale lateralis)

The Black-footed Rock-wallaby was not detected during the April 2013 or November 2016 surveys, but its presence in nearby ranges was confirmed by a GHD ecologist during a helicopter flight for vegetation mapping in April 2013.

Most of the area covered by the mine area and access road is not typically suitable habitat for rock-wallabies, but there are rocky outcrops scattered throughout the area that are likely to be suitable. Individuals may very occasionally move through parts of the Study Area between patches of suitably rocky habitat.

Brush-tailed Mulgara (*Dasycercus blythi*)

The Brush-tailed Mulgara was not observed in April 2013 or November 2016, but is considered likely to be present on the basis of an active burrow observed during the 2013 survey. No further active burrows were found during targeted surveys of extensive areas of spinifex sandplain in November 2016. The population size of this species is known to fluctuate greatly with the quality of season. It is expected that Brush-tailed Mulgara would be present in very low densities throughout the broader sandplain areas of the Study Area.

5.2 Other-threatened species identified for the Study Area

Both Emu and Australian Bustard were recorded during the baseline fauna survey by GHD in April 2013 and November 2016.

Two reptiles (Woma Python *Aspidites ramsayi* and King Brown Snake *Pseudechis australis*) were detected during the baseline fauna survey by GHD in April 2013, and are likely to be widespread but sparse across the region.

6. Assessment of potential impacts on threatened fauna

The original fauna assessment completed by GHD (2015) included a detailed impact and risk assessment of all Matters of National Environmental Significance relevant to the Project, following the guidelines and criteria outlined below. Following the completion of a subsequent targeted threatened species survey in November 2016, the risk assessment for the targeted species has been reviewed and updated where necessary. Risk assessments for impacts on species are presented in Table 8 to Table 11.

6.1 Focus of the impact and risk assessments

All species identified for assessment in the project-specific TOR were considered for the impact and risk assessment in GHD (2015). This assessment focuses on the threatened species targeted during the 2016 surveys only. The species assessed are:

- Greater Bilby (vulnerable EPBC & NT);
- Great Desert Skink (vulnerable EPBC & NT);
- Black-footed Rock-wallaby (MacDonnell Ranges race) (vulnerable EPBC & NT); and
- Brush-tailed Mulgara (vulnerable NT) is also included in the assessment, despite not being listed as threatened under the EPBC Act – see Section 1.6.1 for rationale.

6.2 Criteria for determining significant impacts

Evaluations of the significance of potential impacts are based on the *Commonwealth's Significant Impacts Guidelines: Matters of National Environmental Significance (the guidelines)* as applied to vulnerable species.

6.2.1 Definitions for threatened species impacts

Assessment under the guidelines requires the use of three definitions. These are for *population*, *important population*, and *habitat critical to the survival of a species*, and are presented below. The guidelines also refer to *threatened ecological communities* in these definitions, but because no communities were identified for this project, the term has been omitted.

- A *population* of a species' is defined under the EPBC Act as an occurrence of the species in a particular area. In relation to vulnerable species, occurrences include but are not limited to:
 - A geographically distinct regional population, or collection of local populations
 - A population, or collection of local populations, that occur within a particular bioregion.
- An *important population* is a population necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, or that are:
 - Key source populations either for breeding or dispersal
 - Populations that are necessary for maintaining genetic diversity
 - Populations that are near the limit of the species range.
- *Habitat critical to the survival of a species* refers to areas that are necessary:
 - For activities such as foraging, breeding, roosting, or dispersal

- For the long-term maintenance of the species (including the maintenance of species essential to the survival of the species, such as pollinators)
- To maintain genetic diversity and long-term evolutionary development, or for the reintroduction of populations or recovery of the species.

Such habitat may be, but is not limited to: habitat identified in a recovery plan for the species as habitat critical for that species; and/or habitat listed on the Register of Critical Habitat maintained by the minister under the EPBC Act.

6.2.2 Guideline on impact significance – vulnerable species

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- Lead to a long-term decrease in the size of an important population of a species
- Reduce the area of occupancy of an important population
- Fragment an existing important population into two or more populations
- Adversely affect habitat critical to the survival of a species
- Disrupt the breeding cycle of an important population
- Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
- Introduce disease that may cause the species to decline, or
- Interfere substantially with the recovery of the species.

6.3 Assessment of the “real chance or probability” of an EPBC significant impact

Risk is expressed and assessed in terms of a combination of the consequence of an event and the likelihood of the event occurring. A “real chance or probability” of a significant impact from a particular source is defined as there being an extreme or high risk of a population experiencing a significant consequence as defined in the guidelines e.g. reduce the diversity or modify the composition of plant and animal species in a National Heritage place.

The initial level of risk and residual level of risk (i.e., after avoidance, mitigation and management actions have been applied) have been determined using standard qualitative risk assessment procedures consistent with AS/NZS ISO 31000:2009 ‘Risk Management – Principles and guidelines’. Economic risk is not addressed in the guidelines (Table 5).

Assessment of risk has been conducted through consideration of the circumstances around risks, identifying necessary controls to address potential impacts and assuming effective implementation of planned and committed mitigation of potential impacts. Avoidance, mitigation and management actions are proposed in an attempt to reduce residual risk (risk after actions) as low as reasonably practicable, and where possible to below “Extreme” or “High” risk outcomes.

The depth of focus on risk controls is linked to the level of risk and opportunity for reduction to meet organisational commitments and goals linked to an environmentally and socially responsible operation, and those requirements are part of the regulatory obligations and impact assessment guidelines.

Table 5 presents the qualitative risk matrix adopted and the levels of risk for the various consequence and likelihood combinations. Brief descriptions of likelihood and consequence classifications and the likely responses for the threatened species assessed are provided in Table 6 and Table 7.

Table 5 Qualitative risk analysis matrix

Likelihood	Consequence Level				
	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Almost Certain (5)	Medium	Medium	High	High	Extreme
Likely (4)	Low	Medium	Medium	High	High
Possible (3)	Low	Low	Medium	Medium	High
Unlikely (2)	Very Low	Low	Low	Medium	Medium
Rare (1)	Very Low	Very Low	Low	Low	Medium

Table 6 Definition of levels of likelihood

Level of Likelihood	Definitions
Almost certain	The event is expected to occur in most circumstances This event could occur at least once during a project of this nature 91-100% chance of occurring during the project
Likely	The event will probably occur in most circumstances This event could occur up to once during a project of this nature 51-90% chance of occurring during the project
Possible	The event could occur but not expected This event could occur up to once every 10 projects of this nature 11-50% chance of occurring during the project
Unlikely	The event could occur but is improbable This event could occur up to once every 10-100 projects of this nature 1-10% chance of occurring during the project
Rare	The event may occur only in exceptional circumstances This event is not expected to occur except under exceptional circumstances (up to once every 100 projects of this nature) Less than 1% chance of occurring during the project

Table 7 Definitions of levels of consequence

Levels of Consequence	Definitions
Catastrophic	At least moderate or substantial regional decrease in size of population(s) of listed fauna species
Major	Substantial local decrease in size of population(s) of listed fauna species
Moderate	Moderate local decrease in size of population(s) of listed fauna species
Minor	Minor local decrease in size of population(s) of listed fauna species
Insignificant	No loss of individuals of listed fauna species (thus, no decrease in size of population(s) of listed fauna species)

6.4 The fauna and populations of threatened species

For the purposes of the risk and impact assessment, each of the species to be assessed is regarded as having a “population” in the Mount Peake area. The assessment is risk averse in that only one of the species (Great Desert Skink) was recorded in the Study Area of the proposed mining area, bore field or access road, and nearly all threatened species records are at least 4 km from any of the proposed infrastructure.

The populations of each threatened species occupy specific areas in and around the study area as defined by the species’ preferred habitats and biologies. Areas occupied/possibly occupied by the fauna and population of each species are unlikely to be related to boundaries imposed by mine site/access road boundaries or mineral leases.

The areas occupied by the species are:

- The Greater Bilby was possibly recorded during the 2013 surveys in an area 11 km from the Study Area (despite extensive survey effort in areas of suitable habitats) along with several historic records approximately 4 km from the proposed project footprint. However, it is possible that this mobile species could occur within any of the sandplain habitats of the study area, though is expected to occur in very low numbers and densities, if present.
- Black-footed Rock-wallaby is known (from April 2013 survey and database records) to occur in rocky habitats to the east and west of the Study Area, but not within the Study Area itself. Transient individuals may pass through the actual Study Area on occasion.
- The Great Desert Skink was initially considered unlikely to occur in the area, as the Study Area was considered outside their accepted range. However, one individual was observed fleetingly approximately 7 km from the north of the access road in November 2016. No further evidence of Great Desert Skink, or sign of a warren could be found despite extensive searches of the area. It is likely that this species occurs within the sandplain habitats of the study area, but it is likely to be present in very low densities.
- The Brush-tailed Mulgara is likely to be present in very low densities within the sandplain habitats of the access road. It is expected that this species would be present within sandplain habitats throughout the study area and surrounds in low densities given that the same habitat exists throughout the region.

6.5 Potential sources of impact on fauna

Construction and operation of infrastructure has the potential to result in a broad range of categories of impacts on native terrestrial fauna or sites of biological significance. The following list includes potential impacts that were identified in the NT EPA Terms of Reference, and others that are thought to be possible as a result of the assessment results:

- Clearing of breeding and/foraging habitat through clearing of vegetation;
- Habitat fragmentation and creation of barriers to fauna movement;
- Altered hydrology;
- Water quality impacts (surface water);
- Groundwater contamination or lowering;
- Erosion and sedimentation impacting on waterways;
- Soil compaction;
- Waste material – industrial and domestic;
- Noise disturbance;

- Dust generated by mining and processing activities;
- Visual disturbance (including artificial lights at night);
- Wildfire, inadvertently started by mine construction or operation;
- Risks associated with transport and traffic during construction and operation;
- Introduction and/or spread of weeds and pest animals;
- Poisoning of fauna from drinking contaminated water (e.g., tailings dam); and
- Inappropriate/ineffective rehabilitation.

Some of these impacts may work in combination or synergy with each other, or with external or cumulative impacts, such as exotic predators, grazing or the additional clearance of native vegetation.

6.6 Management, mitigation measures and proposed monitoring

The Terms of Reference for this Project call for the establishment of “mechanisms to determine the long-term impact of environmental impacts associated with key environmental issues (monitoring and reporting)”.

Mitigation measures will be required to reduce or eliminate impacts of mining and processing activities on fauna (particularly threatened species) and their habitat. Section 8 of the Mount Peake Fauna Assessment Report (GHD 2015) provides detailed guidance on the types of mitigation and monitoring that can be considered for the construction and operation phases of the project. An outline of mitigation measures is provided for each impact and for each species to arrive at the residual risk levels shown in Table 8 (Greater Bilby), Table 9 (Great Desert Skink), Table 10 (Black-footed rock-wallaby) and Table 11 (Brush-tailed Mulgara) in Section 6.7 below.

6.7 Evaluation of impact significance for each EPBC Act-listed species

In the sections below, significant impact criteria are assessed for each EPBC Act-listed species against the likelihood and consequence **before mitigation** (i.e. initial risk), as determined in sections 6.2 to 6.5 above.

6.7.1 Greater Bilby (Vulnerable)

The Greater Bilby may occur within the Project area. The local population would be considered an important population because it is necessary for maintaining genetic diversity.

In accordance with EPBC definitions, most of the Project area would be considered to support habitat critical to the survival of the bilby, because it would support activities such as foraging, breeding and dispersal and would be necessary to maintain genetic diversity and long-term evolutionary development of the species.

Potential sources of impact that pose the highest threat to the Greater Bilby are:

- Habitat clearing;
- Habitat fragmentation;
- Impacts associated with inadequate management of industrial waste material;
- Indirect impacts associated with inadequate management of domestic waste material;
- Unplanned wildfire;
- Vehicle movements (e.g. collisions);
- Invasion by exotic plants and animals, particularly predators;
- Inappropriate or ineffective rehabilitation.

Table 8 EPBC risk assessment for impacts on Greater Bilby (vulnerable)

Source of Impact	Likelihood	Consequence	Severity	Comments	Minimising, mitigation and management actions	Residual Risk	Reference (GHD 2015)
Clearing of habitat	4	3	Medium	Construction of the project will result in the loss of approximately 978.8 ha of potential breeding, foraging and dispersal habitat for the Greater Bilby, equating to 97.1% of the vegetation proposed to be cleared as a result of the project. This comprises the loss of 558.58 ha of Spinifex grassland (55.4% of cleared area) and 420.25 ha of Mulga woodland (41.7% of cleared area), though these areas represent a small fraction of the total area of these vegetation communities within the Burt Plain Bioregion. Most of this loss is associated with construction of the haul road. Without mitigation, removal of habitat is likely to impact on the populations of Greater Bilby that occur in the Project area. Impacts have the potential to be moderate . Management and mitigation will be essential, and can reduce the likelihood to possible and the severity to minor .	- Minimise impact via actions in Section 8.2 of GHD (2015); - Implement clearing during autumn when breeding has ended. Avoid clearing during the winter/spring months when some animals are inactive in burrows or breeding; - Have a qualified ecologist on-site during the clearing to capture and translocate animals encountered during the clearing process; - Produce and apply a dedicated BMP and ensure appropriate construction management results in minimizing clearing effects on the threatened species populations of the area.	Low	Sections 7.2.1 and 8.1
Habitat fragmentation	4	3	Medium	Construction of the project will result in the loss of approximately 978.8 ha of potential habitat for the Greater Bilby. Much of the habitat loss is associated with construction of the haul road, which will fragment the habitat and increase the risk of injury or death of bilbies that cross the haul road at inopportune times. Without mitigation, impacts on fauna are likely , and have the potential to be moderate . Management and mitigation will be essential, and can reduce the likelihood to possible and the severity to minor .	- Further minimise impact via actions in Section 8.2 of GHD (2015); - Produce and apply a dedicated BMP and ensure appropriate construction, weed hygiene, fire, dust and rehabilitation management result in minimizing fragmentation effects and edge effects (ie unintentional widening of corridors through weed invasion or subsequent death of retained vegetation along edges); - Implement strict vehicle hygiene protocols to prevent new weed incursion and spread, including a vehicle wash down facility on site; - Limit vehicle speeds and restrict vehicle movements to daylight hours only, to allow bilbies to cross corridors of cleared habitat more safely, thereby reducing the impact of habitat fragmentation.	Low	Sections 7.2.2 and 8.1

Altered hydrology	1	2	Very Low	Altered hydrology as a result of the Project is not expected to impact on bilby. Hydrology impacts on bilby would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.3 and 8.2
Water quality impacts	1	2	Very Low	Deleterious changes in water quality as a result of the Project are unlikely to impact on sandplain ground-dwelling fauna. Water quality impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.4 and 8.2
Erosion and sedimentation	1	2	Very Low	Erosion and sedimentation as a result of the Project are not expected to impact on sandplain ground-dwelling fauna. Erosion and sedimentation impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.5 and 8.2
Soil compaction	1	2	Very Low	Soil compaction as a result of the Project is not expected to impact on sandplain ground-dwelling fauna. Soil compaction impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.6 and 8.3
Lowering or contamination of water table	1	2	Very Low	Lowering or contamination of the water table as a result of the Project is not expected to impact on sandplain ground-dwelling fauna. Water table impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.7 and 8.2
Impacts on surface or groundwater systems	1	2	Very Low	Changes to surface or groundwater systems as a result of the Project are not expected to impact on sandplain ground-dwelling fauna. Impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.8 and 8.2

Waste material - industrial	3	3	Medium	Industrial waste material on its own is not expected to result in direct impacts on Greater Bilby. However, the need to dump and transport waste materials has the potential to contribute to other impacts, namely: – Injury and death of fauna as a result of increase in waste-carrying transport and resulting collisions with wildlife; – Clearing of breeding and/or foraging habitat to create space to store/pile waste products; – Dust as a result of increased traffic and specifically due to haulage of waste rock; and – Spread and invasion of weeds. All of these could indirectly impact on Greater Bilby, and collectively, moderate impacts are possible without mitigation. These impacts are addressed in turn in other sections of this risk assessment. Mitigation and management can reduce the risks to be possible and minor, or lower.	– Minimise potential for impact resulting from injury and death of fauna from vehicle collisions via actions in Section 8.10 of GHD (2015); – Minimise potential for impact resulting from clearing of habitat via actions in Section 8.1 of GHD (2015); – Minimise potential for impact resulting from dust via actions in Section 8.7 of GHD (2015); – Minimise potential for impact resulting from weed invasion via actions in Section 8.11 of GHD (2015); – Further minimise potential for impact via actions in Section 8.4 of GHD (2015).	Low	Sections 7.2.9, 8.1, 8.4, 8.7, 8.10, 8.11.
Waste material – domestic	3	5	High	Domestic waste products (in the form of garbage/refuse) themselves will not impact on Greater Bilby, but there is a risk of indirect impact from the garbage attracting vermin (rats and mice) and the vermin attracting their predators (cats, foxes and dingoes). Larger numbers of predators would greatly increase the risk of predation on ground-dwelling sandplain fauna, including the bilby, possibly to the point of localized extinction. Without mitigation, such impacts are possible and the severity could be catastrophic. Strict management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to moderate.	– Minimise impact via actions in Section 8.5 of GHD (2015); – Produce and apply dedicated BMP and ensure appropriate management of domestic waste to avoid unnatural increases in predator population sizes.	Low	Sections 7.2.10 and 8.5

Noise	3	1	Low	Noise generated by the mine is likely to preclude movements of Greater Bilby through the Mine Site, however particularly noisy activities would likely occur during daylight hours when most of the fauna (mostly nocturnal), including bilbies, tend to be sheltering. Most fauna can habituate to predictable noises with time. Therefore, some of the noise impacts may be short-term impacts. The GHD 2015 Noise and Vibration report indicates that at the proposed mine camp (5 km from mine site), the noise levels would be at predicted level of up to 34.3 dBA. Maximum internal noise levels of 50-55 dBA is recommended for human sleep. Suitable Greater Bilby habitat would be >10 km from the mine camp, therefore background noise levels would be very low. Without mitigation, impacts from noise are possible but the severity would be insignificant. Management and mitigation can reduce the likelihood to unlikely.	– Minimise impact via actions in Section 8.6 of GHD (2015); – The implementation of noise controls as defined in a Noise Management Plan (possibly as part of the Biodiversity Management Plan) – likely to include the avoidance of loud noise at night when most sandplain fauna, including bilby, are active.	Very Low	Sections 7.2.11 and 8.6
Dust	2	1	Very Low	Greater Bilby live in dusty habitats, and dig burrows in dusty ground. Consequently, this species is likely to be adapted to coping with dusty conditions. Additional impacts from dust as a result of this project are considered unlikely and are expected to be insignificant if they occur.	– Further minimise potential for impacts via actions in Section 8.7 of GHD (2015); – Produce and apply dedicated BMP and ensure appropriate dust controls are in place to minimize and mitigate dust effects on sandplain fauna populations, including bilby, of the area.	Very Low	Sections 7.2.12 and 8.7
Visual/Light	2	1	Very Low	Light emitted from the proposed mine could have a small and localized effect on the nocturnal Greater Bilby. Impacts from lighting are unlikely and the severity is likely to be insignificant.	– Further minimise potential for impact via actions in Section 8.8 of GHD (2015); – Avoiding unnecessary lighting at night when sandplain fauna, including bilby, would be most affected and keeping lighting low and directed at operations rather than surrounding habitat will assist greatly in reducing the likelihood and severity of impacts; – Produce and apply dedicated BMP and ensure appropriate lighting controls are in place to minimize artificial light effects on the fauna populations of the area, including the bilby.	Very Low	Sections 7.2.13 and 8.8

Unplanned Wildfire	3	4	Medium	It is possible that extensive unplanned wildfire as a result of mine activities could have a major impact on populations of Greater Bilby. The bilby is likely to rely on the habitats within a relatively small area, and would be more vulnerable if their habitat is burnt out. Mitigation can be used to reduce the likelihood (to unlikely) but a major impact could still result.	- Minimise likelihood of impact via actions in Section 8.9 of GHD (2015); - Produce and apply dedicated BMP and ensure appropriate wildfire controls are in place to minimize and mitigate the potential for impacts on sandplain fauna, including the bilby; - A separate Bushfire Management Plan will be required to manage this risk.	Medium	Sections 7.2.14 and 8.9
Impacts from vehicles/transport	4	3	Medium	Without mitigation, impacts on sandplain fauna, including the bilby, from collisions with vehicles due to increased traffic (particularly along the haul road) are likely , and could have a moderate impact. Vehicle movements during dawn, dusk and nighttime would result in the highest risk to fauna. Management and mitigation efforts can be implemented to reduce the risk to unlikely and minor .	- Minimise likelihood and severity of impact via actions in Section 8.10 of GHD (2015); - Produce and apply a Traffic and Road Safety Management Plan, to be incorporated into a BMP. - Restrict vehicle movements (particularly along the haul road) to be during daylight hours only – this would greatly reduce the chance of vehicle strike with species that are predominantly nocturnal; - Limit vehicle speeds, particularly during dawn, dusk and nighttime (if vehicle movements required during those times). - Produce and apply a Weed Hygiene Procedure and provision of on-site wash down facilities, to minimize the risk of weed invasion which could indirectly impact on sandplain fauna, including Bilby.	Low	Sections 7.2.15 and 8.10
Exotic plants and animals	4	4	High	Without adequate management and mitigation, the introduction of exotic plants and animals as a result of mine activities is likely to result in impacts on sandplain fauna, including bilbies, and those impacts have the potential to be major . Changes to habitats as a result of weed invasion are of concern, but the primary concern is any action that results in an increase in numbers of cats, foxes and dingos, which would then be likely to prey more heavily on sandplain fauna, including bilbies. Strict management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to moderate .	- Minimise likelihood and severity of impact via actions in Section 8.11 of GHD (2015); - Produce and apply a dedicated BMP and ensure appropriate controls are in place to minimize and mitigate the potential 'High' impacts of exotic plants and animals on sandplain fauna populations of the area; - Construct a predator-proof compound to contain food waste; - As part of BMP incorporate a monitoring program for weeds and pest animals.	Low	Sections 7.2.16 and 8.11

Poisoning of fauna from drinking contaminated water	1	1	Very Low	Poisoning of fauna as a result of the Project is not expected occur. Such an impact on these species would be rare , and have an insignificant impact if it occurred.	– Further minimise potential for impact via actions in Section 8.12 of GHD (2015); – Produce and apply a Water Quality Monitoring and Management Plan. A Tailings Dam Wildlife Monitoring Program would be incorporated into a BMP and would be more broadly directed at fauna in general rather than just specifically threatened species.	Very low	Sections 7.2.17 and 8.12
Inappropriate/ ineffective rehabilitation	4	4	High	The biggest potential impact as a result of inappropriate or ineffective rehabilitation is likely to be the spread of weeds. Weed-dominated habitats are generally less favourable for fauna, including bilbies, than weed-free habitats, and may introduce additional risks (e.g., more intense fires, less suitable foraging habitat). Unless rehabilitation is appropriate and effective, impacts are likely to occur and have the potential to be major . Management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to minor .	– Minimise impact via actions in Section 8.13 of GHD (2015); – Produce and apply a dedicated BMP and ensure appropriate construction, weed hygiene and rehabilitation management aspects minimize and mitigate impacts on sandplain fauna populations of the area.	Low	Sections 7.2.18 and 8.13

Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk of impacts on the Greater Bilby is unlikely to be significant according to EPBC Act significant impact guidelines.

6.7.2 Great Desert Skink (Vulnerable)

The Great Desert Skink is likely to occur within the Project area. The local population is likely to be considered an important population because it would be necessary for maintaining genetic diversity.

Most of the Project area would be considered to support habitat critical to the survival of this species, because it would support activities such as foraging, breeding and dispersal and is necessary to maintain genetic diversity and long-term evolutionary development of the species.

Potential impacts that pose the highest risk to the Great Desert Skink are:

- Impacts from habitat clearing
- Impacts from habitat fragmentation
- Impacts associated with management of industrial waste material
- Indirect impacts associated with inadequate management of domestic waste material
- Impacts of unplanned wildfire
- Impacts associated with vehicle movements (e.g. collisions/roadkill)
- Impacts associated with invasion by exotic plants and animals, particularly predators
- Impacts associated with inappropriate or ineffective rehabilitation.

Table 9 EPBC risk assessment for impacts on Great Desert Skink (Vulnerable)

Source of Impact	Likelihood	Consequence	Severity	Comments	Minimising, mitigation and management actions	Residual Risk	Reference (GHD 2015)
Clearing of habitat	4	3	Medium	Construction of the project will result in the loss of approximately 978.8 ha of potential breeding, foraging and dispersal habitat for the Great Desert Skink, equating to 97.1% of the vegetation proposed to be cleared as a result of the project. This comprises the loss of 558.58 ha of Spinifex grassland (55.4% of cleared area) and 420.25 ha of Mulga woodland (41.7% of cleared area). Most of this loss is associated with construction of the haul road. Without mitigation, removal of habitat is likely to impact on the Great Desert Skinks that occur in the Project area. Impacts have the potential to be moderate. Management and mitigation will be essential, and can reduce the likelihood to possible and the severity to minor.	– Minimise impact via actions in Section 8.1 of GHD (2015); – Implement clearing during autumn when breeding has ended. Avoid clearing during the winter/spring months when some animals (particularly reptiles) are inactive in burrows or breeding; – Have a qualified ecologist on-site during the clearing to capture and translocate animals encountered during the clearing process; – Produce and apply a dedicated BMP and ensure appropriate construction management results in minimizing clearing effects on the threatened species populations of the area.	Low	Sections 7.2.1 and 8.1

Habitat fragmentation	4	3	Medium	Construction of the project will result in the loss of approximately 978.8 ha of potential habitat for the Great Desert Skink. Much of the habitat loss is associated with construction of the haul road, which will fragment the habitat for small ground-dwelling fauna, and increase the risk of injury or death of fauna that cross the haul road at inopportune times. Without mitigation, impacts on fauna are likely, and have the potential to be moderate. Management and mitigation will be essential, and can reduce the likelihood to possible and the severity to minor.	– Further minimise impact via actions in Section 8.1 of GHD (2015); – Produce and apply a dedicated BMP and ensure appropriate construction, weed hygiene, fire, dust and rehabilitation management result in minimizing fragmentation effects and edge effects (ie unintentional widening of corridors through weed invasion or subsequent death of retained vegetation along edges); – Implement strict vehicle hygiene protocols to prevent new weed incursion and spread, including a vehicle wash down facility on site; – Limit vehicle speeds and restrict vehicle movements to daylight hours only, to allow fauna (particularly nocturnal species) to cross corridors of cleared habitat more safely, thereby reducing the impact of habitat fragmentation.	Low	Sections 7.2.2 and 8.1
Altered hydrology	1	1	Very Low	Altered hydrology as a result of the Project is not expected to impact on sandplain ground-dwelling fauna. Hydrology impacts on these species would be rare, and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.3 and 8.2
Water quality impacts	1	1	Very Low	Deleterious changes in water quality as a result of the Project are unlikely to impact on sandplain ground-dwelling fauna. Water quality impacts on these species would be rare, and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.4 and 8.2
Erosion and sedimentation	1	1	Very Low	Erosion and sedimentation as a result of the Project are not expected to impact on sandplain ground-dwelling fauna. Erosion and sedimentation impacts on these species would be rare, and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.5 and 8.2
Soil compaction	1	1	Very Low	Soil compaction as a result of the Project is not expected to impact on sandplain ground-dwelling fauna. Soil compaction impacts on these species would be rare, and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.3 of GHD (2015).	Very Low	Sections 7.2.6 and 8.3
Lowering or contamination of water table	1	1	Very Low	Lowering or contamination of the water table as a result of the Project is not expected to impact on sandplain ground-dwelling fauna. Water table impacts on these species would be rare, and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.7 and 8.2

Impacts on surface or groundwater systems	1	1	Very Low	Changes to surface or groundwater systems as a result of the Project are not expected to impact on sandplain ground-dwelling fauna. Impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.8 and 8.2
Waste material - industrial	3	3	Medium	Industrial waste material on its own is not expected to result in direct impacts on sandplain fauna. However, the need to dump and transport waste materials has the potential to contribute to other impacts, namely: – Injury and death of fauna as a result of increase in waste-carrying transport and resulting collisions with wildlife; – Clearing of breeding and/or foraging habitat to create space to store/pile waste products; – Dust as a result of increased traffic and specifically due to haulage of waste rock; and – Spread and invasion of weeds. All of these could indirectly impact on sandplain fauna, and collectively, moderate impacts are possible without mitigation. These impacts are addressed in turn in other sections of this risk assessment. Mitigation and management can reduce the risks to be possible and minor, or lower.	– Minimise potential for impact resulting from injury and death of fauna from vehicle collisions via actions in Section 8.10 of GHD (2015); – Minimise potential for impact resulting from clearing of habitat via actions in Section 8.1 of GHD (2015); – Minimise potential for impact resulting from dust via actions in Section 8.7 of GHD (2015); – Minimise potential for impact resulting from weed invasion via actions in Section 8.11 of GHD (2015); – Further minimise potential for impact via actions in Section 8.4 of GHD (2015).	Low	Sections 7.2.9, 8.1, 8.4, 8.7, 8.10, 8.11.
Waste material – domestic	3	5	High	Domestic waste products (in the form of garbage/refuse) themselves will not impact on sandplain fauna, but there is a risk of indirect impact from the garbage attracting vermin (rats and mice) and the vermin attracting their predators (cats, foxes and dingoes). Larger numbers of predators would greatly increase the risk of predation on ground-dwelling sandplain fauna, including the Great Desert Skink, possibly to the point of localized extinction. Without mitigation, such impacts are possible and the severity could be catastrophic. Strict management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to moderate.	– Minimise impact via actions in Section 8.5 of GHD (2015); – Produce and apply dedicated BMP and ensure appropriate management of domestic waste to avoid unnatural increases in predator population sizes.	Low	Sections 7.2.10 and 8.5

Noise	3	1	Low	Most fauna can habituate to predictable noises with time. Therefore, some of the noise impacts may be short-term impacts. The GHD 2015 Noise and Vibration report indicates that at the proposed mine camp (5 km from mine site), the noise levels would be at predicted level of up to 34.3 dBA. Maximum internal noise levels of 50-55 dBA is recommended for human sleep. Suitable Great Desert Skink habitat would be >10 km from the mine camp, therefore background noise levels would be very low. Without mitigation, impacts from noise are possible but the severity would be minor. Management and mitigation can reduce the likelihood to unlikely.	- Minimise impact via actions in Section 8.6 of GHD (2015); - The implementation of noise controls as defined in a Noise Management Plan (possibly as part of the BMP) – likely to include the avoidance of loud noise at night when most sandplain fauna are active.	Low	Sections 7.2.11 and 8.6
Dust	2	1	Very Low	Sandplain fauna live in dusty habitats, and many of them, including the Great Desert Skink, dig burrows in dusty ground. Consequently, these species are likely to be adapted to coping with dusty conditions. Additional impacts on those species from dust as a result of this project are considered unlikely and are expected to be insignificant if they occur.	- Further minimise potential for impacts via actions in Section 8.7 of GHD (2015); - Produce and apply dedicated BMP and ensure appropriate dust controls are in place to minimize and mitigate dust effects on sandplain fauna populations of the area.	Very Low	Sections 7.2.12 and 8.7
Visual/Light	2	1	Very Low	Light emitted from the proposed mine could have a small and localized effect on nocturnal threatened sandplain fauna, including the Great Desert Skink. Impacts from lighting are unlikely and the severity is likely to be insignificant.	- Further minimise potential for impact via actions in Section 8.8 of GHD (2015); - Avoiding unnecessary lighting at night when sandplain fauna would be most affected and keeping lighting low and directed at operations rather than surrounding habitat will assist greatly in reducing the likelihood and severity of impacts; - Produce and apply dedicated BMP and ensure appropriate lighting controls are in place to minimize artificial light effects on the fauna populations of the area.	Very Low	Sections 7.2.13 and 8.8
Unplanned Wildfire	3	4	Medium	It is possible that extensive unplanned wildfire as a result of mine activities could have a major impact on populations of sandplain fauna, particularly those that are less mobile or that are territorial or tend to remain within discrete areas (rather than being nomadic across a larger area) (e.g., Great Desert Skink). This species is likely to rely on the habitats within a relatively small area, and would be more vulnerable if their habitat is burnt out. Mitigation can be used to reduce the likelihood (to unlikely) but a major impact could still result.	- Minimise likelihood of impact via actions in Section 8.9 of GHD (2015); - Produce and apply dedicated BMP and ensure appropriate wildfire controls are in place to minimize and mitigate the potential for impacts on sandplain fauna, including the Great Desert Skink; - A separate Bushfire Management Plan will be required to manage this risk.	Medium	Sections 7.2.14 and 8.9

Impacts from vehicles/transport	4	3	Medium	Without mitigation, impacts on sandplain fauna from collisions with vehicles due to increased traffic (particularly along the haul road) are likely , and could have a moderate impact on species such as the Great Desert Skink. Vehicle movements during dawn, dusk and nighttime would result in the highest risk to fauna. Management and mitigation efforts can be implemented to reduce the risk to unlikely and minor .	- Minimise likelihood and severity of impact via actions in Section 8.10 of GHD (2015); - Produce and apply a Traffic and Road Safety Management Plan, to be incorporated into a BMP. - Restrict vehicle movements (particularly along the haul road) to be during daylight hours only – this would greatly reduce the chance of vehicle strike with species such as Great Desert Skink, which are predominantly nocturnal; - Limit vehicle speeds, particularly during dawn, dusk and nighttime (if vehicle movements required during those times). - Produce and apply a Weed Hygiene Procedure and provision of on-site wash down facilities, to minimize the risk of weed invasion which could indirectly impact on sandplain fauna.	Low	Sections 7.2.15 and 8.10
Exotic plants and animals	4	4	High	Without adequate management and mitigation, the introduction of exotic plants and animals as a result of mine activities is likely to result in impacts on sandplain fauna, and those impacts have the potential to be major . Changes to habitats as a result of weed invasion are of concern, but the primary concern is any action that results in an increase in numbers of cats, foxes and dingos, which would then be likely to prey more heavily on sandplain fauna, including Great Desert Skink. Strict management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to moderate .	- Minimise likelihood and severity of impact via actions in Section 8.11 of GHD (2015); - Produce and apply a dedicated BMP and ensure appropriate controls are in place to minimize and mitigate the potential 'High' impacts of exotic plants and animals on sandplain fauna populations of the area; - Construct a predator-proof compound to contain food waste; - As part of BMP incorporate a monitoring program for weeds and pest animals.	Low	Sections 7.2.16 and 8.11
Poisoning of fauna from drinking contaminated water	1	1	Very Low	Poisoning of sandplain fauna as a result of the Project is not expected to occur. Such an impact on these species would be rare , and have a minor impact if it occurred.	- Further minimise potential for impact via actions in Section 8.12 of GHD (2015); - Produce and apply a Water Quality Monitoring and Management Plan. A Tailings Dam Wildlife Monitoring Program would be incorporated into a BMP and would be more broadly directed at fauna in general rather than just specifically threatened species.	Very low	Sections 7.2.17 and 8.12

Inappropriate/ineffective rehabilitation	4	4	High	The biggest potential impact as a result of inappropriate or ineffective rehabilitation is likely to be the spread of weeds. Weed-dominated habitats are generally less favourable for fauna than weed-free habitats, and may introduce additional risks (e.g., more intense fires, less suitable foraging habitat). Unless rehabilitation is appropriate and effective, impacts are likely to occur and have the potential to be major. Management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to minor.	– Minimise impact via actions in Section 8.13 of GHD (2015); – Produce and apply a dedicated BMP and ensure appropriate construction, weed hygiene and rehabilitation management aspects minimize and mitigate impacts on sandplain fauna populations of the area.	Low	Sections 7.2.18 and 8.13
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Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk of impacts on the Great Desert Skink is unlikely to be significant according to EPBC Act significant impact guidelines.

6.7.3 Black-footed Rock-wallaby (Vulnerable)

The Black-footed Rock-wallaby is known to occur near the mine site, and has the potential to use all suitable rocky habitat in the region, and disperse across other habitats occasionally. Given the biology of the species and the fact that it comprises a set of discrete sub-populations that rely on occasional genetic mixing, all populations contribute to the persistence of the species, and all populations should be considered to be important populations.

Habitat that provides foraging resources and shelter from predators and exposure would be considered critical habitat. For this project, that includes all rocky habitats within and surrounding the Project area. Other habitats are likely to be used for dispersal and occasional foraging by this species, but are not likely to be considered critical habitat.

Potential impacts that pose the highest risk to the Black-footed Rock-wallaby are:

- Indirect impacts associated with inadequate management of domestic waste material
- Impacts of unplanned wildfire
- Impacts associated with invasion by exotic plants and animals, particularly predators
- Impacts associated with inappropriate or ineffective rehabilitation.

Table 10 EPBC risk assessment for impacts on Black-footed Rock-wallaby (MacDonnell Ranges Race) (vulnerable)

Source of Impact	Likelihood	Consequence	Severity	Comments	Minimising, mitigation and management actions	Residual Risk	Reference (GHD 2015)
Clearing of habitat	2	1	Low	A loss of 8.35 ha of potentially suitable (low quality) rocky habitat, and additional loss of habitats that may be used rarely by dispersing individuals to access other rocky areas. The loss of rocky habitat equates to 0.83% of the vegetation proposed to be cleared as a result of the project. Removal of habitat is considered to be unlikely to result in impacts on the local population of Black-footed Rock-wallaby, and to have a minor impact if it does.	- Minimise impact via actions in Section 8.1 of GHD (2015); - Produce and apply dedicated Biodiversity Management Plan (BMP) and ensure appropriate construction, weed, weed hygiene, fire and rehabilitation management aspects are covered in an attempt to minimise and mitigate clearing effects on the Black-footed Rock-wallaby population of the area.	Very Low	Sections 7.2.1 and 8.1
Habitat fragmentation	2	1	Low	The project is not expected to result in further isolation of any population of Black-footed Rock-wallaby. Habitat fragmentation is considered unlikely to occur, and to have a minor impact on the Black-footed Rock-wallaby if it does.	Further minimise potential for impact via actions in Section 8.1 of GHD (2015).	Very Low	Sections 7.2.2 and 8.1
Altered hydrology	1	1	Very Low	Altered hydrology as a result of the Project is not expected to impact on any population of Black-footed Rock-wallaby in its core habitat (rocky rises). Altered hydrology may impact on non-rocky habitats that are used occasionally for dispersal or foraging. Hydrology impacts on this species would be rare , and have a insignificant impact if they occurred.	Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.3 and 8.2
Water quality impacts	3	2	Low	Deleterious changes in water quality as a result of the Project could impact on the Black-footed Rock-wallaby when it comes to affected watercourses or waterbodies to drink. Without mitigation, impacts of this nature on this species are possible , and would have a minor impact if they occurred.	- Minimise impact via actions in Section 8.2 of GHD (2015); - Produce and apply dedicated BMP and ensure appropriate management of water and run-off is implemented to avoid contamination or deleterious changes in water quality.	Very Low	Sections 7.2.4 and 8.2

Erosion and sedimentation	1	1	Very Low	Erosion and sedimentation as a result of the Project are not expected to impact on any population of Black-footed Rock-wallaby. Impacts on this species would be rare , and have a insignificant impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.5 and 8.2
Soil compaction	1	1	Very Low	Soil compaction is not expected to impact on any population of Black-footed Rock-wallaby. Impacts on this species would be rare , and have a insignificant impact if they occurred.	– Further minimise potential for impact via actions in Section 8.3 of GHD (2015).	Very Low	Sections 7.2.6 and 8.3
Lowering or contamination of water table	1	1	Very Low	Because the Black-footed Rock-wallaby occupies rocky hills and slopes, it does not rely on groundwater dependent ecosystems or habitats. Therefore, lowering or contamination of the water table would have insignificant impacts on the Black-footed Rock-wallaby population, and it would be a rare event.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.7 and 8.2
Impacts on surface or groundwater systems	3	2	Low	Impacts on surface or groundwater systems as a result of the Project could impact on the Black-footed Rock-wallaby if individuals come to contaminated watercourses or waterbodies to drink. Without mitigation, impacts of this nature on this species are possible , and would have a moderate impact if they occurred.	– Minimise impact via actions in Section 8.2 of GHD (2015); – Produce and apply dedicated BMP and ensure appropriate management of water and run-off is implemented to avoid impacts on surface or groundwater systems.	Very Low	Sections 7.2.8 and 8.2
Waste material - industrial	1	1	Very Low	Because the Black-footed Rock-wallaby occupies rocky hills and slopes, it is unlikely to encounter waste materials that result from the project. Therefore, impacts of this nature on this species would be rare , and would have a insignificant impact if they occurred.	– Further minimise potential for impact via actions in Section 8.4 of GHD (2015).	Very Low	Sections 7.2.9 and 8.4
Waste material – domestic	3	4	Medium	Domestic waste products (in the form of garbage/refuse) themselves will not impact on the Black-footed Rock-wallaby, but there is a risk of indirect impact from the garbage attracting vermin (rats and mice) and their predators (cats, foxes and dingoes), which might then prey more heavily on Rock-wallabies. Without mitigation, such impacts are possible and the severity could be major . Management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to minor .	– Minimise impact via actions in Section 8.5 of GHD (2015); – Produce and apply a dedicated BMP and ensure appropriate management of domestic waste to avoid unnatural increases in predator population sizes.	Low	Sections 7.2.10 and 8.5

Noise	3	1	Low	Noise generated by the mine is likely to preclude rock-wallaby movements through the Mine Site, however particularly noisy activities would likely occur during daylight hours when rock-wallabies (generally nocturnal) tend to be sheltering, and noise would be somewhat buffered and deflected by their rocky, elevated habitat. Fauna can habituate to predictable noises with time (this includes the Black-footed Rock-wallaby, which occurs in the rocky hills in central Alice Springs). Therefore, some of the noise impacts may be short-term. The GHD 2015 Noise and Vibration report indicates that at the proposed mine camp (5 km from mine site), the noise levels would be at predicted level of up to 34.3 dBA. Maximum internal noise levels of 50-55 dBA is recommended for human sleep. Suitable Black-footed Rock-wallaby habitat occurs as close as approximately 8 km from the mine camp, therefore background noise levels would be very low. Without mitigation, impacts from noise are possible but the severity would be insignificant. Management and mitigation can reduce the likelihood to unlikely. It should be noted that blasting results in noise levels of approx. 115 dB(A), which could potentially negatively impact on rock-wallaby behavior. It is recommended that blasting occur during the day only when rock-wallabies are inactive.	– Minimise impact via actions in Section 8.6 of GHD (2015); – The implementation of noise controls as defined in a Noise Management Plan – likely to include the avoidance of loud noise at night when rock-wallabies are active; – Produce and apply dedicated BMP and ensure appropriate noise controls are in place in an attempt to minimize and mitigate noise effects on the Black-footed Rock-wallaby population of the area.	Very Low	Sections 7.2.11 and 8.6
Dust	3	1	Low	There is habitat for the Black-footed Rock-wallaby within 2 km of the Mine Site, and this species may be exposed to higher levels of dust. Without mitigation, impacts from dust are possible but the severity is expected to be insignificant. Mitigation and management can reduce the likelihood to unlikely.	– Minimise impact via actions in Section 8.7 of GHD (2015); – Produce and apply dedicated BMP and ensure appropriate dust controls are in place in an attempt to minimize and mitigate dust effects on the Black-footed Rock-wallaby population of the area.	Very Low	Sections 7.2.12 and 8.7

Visual/Light	2	1	Very Low	Light emitted from the proposed mine could have a small effect on any transitory rock-wallabies moving through the mine site footprint. Light emitted from the proposed mine is unlikely to impact on rock-wallaby populations >2 km from the proposed mine site. Impacts from lighting are unlikely and the severity is likely to be insignificant .	- Further minimise potential for impact via actions in Section 8.8 of GHD (2015); - Avoiding unnecessary lighting at night when rock-wallabies are active and keeping lighting low and directed at operations rather than surrounding habitat will assist greatly in reducing the likelihood of impacts; - Produce and apply dedicated BMP and ensure appropriate lighting controls are in place in an attempt to minimize and mitigate artificial light effects on the Black-footed Rock-wallaby population of the area.	Very Low	Sections 7.2.13 and 8.8
Unplanned Wildfire	3	4	Medium	Wildfire within Black-footed Rock-wallaby habitat can have a major impact as it burns food plants rendering habitats unsuitable for periods of time. Continued persistence of the Black-footed Rock-wallaby in the area will depend on prevention of wildfire in the rocky habitats of the study area and surrounds. It is possible that extensive unplanned wildfire as a result of mine activities could have a major impact. Mitigation can be used to reduce the likelihood (to unlikely) but a major impact could still result.	- Minimise likelihood of impact via actions in Section 8.9 of GHD (2015); - Produce and apply dedicated BMP and ensure appropriate wildfire controls are in place in an attempt to minimize and mitigate the potential impacts on the Black-footed Rock-wallaby population of the area; - A Bushfire Management Plan will be required to manage the risk.	Medium	Sections 7.2.14 and 8.9
Impacts from vehicles/transport	1	1	Very Low	Because the Black-footed Rock-wallaby occupies rocky hills and slopes, and occasionally disperses across lower ground to reach other rocky slopes, it would be rarely encountered on roads or tracks. Therefore, mortality from collisions with vehicles would be rare and would have a insignificant impact on the local Black-footed Rock-wallaby population.	- Further minimise potential for impact via actions in Section 8.10 of GHD (2015); - Produce and apply a Traffic and Road Safety Management Plan, to be incorporated into a BMP.	Very Low	Sections 7.2.15 and 8.10
Exotic plants and animals	4	4	High	Without efforts to minimize its likelihood, the introduction of exotic plants and animals as a result of mine activities is likely to occur and could have a major impact on the survival of the Black-footed Rock-wallaby population. An increase in the incidence of cats, foxes and dingos (e.g., through inadequate management of garbage) could result in increased rock-wallaby predation, particularly of more vulnerable juveniles. An increase in the incidence of weeds, particularly Buffel Grass, could have major implications for rock-wallaby habitat. Management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to moderate .	- Minimise impact via actions in Section 8.11 of GHD (2015) - Produce and apply a dedicated BMP and ensure appropriate controls are in place to minimise and mitigate the potential 'High' impacts of exotic plants and animals on the Black-footed Rock-wallaby population of the area; - Construct a predator-proof compound to contain food waste; - As part of BMP incorporate a monitoring program for weeds and pest animals.	Low	Sections 7.2.16 and 8.11

Poisoning of fauna from drinking contaminated water	1	2	Very Low	There is a low likelihood that rock-wallabies would descend from their rocky habitats to drink from tailings facilities. Impacts of this nature on this species are likely to be rare , and would have a minor impact on a population if they occurred.	– Further minimise potential for impact via actions in Section 8.12 of GHD (2015); – Produce and apply a Water Quality Monitoring and Management Plan. A Tailings Dam Wildlife Monitoring Program would be incorporated into a BMP and would be more broadly directed at fauna in general rather than rock-wallabies.	Very low	Sections 7.2.17 and 8.12
Inappropriate/ineffective rehabilitation	4	4	High	The biggest potential impact as a result of inappropriate or ineffective rehabilitation is likely to be the spread of weeds. Weed dominated habitats are generally less favourable for fauna than weed-free habitats, and may introduce additional risks (e.g., more intense fires, less suitable foraging habitat). Weeds are likely to invade unless mitigation efforts are undertaken, and could have a major impact. Management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to minor .	– Minimise impact via actions in Section 8.13 of GHD (2015); – Produce and apply dedicated BMP and ensure appropriate construction, weed, weed hygiene, fire and rehabilitation management aspects are covered to minimize and mitigate clearing effects on the Black-footed Rock-wallaby population of the area.	Low	Sections 7.2.18 and 8.13

Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk of impacts on Black-footed Rock-wallaby is unlikely to be significant according to EPBC Act significant impact guidelines.

6.7.4 Brush-tailed Mulgara (Vulnerable)

The Brush-tailed Mulgara occurs within the Project area. The local population is likely to be considered an important population because it is necessary for maintaining genetic diversity.

Most of the Project area would be considered to support habitat critical to the survival of this species, because it would support activities such as foraging, breeding and dispersal and is necessary to maintain genetic diversity and long-term evolutionary development of the species.

Potential impacts that pose the highest risk to the Brush-tailed Mulgara are:

- Impacts from habitat clearing
- Impacts from habitat fragmentation
- Impacts associated with management of industrial waste material
- Indirect impacts associated with inadequate management of domestic waste material
- Impacts of unplanned wildfire
- Impacts associated with vehicle movements (e.g. collisions)
- Impacts associated with invasion by exotic plants and animals, particularly predators
- Impacts associated with inappropriate or ineffective rehabilitation.

The Brush-tailed Mulgara is no longer listed as threatened under the EPBC Act, but remains listed as Vulnerable under the TPWC Act and is likely to occur within the Study Area. For consistency in the risk assessment, the EPBC criteria for a Vulnerable species are applied to this species also.

Table 11 Risk assessment for impacts on Brush-tailed Mulgara (NT Vulnerable)

Source of Impact	Likelihood	Consequence	Severity	Comments	Minimising, mitigation and management actions	Residual Risk	Reference (GHD 2015)
Clearing of habitat	4	3	Medium	Construction of the project will result in the loss of approximately 978.8 ha of potential breeding, foraging and dispersal habitat for the Brush-tailed Mulgara, equating to 97.1% of the vegetation proposed to be cleared as a result of the project. This comprises the loss of 558.58 ha of Spinifex grassland (55.4% of cleared area) and 420.25 ha of Mulga woodland (41.7% of cleared area). Most of this loss is associated with construction of the haul road. Without mitigation, removal of habitat is likely to impact on the Brush-tailed Mulgara that occur in the Project area. Impacts have the potential to be moderate. Management and mitigation will be essential, and can reduce the likelihood to possible and the severity to minor.	– Minimise impact via actions in Section 8.1 of GHD (2015); – Avoid clearing during the winter/spring months when some animals are inactive in burrows or breeding; – Have a qualified ecologist on-site during the clearing to capture and translocate animals encountered during the clearing process; – Produce and apply a dedicated BMP and ensure appropriate construction management results in minimizing clearing effects on the threatened species populations of the area.	Low	Sections 7.2.1 and 8.1

Habitat fragmentation	4	3	Medium	Construction of the project will result in the loss of approximately 978.8 ha of potential habitat for the Brush-tailed Mulgara. Much of the habitat loss is associated with construction of the haul road, which will fragment the habitat for small ground-dwelling fauna, and increase the risk of injury or death of fauna that cross the haul road at inopportune times. Without mitigation, impacts on fauna are likely , and have the potential to be moderate . Management and mitigation will be essential, and can reduce the likelihood to possible and the severity to minor .	– Further minimise impact via actions in Section 8.1 of GHD (2015); – Produce and apply a dedicated BMP and ensure appropriate construction, weed hygiene, fire, dust and rehabilitation management result in minimizing fragmentation effects and edge effects (ie unintentional widening of corridors through weed invasion or subsequent death of retained vegetation along edges); – Implement strict vehicle hygiene protocols to prevent new weed incursion and spread, including a vehicle wash down facility on site; – Limit vehicle speeds and restrict vehicle movements to daylight hours only, to allow fauna (particularly nocturnal species, such as Brush-tailed Mulgara) to cross corridors of cleared habitat more safely, thereby reducing the impact of habitat fragmentation.	Low	Sections 7.2.2 and 8.1
Altered hydrology	1	1	Very Low	Altered hydrology as a result of the Project is not expected to impact on sandplain ground-dwelling fauna. Hydrology impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.3 and 8.2
Water quality impacts	1	1	Very Low	Deleterious changes in water quality as a result of the Project are unlikely to impact on sandplain ground-dwelling fauna. Water quality impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.4 and 8.2
Erosion and sedimentation	1	1	Very Low	Erosion and sedimentation as a result of the Project are not expected to impact on sandplain ground-dwelling fauna. Erosion and sedimentation impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.5 and 8.2
Soil compaction	1	1	Very Low	Soil compaction as a result of the Project is not expected to impact on sandplain ground-dwelling fauna. Soil compaction impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.3 of GHD (2015).	Very Low	Sections 7.2.6 and 8.3
Lowering or contamination of water table	1	1	Very Low	Lowering or contamination of the water table as a result of the Project is not expected to impact on sandplain ground-dwelling fauna. Water table impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.7 and 8.2

Impacts on surface or groundwater systems	1	1	Very Low	Changes to surface or groundwater systems as a result of the Project are not expected to impact on sandplain ground-dwelling fauna. Impacts on these species would be rare , and have a minor impact if they occurred.	– Further minimise potential for impact via actions in Section 8.2 of GHD (2015).	Very Low	Sections 7.2.8 and 8.2
Waste material - industrial	3	4	Medium	Industrial waste material on its own is not expected to result in direct impacts on sandplain fauna. However, the need to dump and transport waste materials has the potential to contribute to other impacts, namely: – Injury and death of fauna as a result of increase in waste-carrying transport and resulting collisions with wildlife; – Clearing of breeding and/or foraging habitat to create space to store/pile waste products; – Dust as a result of increased traffic and specifically due to haulage of waste rock; and – Spread and invasion of weeds. All of these could indirectly impact on sandplain fauna, and collectively, major impacts are possible without mitigation. These impacts are addressed in turn in other sections of this risk assessment. Mitigation and management can reduce the risks to be possible and minor, or lower.	– Minimise potential for impact resulting from injury and death of fauna from vehicle collisions via actions in Section 8.10 of GHD (2015); – Minimise potential for impact resulting from clearing of habitat via actions in Section 8.1 of GHD (2015); – Minimise potential for impact resulting from dust via actions in Section 8.7 of GHD (2015); – Minimise potential for impact resulting from weed invasion via actions in Section 8.11 of GHD (2015); – Further minimise potential for impact via actions in Section 8.4 of GHD (2015).	Low	Sections 7.2.9, 8.1, 8.4, 8.7, 8.10, 8.11
Waste material – domestic	3	5	High	Domestic waste products (in the form of garbage/refuse) themselves will not impact on sandplain fauna, but there is a risk of indirect impact from the garbage attracting vermin (rats and mice) and the vermin attracting their predators (cats, foxes and dingoes). Larger numbers of predators would greatly increase the risk of predation on ground-dwelling sandplain fauna, possibly to the point of localized extinction. Without mitigation, such impacts are possible and the severity could be catastrophic. Strict management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to moderate.	– Minimise impact via actions in Section 8.5 of GHD (2015); – Produce and apply dedicated BMP and ensure appropriate management of domestic waste to avoid unnatural increases in predator population sizes.	Low	Sections 7.2.10 and 8.5

Noise	3	2	Low	Noise generated by the mine is likely to preclude movements of Brush-tailed Mulgara through the Mine Site, however particularly noisy activities would likely occur during daylight hours when most of the fauna (mostly nocturnal) tend to be sheltering. Most fauna can habituate to predictable noises with time. Therefore, some of the noise impacts may be short-term. The GHD 2015 Noise and Vibration report indicates that at the proposed mine camp (5 km from mine site), the noise levels would be at predicted level of up to 34.3 dBA. Maximum internal noise levels of 50-55 dBA is recommended for human sleep. Suitable Brush-tailed Mulgara habitat would be >10 km from the mine camp, therefore background noise levels would be very low. Without mitigation, impacts from noise are possible but the severity would be minor. Management and mitigation can reduce the likelihood to unlikely.	- Minimise impact via actions in Section 8.6 of GHD (2015); - The implementation of noise controls as defined in a Noise Management Plan (possibly as part of the BMP) – likely to include the avoidance of loud noise at night when most sandplain fauna are active.	Very Low	Sections 7.2.11 and 8.6
Dust	2	2	Low	Sandplain fauna live in dusty habitats, and many of them, including Brush-tailed Mulgara, dig burrows in dusty ground. Consequently, this species is likely to be adapted to coping with dusty conditions. Additional impacts on those species from dust as a result of this project are considered unlikely and are expected to be minor if they occur.	- Further minimise potential for impacts via actions in Section 8.7 of GHD (2015); - Produce and apply dedicated BMP and ensure appropriate dust controls are in place to minimize and mitigate dust effects on sandplain fauna populations of the area.	Very Low	Sections 7.2.12 and 8.7
Visual/Light	2	1	Very Low	Light emitted from the proposed mine could have a small and localized effect on nocturnal threatened sandplain fauna (e.g. Crest-tailed Mulgara). Impacts from lighting are unlikely and the severity is likely to be minor.	- Further minimise potential for impact via actions in Section 8.8 of GHD (2015); - Avoiding unnecessary lighting at night when sandplain fauna would be most affected and keeping lighting low and directed at operations rather than surrounding habitat will assist greatly in reducing the likelihood and severity of impacts; - Produce and apply dedicated BMP and ensure appropriate lighting controls are in place to minimize artificial light effects on the fauna populations of the area.	Very Low	Sections 7.2.13 and 8.8

Unplanned Wildfire	3	4	Medium	It is possible that extensive unplanned wildfire as a result of mine activities could have a major impact on populations of sandplain fauna, particularly those that are less mobile or that are territorial or tend to remain within discrete areas (rather than being nomadic across a larger area), such as Brush-tailed Mulgara. These species are likely to rely on the habitats within a relatively small area, and would be more vulnerable if their habitat is burnt out. Mitigation can be used to reduce the likelihood (to unlikely) but a major impact could still result.	- Minimise likelihood of impact via actions in Section 8.9 of GHD (2015); - Produce and apply dedicated BMP and ensure appropriate wildfire controls are in place to minimize and mitigate the potential for impacts on sandplain fauna, including the Great Desert Skink and Brush-tailed Mulgara; - A separate Bushfire Management Plan will be required to manage this risk.	Medium	Sections 7.2.14 and 8.9
Impacts from vehicles/transport	4	3	Medium	Without mitigation, impacts on sandplain fauna, including Brush-tailed Mulgara, from collisions with vehicles due to increased traffic (particularly along the haul road) are likely , and could be moderate . Vehicle movements during dawn, dusk and nighttime would result in the highest risk to fauna. Management and mitigation efforts can be implemented to reduce the risk to unlikely and minor .	- Minimise likelihood and severity of impact via actions in Section 8.10 of GHD (2015); - Produce and apply a Traffic and Road Safety Management Plan, to be incorporated into a BMP. - Restrict vehicle movements (particularly along the haul road) to be during daylight hours only – this would greatly reduce the chance of vehicle strike with Brush-tailed Mulgara, which is predominantly nocturnal; - Limit vehicle speeds, particularly during dawn, dusk and nighttime (if vehicle movements required during those times). - Produce and apply a Weed Hygiene Procedure and provision of on-site wash down facilities, to minimize the risk of weed invasion which could indirectly impact on sandplain fauna.	Low	Sections 7.2.15 and 8.10
Exotic plants and animals	4	4	High	Without adequate management and mitigation, the introduction of exotic plants and animals as a result of mine activities is likely to result in impacts on sandplain fauna, and those impacts have the potential to be major . Changes to habitats as a result of weed invasion are of concern, but the primary concern is any action that results in an increase in numbers of cats, foxes and dingos, which would then be likely to prey more heavily on sandplain fauna, including Brush-tailed Mulgara. Strict management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to moderate .	- Minimise likelihood and severity of impact via actions in Section 8.11 of GHD (2015); - Produce and apply a dedicated BMP and ensure appropriate controls are in place to minimize and mitigate the potential 'High' impacts of exotic plants and animals on sandplain fauna populations of the area; - Construct a predator-proof compound to contain food waste; - As part of BMP incorporate a monitoring program for weeds and pest animals.	Low	Sections 7.2.16 and 8.11

Poisoning of fauna from drinking contaminated water	1	1	Very Low	Poisoning of sandplain fauna as a result of the Project is not expected to occur. Such an impact on these species would be rare , and have a minor impact if it occurred.	– Further minimise potential for impact via actions in Section 8.12 of GHD (2015); – Produce and apply a Water Quality Monitoring and Management Plan. A Tailings Dam Wildlife Monitoring Program would be incorporated into a BMP and would be more broadly directed at fauna in general rather than just specifically threatened species.	Very low	Sections 7.2.17 and 8.12
Inappropriate/ineffective rehabilitation	4	4	High	The biggest potential impact as a result of inappropriate or ineffective rehabilitation is likely to be the spread of weeds. Weed-dominated habitats are generally less favourable for fauna than weed-free habitats, and may introduce additional risks (e.g., more intense fires, less suitable foraging habitat). Unless rehabilitation is appropriate and effective, impacts are likely to occur and have the potential to be major . Mitigation efforts should reduce the likelihood of impacts to be unlikely, and reduce the scale of the impact to be localized such that it is minor. Management and mitigation will be essential, and can reduce the likelihood to unlikely and the severity to minor .	– Minimise impact via actions in Section 8.13 of GHD (2015); – Produce and apply a dedicated BMP and ensure appropriate construction, weed hygiene and rehabilitation management aspects minimize and mitigate impacts on sandplain fauna populations of the area.	Low	Sections 7.2.18 and 8.13

Application of appropriate management and mitigation efforts is expected to reduce the likelihood and severity of risk to acceptably low levels, such that the residual risk of impacts on Brush-tailed Mulgara is unlikely to be significant according to EPBC Act significant impact guidelines.

7. Conclusion

The Study Area has the potential to support a range of threatened fauna species, including three listed as *vulnerable* under the EPBC Act and another listed as *vulnerable* under the TPWC Act. These species are likely to occupy the full range of available fauna habitats within the Project area, but the sandplain spinifex habitat has the potential to support more threatened species than other habitats. The four threatened fauna species particularly relevant to the Project and that form the focus of this targeted survey report are as follows:

- Ground-dwelling sandplain fauna with limited mobility (Greater Bilby, *Macrotis lagotis*; Great Desert Skink, *Liopholis kintorei*; Brush-tailed Mulgara, *Dasycercus blythi*);
- Fauna in rocky habitat (Black-footed Rock-wallaby (MacDonnell Ranges race), *Petrogale lateralis*).

It is acknowledged that the Greater Bilby uses habitats other than sand plains as well.

The Project poses a range of potential impacts on some of these threatened fauna species. Before mitigation, a small number of impacts have the potential to be medium or high risk. The main sources of impact on fauna are expected to be from:

- Clearing of vegetation, particularly for the 100 km access road, which is expected to impact on ground-dwelling sandplain fauna, but less so on Black-footed Rock-wallaby;
- Unplanned wildfire, inadvertently started by mine construction or operation, which could impact greatly on all threatened species;
- Collisions between fauna and traffic during construction and operation, particularly in spinifex sandplain habitat and particularly at night;
- Introduction and/or spread of weeds (particularly through inadequate site reinstatement), which could impact on all threatened species; and
- Increase in population size of native and non-native predators (particularly through inadequate management of garbage/waste, which could attract vermin, and subsequently their predators such as cats and foxes). This could impact greatly on all threatened species.

The extent and severity of impact that this Project has on fauna depends entirely on the level of management and mitigation effort given. There is potential for all impacts and risks to be reduced to an acceptable level (i.e. not significant) through the use of effective and appropriate management and mitigation. Inadequate management and mitigation has the potential to lead to irreversible long-term impacts on some threatened fauna species. Monitoring will be required to measure the effectiveness of mitigation and to identify where changes in effort may be required.

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Appendices

Appendix A - Results of the EPBC protected matters search tool



EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about [Environment Assessments](#) and the EPBC Act including significance guidelines, forms and application process details.

Report created: 14/02/14 13:08:37

[Summary](#)

[Details](#)

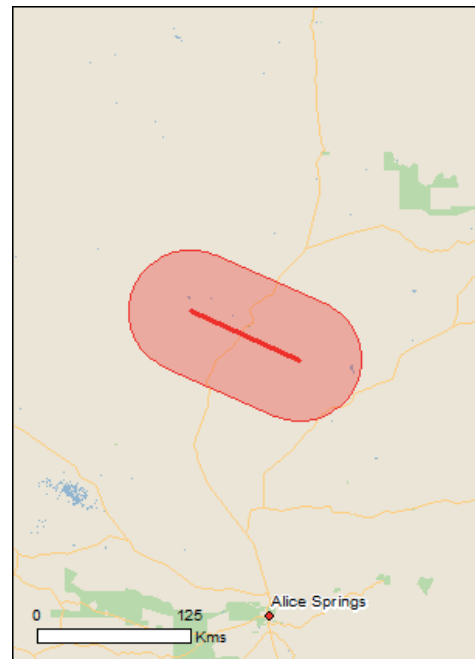
[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

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Buffer: 50.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	8
Listed Migratory Species:	7

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As [heritage values](#) of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A [permit](#) may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	7
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	1
State and Territory Reserves:	2
Regional Forest Agreements:	None
Invasive Species:	12
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Erythrorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat may occur within area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Notoryctes typhlops Itjaritjari, Southern Marsupial Mole, Yitjarritjarri [296]	Endangered	Species or species habitat likely to occur within area
Petrogale lateralis MacDonnell Ranges race Waru, Black-footed Rock-wallaby (MacDonnell Ranges race) [66649]	Vulnerable	Species or species habitat known to occur within area
Plants		
Eleocharis papillosa Dwarf Desert Spike-rush [2519]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Liopholis kintorei Great Desert Skink, Tjakura, Warrarna, Mulyamiji [83160]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within

Name	Threatened	Type of Presence area
------	------------	-----------------------

Extra Information

Places on the RNE	[Resource Information]
-------------------	--

Note that not all Indigenous sites may be listed.

Name	State	Status
Historic		
Barrow Creek Telegraph Station - OTL Site	NT	Registered

State and Territory Reserves	[Resource Information]
------------------------------	--

Name	State
Barrow Creek Telegraph Station	NT
Central Mount Stuart	NT

Invasive Species	[Resource Information]
------------------	--

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resources Audit, 2001.

Name	Status	Type of Presence
Birds		

Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area

Mammals

Bos taurus		
Domestic Cattle [16]		Species or species habitat likely to occur within area

Camelus dromedarius		
Dromedary, Camel [7]		Species or species habitat likely to occur within area

Canis lupus familiaris		
Domestic Dog [82654]		Species or species habitat likely to occur within area

Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area

Mus musculus		
House Mouse [120]		Species or species habitat likely to occur within area

Vulpes vulpes		
Red Fox, Fox [18]		Species or species habitat likely to occur within area

Plants

Name	Status	Type of Presence
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Coordinates

-21.642048 133.296748,-21.968456 134.09875,-21.968456 134.09875

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- [Department of Environment, Climate Change and Water, New South Wales](#)
- [Department of Sustainability and Environment, Victoria](#)
- [Department of Primary Industries, Parks, Water and Environment, Tasmania](#)
- [Department of Environment and Natural Resources, South Australia](#)
- [Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts](#)
- [Environmental and Resource Management, Queensland](#)
- [Department of Environment and Conservation, Western Australia](#)
- [Department of the Environment, Climate Change, Energy and Water](#)
- [Birds Australia](#)
- [Australian Bird and Bat Banding Scheme](#)
- [Australian National Wildlife Collection](#)
- Natural history museums of Australia
- [Museum Victoria](#)
- [Australian Museum](#)
- [SA Museum](#)
- [Queensland Museum](#)
- [Online Zoological Collections of Australian Museums](#)
- [Queensland Herbarium](#)
- [National Herbarium of NSW](#)
- [Royal Botanic Gardens and National Herbarium of Victoria](#)
- [Tasmanian Herbarium](#)
- [State Herbarium of South Australia](#)
- [Northern Territory Herbarium](#)
- [Western Australian Herbarium](#)
- [Australian National Herbarium, Atherton and Canberra](#)
- [University of New England](#)
- [Ocean Biogeographic Information System](#)
- [Australian Government, Department of Defence](#)
- [State Forests of NSW](#)
- [Geoscience Australia](#)
- [CSIRO](#)
- Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the [Contact Us](#) page.

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[Department of the Environment](#)
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Appendix B - List of threatened fauna species for the Project Area recorded during the current and previous surveys, and from database searches

GHD 2013 = Detected during baseline fauna survey by GHD, April 2013.

GHD 2016 = Detected during targeted threatened species survey by GHD, November 2016.

DLRM = recorded on the DLRM Database.

PMST = Identified by the Protected Matters Search Tool.

EPBC = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

TRWC = Northern Territory *Territory Parks and Wildlife Conservation Act 2006*.

VU = Vulnerable; EN = Endangered; CR = Critically Endangered;

EX = Extinct; LC = Least concern; RX = Regionally extinct;

NT = Near threatened; EW = Extinct in the wild; DD = Data deficient;

Mi = Migratory; Ma = Marine; Invasive = non-native.

* = observed outside the Study Area

** = Recently de-listed from the EPBC threatened species list.

Common Name	Scientific Name	GHD 2013	GHD 2016	DLRM	PMST	EPBC	TPWC
Mammals							
Brush-tailed Mulgara	<i>Dasyercus blythi</i>	1		X		**	VU
Crest-tailed Mulgara	<i>Dasyercus cristicauda</i>				X	VU	VU
Kowari	<i>Dasyuroides byrnei</i>			X		VU	RX
Western Quoll	<i>Dasyurus geoffroii</i>			X		VU	RX
Red-tailed Phascogale	<i>Phascogale calura</i>			X		EN	RX
Kultarr	<i>Antechinomys laniger</i>			X			NT
Pig-footed Bandicoot	<i>Chaeropus ecaudatus</i>			X		EX	EX
Golden Bandicoot	<i>Isoodon auratus</i>			X		VU	EN
Bilby	<i>Macrotis lagotis</i>	1?		X	X	VU	VU
Lesser Bilby	<i>Macrotis leucura</i>			X		EX	EX
Common Brushtail Possum (Southern N.T.)	<i>Trichosurus vulpecula vulpecula</i>			X			EN
Burrowing Bettong	<i>Bettongia lesueur</i>			X		EX	RX
Spectacled Hare-wallaby	<i>Lagorchestes conspicillatus</i>			X			NT
Mala	<i>Lagorchestes hirsutus</i>			X		EN	EW
Northern Nailtail Wallaby	<i>Onychogalea unguifera</i>			X			NT
Black-footed Rock-wallaby	<i>Petrogale lateralis</i>	*		X	X	VU	NT
Southern Marsupial Mole	<i>Notoryctes typhlops</i>			X	X	**	VU
Long-tailed Hopping-mouse	<i>Notomys longicaudatus</i>		1	X		EX	EX
Birds							
Emu	<i>Dromaius novaehollandiae</i>	1	1	X			NT
Malleefowl	<i>Leipoa ocellata</i>			X		VU	CR
Fork-tailed Swift	<i>Apus pacificus</i>		1		X	Mi / Ma	LC
Great Egret	<i>Ardea alba</i>				X	Mi / Ma	LC
Cattle Egret	<i>Ardea ibis</i>				X	Mi / Ma	LC
Red Goshawk	<i>Erythroriorchis radiatus</i>				X	VU	VU
Grey Falcon	<i>Falco hypoleucos</i>	1		X			VU
Australian Bustard	<i>Ardeotis australis</i>	8	1	X			NT
Bush Stone-curlew	<i>Burhinus grallarius</i>			X			NT
Oriental Plover	<i>Charadrius veredus</i>				X	Mi / Ma	LC
Australian Painted Snipe	<i>Rostratula australis</i>				X	EN / Mi / Ma	VU
Oriental Pratincole	<i>Glareola maldivarum</i>				X	Mi / Ma	LC
Princess Parrot	<i>Polytelis alexandrae</i>				X	VU	VU
Night Parrot	<i>Pezoporus occidentalis</i>			X		EN	CR
Rainbow Bee-eater	<i>Merops ornatus</i>	1		X	X	Mi / Ma	LC
Reptiles							
Great Desert Skink	<i>Liopholis kintorei</i>		1		X	VU	VU
Woma Python	<i>Aspidites ramsayi</i>	2		X			NT
Mulga Snake	<i>Pseudechis australis</i>	2		X			NT

GHD

57 Orange Avenue
Mildura, Victoria 3500

T: (03) 5018 5200 F: (03) 5018 5201 E: milduramail@ghd.com.au

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Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft A	D Eyles	R Retallick		Ian McCardle		22/01/17
Final	D Eyles	A Holmes		Ian McCardle		08/02/17

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Appendix D

Groundwater Supplementary Report





TNG Limited
Mount Peake Project
Groundwater Supplementary Report

March 2017

Limitations

This report has been prepared by GHD for TNG Limited and may only be used and relied on by TNG Limited for the purpose agreed between GHD and TNG Limited as set out in this report.

GHD otherwise disclaims responsibility to any person other than TNG Limited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by TNG Limited and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Executive summary

Background

TNG Limited (TNG) is proposing to develop the Mount Peake Project (the Project) on Stirling Station, approximately 235 km north-northwest of Alice Springs. TNG commissioned GHD Pty Ltd (GHD) to prepare an Environmental Impact Statement (EIS) for the Project to support key Commonwealth and Territory Government approvals. GHD prepared various technical reports for the EIS, including a water resource assessment report. Following review of the technical reports, various areas were identified that would require further assessment and clarification. In order to address specific concerns regarding groundwater supply, TNG commissioned further groundwater drilling, testing and subsequent modelling to be completed.

This supplementary groundwater assessment report has been prepared to provide further information and updated details to inform the EIS. This includes further definition of the project conceptual hydrogeological model following an additional drilling and testing program, and the subsequent revision of the numerical groundwater model. The revised model will allow the assessment of the potential cumulative impacts of borefield operation and pit dewatering, and potential impacts following cessation of operations.

This report supersedes the groundwater components of the report Mount Peake Project Groundwater and Surface Water Assessment Report (GHD 2016).

Groundwater investigations

An initial drilling and testing program for groundwater assessment was completed in 2015 along a 50 km length of the Hanson River. The program was aimed at identifying if the Hanson River palaeovalley aquifer could meet the supply demands of the project, namely delivering 1.6 GL/annum for Stage 1 (years 1 to 4), and 2.6 GL/annum for Stage 2 (years 5-17).

Drilling was completed at four locations with monitoring bores established at each and a production bore at the most prospective site. The production bore was pump tested and data interpreted from this test used to interpret aquifer properties. The program highlighted that the Hanson River palaeovalley has the potential to provide significant volumes of relatively brackish groundwater and the subsequent groundwater modelling supported this.

To provide further definition on the extent of the Hanson River palaeovalley and to determine if it had the potential to meet the water supply demands for the Project, further drilling and testing was completed in July and December 2016.

The 2016 drilling and testing program included the construction of an additional 10 monitoring bores (investigation sites) and 2 production bores. Drilling included locations to provide better definition of the lateral extents of the Hanson River palaeovalley. The drilling provided further data on the Hanson River palaeovalley aquifer, identifying a variable sequence of sands and gravels, offering good aquifer potential. The two production bores were pump tested, with the highest yielding bore (16MPWB017) pumped for 11 days at a rate of 18 L/s. The extended period pump test was completed to assess the long term viability of pumping at higher rate at this location as well as to provide higher confidence in interpreted aquifer parameters.

This drilling and testing programs have confirmed the presence of the Hanson River palaeovalley aquifer, highlighting its broad extent and relatively prospective groundwater yields. The programs have provided reliable data from which to develop an indicative design for the borefield and to develop a representative numerical groundwater model.

For Stage 1 water supply, the proposed borefield will require six production bores. Of these, three have already been installed. Bore 16MPWB017 will be operated at a recommended pump rate of 15 L/s, with the remaining five bores pumped at 7.1 L/s. For Stage 2, a further three bores are required (total of nine), with 16MPWB017 operated at a recommended pump rate of 15 L/s, with the remaining eight bores pumped at 8.4 L/s.

Groundwater modelling

Groundwater flow modelling was undertaken to assess the cumulative impact of the operation of the borefield and pit dewatering.

The project conceptual hydrogeological model was further developed based on the outcomes of the drilling and testing programs, and consideration of available data, maps and reports to provide a framework for numerical model development. A broad four layer system was adopted to describe the key modelling areas of the mine site and palaeovalley aquifer. The layers were:

- Layer 1 represents the extent of the weathered zone in the bedrock outside of the palaeovalley and sandy-silt layer in the palaeovalley;
- Layer 2 represents a transition zone between the weathered bedrock and fresh bedrock in the area outside of the palaeovalley and lower sand/gravel aquifer in the palaeovalley;
- Layer 3 represents fresh bedrock (igneous and metamorphic) in the area outside of the palaeovalley and sedimentary rock (claystone/sandstone) in the palaeovalley; and
- Layer 4 represents fresh bedrock throughout the model domain in order to account for the potential vertical flow into the proposed mine pit.

During flood events of the Hanson River, it is expected that surface water would infiltrate to groundwater, recharging the aquifer. However, due to the periodic nature of these events, and lack of monitoring within the Hanson River, these events are not included in the model recharge. As such the overall recharge used for the model is considered to be a conservative estimate.

The MODFLOW-2005 model configured in three-dimensional mode was used for simulations. Layer thicknesses and hydraulic properties were determined based on resource drilling within and around the mine site, groundwater drilling and testing in the palaeovalley and lithology data from historic drilling. Both steady state and transient modelling was undertaken.

The steady state model was calibrated to fit historical water level observations tests undertaken for model convergence, water balance and other qualitative and quantitative measures. Model parameters and boundary conditions were changed to match the measured head with the modelled head. Of note, depth to groundwater in the area of Mud Hut Swamp is modelled as being around 20 mbgl (i.e. conceptually the swamp is not connected to the regional groundwater system).

The model was applied in transient state mode to assess the maximum potential drawdown of the palaeochannel aquifer through borefield abstractions and from pit development. This allowed the simulation of both drawdown and recovery in annual increments over a period of 100 years (17 years of abstraction followed by 83 years of recovery). This also allowed the staging of the borefield operation to be assessed.

Modelling results indicate that:

- Maximum groundwater drawdown at the borefield at the end of borefield operation (year 17) is modelled as being up to 12 m at the location of the operating bores in the centre of the borefield. Drawdown is centred on each production bore, with drawdown decreasing significantly with distance away from the palaeovalley. The 1 m drawdown contour extends to a maximum distance from a pumping bore of around 6.5 km to the south of the borefield at the end of year 17;

- At the end of mining, drawdown under transient conditions reaches a maximum of around 80 m within the immediate area of the mine pit, and rapidly decreases with distance from the pit. The 1 m drawdown contour is modelled to occur to a maximum distance from the pit of around 1.3 km to the east and west of the pit. Drawdown of up to 10 m is expected on the western side of Murray Creek;
- Due to the relatively localised drawdown, no drawdown impacts at 17 years are expected within the area of Mud Hut Swamp. Drawdown extent in the area of the mine site at 100 years increases to 3.5 km from the mine pit for the 1 m drawdown contour. No drawdown impacts are expected at Mud Hut Swamp;
- Drawdown is predicted at several pastoral bores located close to the borefield, with groundwater levels expected to reduce by up to 3.0 m. Such a reduction in groundwater levels may lead to the existing stock bore infrastructure being inadequate to provide stock water supply;
- The model water balance for the end of mining and borefield operation (17 years) demonstrates that the majority of water abstracted from the bores is coming from storage within the aquifer (85%), and not from either throughflow or rainfall recharge. As such, the model predictions indicate that groundwater levels at the up-gradient model boundary, in the area adjacent to Stirling Swamp and outflow of the Ti Tree basin, are not impacted by abstraction from the borefield;
- The transient simulations indicate that groundwater level recovery is slow in the palaeovalley, largely related to the recharge characteristics of the model, which are conservative;
- The results of the sensitivity analysis (with no recharge for 12 years and lowering the head by 0.7 m to the south) show that there is insignificant additional impact/drawdown within the zone of influence of the borefield; and
- Following cessation of mining a shallow pit lake is predicted to form due to the minor ingress of groundwater (peaking at just over 100 m³/d). The pit lake will become progressively more saline due to the accumulations of salts from groundwater, surface water and rainfall ingress. By around 7 years post-closure a salinity of around 35,000 mg/L is predicted.

Based on results of the groundwater flow modelling, the following recommendations are made:

- The groundwater model should be revisited and updated following the completion of additional drilling that is required to complete the Stage 1 and Stage 2 borefield. For example, if aquifer parameters (and recommended bore pumping rates) at new drill sites differ to those assumed in the model, further assessment will be required to quantify potential groundwater impacts;
- A borefield monitoring plan (water level and quality) comprising of locations between pumping bores and at the extents (especially to the north and south) of the borefield should be implemented to further assess baseline groundwater conditions, to monitor aquifer performance and to feed back into modelling data; and
- Since a number of stock bores are likely to be impacted due to borefield abstraction, a base line assessment of these bores and a make good agreement should be developed with the owners prior to the development of the mine and borefield. This could involve either the deepening of the existing bore, lowering the pump setting, drilling another bore next to existing bore, or by supplying the required water demand from external sources (e.g. pipeline offtake).

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Appendices

Appendix A - Bore Completion Report (2015 & 2016 drilling program)

1. Introduction

1.1 Background

TNG Limited (TNG) is proposing to develop the Mount Peake Project (the Project), approximately 235 km north-northwest of Alice Springs in the Northern Territory.

TNG commissioned GHD Pty Ltd (GHD) to prepare an Environmental Impact Statement (EIS) for the Project to support key Commonwealth and Territory Government approvals. The Terms of Reference for the preparation of the EIS was issued by the Northern Territory Environment Protection Authority (NT EPA) in March 2014. GHD prepared various technical reports for the EIS, including a water resource assessment report (GHD 2016). Following review of the technical reports, various areas were identified that would require further assessment and clarification. In order to address specific concerns regarding groundwater supply, TNG commissioned further groundwater drilling, testing and subsequent modelling to be completed.

This supplementary groundwater assessment report has been prepared to provide further information and updated details to inform the EIS. In essence, this report supersedes the groundwater components of the report *Mount Peake Project Groundwater and Surface Water Assessment Report* (GHD 2016).

1.2 Scope of work

The scope of this groundwater supplementary assessment included the following:

- Further definition of a conceptual hydrogeological model including incorporating the outcomes of the 2016 drilling and testing program; an assessment of geological sequences / units, inferring the extents of potential aquifers; and
- Configuration of a numerical groundwater model to undertake hydrogeological assessments to establish the likely baseline groundwater conditions and evaluate potential hydrogeological changes from groundwater extraction.

1.3 EIS term of reference

The Terms of Reference for the preparation of an EIS (NT EPA 2014) identified the following key risks to groundwater resources:

- Potential for Acidic and/or Metalliferous Drainage (AMD) from the waste rock dump, tailings storage facility and other mine infrastructure, to contaminate shared water resources;
- Contamination of groundwater could occur through leaks from storages or pipelines and spills during handling of contaminants, chemicals and toxicants; and
- Practically available water sources will not be sufficient to supply the needs of the proposed Project configuration, or will not be sufficient without causing environmental or social impacts.

The environmental objectives pertaining to groundwater resource protection (NT EPA 2014) are:

- Demonstrate that available water supplies will be sufficient to fulfil the Project needs over the predicted life-of-mine, without causing environmental or social impacts;
- Demonstrate that Project configuration will optimise reduction of net water use for the Project and minimise contamination of water resources; and
- Ensure that surface water and groundwater resources and quality are protected both now and in the future, such that ecological health and land uses, and the health, welfare and amenity of people are maintained.

Groundwater

The NT EPA (2014) specified that the EIS should include information on the current groundwater resources, particularly:

- Define water sources that may be used to fulfil the requirements of the Project, including:
 - Target bore fields (existing / proposed) and surface waters;
 - Predicted extraction rates;
 - Seasonal requirements for additional clean water;
 - Sources of water for construction of roads and other infrastructure; and
 - Sources and requirements of potable water.
- Describe the existing mine-site and regional hydrogeology in terms that will provide a comprehensive baseline of pre-disturbance conditions;
- Map, describe and model site and regional groundwater resources for the mining leases, ore-processing and water extraction points;
- Discuss significance and sensitivity of site and regional groundwater resources from ecological, public / social and economic perspectives, including descriptions of:
 - Existing groundwater users;
 - Location of groundwater bores for the Project with respect to any groundwater dependent natural features and community uses;
 - Groundwater depths;
 - Directions and rates of groundwater flow;
 - Groundwater quality, with particular emphasis on contaminants likely to be elevated from mining activities;
 - Connectivity between aquifers and with surface waters;
 - Points of recharge / discharge;
 - Whether proposed bores or the Project footprint are within a declared Water Allocation Planning area; and
 - Estimate total reserves and annual recharge.

2. Groundwater resources setting

The following section is reproduced from the *Mount Peake Project Groundwater and Surface Water Assessment Report* (GHD 2016), and presented here to add context to the groundwater modelling assessment.

2.1 Regional geology

2.1.1 Overview

The Project area is located predominantly within the northern province of the Palaeoproterozoic Arunta Block, with the eastern area of the project (encompassing the eastern access road and rail node) being within the western margin of the neoproterozoic Georgina Basin.

The northern province of the Arunta Block contains various metasedimentary rocks and minor volcanics metamorphosed to a generally low-grade facies (Andrew *et al.* 1998). Within the Project area, there are various important unconformably overlying units within the Arunta Block region, such as Central Mount Stuart Formation which forms the high ground (Central Mount Stuart) to the South of the mine site and adjacent to the access road.

The Georgina Basin is comprised of a thick sequence of sedimentary units, typically ranging from pre-Cambrian to Cretaceous. They are predominately comprised of siliciclastic rocks.

These two broad geological regions form the main basement geology of the Project area and are most commonly observed forming the outcropping rocks of the ranges. More recent Quaternary and Tertiary aged deposits dominate the Projects areas surface geology and regolith and generally mask the underling Palaeozoic and Proterozoic units.

2.1.2 Mine site geology

The orebody target for the mine is the mineralised Mount Peake gabbros, which are generally found concealed beneath recent Quaternary sediments. The gabbro unit is located within outliers of Neoproterozoic sediments of the Georgina Basin. The Neoproterozoic sediments rest unconformably on metasediments and granites of the Aileron Province within the Lower Proterozoic Arunta Region.

Within the area of the mine site, the orebody gabbro occurs at relatively shallow depths of around 40 m, striking along a northwest trending sill around 1.3 km length, approximately 500 m wide and 100 m thick.

Within the immediate area of the mine site, Quaternary sediments are the dominant surface geological unit and regolith. The surficial deposits can generally be divided into two units either relating to the current cycle of weathering or erosion, or relating to earlier cycles of weathering. Generally within the area of the mine site, the more recent unit is present comprised of red earth soil (Qr unit), with alluvial deposits present in active channels and on floodplains (Qa unit).

Immediately to the northeast of the proposed pit, a small outcrop of the Mount Stuart Formation is present forming a small rise immediately adjacent to Murray Creek. The same unit also forms the high ground east of the proposed mine camp area. The unit is described as a basal tillite, grey arkosic conglomerate, grey green calcareous pelite and minor dolomitic limestone; grey pelite, grey arkose, and reddish purple coarse feldspar-quartz sandstone. At the base of these units scree slopes and regolith are present (Donnellan 2008).

2.1.3 Borefield geology

The borefield is located on the western bank of the Hanson River. The dominant surface geological unit here is the alluvial deposits of relict fluvial system largely covered by sheet sand (Qas unit) and alluvial/red soil plain deposits (Qra unit).

As further discussed in the hydrogeology section below, the thickness of the alluvial units within the borefield locations are significantly thicker in comparison to the general alluvial units found on the plains. The increased thickness relates to the incised channels of the palaeodrainages of the Hanson River.

It is likely that the thickened alluvial units are geologically equivalent or related to the same units found at depth in the Ti Tree Basin, approximately 70 km to the south (see below). The Hanson River alluvials are possible equivalent to the upper Ti Tree basin facies (facies 4) which have been described as reddish brown mottled sediments deposited in a fluvial environment and of Miocene age (7-20 MYA) (Wischusen *et al.* 2012). The Ti Tree Basin is further discussed below.

2.1.4 Access road geology

The access road is approximately 100 km in length and transects various differing geologies and regolith units. The eastern half of the road alignment is predominately within the Georgina Basin, whereas the western half is within the Arunta Block. The alignment is located on the plains and therefore the surface geology and regolith is mainly comprised of alluvials. In the western area where the alignment is to the east of the ridge line formed from the Stuart Ranges, some localised scree and colluvial fan deposits are present.

In the eastern area of the alignment, the road passes through the palaeovalley associated with the Hanson River. In this location, older Cainozoic sediments are mapped, which are expected to include calcrete deposits.

Where the road alignment meets the existing rail line, the alluvial plain is relatively narrow with units of the Central Mount Stuart Formation being present both north and south of the road alignment.

2.2 Regional hydrogeology

2.2.1 Overview

In general the basement rocks of the Arunta and Georgina geological provinces are not well studied in terms of their groundwater potential, largely as a result of the regions remoteness. The deep basins may offer groundwater resources, but groundwater drilling investigations have generally focused on providing water for communities or for stock watering. As such only relatively minor yields have been required so drilling of production bores would tend to cease at relatively shallow depths once sufficient yield was obtained (Ride 2007).

Regional aquifer mapping by the Department of Land Resources Management (Tickell 2013) summarises that the general Project area contains two predominant aquifer types that are termed local scale aquifers only:

- Fractured and weathered rocks with minor groundwater resources; and
- Fractured and weathered rocks.

The distribution of these two systems is illustrated in Figure 2-1. The fractured rock aquifers are likely to offer generally low groundwater yields. In addition to the two units that dominate the Project region, the Ti Tree basin is mapped as an aquifer of 'Unconsolidated sediments with intergranular porosity'. This unit is not mapped as continuing through the identified palaeovalley of the Hanson River (see further discussion below).

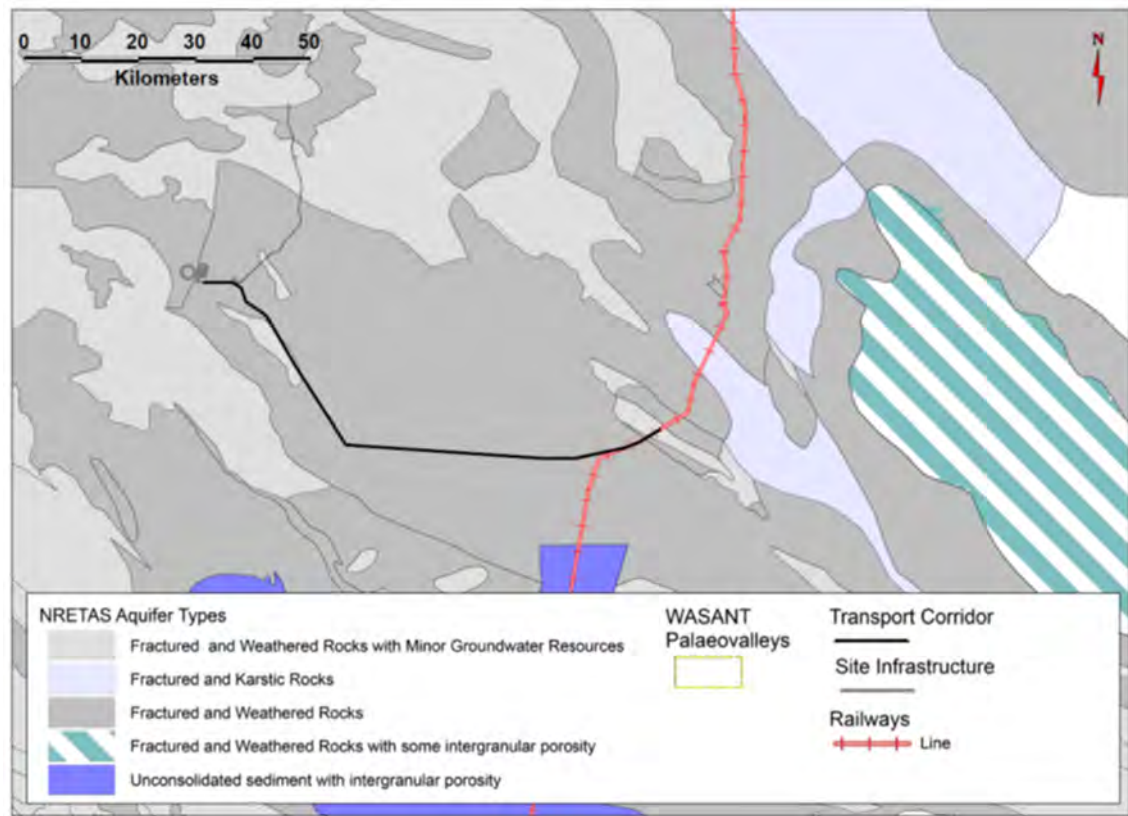


Figure 2-1 Regionally mapped aquifer systems¹

2.2.2 Cainozoic basins and palaeovalley systems

In addition to the broad fractured rock systems that are possibly present throughout the study area, a number of significant Cainozoic basins and palaeovalley systems have been identified within or adjacent to the Project area (Tickell 2013). The palaeovalley and sedimentary basins are relict drainage features that formed between 2 and 65 million years ago. Aquifer systems are present within the river sands and gravels that formed the channel systems within these relict drainage features.

These systems have been mapped and described in the publication “Water for Australia’s arid zone – identifying and assessing Australia’s palaeovalley groundwater resources” (English *et al.* 2012). A brief summary of these systems is provided in the following sections.

2.2.3 Ti Tree Basin

The Ti Tree Basin is the most studied and the most exploited groundwater resource in the region. The groundwater potential of the basin has been the focus of various government reports and policies since the early 1960s (English *et al.* 2012). The Basin is an intracratonic Cainozoic basin that is infilled with up to several hundred metres of alluvial and lacustrine sediments.

The basin is approximately 100 km wide from east to west and 75 km north to south. The basin sediments are known to be in excess of 300 m in depth, however the upper 100 m of sediments is most commonly targeted for groundwater abstraction. The primary use of the groundwater is horticulture. Data indicates that abstraction from the Ti Tree went through a period of increasing demand up to around 2005 when a maximum of around 4 GL/annum was abstracted. Demand has reduced since 2005 with the current demand being less than 2 GL/annum.

¹ Department of Land Resources Management

Groundwater within the basin generally flows from south to north, with discharge known to occur towards the Hanson River and Stirling Swamp. The Stirling Swamp area may be an expression of discharge from the Ti Tree aquifer where evapotranspiration could be a major component of the water balance for the aquifer (English *et al.* 2012).

2.2.4 Hanson River palaeovalley

The extent of the palaeovalley was determined through assessment of spatial data, including existing geological mapping, satellite imagery and available drilling data. It is recognised that within the Hanson River area, drilling data is relatively limited (Section 2.4), therefore the mapped extent of the palaeovalley could be highly speculative (Tickell 2013).

The Hanson River palaeovalley is mapped as continuing from the northern discharge of the Ti Tree Basin, passing through Stirling Swamp and connecting with the existing Hanson River channel. The channel then passes through the Project area before continuing north for approximately 200 km before it merges with the Palparti palaeovalley. The Hanson River palaeovalley is generally identified as being around 4 km wide, but as narrow as 2 km and as wide as 10 km.

With the exception of work undertaken by TNG (Section 3), there has been no known groundwater investigative drilling undertaken in the area of the Hanson River palaeovalley. Drilling within the identified extents of the system has been limited to stock bores (further discussed in Section 2.4.1). Stock bores have generally been successful in terms of yield, and in some instances may have not fully intersected the aquifer.

Utilisation of the Hanson River palaeovalley is currently limited to the stock bores. The majority of bores are equipped with solar powered low volume shaft driven pumps, which are used to fill water tanks that keep cattle troughs filled.

2.2.5 Willowra Basin

The Willowra Basin and associated palaeovalley is located approximately 30 km west of the mine site at the junction of the Lander River and Ingallana Creek. Unlike the Hanson River palaeovalley, the Willowra Basin has been investigated for groundwater resources through a drilling program conducted by the Northern Territory Water Resources section in 1963. A total of 45 holes were drilled for a total of 1,424 m of drilling. The drilling locations were orientated on a grid basis in order to determine the extent of the basin and determine the profile of the potential groundwater resource.

The investigation determined that around 25 km south of Willowra Homestead the palaeovalley is about 18 m deep and 3 km wide, deepening to 35 m just north of the homestead. The shape and sediment composition of the infill sequence indicates that it formed in a fluvial environment, with elongate sand and gravel channel lenses and clay and silty-clay sediments typical of floodplain overbank deposits. The main aquifer unit was identified as a Quaternary lower sand unit with some local confinement by clay rich floodplain deposits (Magee 2009).

The Quaternary alluvial aquifers have low volumes of groundwater storage after long periods of low flow, with the watertable depth in the Willowra Homestead bore, which penetrates 15 m of Quaternary sands known to vary from about 12 m (in dry periods) to near-surface immediately after streamflow.

The only known groundwater use within the Willowra Basin is for stock use. The use of the groundwater resource for horticultural purposes was identified as having potential, however this has not been further pursued.

The drilling data for the Willowra Basin could offer an insight into the Hanson River palaeovalley system, with both systems expected to have formed under similar conditions.

2.3 Water control districts

2.3.1 Overview

The Department of Land Resource Management declares Water Control Districts in areas that need close management of water resources. Managing of the water resource will avoid stressing groundwater reserves, river flows or wetlands.

Each Water Control District is subject to water allocation planning that establishes a framework to share water between human and environmental needs. An allocation plan is declared to ensure that water is allocated to beneficial uses, as defined in the *Water Act 1992*. The defined beneficial uses of water include agriculture, public water supply, the environment, cultural needs, industrial needs, aquaculture and to provide water for stock and domestic purposes.

Of relevance to the Project are the Western Davenport Water Control District, and the Ti Tree Water Control District. These are summarised below.

2.3.2 Western Davenport Water Control District

The Western Davenport Water Control District covers an area of almost 25,000 km², extending north from the Ti Tree Basin Water Control District for around 200 km, including the community of Mungkarta at its northern edge. From the west it includes the Hanson River and the proposed location of the borefield, and extends east to cover most of Murray Downs Station. The Stuart Highway bisects the District passing through Barrow Creek, Wycliffe Well and Wauchope.

The allocation plan (Department of Natural Resources 2009) recognises that there are currently no known or significant surface water extraction activities and the total of the current licensed and unlicensed groundwater extraction per annum is estimated to be less than 0.004% of estimated storage. The allocation plan and associated technical documentation also note that further scientific work needs to be undertaken to improve the knowledge about the areas water resources and estimation of their characteristics. In particular, more evenly spread and deeper groundwater drilling investigations are recommended to determine bore yields and consequential sustainable yields of aquifers. Identification and measurement of recharge mechanisms is also recommended.

As identified in Section 2.2, the regions aquifers are typically either low yielding fractured rock systems, or Cainozoic sedimentary aquifers. The technical assessment for the Western Davenport Water Control District estimates that groundwater storage in the Cainozoic or upper level aquifers in the larger regional scale aquifer is in the order of 12,800 GL and storage in the deeper fractured rock aquifers is in the order of 16,000 GL.

The allocation plan identifies that current licensed groundwater abstraction is limited, with the main uses for horticulture and community supply. An additional unlicensed volume is attributed to stock bores, which based on an estimation of bore numbers and stock is estimated to be in the region of 350 ML/year.

The Water Control District is separated into five management zones based on a consideration of topography, underlying geology, hydrogeochemistry and stratigraphy. The Territory Government has followed the principle that in the absence of adequate scientific information, total extraction of groundwater over a century should not exceed 80% of the estimated total aquifer storage. The Project area overlaps with part of the Southern Ranges management zone. A summary of this zone is provided below as Table 2-1.

Table 2-1 Southern Ranges management zones summary

Area	Estimated storage	Estimated annualised recharge	Available allocation
8498 km ²	147 GL	8.5 GL	6.8 GL/annum

2.3.3 Ti Tree Water Control District

The Ti Tree Water Control District covers an area of almost 15,000 km², covering the extent of the Ti Tree aquifer and its surface water catchments. The northern area of the district extends to Willowra and Stirling Station, and therefore includes a large section of the access road alignment and the rail siding.

Unlike the Western Davenport Water Control District, the Ti Tree area has a significant groundwater use, largely for horticultural purposes and public water supply. Abstraction occurs from the Ti Tree aquifer which is present at relatively shallow depths across the majority of the Water Control District. As a result of the demand and utilisation of the aquifer, a groundwater model has been developed, which has been used to develop allocations and sustainable water use volumes. The groundwater model is scheduled to be updated and refined every 5 years to take into account the latest abstraction data and incorporate any new hydrological or hydrogeological data that has been developed.

The Water Control District is separated into four management areas, with the Northern Zone being of relevance to the Project due to its overlap with the access road, the Hanson River and Stirling Swamp. The northern zone is relatively un-utilised in terms of abstraction compared to the other areas, with the only groundwater use by the Willowra community and Stirling Station. It is estimated that a total of 50 ML/year is currently used, with 10 ML/yr for Public Water Supply (licenced) and 40 ML/year for rural and domestic use (unlicensed).

2.4 Existing groundwater use within the Project area

As indicated in the above sections, there are relatively few existing users of groundwater within the Project area. However, an understanding of these existing groundwater users is required in order to identify them and protect them from potential adverse impacts. The following sections summarise the key known groundwater users within the Project area.

2.4.1 Stock bores

The pastoral lease of Stirling Station covers most of the Project area, with Anningie Station being immediately to the south of the Project area. The access road corridor follows the boundary of the two stations lying on the Stirling Station side of the boundary.

Both pastoral stations use stock bores and wells for year-round water supplies. The operational stock bores identified within and around the Project are shown on Figure 2-2. In general, stock bores are relatively evenly distributed around the Project area with typical distance between stock bores of around 10 km. The majority of the bores within the Project area are located along existing creek and drainage lines. For example, there are a series of stock bores along the western bank of the Hanson River Channel, with bores located at 10 km intervals between Hansons Bore on Stuart Highway to Prosperity Bore, some 90 km north down-stream.

The majority of stock bore and well locations are historic having been established early in the pastoral stations development. As such, some locations have since been re-drilled, or bores installed to replace old wells which were traditionally hand dug and relatively shallow. Due to the relatively low volumes of groundwater required at each location, bores tend to be relatively shallow and generally less than 40 m deep. Due to the widespread nature of these bores, they tend to target different units but are predominately targeting the fresher shallow groundwater associated with recent alluvial sediments.

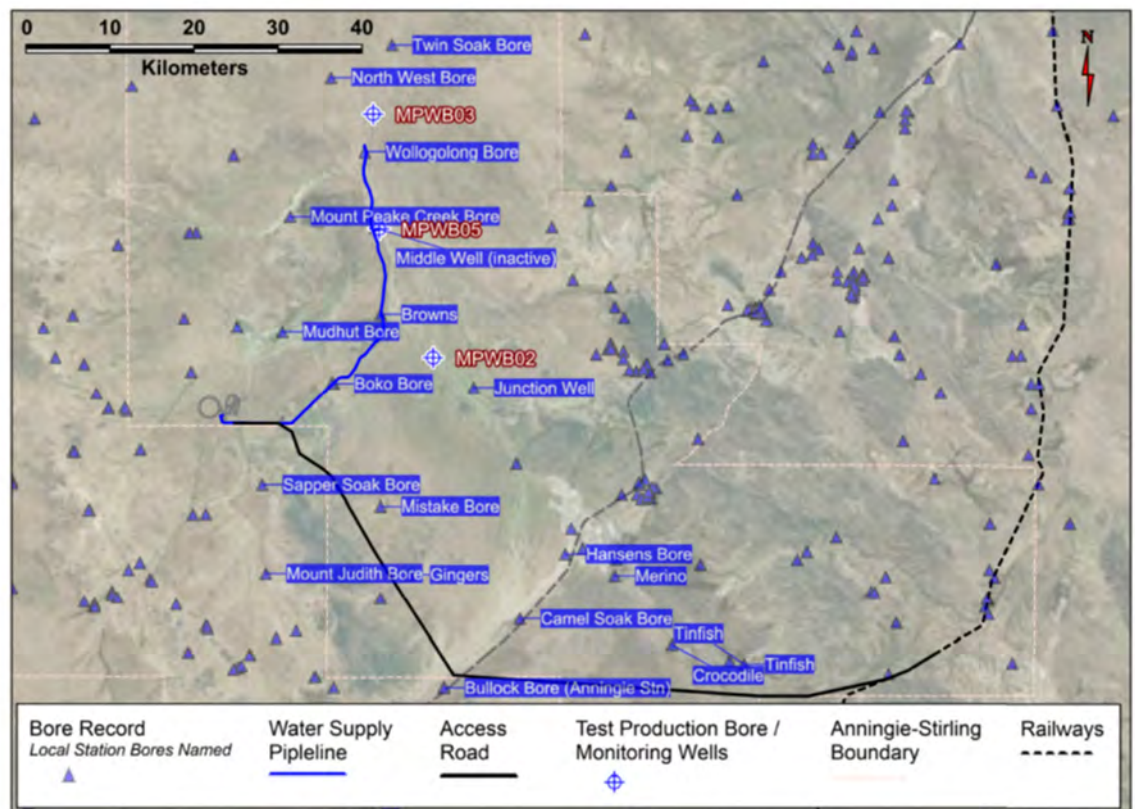


Figure 2-2 Stock bores within and around the Project

Most active stock bores are equipped with either a wind powered shaft drive positive displacement pump, or a solar powered electric submersible pump. In general, wind powered bores will pump continuously when there is sufficient wind, whereas solar pumps will fill a tank and only pump when levels in the tank drop below a specified level.

Due to the relatively shallow nature of stock bores, they can have the potential to be impacted by any reduction in groundwater levels, therefore consideration of impacts on these bores will be a key factor when assessing drawdown impacts from the mine site and borefield.

2.4.2 Community and domestic supply

Within the Project area, there are a number of groundwater abstraction bores that are used for public water supply. These include supply for Stirling Station homestead, Barrow Creek and the Willowra community. All of these locations have dedicated bores that provide a permanent water supply. The Willowra community is supplied with groundwater with an existing licence for 40 ML/year (issued to the Power and Water Corporation). Barrow Creek service station is licensed for 1 ML/year. No current licence data is available for Stirling Station homestead.

All of these bores are located over 40 km from the mine site.

2.4.3 Groundwater dependent ecosystems

Stirling Swamp (Anmatyerr North) and Mud Hut Swamp are Sites of Conservation Significance located within the Study Area. These wetland features have the potential to be maintained by groundwater.

Stirling Swamp, located north-west of the access road and rail node, comprises a large network of claypans, lignum swamp, semi-saline samphire and temporary open water, and the adjacent Hanson River. Stirling Swamp is thought to be connected to groundwater through a topographic low forming a 'window' to the relatively shallow Ti Tree aquifer water table. This area is therefore considered a discharge zone of the Ti Tree aquifer.

Mud Hut Swamp is located approximately 8 km north of the mine site. It is formed from a flood-out of the Bloodwood Creek and, based on its location as an outflow of the creek, it is unlikely that the swamp is maintained by groundwater.

There are no known permanent or semi-permanent water holes along the Hanson River, with any pools formed through surface water flow. These are relatively short lived as they are subject to evaporation and drain to the underlying aquifer.

2.5 Groundwater levels

2.5.1 Regional data

Development of an understanding of the baseline groundwater levels for the Project area is required to assist in determining any potential impacts from Project operations. It is important to understand the seasonal and temporal changes of groundwater levels.

The NRETAS bore database includes data on groundwater levels. Interrogation of this data highlighted the lack of bores within close proximity of the Project that have a good record of current and historic groundwater levels. Sites where groundwater level data is available are presented on Figure 2-3 and summarised in Table 2-2. Hydrographs for select bores are presented as Figure 2-4.

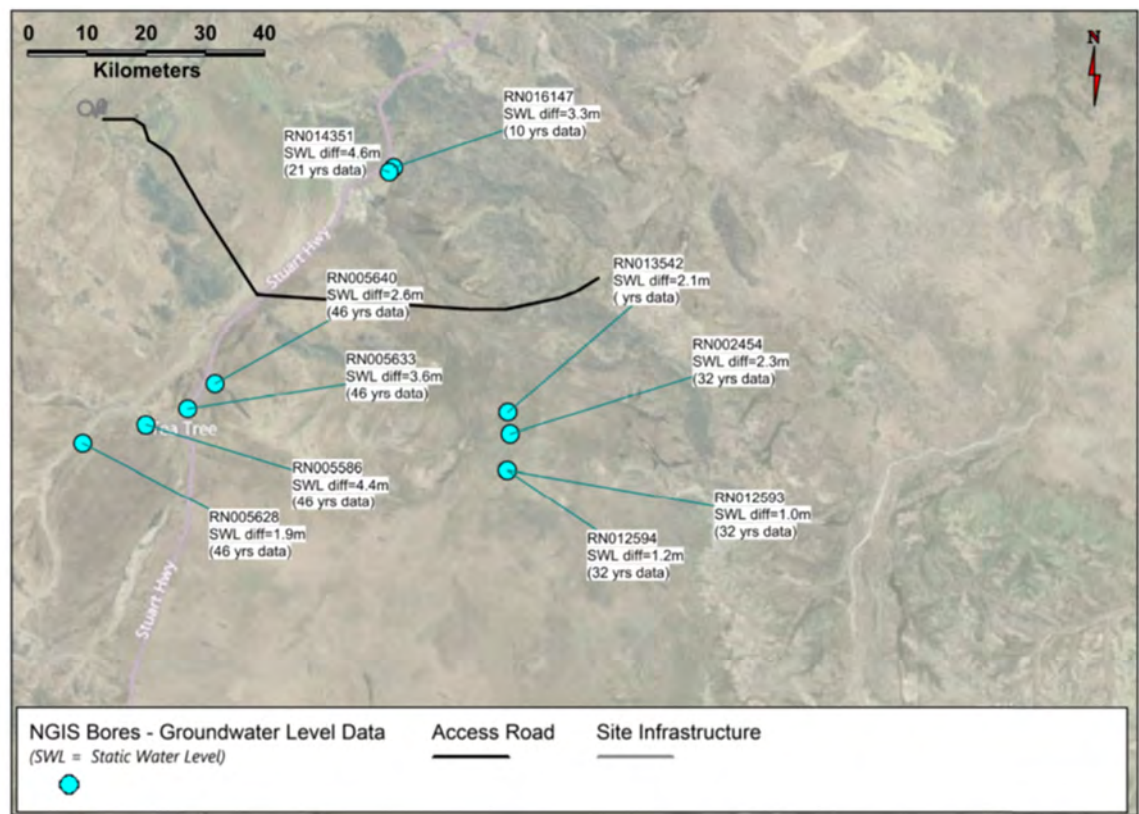
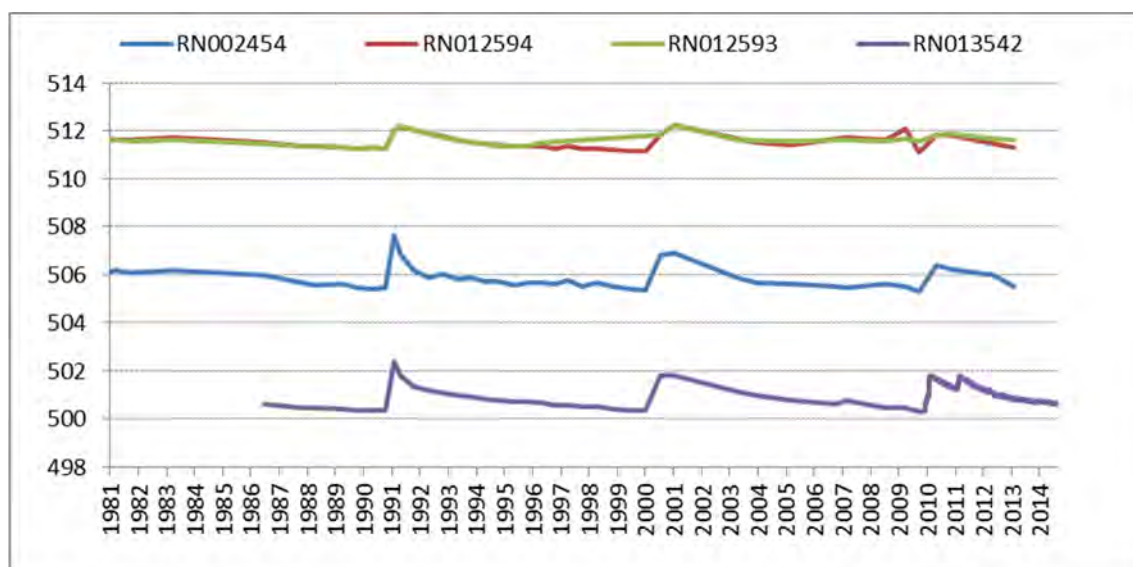


Figure 2-3 Sites with groundwater level data

Table 2-2 Groundwater level data summary

Site ID	Groundwater elevation range (mAHD)	Monitoring period	Comment
RN016147	474.8 to 478.1	10 years (1992-2002)	Located at Willowra. Generally increasing groundwater levels.
RN014351	472.9 to 477.5	21 years (1992-2003)	Located at Willowra. Record includes hourly data highlighting response of pumping.
RN005628	550.3 to 552.2	46 years (1967-2013)	Adjacent to Hanson River Channel. 2 m rise in levels between 1970-1979, with subsequent gradual reduction.
RN005586	543.6 to 548.0	46 years (1967-2013)	Adjacent to Hanson River Channel. General reduction in levels, with significant response to rainfall events/river flow.
RN005633	528.2 to 531.8	46 years (1967-2013)	Adjacent to Hanson River Channel. 2 m rise in levels between 1970-1979, with subsequent gradual reduction.
RN005640	519.1 to 521.7	46 years (1967-2013)	Adjacent to Hanson River Channel. 2 m rise in levels between 1970-1979, with subsequent gradual reduction.
RN012594	511.1 to 512.3	32 years (1981-2013)	Ti Tree Basin north. Significant rise in levels in 1991 and 2001.
RN012593	500.3 to 502.4	32 years (1981-2013)	Ti Tree Basin north. Significant rise in levels in 1991, 2001 and 2009.
RN013542	505.3 to 507.6	32 years (1981-2013)	Ti Tree Basin north. Significant rise in levels in 1991, 2000 and 2010.

**Figure 2-4 Hydrographs for select monitoring bores**

As highlighted by the data, there are two sites at Willowra with a historic record of groundwater levels and several sites south of the Project area in the north of the Ti Tree Basin and along the Hanson River. For some of these sites a good record of groundwater levels is available. Groundwater levels tend to vary by between 2 m and 4 m, with the data highlighting the response of the aquifers to large rainfall river flow/flood events. For example, at monitoring bore RN005586 (52 m deep), located 6 km west of Stuart Highway near Ti Tree, and on the southern edge of the Hanson River floodplain, groundwater levels increase by up to 2 m after significant flood events, and then recede until the following flood event. A gradual decrease in levels is noted between the summer of 1984 (when over 150 mm of rainfall was recorded in one day at Barrow Creek) until the summer of 1991 when another large rainfall event was recorded. During this seven year period, groundwater levels reduce by around 2.5 m.

Data from the available NRETAS bores indicates that groundwater between these locations has a gradient to the north, comparable to the general topographic elevations.

2.5.2 Site specific data

Groundwater and resource drilling for the Project has provided additional groundwater level data, albeit for a limited monitoring period. Groundwater level data has been collected since the completion of the 2015 drilling program (Section 3). The data indicated groundwater levels being relatively consistent between sites along the Hanson River palaeochannel at a depth of around 10 mbgl.

An assessment of resource drilling in the pit area in 2014 highlighted that depth to water was typically 20 to 22 mbgl.

2.6 Recharge

Aquifer recharge predominantly occurs from direct infiltration of rainfall. Due to the sporadic and minimal amount of rainfall typical of the region, this volume is quite low. Previous studies in the region, most notably for the Ti Tree Basin, have used an average long term recharge of 2 mm per year (Wischusen *et al.* 2012).

Whereas regional recharge is relatively low, large rainfall and subsequent flood events are known to significantly increase groundwater levels in areas close to active flow channels. However, a lack of monitoring data for the Hanson River channel means that recharge volumes for this system cannot be accurately quantified.

3. Summary of TNG groundwater investigations

3.1 Introduction

In order to source a water supply for the Project, various stages of investigation have been undertaken to determine if groundwater could meet the proposed water supply demands of up to 7.1 ML/d (82.5 L/s). The following sections provide a brief summary of the investigations, with the data from them incorporated into the general understanding of the site and the development of the site conceptual and numerical groundwater models. Further data is included for the drilling investigations in the Bore Completion Report (Appendix A).

3.2 Mine pit airlift investigation – March 2014

An investigation of the groundwater potential in the area of the pit was undertaken in March 2014 through airlifting of existing exploration holes. The airlifting program aimed to determine the likely groundwater in-flow to the pit area and whether there may be sufficient volumes of water available for mine site water use, for example using the potential dewater for ore processing and dust suppression.

Eleven holes were assessed at locations both within and adjacent to the pit area. Groundwater levels were measured at a depth around 20 to 22 mbgl with salinity generally between 6000 and 8000 mg/L TDS. During air-lifting of the exploration holes, low volumes of groundwater were able to be purged with only a low flow volume sustained in five of the 11 sites at rates less than 12 L per minute.

The air-lifting tests allowed the determination of indicative aquifer parameters through the analysis of groundwater recovery data at each test site. This is further discussed in Section 4.2.

Outcomes: The testing demonstrated that the pit area will not be subject to significant groundwater inflow, and as such, there is no indication the pit will require substantial dewatering infrastructure.

Alternative water sources for mine site water supply would be required as there will be insufficient volumes available from the pit to meet Project requirements.

3.3 Murray Creek groundwater assessment March 2014

Two drilling locations were determined on the eastern bank of Murray Creek, immediately east of the mine site, to determine if the river alluvials or structural features would offer any groundwater supply potential.

Drilling was completed to 35 m and 36 m at each location. Despite the proximity to the existing creek, Quaternary alluvials were only intersected for the upper 10-14 m, with fresh gabbro or the Central Mount Stuart Formation basement intersected for the remainder of each hole. No groundwater flow was identified.

Outcomes: The drilling demonstrated that Murray Creek alluvials do not offer suitable groundwater supplies for the Project. The drilling also indicates that riparian vegetation within this area is unlikely to rely on groundwater resources.

3.4 Hanson River - 2015 Groundwater drilling and test pumping

3.4.1 Drilling

A drilling and testing program was undertaken in March 2015 to assess the groundwater supply potential of the Hanson River palaeovalley. Drilling locations were determined by TNG at targeted locations along the existing Hanson River and at maximum distances from existing stock bores. The drilled locations are approximately spaced at 15 km intervals, over a total distance of 50 km of the Hanson River. Drilling locations are presented on Figure 3-1, with installation details summarised in Table 3-1. Additional information, including detailed bore logs and water quality data are presented in the Bore Completion Report (Appendix A).

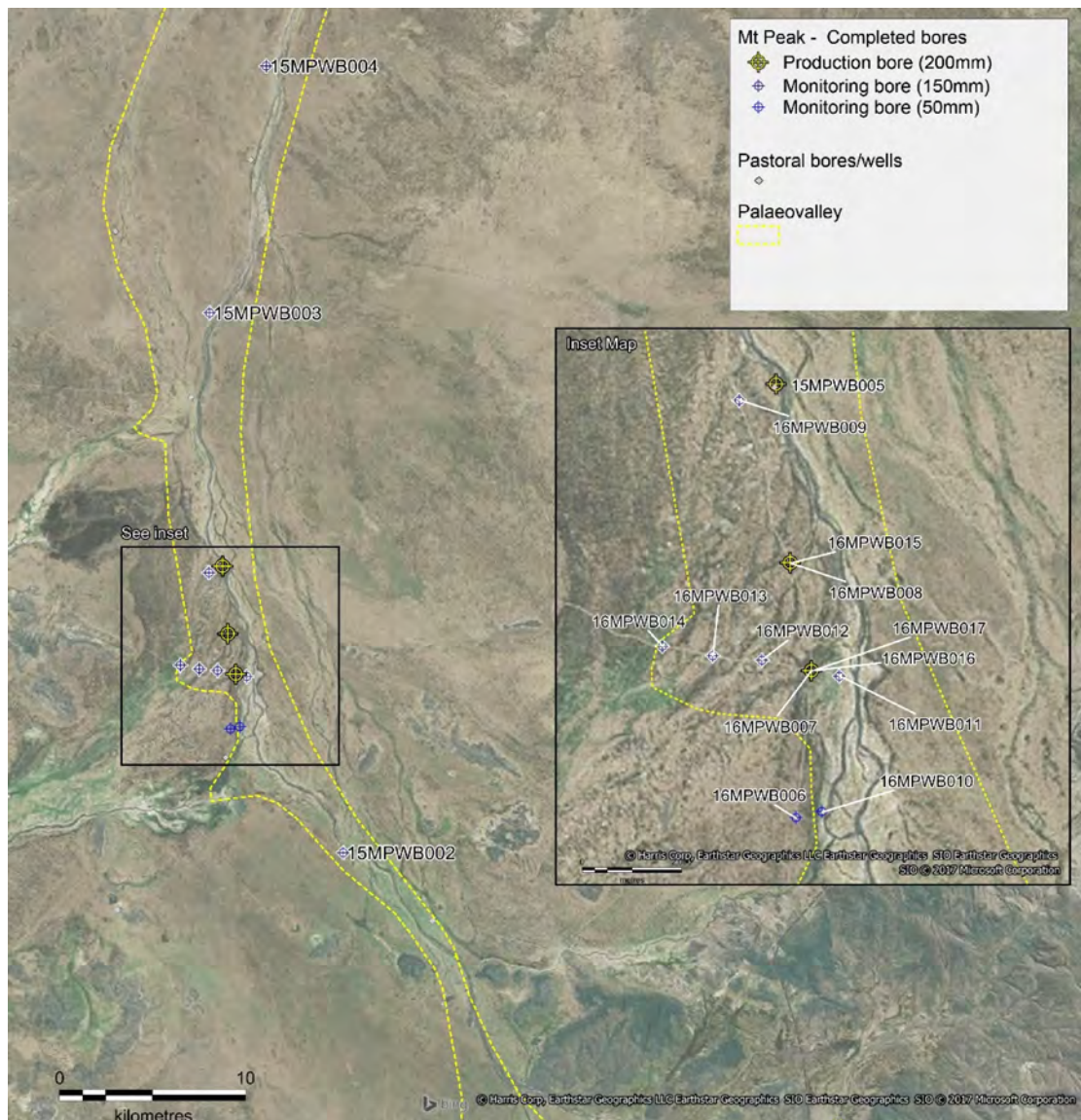


Figure 3-1 Installed bore locations

All drilled bores intersected a sequence of sands and gravels with varying thicknesses and varying clay and silt contents overlying a variable basement. In general, an upper silty unit was identified above a coarser grained sand and gravel unit (main aquifer). All bores produced significant water volumes during drilling, with yields from the final depth air-lift generally between 5 L/s and 20 L/s from the open hole. All investigation sites were constructed as 150 mm PVC cased monitoring bores.

Due to the favourable yields, a test production bore (15MPWB005) was constructed adjacent to the location of 15MPWB001.

Table 3-1 Summary of TNG drilling completed 2015-2016

Drilling program	Completed Bore ID		Type	Installed depth (m)	Comment*
2015	15MPWB002		Monitoring (150 mm)	54	6.5 L/s, TDS 28380 mg/L
	15MPWB003		Monitoring (150 mm)	66	>20 L/s, TDS 14460 mg/L
	15MPWB004		Monitoring (150 mm)	48	>10 L/s, TDS 5040 mg/L
	Same site	15MPWB001	Monitoring (150 mm)	62	4 L/s, TDS 4956 mg/L
		15MPWB005	Production (200 mm)	60	>15 L/s, TDS 5082 mg/L
2016	16MPWB009		Monitoring (150 mm)	60	6 L/s, TDS 5130 mg/L
	16MPWB006		Monitoring (50 mm)	60	0.4 L/s, TDS 25100 mg/L
	16MPWB010		Monitoring (50 mm)	84	0.4 L/s, TDS 13250 mg/L
	Same site	16MPWB008	Monitoring (150 mm)	66	10 L/s, TDS 4080 mg/L
		16MPWB015	Production (200 mm)	66	10 L/s, TDS 4680 mg/L
	16MPWB014		Monitoring (150 mm)	48	5 L/s, TDS 3710 mg/L
	16MPWB013		Monitoring (150 mm)	54	8 L/s, TDS 4610 mg/L
	16MPWB012		Monitoring (150 mm)	48	10 L/s, TDS 3950 mg/L
	16MPWB011		Monitoring (150 mm)	54	10 L/s, TDS 9960 mg/L
	Same site	16MPWB016	Monitoring (150 mm)	21	3 L/s, no water quality data
		16MPWB007	Monitoring (150 mm)	54	10 L/s, TDS 3810 mg/L
		16MPWB017	Production (200 mm)	54	20 L/s, TDS 3700 mg/L

* water yield and salinity from air-lift data

15MPWB005, 16MPWB015 and 16MPWB017 (in bold) are the production bores

3.4.2 Test pumping

A test pumping program was completed on the constructed monitoring bores and test production bore. The pumping test program included:

- 100 minute pump tests on 3 monitoring bores (15MPWB002, 15MPWB003, 15MPWB004), all pumped at approximately 3 L/s (maximum rate for size pump available for 150 mm bore diameter); and
- Step tests and 48 h constant rate test and recovery test on production bore 15MPWB005, including monitoring of groundwater level response in 15MPWB001 located on the same site 15 m from the production bore. The 48 h constant rate test was completed at 12 L/s.

The analysis of the 48-hour pump test data allowed the determination of aquifer properties and recommendations for operational pump rates for the production bore. Pumping test analysis is included in the Bore Completion Report (Appendix A). Based on the analysis from the constant rate test on production bore 15MPWB005, bulk aquifer parameters are presented as:

- Transmissivity = 100 m²/d;
- Horizontal Hydraulic Conductivity = 2.2 m/d;
- Vertical Hydraulic Conductivity = 0.2 m/d;
- Specific Yield = 0.075; and
- Storage Coefficient= 0.0002.

Outcomes: The 2015 drilling and testing demonstrated that the Hanson River palaeovalley has the potential to provide significant volumes of relatively brackish groundwater.

3.5 Hanson River - 2016 Groundwater drilling and test pumping

3.5.1 Drilling

To provide further definition on the extent of the Hanson River palaeovalley and to determine if it had the potential to meet the water supply demands for the Project, further drilling and testing was completed in July and December 2016. Drilling locations were determined to provide a representative east-west cross section of the western side of the palaeovalley and to assess the aquifers properties at additional locations within the area investigated in 2015.

Drilling locations are presented on Figure 3-1, with installation details summarised in Table 3-1. Additional information, including detailed bore logs and water quality data are presented in the Bore Completion Report (Appendix A).

The east-west cross section incorporated five locations spanning around 4 km. This identified the thinning of the palaeochannel in the far west at 16MPWB014 where the aquifer was relatively thin (24 m) with the basement intersected at around 36 m. A cross section for this area is presented in the Bore Completion Report (Appendix A).

High groundwater yields were found from a gravel rich unit at 16MPWB007, and as such a test production bore was drilled at this location (16MPWB017). To provide additional data on aquifer connectivity, a shallow 21 m deep monitoring bore was also installed at this location (16MPWB016).

A basement high and relatively low groundwater yields were found in the south at 16MPWB006 and 16MPWB010. At these locations, 50 mm monitoring bores were installed.

Relatively good yields (> 10 L/s) were found at 16MPWB008, and as such a test production bore was also completed here (16MPWB015).

3.5.2 Test Pumping

Following completion of the two production bores, test pumping was completed to determine their supply potential and extent of drawdown influence. The pumping test program included:

- Step tests and 48 h constant rate test and recovery test on production bore 16MPWB015, including monitoring of groundwater level response in 16MPWB008 located on the same site. The 48 h constant rate test was completed at 8.3 L/s; and
- Step tests and 11 day (264 h) constant rate test and recovery test on production bore 16MPWB016. This included monitoring of groundwater level responses in shallow (16MPWB016) and fully penetrating (16MPWB007) monitoring bores adjacent to the bore, and other monitoring locations along the drilled transect, for example 16MPWB011 located 600 m east of the test bore. The 11 day constant rate test was completed at 18 L/s.

The analysis of the pump test data allowed the determination of aquifer properties and recommendations for operational pump rates for the two production bores. Pumping test analysis is included in the Bore Completion Report (Appendix A). Based on the analysis from the constant rate test on the production bores, bulk aquifer parameter ranges are presented as:

- Transmissivity = 115 to 400 m²/d;
- Horizontal Hydraulic Conductivity = 2 to 10 m/d;
- Vertical Hydraulic Conductivity = 0.04 to 0.1 m/d;
- Specific Yield = 0.05 to 0.15; and
- Storage Coefficient = 0.0002 to 0.004.

Outcomes: The 2016 drilling and testing confirmed the presence of the Hanson River palaeovalley, and indicated its overall width to the western side of the channel. High yielding zones within the alluvial aquifer demonstrated that pumping rates up to 18 L/s could be sustained.

3.6 Drilling program conclusions

The completed drilling programs have confirmed the presence of the Hanson River palaeovalley aquifer, highlighting its broad extent and relatively prospective groundwater yields. The water quality was found to be brackish to saline, however this is not considered a limitation to Project water supply as the proposed main use of water will be for ore processing (no salinity restrictions).

Due to the favourable drilling, and consideration of the pump testing results, indicative locations for production bores to complete the proposed borefield have been adopted. These are presented in Figure 3-2 and used in the groundwater modelling, as further discussed in Section 4.

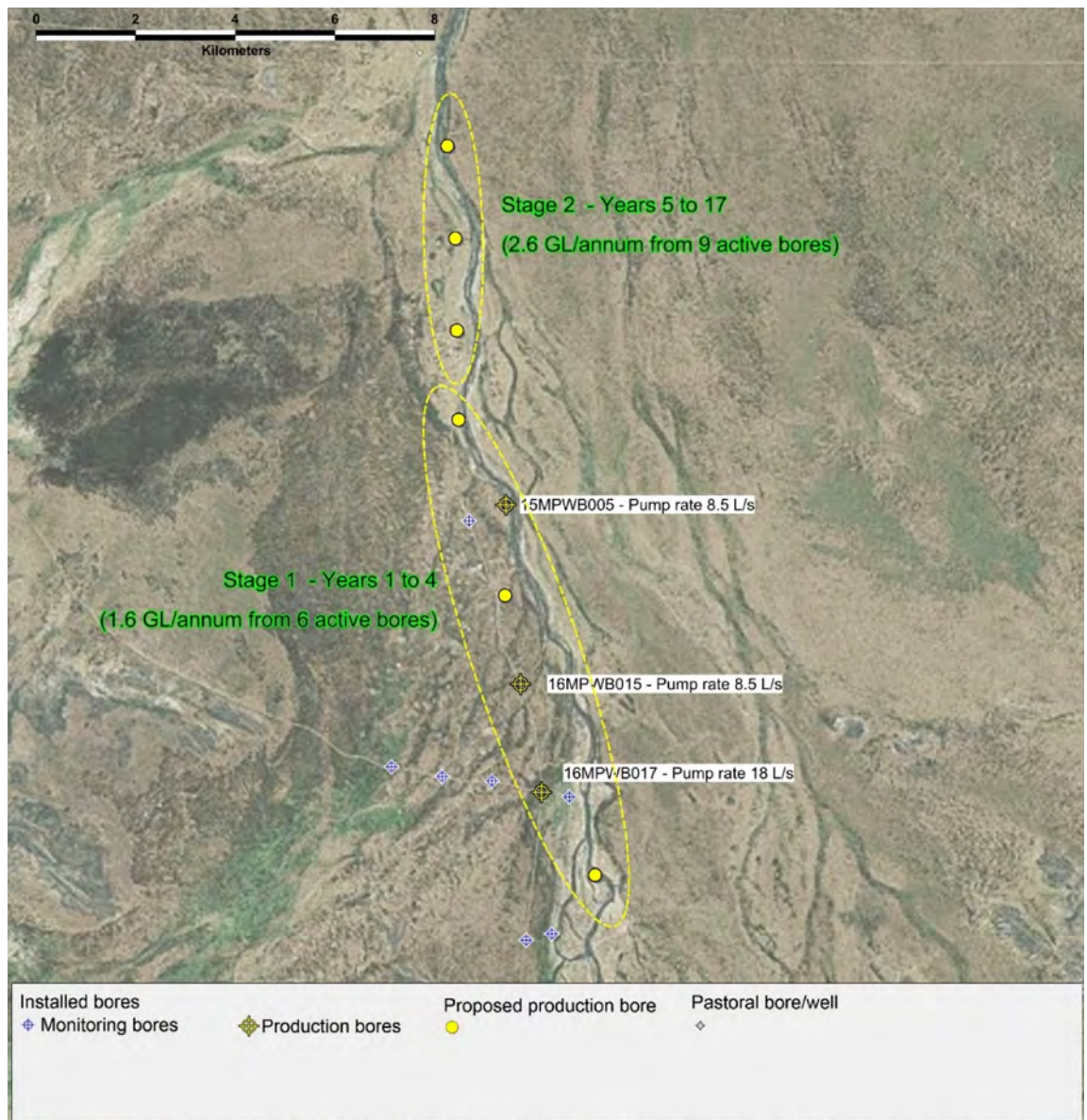


Figure 3-2 Proposed borefield layout

4. Groundwater model set-up

4.1 Purpose of groundwater modelling

The main purpose of the groundwater flow modelling is to assess potential cumulative impacts of borefield operation and pit dewatering, and potential impacts following cessation of operations.

The groundwater model is a regional scale model as it needs to determine potential groundwater level effects in both the area of the borefield and the mine site. The modelling has not included the assessment of impacts from temporary road construction supply bores. Water supply for road construction will be short term (< 2 years) and at relatively low rates from approximately seven locations that include existing pastoral bores/wells along the proposed access road alignment. Due to the low rates, and short term nature, this has been excluded from the modelling.

4.2 Conceptual hydrogeological model

A conceptual hydrogeological model was developed based on the available data, maps and reports. The conceptual model provides a framework for the numerical model development. Based on the regional scale of the model, a broad four layer system has been proposed encompassing the two key modelling areas. This can be summarised as:

- **mine-site** - weathered rock underlain by the fresh rock; and
- **palaeovalley area** - silty/sandy clay underlain by silty sand/gravel aquifer.

4.2.1 Mine-site and surrounds

Data from exploration drill-holes was reviewed for the mine site, together with regional lithological logs and published geological data. The data indicated that the minesite and surrounds are typically located within a basement of hard rock (gabbro, granites and metasediments) that are largely fresh and unfractured, i.e. they are considered to offer low volumes of groundwater. This was supported by the airlift investigation of the exploration holes completed in 2015 and discussed in Section 3.2.

The cover of Quaternary alluvials within the mine site and surrounds was found to be relatively thin, generally not exceeding more than 20 m. For the area investigated, and the purposes of this assessment, the shallow alluvial cover over a solid basement can be considered as hydrogeologically representative for all areas outside of the palaeovalley.

4.2.2 Palaeovalley area

The extent of the Hanson River palaeovalley was mapped as part of a national assessment based on a review of spatial data, including existing geological mapping, satellite imagery and available drilling data (English *et al.* 2012).

The mapped area was used to determine the initial drilling investigation locations completed in 2015 and summarised in Section 3.4. The 2015 drilling confirmed the presence of the palaeovalley, and the 2016 drilling program was completed to provide more definition of the extent and variability of the palaeovalley. As discussed in Section 3.5, this included drilling perpendicular to the palaeovalley to determine its width.

The investigations indicated that the palaeovalley was wider than the original area mapped, and as such the modelled extent of the palaeovalley was increased slightly within this area. Conversely, a basement high was identified within the original mapped extent of the palaeovalley, therefore the width of the mapped palaeovalley was reduced in this area.

Where encountered, the palaeovalley was found to comprise an upper silty/sand layer, overlying a more gravel rich basal layer. The gravel rich basal layer is considered the main aquifer source, and was found to be variable in terms of yields. In order to reflect the variability of this unit, a range of K values (hydraulic conductivities) were assigned based on the drilling results. This is further discussed in Section 4.3.3.

4.2.3 Conceptual hydrogeological model

Based on the two layer concept summarised above, a four layer numerical model is considered most appropriate to predict the potential cumulative impact of mine dewatering and water supply.

The proposed model thicknesses, hydraulic properties of each of the four layers and rationale for using a four layer model is discussed in Section 4.3.3. The four layer model has been graphically conceptualised and is presented as Figure 4-1.

4.3 Numerical model set up

4.3.1 Approach

The industry standard numerical groundwater flow modelling code MODFLOW-2005 (Harbaugh 2005) has been selected for modelling of groundwater flow for the Project. MODFLOW is widely used to assess groundwater effects relating to mine dewatering and groundwater abstraction.

Groundwater Modelling System (GMS v 10.1) has been used as a graphical user interface (GUI) for pre and post processing of the data.

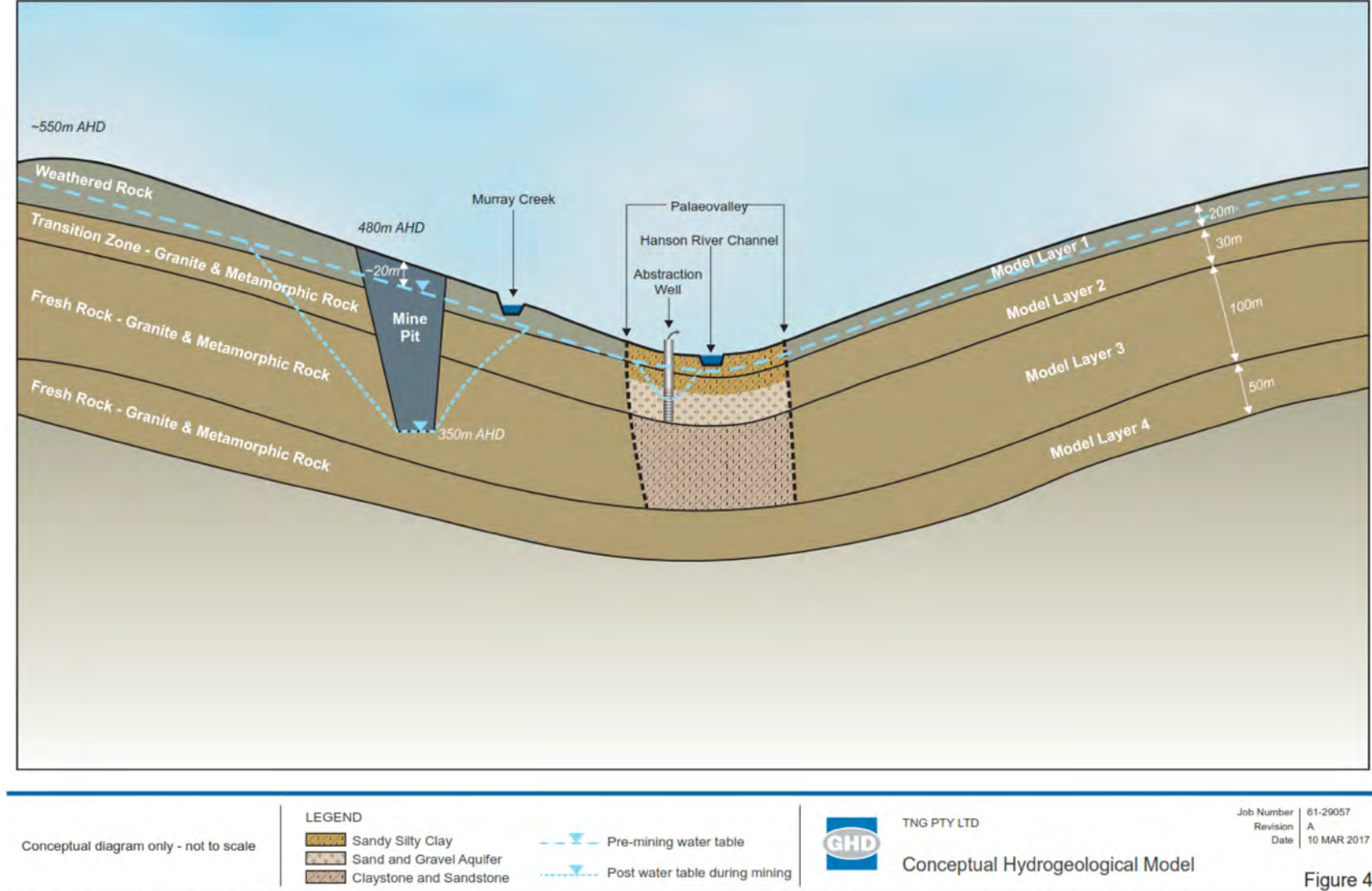
4.3.2 Model dimension, extent and grid design

A three-dimensional (3D) model has been chosen for this project, as groundwater flow is anticipated in all three directions. Whilst a one or two dimensional model could offer simplified results, taking into account the overall considerations of the project, a more detailed and defensible 3D model will better address the overall project requirements.

The model extends approximately 84 km in the east-west direction and 92 km in the north-south direction. The model extent is shown in Figure 4-2. The model extent was determined following consideration of the catchments, and an understanding of the site conceptual model. The model spatial extents are sufficiently large to allow assessment of potential impact at critical receptors, and to consider future model refinement if required during the operational stages of the Project.

A uniform grid size of 200 m was chosen throughout the model domain. The grid size produces 575 rows, 490 columns over 4 layers which results in a total of 1,127,000 grid cells. Of these, 776,304 are active cells within the modelled boundary.

Figure 4-1 Conceptual hydrogeological model



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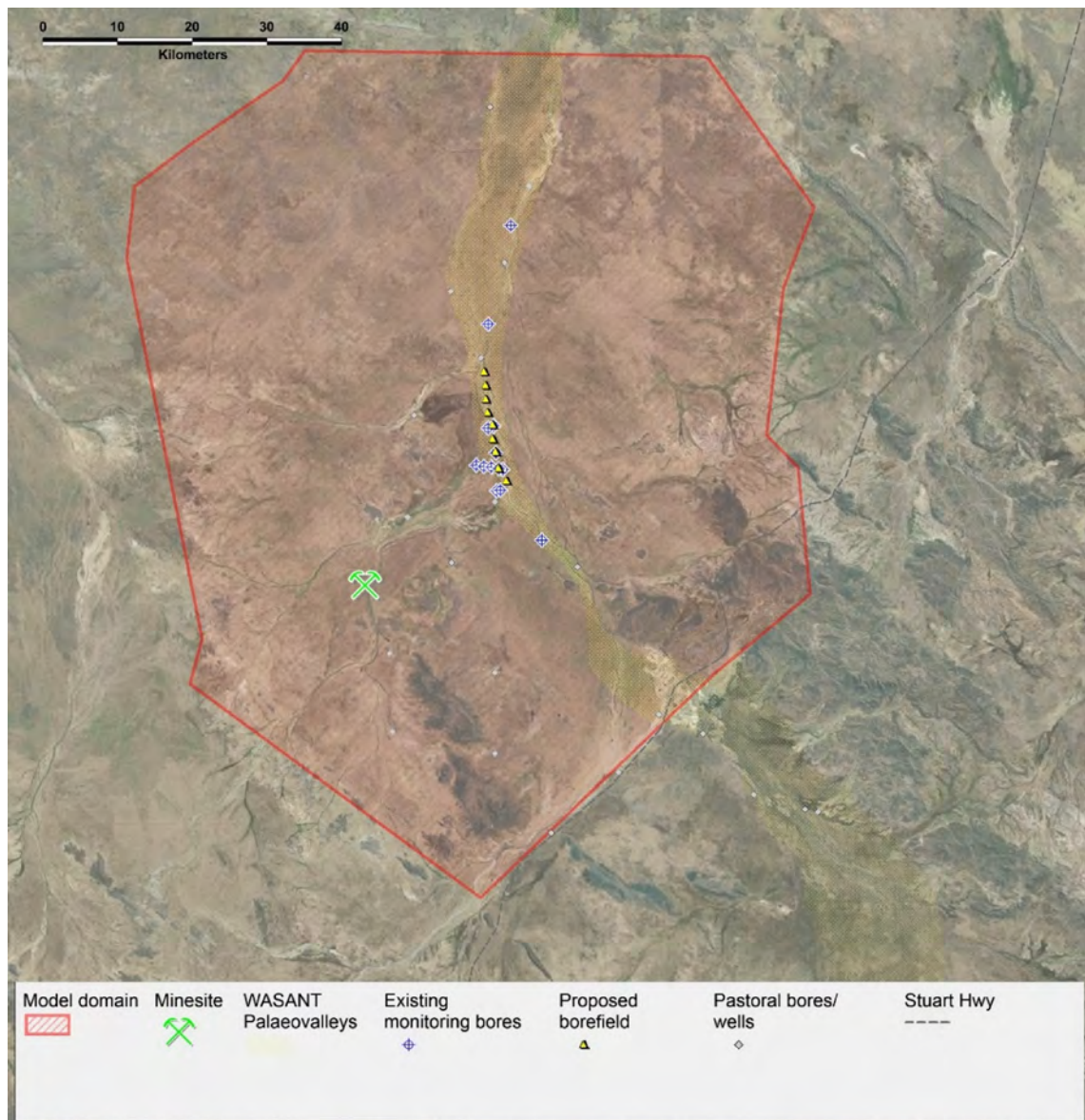


Figure 4-2 Groundwater model domain

4.3.3 Model layers

A four layer model has been developed to represent the geology and hydrogeology around the mine pit and palaeovalley as well as to account for the potential vertical flow coming from beneath the pit. The depth/thickness of each layer was determined following consideration of the hydrogeological conceptual model (Section 4.2) which included assessment of the following available information:

- Resource drilling within and around the mine site;
- Groundwater drilling and testing in the palaeovalley; and
- Lithology data from historic drilling within the model domain.

A summary of the layers and initial hydraulic properties of the units is presented in Table 4-1.

Table 4-1 Model layer and proposed initial hydraulic properties

Layer	Description	Outside Palaeovalley		Palaeovalley	
		Kh (m/d)	Kv (m/d)	Kh (m/d)	Kv (m/d)
Layer 1	Weathered bedrock outside palaeovalley and sandy silt layer in the palaeovalley.	0.1	0.01	0.5	0.05
Layer 2	Transition zone outside palaeovalley and lower sand and gravel aquifer in the palaeovalley	0.01	0.01	4.0 to 10	0.4 to 1.0
Layer 3	Fresh bedrock	0.002	0.002	0.002	0.002
Layer 4	Fresh bedrock	0.001	0.001	0.001	0.001

Within the palaeovalley area Layer 1 is represented by the upper sandy-silt layer. In areas outside of the palaeovalley, including the mine site, Layer 1 is represented by the weathered zone in the bedrock. Layer 1 has been modelled as 20 m thick based on the average thickness of the sandy silt and weathered zone layers.

Within the palaeovalley area Layer 2 represents the lower sand and gravel aquifer. This unit includes a zone of increased hydraulic conductivity to represent the area around production bore 16MPWB017 that was found to be high yielding. In areas outside of the palaeovalley, including the mine site, Layer 2 is represented by a transition zone between the weathered bedrock and fresh bedrock. Layer 2 has been modelled as 30 m thick based the average thickness of the sand and gravel aquifer in the palaeovalley area.

Layer 3 represents the basement sedimentary rock (claystone/sandstone) in the palaeovalley area and the fresh bedrock (igneous and metamorphic) in the area outside of the palaeovalley. Layer 3 has been assigned a nominal thickness of 100 m to capture the base of the proposed mine pit.

Layer 4 represents fresh bedrock throughout the model domain in order to account for the potential vertical flow into the proposed mine pit. A nominal thickness of the 50 m has been assigned for this layer.

The model base elevation has been derived from the topographic data by subtracting appropriate thickness for each of the four model layers from the topographic elevation. The topography elevation is based on SRTM-derived 1-second (near mine site with 1 km buffer) and 9-second (outside of the mine) Digital Elevation Models.

4.3.4 Recharge

Recharge of the aquifer is expected to vary across the model domain in response to the varying soil properties. It is noted that during flood events of the Hanson River significant volumes of surface water would likely infiltrate to groundwater, recharging the aquifer. However, due to the periodic nature of these events, and lack of monitoring within the Hanson River, these events are not included in the model recharge.

The recharge concept used for modelling separates the model domain into the following zones:

- **active Hanson River channel:** area of highest recharge due to relative high conductivities of the upper layer;
- **confluence zones of Hanson River:** increased recharge in areas of inflow from tributaries of the Hanson, for example the area of inflow from Bloodwood Creek and Murray Creek;
- **the general extent of the palaeovalley:** the remaining extent of the palaeovalley; and
- **remaining model area, including mine site** – area of lowest recharge due to poorly conductive surface layer.

The recharge rates for the above zones are estimated during model calibration. Rates used are conservative and less than 1% of the total annual average rainfall volume. This is further discussed in Section 5.3.

4.3.5 Boundary conditions

The following boundary conditions are applied in the model:

- **Eastern and western boundaries:** No-flow in all layers. This assumes no groundwater is either flowing in or out of the model along these boundaries, with flow perpendicular to the boundary;
- **Southern boundary:** Constant Head Boundary (CHB) condition in all layers in the area of the palaeovalley and in the area of the Hanson River in the south west corner of the model domain. This represents groundwater inflow from the Ti Tree Basin and no-flow boundary to the rest of the area; and
- **Northern boundary:** CHB in all layers. This represents groundwater outflow from the model domain to the north in the area of palaeovalley and no-flow boundary to the rest of the area.

The head values applied in the Constant Head Boundary are approximately 10 m below topography in the palaeovalley area, which are reflective of the known average groundwater levels in this area.

4.3.6 Temporal discretisation

No temporal discretisation is needed for a steady state model. The transient model which is used to predict the impact of groundwater pumping from the palaeovalley and mine pit development is assigned with stress periods ranging from 1 year (with 12 time steps) to 60 years (with 30 time steps) and are discussed further in the Section 6.1.

4.3.7 Initial conditions

For the steady state model runs, initial conditions are assigned as topographic elevations, to provide the model with an initial estimate which are subsequently changed during model calibration. For all transient simulations, the initial heads are derived from the corresponding steady state simulations.

5. Model calibration

5.1 Introduction

Model calibration is the process in which model parameters are adjusted until model predictions fit historical measurements or observations. This is required in order that the model can be accepted as a good representation of the physical system of interest. This process is also known as model fitting, history matching, parameter estimation and the inverse problem. Calibration is generally followed by sensitivity analysis to test robustness of the model to changes in parameters during the calibration (Barnet *et al.* 2012).

Following the steady state calibration a sensitivity analysis on model parameters is generally undertaken to provide a realistic bounds of parameters to be used in the prediction and uncertainty analysis.

5.2 Steady state flow model calibration

During the steady state calibration, model parameters and boundary conditions were changed to match the measured head with the modelled head.

The steady state model calibration was undertaken by trial and error (also known as manual calibration) by changing the recharge and boundary conditions.

5.3 Steady state flow model calibration results

After calibration the combinations of recharge and boundary conditions identified in Table 5-1 provided a reasonable fit between observed head with modelled head. The calibration statistics and modelled water balance from the steady state calibration are provided in Table 5-2 and Table 5-3 respectively.

Table 5-1 Recharge and boundary conditions from steady state calibration

Model Run ID	Recharge rate mm/year (% of average annual rainfall) ²			Constant head boundary elevation in palaeovalley (m AHD) ³	
	Current Hanson River channel	Palaeovalley	Weathered zone	Southern boundary	Northern boundary
Cum_5_009	1.3 (0.36%)	0.5 (0.14%) to 2.6 (0.72%)	0.005 (0.002%)	470	385

Table 5-2 Calibration statistics from the steady state model calibration

Model run ID	Absolute residual mean (m)	Root Mean Squared (m)	SRMS (%) ⁴	Mass balance error (%)	Maximum residual (m)
Cum_5_009	-0.77	1.38	3.3	<0.1	5.5

² Stirling station (no 15572) with an average annual rainfall of 355 mm was used in the calculation of rainfall recharge %

³ Constant head boundary head values were assigned to 510 m AHD outside of the palaeovalley area to account for groundwater inflow into the model domain

⁴ SRMS (%) stands for scaled root mean square error and values below 5 to 10% are considered appropriate for a model calibration

Table 5-3 Calibration statistics from the steady state model calibration

Water Balance Component	Inflow (m ³ /d)	Outflow (m ³ /d)
Recharge	1199	0
Constant head boundary	89	1288
Total	1288	1288
Water Balance Error	0.01	

As shown in Table 5-1, recharge rates were applied to each zone (as discussed in Section 4.3.4) to account for the different settings of the various areas within the model boundary. Lowest recharge rates were used in the areas outside of the palaeovalley, with an adopted rate of 0.005 mm/year. Within the palaeovalley, three recharge rates were used with a slightly higher rate (1.3 mm/year) applied to the active channel in comparison to the extent of the general palaeovalley (0.5 mm/year), and high recharge zone of 2.6 mm/year has been applied near the confluence of Hansen River and its major tributaries.

As discussed in Section 4.3.4, It should be noted that these recharge rates are considered as conservative estimates (in terms of assessing the impact due to abstraction) with consideration to the palaeovalley aquifer system, as they do not include any losses of surface water to the aquifer from river flow. During periodic flood events of the Hanson River, it is expected that significant volumes of surface water would infiltrate to groundwater. However, due to the periodic nature of these events, and lack of monitoring within the Hanson River, these events are not included in the model/recharge estimates.

A scatter plot showing computed versus observed head is presented in Figure 5-1. Groundwater contours for the steady state model calibration are presented in Figure 5-2. The steady state modelled groundwater contours (initial conditions) highlight a generally consistent groundwater gradient across the model domain, with groundwater elevations increasing with distance to the south (i.e. groundwater flowing in a northerly direction). Over the model domain, head differences are over 100 m between the southern inflow areas and the northern outflow areas (over a distance of around 110 km).

When the head values are compared to the topographic elevation data, depth to groundwater is generally around 10 m in the area of the palaeovalley, and increases with distance from the palaeovalley. Of note, depth to groundwater in the area of Mud Hut Swamp is modelled as being around 15 to 20 m below ground level (i.e. conceptually the swamp is not connected to the regional groundwater system).

As shown in Table 5-3, the main input/inflow into the model is rainfall recharge which contributes approximately 93% (1199 m³/d) of the total inflow of 1288 m³/d, followed by inflow from the constant head boundary located to the south (representing groundwater inflow into the model from the Ti Tree Basin which contributes approximately 7% (89 m³/d) of the total inflow. The main output/outflow from the model is via a constant head boundary located to the north which takes 100% of the total outflow of 1288 m³/d. The overall water balance error in the model was approximately 0.01% which is within the recommended guideline value of less than 1% (Barnet *et al.* 2012).

According to Barnet *et al.* (2012) a models acceptance should be based on a number of measures that are not specifically related to model calibration. These are required to demonstrate that a model is robust, simulates the water balance as required and is consistent with the conceptual model on which it is based. The performance measures of the steady state calibration are provided in Table 5-4.

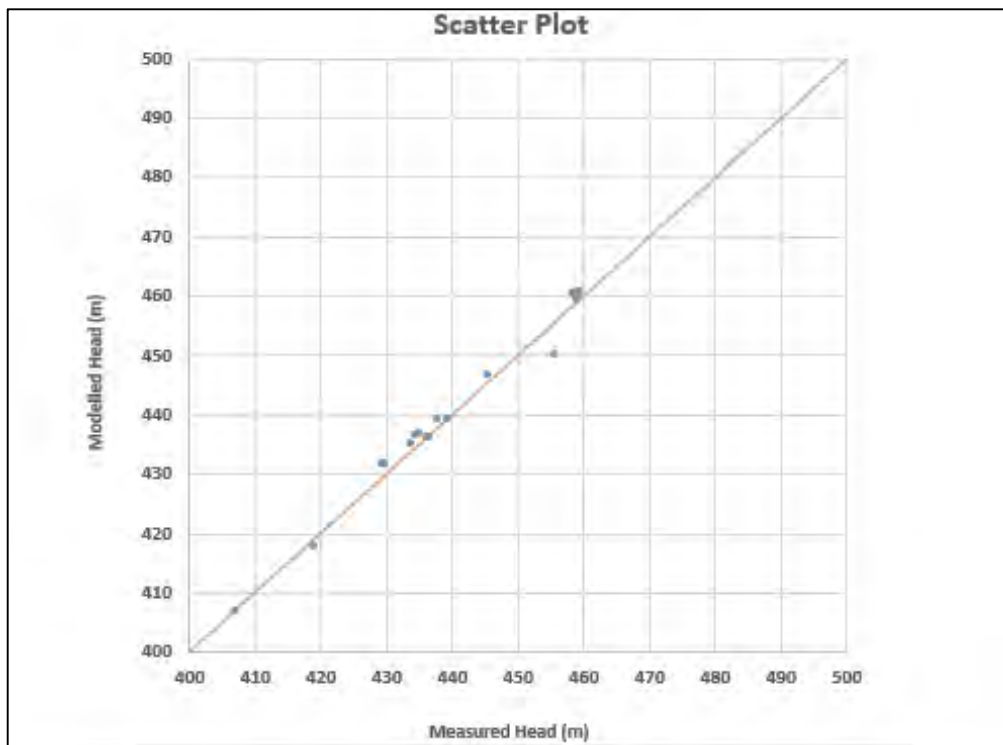


Figure 5-1 Modelled versus observed groundwater head (mAHD)

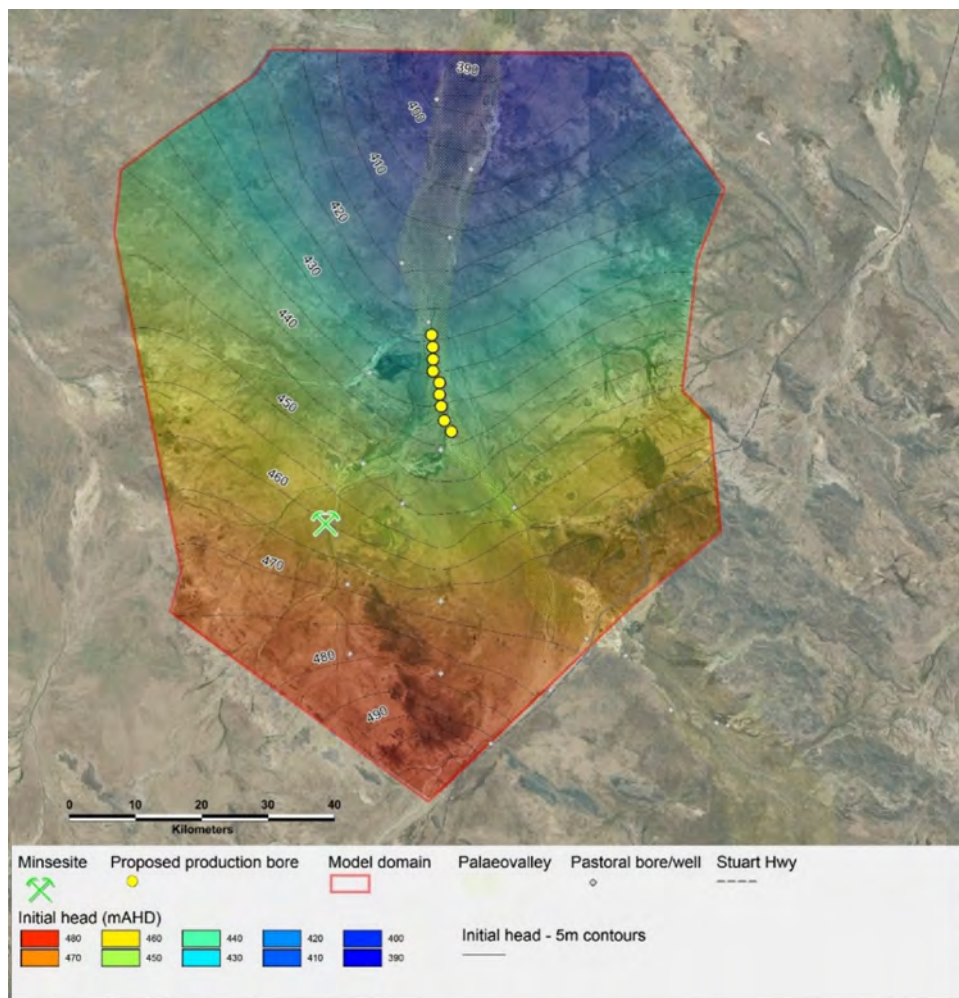


Figure 5-2 Steady state modelled groundwater contours (initial conditions)

Table 5-4 Performance measures of steady state calibration-

Performance measure	Criteria	Criteria met (yes/no)
Model convergence: The model must converge in the sense that the maximum change in heads between iterations is acceptably small.	The iteration convergence criteria should be one or two orders smaller than the level of accuracy required in the head prediction. Typically of the order of centimetres or millimetres.	Yes: Convergence criteria used in the model was 0.001 m.
Water balance: The model must demonstrate an accurate water balance, at all times and in steady state.	A value of less than 1% should be achieved and reported.	Yes: Water balance error was approximately 0.01%.
Qualitative measures: The model results must make sense and be consistent with the conceptual model. Contours of heads, estimated parameters must make sense, and be consistent with the conceptual model with expectations based on similar hydrogeological setting	There is no specific measure of success. A subjective assessment is required as to the reasonableness of model results, relative to observations and expectations.	Yes: Modelled steady state contours show a small hydraulic gradient (0.001) towards the north, this is in line with current conceptual understanding of the area. The aquifer parameters are within the expected range of each of the lithological units.
Quantitative measures: The goodness of fit between the model and historical measurements can be quantified, using statistics such as RMS, SRMS, MSR and SMSR for trial-and-error calibration and objective function in automated calibration.	Quantitative measures only apply during calibration. Statistics of goodness of fit are useful descriptors but should not necessarily be used to define targets. Targets such as SRMS <5% or SRMS <10% may be useful if model is similar to other existing models and there is good reason to believe that the target is achievable.	Yes: SRMS was 3.3% which is less than 5% with relatively low value (1.38 m) of RMS. The maximum residual error was 5.5 m, at one location of Boko Bore, given the potential for error in measured groundwater elevation using STRM data, this error is not considered significant

5.4 Numerical model calibration conclusion

Since the steady state model has met the criteria for model convergence, water balance, qualitative measures and quantitative measures, the flow model can be considered calibrated and can be used in prediction.

6. Model prediction

6.1 Simulation scenarios

Following successful calibration in steady state, the model was used to predict the operation of the Project area, including mine pit development and operation of the borefield.

The aquifer parameters used in the predictive model were derived from the aquifer testing, steady state calibration and a likely range of the parameters based on past experience and literature values of similar formations. The storage parameters used are presented in Table 6-1. The hydraulic conductivity and recharge values used in the prediction are the same as those used in the steady state calibration as presented in Table 4-1 and Table 5-1 respectively.

Table 6-1 Storage parameters used in the prediction⁵

Layer	Description	Outside palaeovalley		Palaeovalley	
		Ss	Sy	Ss	Sy
1	Weathered bedrock outside palaeovalley, and sandy silt layer in the palaeovalley.	1E-5	0.01	1E-5	0.05
2	Transition zone outside palaeovalley and, lower sand and gravel aquifer in the palaeovalley	1E-5	0.005	1E-5	0.1
3	Fresh bedrock	1E-5	0.001	1E-5	0.001
4	Fresh bedrock	1E-5	0.001	1E-5	0.001

A transient prediction run was undertaken to model cumulative impacts from the borefield operation and the mine pit development. The scenario represents the operation of the borefield in the palaeovalley and development of the mine pit. The mine pit is modelled with incremental pit advancement between year 1 and 17.

The transient prediction model was run for 100 years. This includes two stages of borefield operation over a period of 17 years. Stage 1 (year 1 to 4) borefield operation is at an abstraction rate of 1.6 GL/year (51 L/s) from a total of 6 active bores. Stage 2 (from year 5 to 17) borefield operation is at an abstraction rate of 2.6 GL/year (82 L/s) from a total of 9 active bores.

Following cessation of mining, borefield abstraction stops and the model is run for a further 83 years to predict groundwater level recovery in the palaeovalley and surrounding the pit.

This model has been set up with annual stress periods for the first 20 years with each stress period comprising 12 time steps followed by two stress periods of 10 year duration (with 10 time steps each) and the last stress period of 60 years duration with 20 time steps.

6.2 Simulation results

6.2.1 During mining – Stage 1 (years 1-4)

For Stage 1 borefield operation, a total of six active production bores are simulated. This includes a bore (16MPWB017) being operated at 15 L/s and the remaining five bores operating at 7.1 L/s.

⁵ Ss: Specific Storage (1/m), Sy: denotes Specific Yield

Transient model drawdown impacts are illustrated for the end of Stage 1 in year 4 on Figure 6-1. Drawdown profiles for the borefield are presented on Figure 6-2 which shows the drawdown in metres along the length of the Hanson River channel. As illustrated by Figure 6-1 and Figure 6-2, at the end of Stage 1 a drawdown more than 1 m is only occurring in the immediate region of the borefield and palaeovalley.

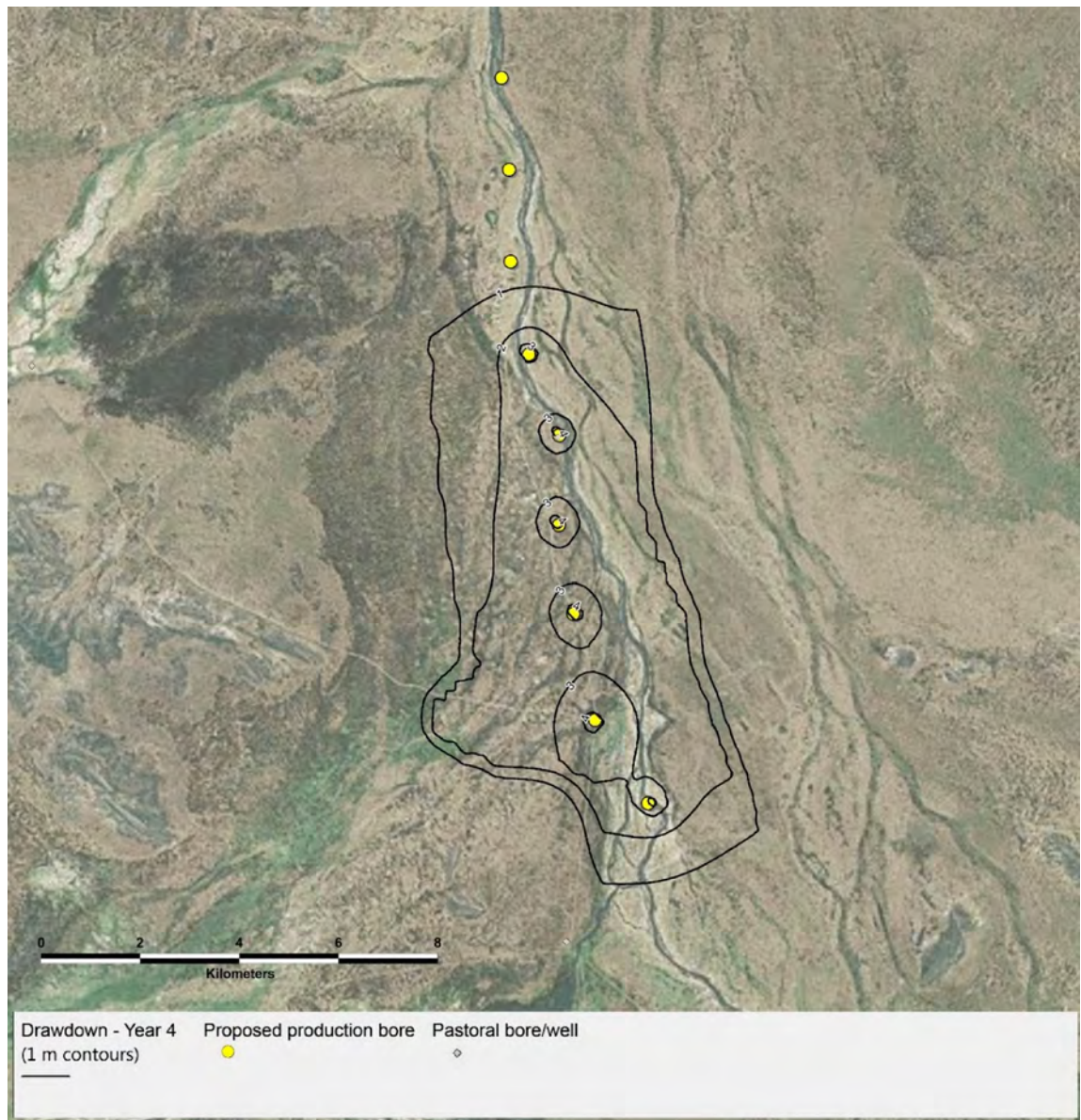


Figure 6-1 Simulated transient groundwater levels for end of Stage 1 (year 4)

A maximum drawdown of less than 5 m is predicted to occur in the region of the six active production bores. This is the maximum drawdown predicted for the grid cell (cell size 200 m²), therefore drawdown greater than this may occur immediately adjacent to the active abstraction bores. Analysis of the data from the 11 day constant rate test for monitoring bore 16MPWB007 which is located 13 m from 16MPWB017 confirms the drawdown estimate, with around 4 m of total drawdown predicted by forward plotting the monitoring bore drawdown, albeit at slightly higher pumping rate used during the test (18 L/s), but with no cumulative effect from multiple pumping bores.

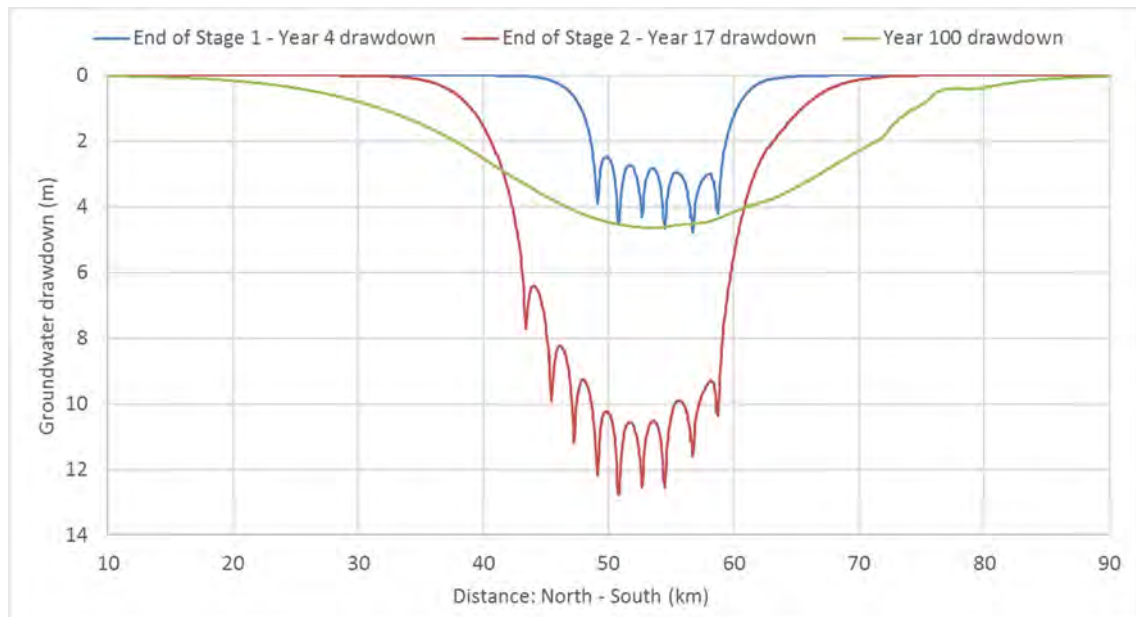


Figure 6-2 Drawdown profile – Hanson River alignment

The extent of drawdown at the end of Stage 1 is limited to the palaeovalley, with up to 1 m drawdown extending to around 1.8 km south of the borefield, and 1.5 km north of the borefield. Predicted drawdowns at the existing pastoral bores are presented as Table 6-2. This data shows that at the end of Stage 1 (4 years of borefield operation), Browns Well will be impacted by 0.1 m of drawdown, and Middle Well (inactive) by 3.9 m of drawdown. Middle Well is located immediately adjacent to the proposed operational bore 16MPWB05.

Table 6-2 Modelled drawdown at pastoral bores/wells

Bore/well	Distance from mine ⁶	Distance from borefield ⁷	Transient drawdown (4 yrs)	Transient drawdown (17 yrs)	Transient drawdown (100 yrs)
Mudhut Bore	9	14	<0.05	<0.05 m	<0.05 m
Boko Bore	11	12	<0.05 m	<0.05 m	<0.05 m
Browns Well	19	2	0.1	2.2 m	3.9
Wollogolong Bore	33	2	<0.05 m	2.9 m	2.9 m
Middle Well (inactive)	28	0	3.9	12.0 m	4.5 m
Mt Peake Creek Bore	22	9	<0.05 m	<0.05 m	<0.05 m
Mistake Bore	20	24	<0.05 m	<0.05 m	<0.05 m
Junction Well	28	14	<0.05 m	<0.05 m	1.3 m
Twin Soak Bore	45	15	<0.05 m	<0.05 m	0.7 m

The water balance at the end of stage 1 borefield operation is presented as Table 6-3. The data highlights that the majority of water abstracted from the bores is coming from storage within the aquifer, and not from either throughflow or rainfall recharge.

⁶ Distance from centroid of drawdown cone at mine (km)

⁷ Distance from centroid of drawdown cone at borefield (km)

Table 6-3 Water Balance at the End of Stage 1 (year 4)

Water Balance Component	Inflow (m ³ /d)	Outflow (m ³ /d)
Storage	4387	0
Recharge	1199	0
Constant head boundary	89	1288
Abstraction bores		4386
Total	5675	5674
Water Balance Error	0.02%	

6.2.2 During mining – Stage 2 (years 5-17)

For Stage 2 borefield operation, a total of nine active production bores are simulated. This includes a bore (16MPWB017) being operated at 15 L/s and the remaining eight bores operating at 8.4 L/s.

Transient model drawdown impacts are illustrated for the end of Stage 2 in year 17 on Figure 6-3 for the area of the mine pit, and Figure 6-4 for the area of the borefield. Drawdown profiles for the borefield and mine site are presented on Figure 6-2 (borefield) and Figure 6-5 (mine site and borefield) which shows the drawdown in metres along the length of the Hanson River channel and west east through the mine site and borefield respectively.

As illustrated by Figure 6-3 and Figure 6-5, at the end of Stage 2, due to the depth of excavation within the mine pit, mining dewatering has resulted in drawdown of up to 80 m in the area immediately around the areas of the deepest part of mining. Dewatering within the pit is to be facilitated through use of in-pit sumps, therefore the areas of dewatering impact will largely mimic the outline of the pit. The modelled extent of drawdown resulting from pit dewatering is relatively limited to areas close to the pit, with drawdown more than 1 m modelled to occur to a maximum distance from the pit of around 1.3 km to the east and west of the pit. This includes drawdown of up to 10 m at the western side of Murray Creek. Due to the relatively localised drawdown, no drawdown impacts at 17 years are expected within the area of proximate receptors such as Mud Hut Swamp.

As illustrated by Figure 6-4 and Figure 6-2, drawdown within the borefield area is modelled as being up to 12 m at the location of the operating bores in the centre of the borefield. Drawdown decreases significantly with distance away from the palaeovalley. The 1 m drawdown contour extends to around 6.5 km south of the borefield, and 4.8 north of the borefield. The extent of drawdown is a considerable distance away (approximately 28 km for the modelled 1 m drawdown) from the inflow zone around Stirling Swamp.

The predicted drawdowns at the existing pastoral bores for the end of mining (year 17) are presented as Table 6-2. The data indicates that the inactive Middle Well, located adjacent to an active production bore, will experience up to 12 m drawdown. The only active bores that are impacted are those two closest to the borefield; Browns Well and Wollogolong Bore are modelled to be impacted by 2.2 m and 2.9 m of drawdown respectively.

The water balance at the end of stage 2 borefield operation is presented in Table 6-4. As presented in Table 6-4, the main input in to the model is via storage which accounts for 85% (7244 m³/d) of the total input followed by recharge 14% (1199 m³/d). The main output from the model is via groundwater abstraction (bores) which account for 83% (7120 m³/d) followed by constant head boundary 15% (1288 m³/d). The mine-pit accounts for only 1% (124 m³/d) of the total water balance.

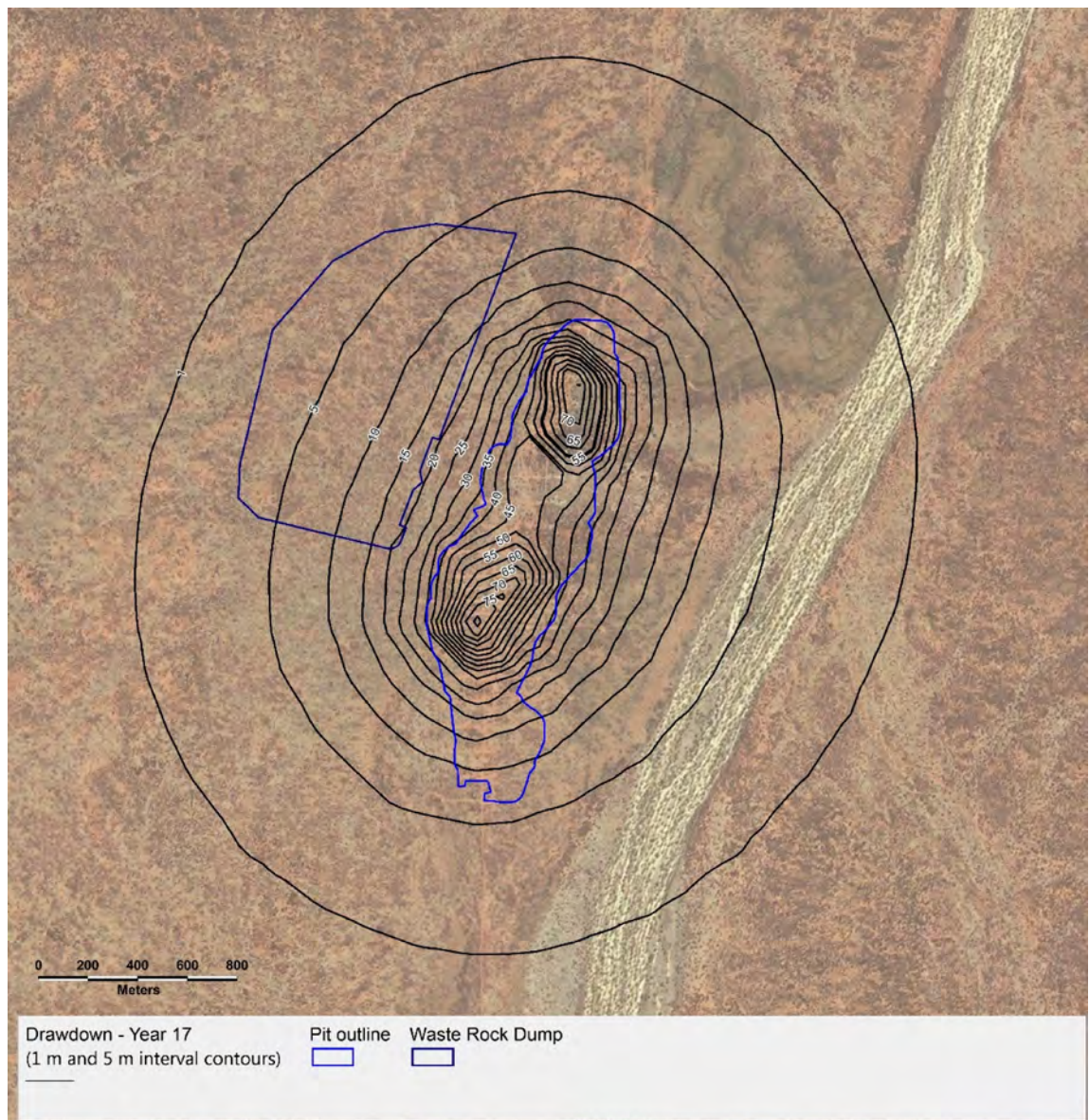


Figure 6-3 Simulated transient groundwater drawdown – mine site at 17 years (contours 1 m and 5 m intervals)

The data highlights that the majority of water abstracted from the bores is coming from storage within the aquifer, and not from either throughflow or rainfall recharge. Also, it should be noted that constant head boundary inflow and outflow remains the same with comparison to the steady state simulations, this also indicates that no impact reaches the model inflow/outflow boundaries.

Plots for groundwater level changes over time (hydrographs) are presented in Figure 6-6 and Figure 6-7 which represent drawdown and recovery at a location between pumping bores and at a location on the edge of the palaeovalley aquifer respectively. As illustrated by these figures, groundwater levels are slow to recover, largely due to the modelling of conservatively low levels of recharge. For locations outside of the palaeovalley, some minor increased drawdown is expected after cessation of abstraction.

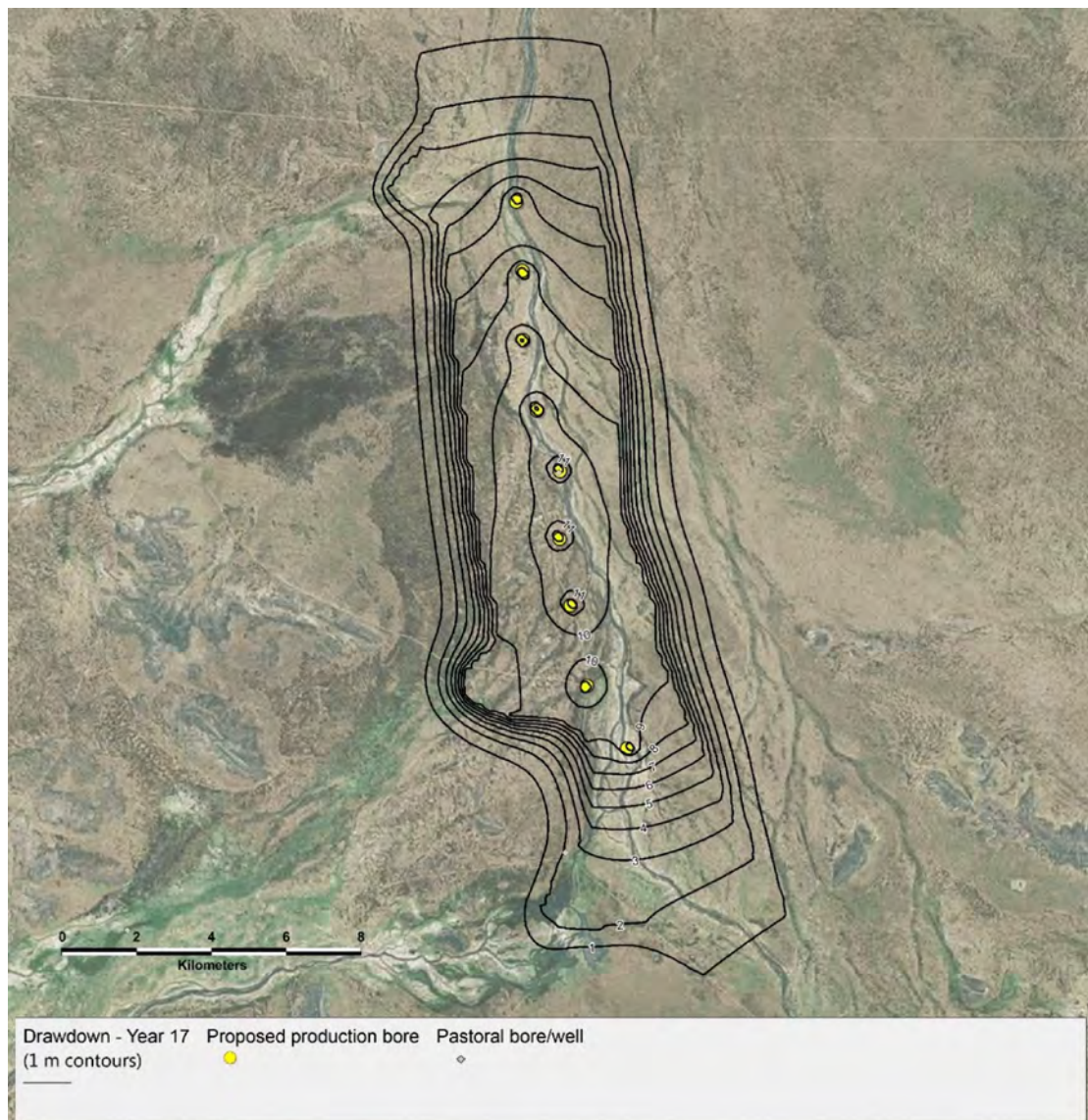


Figure 6-4 Simulated transient groundwater drawdown – borefield at 17 years

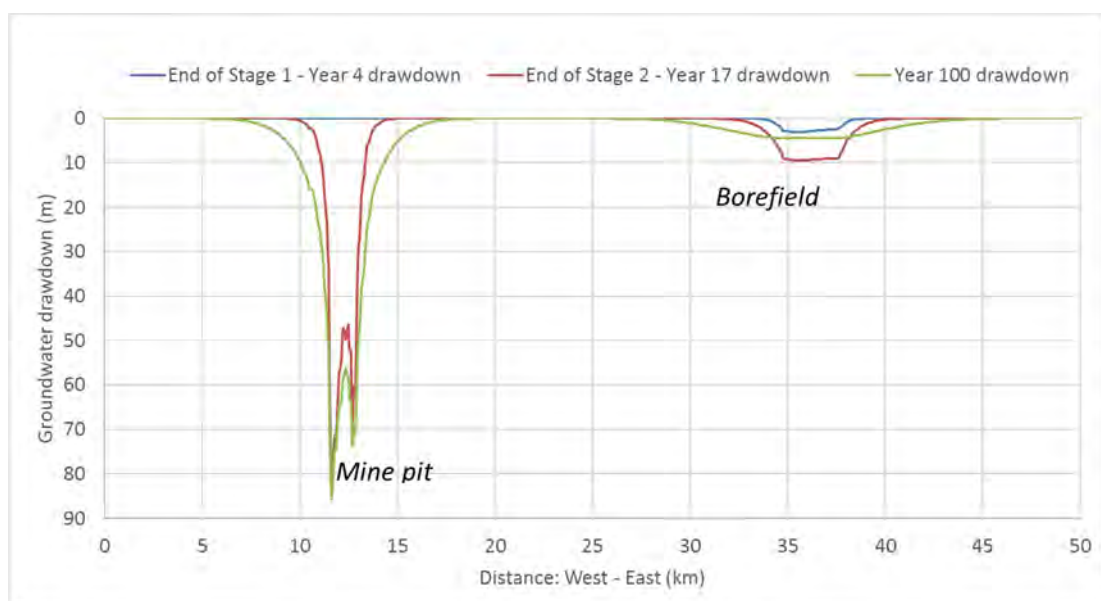


Figure 6-5 Drawdown profile – West-east alignment through minesite and borefield

Table 6-4 Water Balance at the End of Stage 2 (year 17)

Water Balance Component	Inflow (m ³ /d)	Outflow (m ³ /d)
Storage	7244	0
Recharge	1199	0
Constant head boundary	89	1288
Abstraction bores	0	7120
Mine pit	0	124
Total	8532	8532
Water Balance Error	0.01	

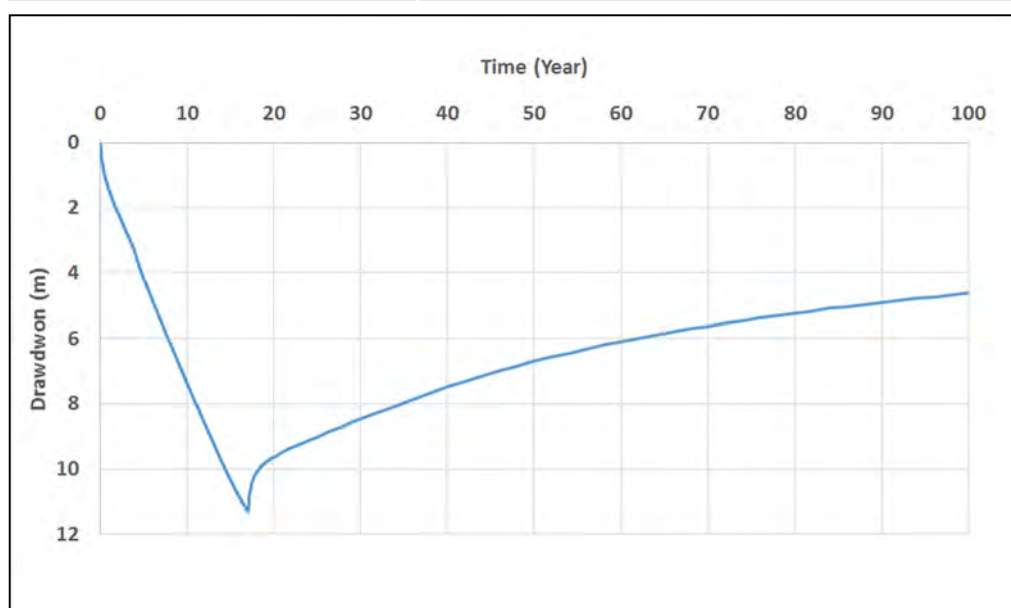


Figure 6-6 Drawdown and recovery between two pumping bores

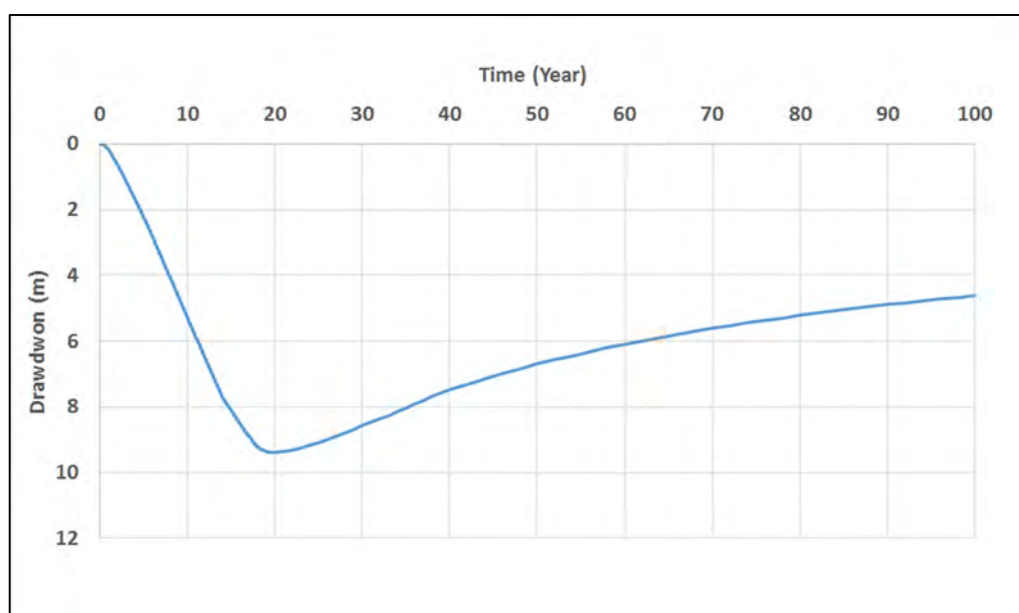


Figure 6-7 Drawdown and recovery at edge of palaeovalley aquifer

6.2.3 Post mining – 100 years

Transient model drawdown impacts are illustrated for year 100 on Figure 6-8. The 100 year drawdown plot represents the drawdown and subsequent recovery at the borefield and drawdown around the pit after cessation of mining/abstraction for 83 years.

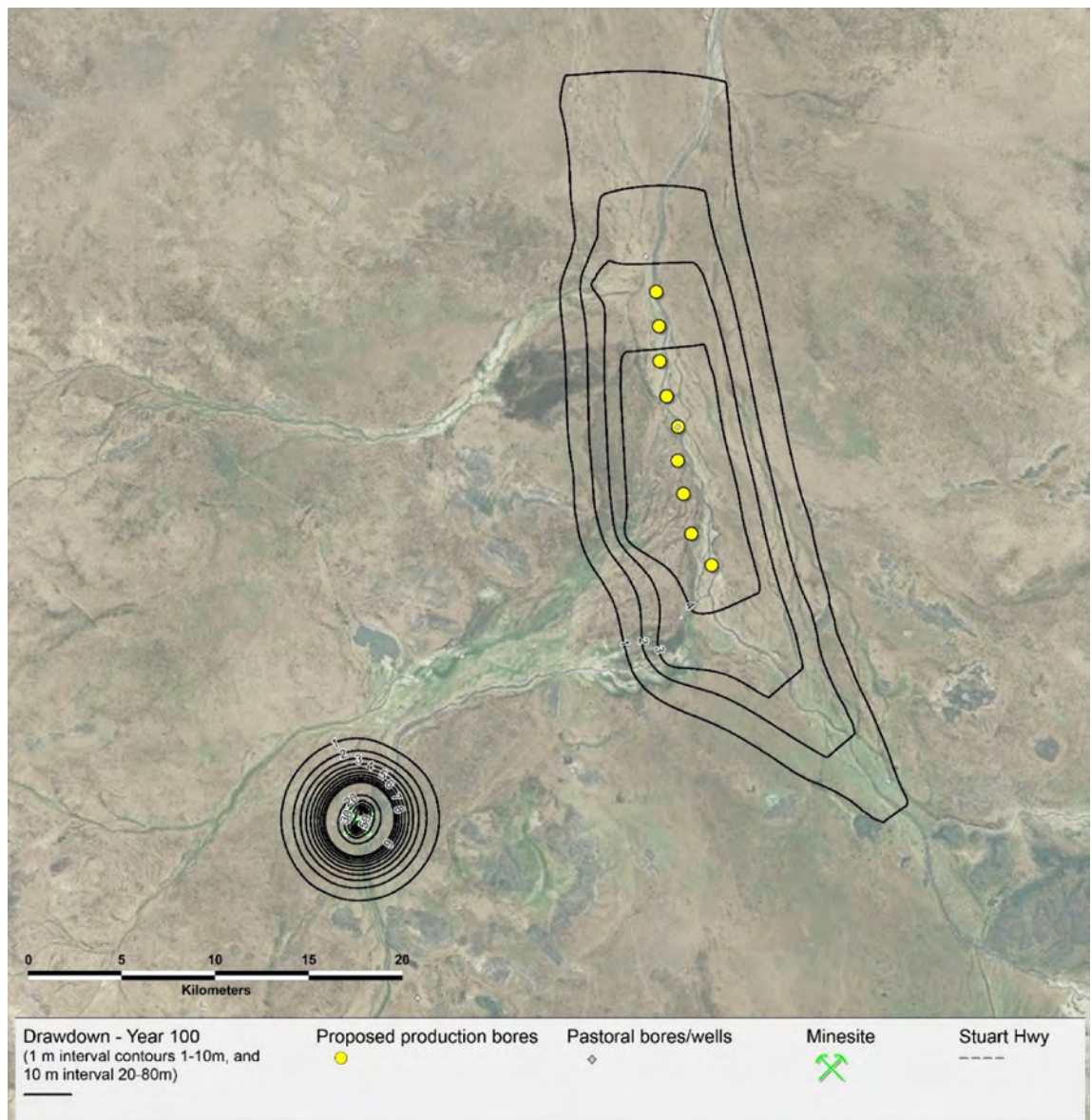


Figure 6-8 Drawdown at 100 years

At 100 years, the drawdown within the area of the borefield has recovered from a maximum drawdown at 17 years, to a 100 year drawdown of generally less than 4.5 m. Whereas the amount of drawdown near the borefield is reduced, the extent of drawdown increases slightly as groundwater from storage drains to the area of the recovering borefield.

In the area of the minesite, the extent of drawdown increases slightly with respect to the 17 year drawdown. The 1 m drawdown contour extends to around 4 km from the mine pit. This indicates that impacts at 100 years are unlikely to reach the area of Mud Hut Swamp, which is located 8 km north of the mine pit.

6.3 Sensitivity / scenario analyses

The following sensitivity / scenario analyses have been undertaken to demonstrate the appropriateness of the adopted modelling approach.

6.3.1 No recharge for 12 years

The calibrated transient model was run with no recharge applied for the first 12 years and then an average rate applied after this period. This was to demonstrate what impact a significant reduction in rainfall may have on the modelling results/water supply.

The results for modelling show that there is:

- No significant difference between the no-recharge and recharge scenarios with regards to the extent of drawdown at 17 years or 100 years;
- A maximum of 0.10 m and 0.25 m further reduction in water level at the edge and in the middle of the palaeovalley aquifer respectively at the end of stage 2 (Figure 6-9); and
- A maximum 0.20 m further reduction in water level in the aquifer at 100 years (Figure 6-10).

These further reductions in water levels are considered insignificant in comparison to the magnitude of the drawdown predicted by the base case scenario. As demonstrated by Table 6-4 the majority of the abstracted water comes from storage within the aquifer, hence, the overall impact associated with no recharge for 12 years can be considered insignificant.

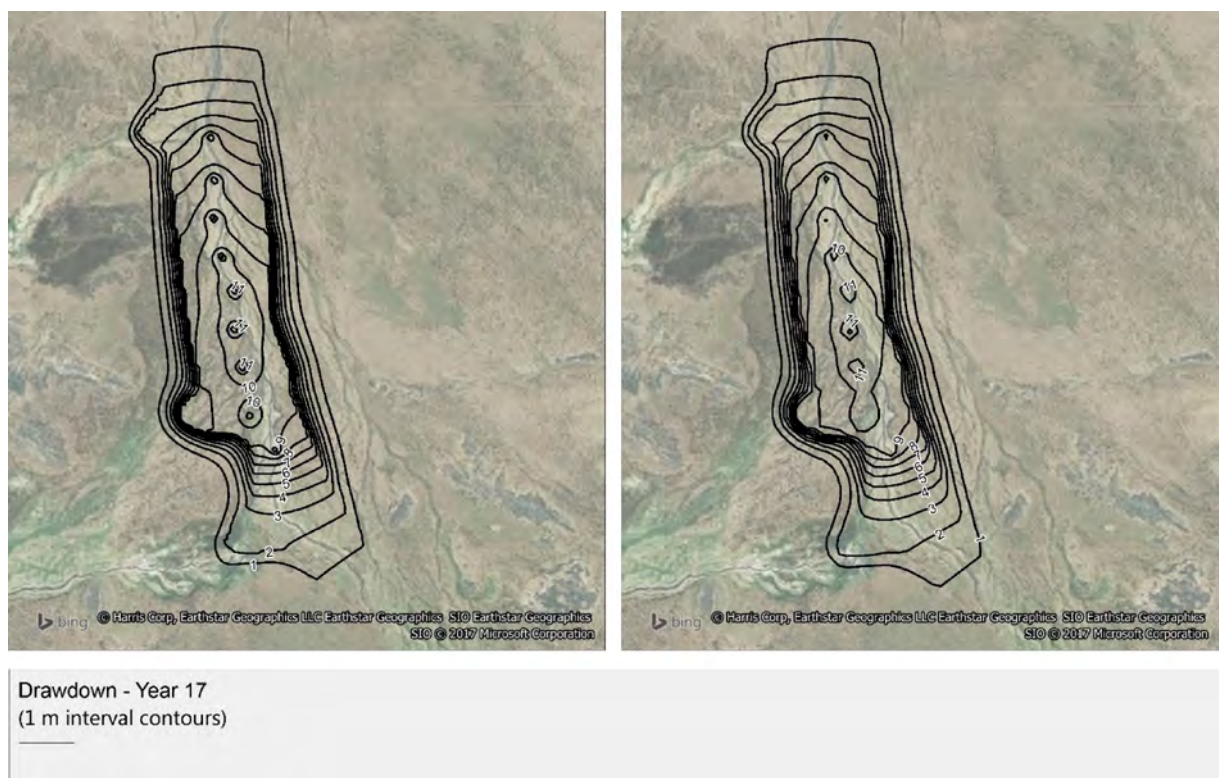
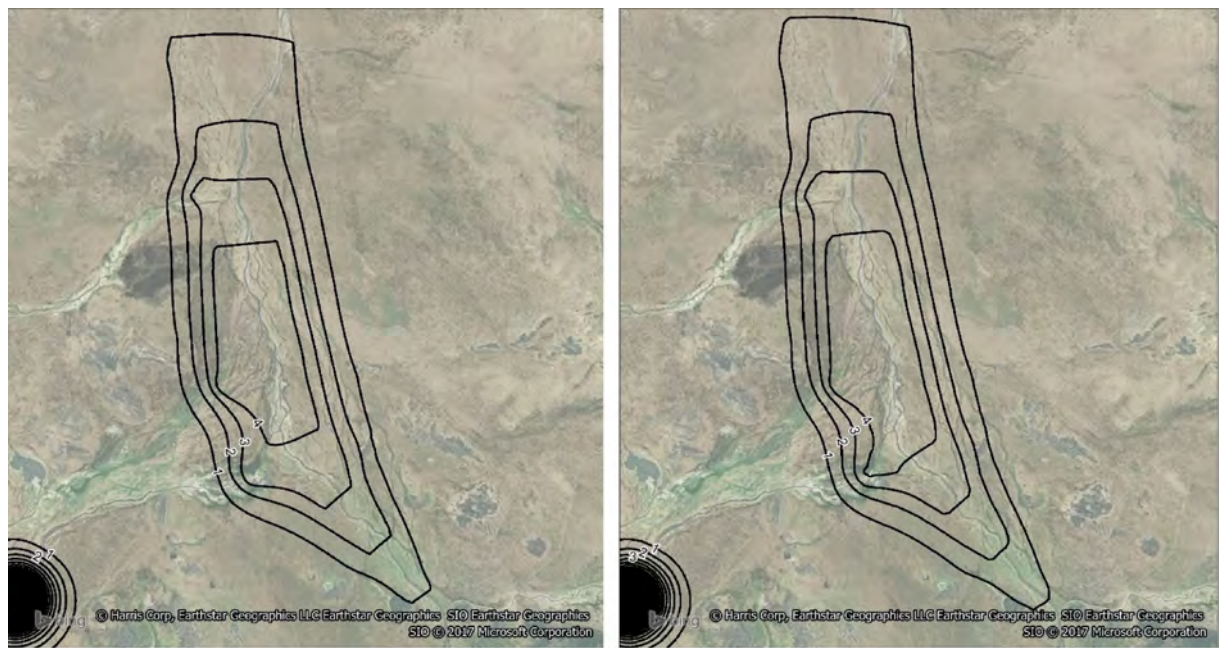


Figure 6-9 Drawdown at 17 years – comparison with recharge (left) and no recharge for 12 years (right)



Drawdown - Year 100
(1 m interval contours)

Figure 6-10 Drawdown at 100 years – comparison with recharge (left) and no recharge for 12 years (right)

6.3.2 Constant head boundary (inflow boundary) lowered by 0.7 m

The calibrated transient model was run with the constant head boundary to the south lowered by 0.7 m to 469.3 mAHD (from the base case head of 470 mAHD). This was completed to highlight what impact a reduced flow from the Ti Tree basin may have on the model.

The results for modelling show that:

- There is no additional drawdown within the proposed borefield and borefield-related impact area in Stage 2 or 100 years into the future (Figure 6-11); and
- There is no further reduction in water level in the borefield area due to lowering of the head to the south. The constant head boundary provides insignificant input (less than 1% of the overall flow) to the abstraction, hence the overall impact associated with lowering boundary conditions by 0.7 m can be considered insignificant.

The data does highlight the lack of connection of the borefield to the lower Hanson River palaeovalley and consequently the area of Stirling Swamp/Ti Tree outflow. As illustrated by Figure 6-11, the 0.7 m head reduction results in the 0.5 m drawdown contour extending from the model boundary by around 10 km, but not far enough to merge with the borefield drawdown.

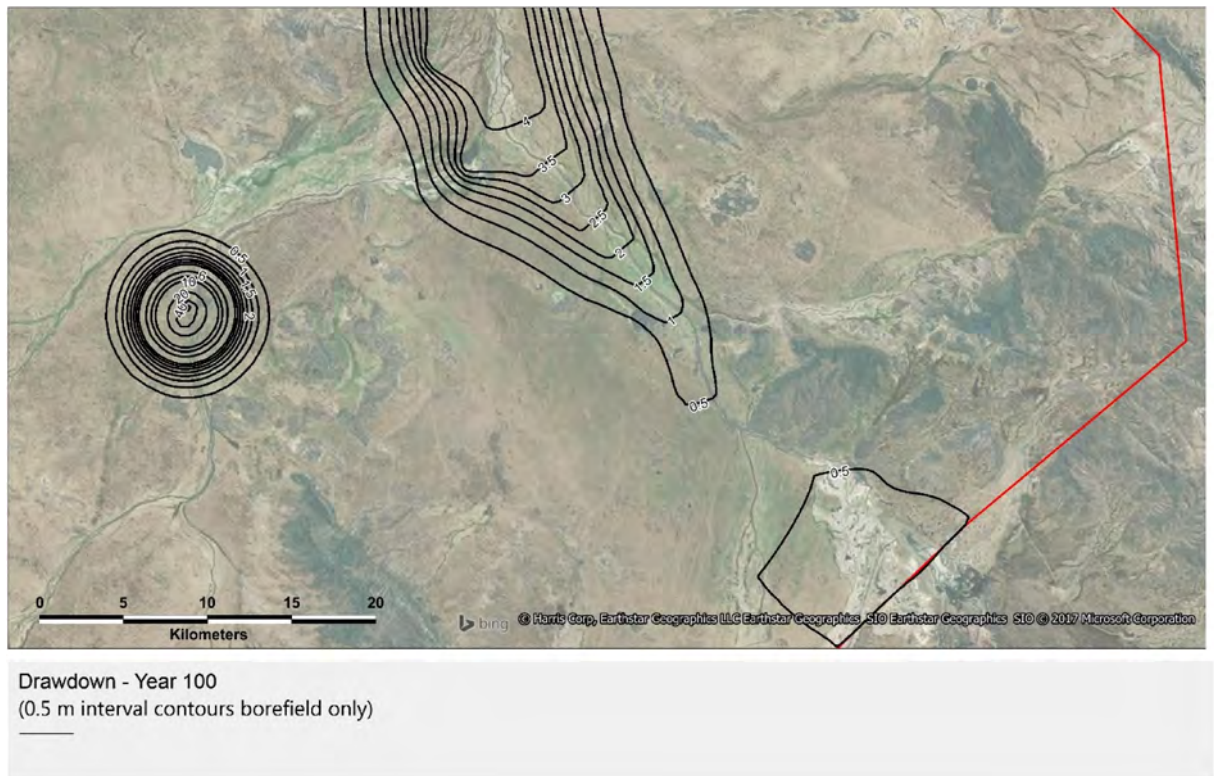


Figure 6-11 100 year drawdown contours – reduced head by 0.7 m at southern boundary

6.4 Pit lake development

Following the completion of mining at 17 years any in-pit dewatering will cease which will result in groundwater ingress to the pit void. The predicted inflow to the pit is expected to be relatively low, reflective of the low permeability of the pit wall.

Modelling data indicates that groundwater inflow at year 17 is just over 100 m³/d and reduces to about 60 m³/d over the next 80 years. It should be noted that this volume is highly sensitive to the parameters used in the model, therefore could potentially change by orders of magnitude should actual parameters differ to model parameters.

The development of a pit lake was calculated, taking into consideration the parameters summarised in Table 6-5. The calculated data indicates that a pit lake would develop, with pit lake water levels stabilising after about a year (inflow becoming equal to evaporation). It is predicted that the pit lake would stabilise at around 365 mAHD, equivalent to around 10 m deep at its deepest part. The pit lake will become increasingly saline as salts from groundwater, surface water and rainfall accumulate. By around 7 years post-closure a salinity of around 35,000 mg/L is predicted.

Table 6-5 Parameters used for calculation of Pit lake development

Parameter	Value
Rainfall	355 mm/year based on Stirling Station data at a TDS concentration of 50 mg/L.
Evaporation	3,141 mm based on Alice Springs data with a Lake-Pan Evaporation Coefficient of 0.6.
Runoff	Nominal value of 1000 mg/L for TDS concentration, with a Runoff coefficient (between pit lake and pit wall) of 0.9.
Groundwater	96 m ³ /d average groundwater inflow rate after 17 year from groundwater flow model. TDS of 7000 mg/L based on levels found at in-pit exploration drill holes.

6.5 Model limitations

This model has been classified as Class 1 (low confidence model), based on steady state calibration followed by transient predictions (Barnett *et al.* 2012), hence its results should be treated in line with the expectation of a low confidence model.

The aquifer characteristics (their property, lateral and vertical extent) of the palaeovalley aquifer have been developed from drilling investigations limited to the western half of the palaeovalley due to the limited access to the east of the valley. Aquifer characteristics have been reasonably well tested and defined in this western area, particularly for the area of the Stage 1 (year 1 to 4) borefield. However, a total of six additional bores are still required (three extra for each stage) to meet the supply demand of the project (assuming a typical bore yield of around 8 L/s). Due to the heterogeneous nature of the aquifer, the actual supply from these proposed bores could provide greater or lower yields, and therefore the borefield plan would need to be adjusted accordingly and further modelling completed to determine the change in potential impacts.

The model has taken a conservative approach to the recharge characteristics (i.e. low recharge value used) to allow for uncertainty in the recharge mechanisms that may be present along the active river channels. There is regional evidence that flood events can directly recharge the alluvial aquifer resulting in significant groundwater level increases that perpetuate for over a period of years to decades (Wischusen *et al.* 2012). Such events could result in a sudden recovery of groundwater levels that have declined from pumping, however this needs to be substantiated through on-site monitoring of levels and responses to flood/flow events. The infrequent nature of such flood events is also problematic to account for in prediction modelling.

6.6 Modelling conclusions

Confidence in the groundwater modelling results has been improved following the additional drilling and testing that has been completed during 2016 in the area of the proposed borefield. This has provided further definition of the aquifer extents and has provided further data on aquifer properties.

The modelling has demonstrated that a maximum groundwater drawdown up to around 12 m is expected at the location of operating bores within the borefield. Drawdown is seen to slowly increase over the duration of operation, with the maximum observed at the end of the 17 year operations period. Drawdown decreases significantly with distance away from the palaeovalley and borefield. The 1 m drawdown contour extends to a maximum distance from a pumping bore of around 6.5 km to the south of the borefield at the end of 17 year.

The model water balance for the end of mining and borefield operation (17 years) demonstrates that the majority of water abstracted from the bores is coming from storage within the aquifer (85%), and not from either throughflow or rainfall recharge. As such, the model predictions indicate that groundwater levels at the up-gradient model boundary, in the area adjacent to Stirling Swamp and outflow of the Ti Tree basin, are not impacted by abstraction from the borefield.

At the end of mining, drawdown under transient conditions reaches a maximum of around 80 m within the immediate area of the mine pit, and rapidly decreases with distance from the pit. The 1 m drawdown is modelled to occur to a maximum distance from the pit of around 1.3 km to the east and west of the pit. Drawdown of up to 10 m is expected at the western side of Murray Creek. Due to the relatively localised drawdown, no drawdown impacts at 17 years are expected within the area of Mud Hut Swamp.

The modelling indicates groundwater level impacts at some existing stock bores as a result of borefield abstraction. Existing active stock bores closest to the borefield are modelled as having a groundwater level reduction by up to around 3 m. Such a reduction in groundwater levels may lead to the existing stock bore infrastructure being inadequate to provide stock water supply.

At 100 years, the groundwater levels recover in the area of the borefield, with maximum drawdown reducing to around 4 m. However the overall extent of drawdown does increase with the 1 m drawdown contouring reaching 16 km from the borefield as groundwater from storage drains to the recovering borefield.

Drawdown extent in the area of the mine site at 100 years increases to around 4 km from the mine pit for a 1 m drawdown. No drawdown impacts at 100 years are expected at Mud Hut Swamp.

7. Recommendations

Based on results of the groundwater flow modelling, the following recommendations are made:

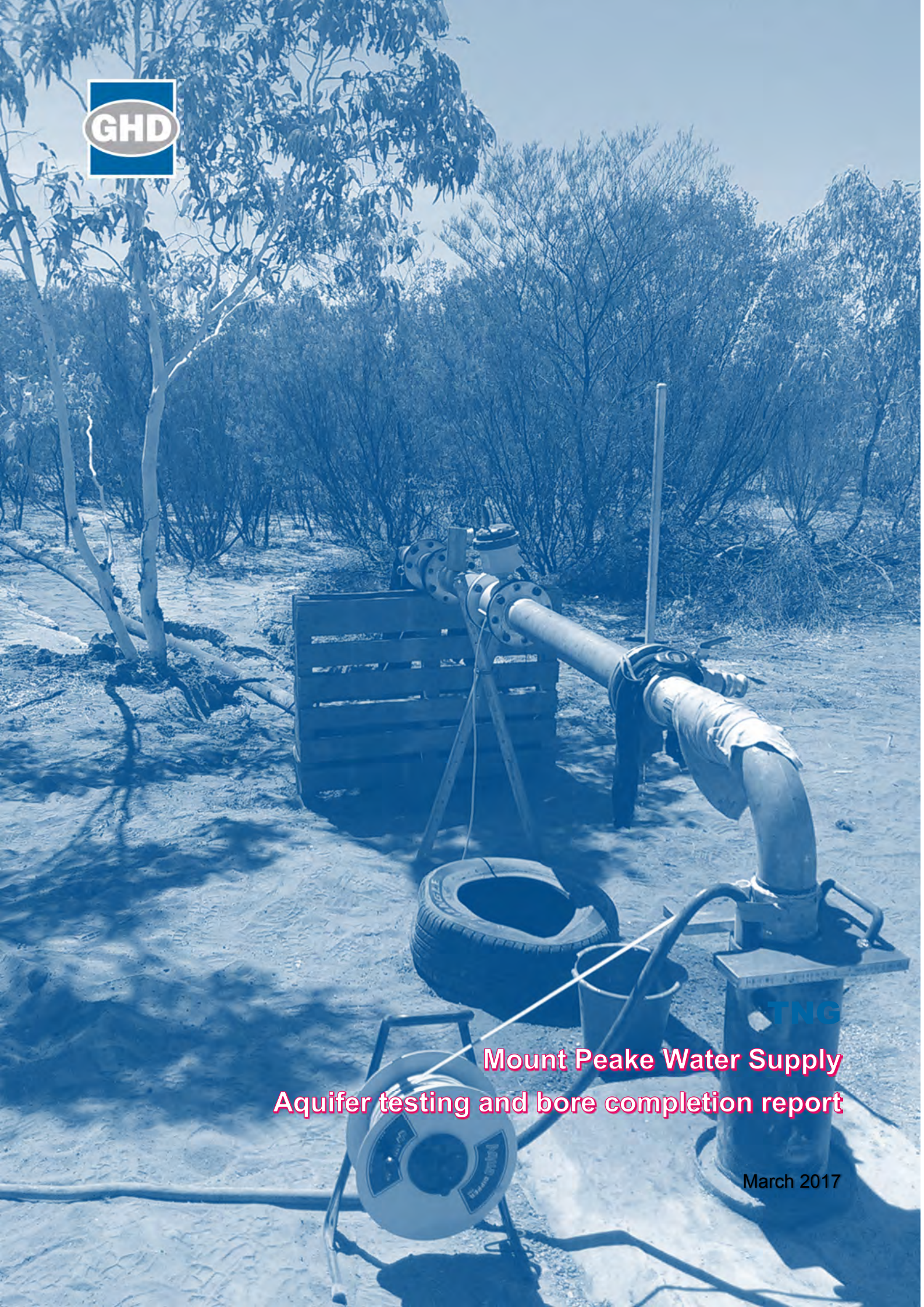
- The groundwater model should be revisited and updated following the completion of additional drilling that is required to complete the Stage 1 and Stage 2 borefield. For example, if aquifer parameters (and recommended bore pumping rates) at new drill sites are different to those assumed in the model, further assessment will be required to quantify potential groundwater impacts. Additional data will allow the model to be refined and improve its confidence levels;
- A borefield monitoring plan (water level and quality) comprising of locations between pumping bores and at the extents (especially to the north and south) of the borefield should be implemented to further assess baseline groundwater conditions and to monitor aquifer performance and to feed back into modelling data;
- Since a number of stock bores are likely to be impacted due to borefield abstraction, a base line assessment of these bores and a make good agreement should be developed with the owners prior to the development of the mine and borefield. This could involve either the deepening of the existing bore, lowering the pump setting, drilling another bore next to existing bore or by supplying the required water demand from external sources (e.g. pipeline offtake).

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Appendices

Appendix A - Bore Completion Report (2015 & 2016 drilling program)



Mount Peake Water Supply Aquifer testing and bore completion report

March 2017

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Appendices

- Appendix A - Bore logs
- Appendix B – Borefield cross sections

1. Introduction

TNG is currently planning to develop its Mount Peake mine, which requires water supply of up to 7.1 ML/d (82.5 L/s). The Hanson River palaeochannel aquifer was identified as having the potential to meet this water demand. As part of the groundwater resource assessment, drilling and testing of this aquifer has been completed in various stages, with the outcomes from the investigation to be used in subsequent groundwater model development.

The following report provides a summary of drilling and testing programs completed at the Hanson River palaeochannel to date (February 2017). These include the drilling and testing programs summarised in Table 1-1.

Table 1-1 Groundwater drilling and testing program summary

Drilling and testing program	Summary
2015 Drilling and testing program	• Drilling in four areas, along a 50 km long section of the palaeochannel. • Construction of 4 monitoring wells, and 1 test production bore. • 100 minute pump tests on 3 monitoring bores • Step tests and 48 h Constant Rate Test and recovery test on the production bore.
2016 Drilling and testing program	• Drilling in nine areas, along a 10 km long section of the palaeochannel. • Construction of 10 monitoring bores, and 2 test production bores • Step tests and Constant Rate Test and recovery test on the production bores including extended (11 day) pump test on high yielding bore.

2. Exploration and production bore drilling

A total of 14 exploration bores and three production bores were drilled during the 2015 and 2016 drilling programs. Locations of these bores are presented in Figure 2-1. A summary table with bore information presented Table 2-1 with bore logs provided in Appendix A.

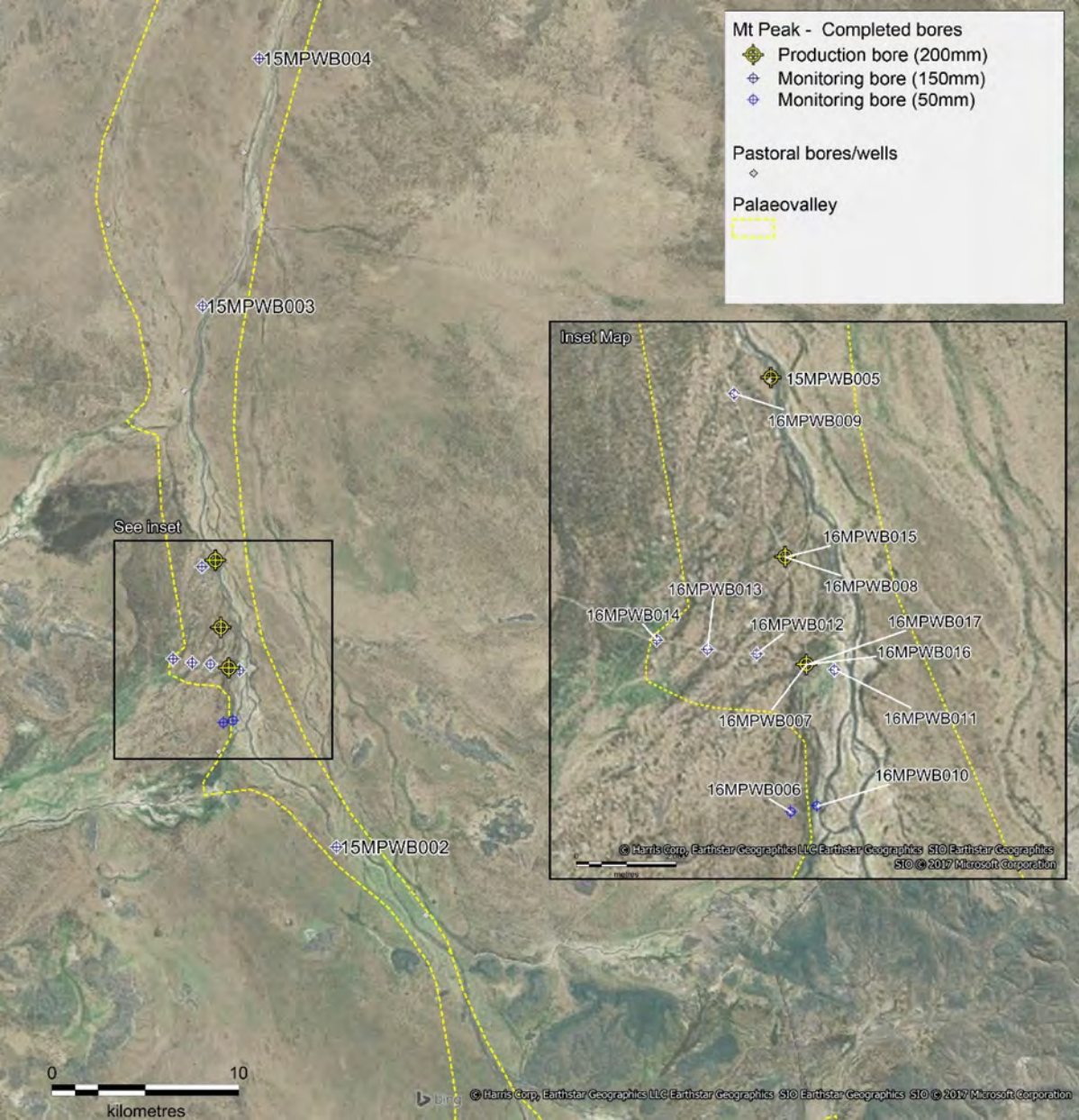


Figure 2-1 Bore locations

Table 2-1 Bore summary - groundwater exploration and supply 2015-2016

HOLE_ID	HOLE_RN	EASTING (GDA 94 Zone 53)	NORTHING (GDA 94 zone53)	Hole Diameter (mm)	Date Started	Date Completed	GROUND RL mAHD**	COLLAR RL mAHD	DEPTH (m)	DRILLED BY	CASING IN HOLE
15MPWB002	RN19115	346,150	7,612,693	200	21/03/2015	22/03/2015	457.423	457.843	66	Tomlin WB Drilling	150mm CL19PVC (1.5mm slots), screened 36-54m
15MPWB003	RN19136	338,709	7,641,403	200	22/03/2015	23/03/2015	426.684	427.264	72	Tomlin WB Drilling	150mm CL19PVC (1.5mm slots), screened 24-66m
15MPWB004	RN19137	341,613	7,654,621	200	23/03/2015	23/03/2015	414.129	414.609	48	Tomlin WB Drilling	150mm CL19PVC (1.5mm slots), screened 18-48m
15MPWB001	RN19114	339,560	7,627,834	200	19/03/2015	20/03/2015	439.091	439.566	78	Tomlin WB Drilling	150mm CL19PVC (1.5mm slots), screened 48-62m
15MPWB005*	RN19138	339,554	7,627,846	300	24/03/2015	25/03/2015	438.989	439.669	66	Tomlin WB Drilling	200mm steel, machine (2mm) and stainless (1mm) slotted. 6m sump. , screened 36-48(machine), 48-60(stainless steel). m
16MPWB006	RN19336	340042.18	7619180.72	200	8/07/2016	9/07/2016	446.32	446.89	72.0	Tomlin WB Drilling	50mm PVC to bottom, slotted from 12-18 and 54-60m
16MPWB007	RN19337	340316.34	7622132.85	200	9/07/2016	10/07/2016	442.37	442.95	66.0	Tomlin WB Drilling	150mm PVC to bottom, slotted from 12 to 54m
16MPWB008	RN19338	339894.44	7624267.98	200	10/07/2016	11/07/2016	442.87	443.23	78.0	Tomlin WB Drilling	150mm PVC to bottom, slotted from 18 to 66m
16MPWB009	RN19339	338815.04	7627527.88	200	11/07/2016	11/07/2016	438.91	439.27	72.0	Tomlin WB Drilling	150mm PVC to bottom, slotted from 12 to 60m
16MPWB010	RN19340	340557.98	7619307.92	200	12/07/2016	12/07/2016	446.12	446.69	84.0	Tomlin WB Drilling	50mm PVC to bottom, slotted from 12-30m and 66-84m
16MPWB011	RN19341	340882.97	7622041.08	200	13/07/2016	13/07/2016	458.66	459.26	60.0	Tomlin WB Drilling	150mm PVC to bottom, slotted from 12 to 54m
16MPWB012	RN19342	339324.41	7622344.34	200	13/07/2016	14/07/2016	445.81	446.51	60.0	Tomlin WB Drilling	150mm PVC to bottom, slotted from 18 to 48m
16MPWB013	RN19343	338330.36	7622422.84	200	14/07/2016	14/07/2016	445.96	446.56	60.0	Tomlin WB Drilling	150mm PVC to bottom, slotted from 18 to 54m
16MPWB014	RN19344	337310.36	7622606.88	200	14/07/2016	15/07/2016	447.27	448.01	60.0	Tomlin WB Drilling	150mm Steel to 54m, slotted from 21-36m and 42-48m
16MPWB015*	RN19365	339883.0	7624273.0	300	16/07/2016	17/07/2016	442.9	443.5	72.0	Tomlin WB Drilling	200mm Steel to bottom, slotted from 18 to 66m, Stainless Steel mesh 54-66m
16MPWB016	RN19424	340322	7622133	200	01/12/2016	01/12/2016	442.4	442.83	21.0	Silver City Drilling	150mm PVC to bottom, slotted from 9 to 21m
16MPWB017*	RN19425	340327	7622126	300	01/12/2016	02/12/2016	442.4	442.65	60.0	Silver City Drilling	200mm Steel to bottom, slotted steel from 18 to 42m, Stainless Steel mesh 42-54m

*production bore

3. Lithology and drilling logs

Lithological bore logs for investigation holes are presented as Appendix A, and a summary of the general lithological profile is presented as Table 3-1.

The drilling has been completed over an area extending 50 km along the western bank of the current Hanson River. An east-west transect (2016 drilling) spanning around 4 km and incorporating 5 drilled locations was also completed to further delineate the aquifer extents.

The palaeochannel aquifer, comprised of alluvial sediments ranging from silt to coarse gravels, was identified in all locations drilled, with the exception of the area around 16MPWB006 and 16MPWB010. In this location, between the confluence of the Hanson River and the confluences of Bloodwood Creek and Murray Creek, a basement high was identified that resulted in a thinning of the alluvial sediments and consequently significantly lower groundwater yield.

In the remaining locations, the palaeochannel aquifer was found to comprise alluvial sands generally overlying alluvial gravels. Within both units, finer grained lenses, including minor clays were found, but their distribution, both laterally and vertically could not be well correlated. In general the base of the palaeochannel was found to be around 50 m bgl, but in places up to 66 (i.e. 16MPWB008 and 16MPWB015).

The cross section drilled west-east perpendicular to the flow direction of the palaeochannel, identified the thinning of the palaeochannel in the far west at 16MPWB014. At this location, the aquifer was relatively thin (24 m) with the basement intersected at around 36 m. Conceptual long/cross sections prepared by TNG are presented as Appendix B.

The variability in clay to gravel results in a range of groundwater yields, as demonstrated by the pump test data presented in Section 4.

Table 3-1 Geological summary

Unit	Depth range (mbgl)	Description
Surface alluvium	0-5	Surface sheetwash alluvium, silty sand and sands. Generally unsaturated.
Upper alluvials	5-20	Alluvial sands. Mostly medium to coarse grained sands, with minor silts, clay and gravels. Upper aquifer.
Lower alluvials	20-50	Alluvial sands and gravels, ranging from fine to cobbles. Minor clay/silt bands.. Lower main aquifer.
Basement	>50	Neoproterozoic siltstones and sandstones – Georgina Basin. Low groundwater potential.

4. Pump testing and interpretation

Aquifer pump testing was undertaken at all three completed test production bores (15MPWB005, 16MPWB015 and 16MPWB017). All pump testing was undertaken in accordance with Australian Standard for Pumping Test (AS 2368:1990). At each location, a pre-test, step test, Constant Rate Test and recovery test were carried out.

In addition to the pump tests on the three production bores, short term pumping and subsequent monitored recovery was completed on the 2015 monitoring bores.

The following sections provide a summary of the tests and an interpretation of the resultant drawdown data.

4.1 Testing and interpretation at monitoring bores 15MPWB002, 15MPWB003 and 15MPWB004

The three 150 mm monitoring bores 15MPWB002, 15MPWB003 and 15MPWB004 were subject to 100 minute pump tests. Water levels were recorded manually and with data-loggers at the pumped bore. All bores were tested at a constant rate of approximately 3 L/s.

A summary of the interpreted test pump data is presented below as Figure 4-1, Figure 4-2 and Figure 4-3. The presented data from the limited testing of the monitoring bores were used to estimate aquifer parameters initially using the Copper Jacob's Method (1946) and refined using Newman's Method (1974). Based on this interpretation, recommended (bulk) aquifer parameter ranges for the formations tested are as follows:

- Transmissivity range = 50-300 m²/d;
- Horizontal Hydraulic Conductivity range = 1 - 7 m/d.

4.2 Testing and interpretation at 15MPWB005

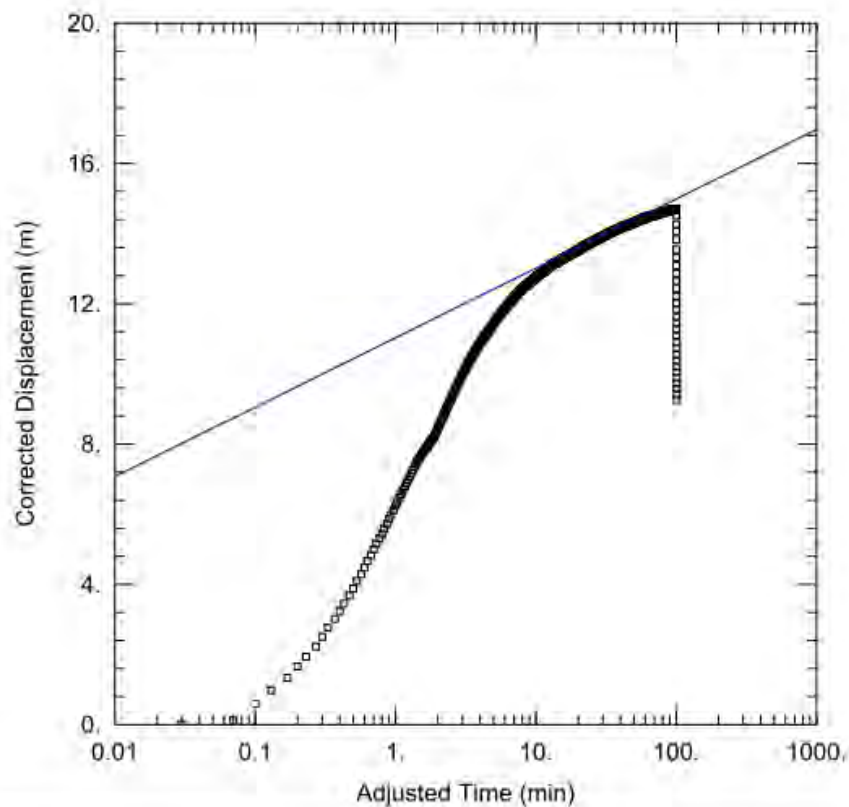
Due to the relatively high groundwater yields found during drilling at 15MPWB001, it was determined that a test production bore be drilled at this location. Test production bore 15MPWB005 was installed 16 m from 15MPWB001, with groundwater levels in both the pumping bore and observation bore recorded during the pump testing.

In order to determine the appropriate pumping rate for the Constant Rate Test, step tests were undertaken at 15MPWB005 at rates of 8, 10, 12, and 15 L/s (each step pumped for 60 minutes). A maximum drawdown recorded at the end of 4th step was 29.9 m. Following interpretation of the drawdown data from the step test, a pumping rate for a 48 hour Constant Rate Test was determined to be 12 L/s.

During the 48 hour Constant Rate Test at 15MPWB005 (from 18/03/2015 to 30/03/2015), water levels were recorded manually and with data-loggers at the pumping bore (15MPWB005) and monitoring bore (15MPWB001).

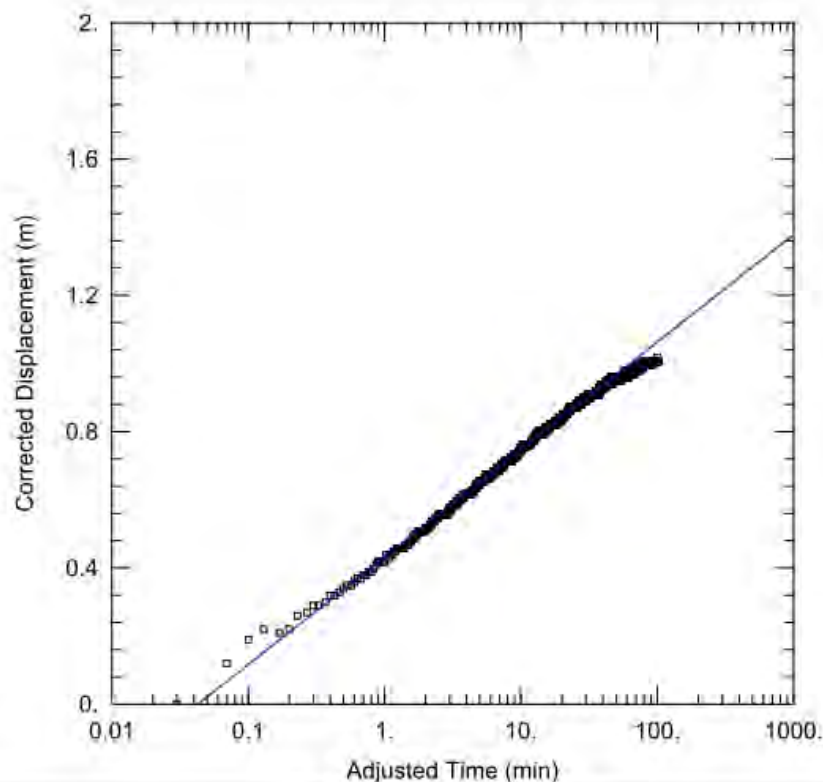
Semi-log plots of the drawdown data versus time from the Constant Rate Tests followed by recovery test for the pumping bore and observation bore are presented in Figure 4-4 and Figure 4-5 respectively. Recovery was almost instantaneous in the pumping bore, with relatively slow recovery at the observation bore.

During the pumping test, the flow rate was checked at the gauge installed, as well as using a bucket and stop watch, at the discharge outlet (300 m from the bore, discharging to the dry river channel). Data indicated a consistent flow rate of 12 L/s with minor deviation at the commencement of the test.



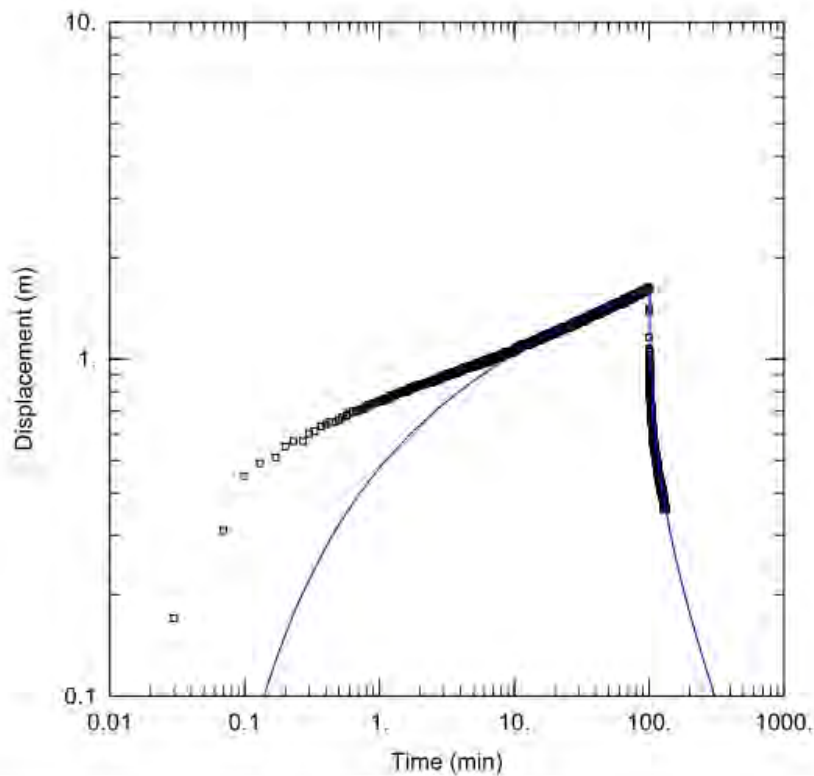
WELL TEST ANALYSIS	
Data Set: G:\61\2905729\Tech\Design\data\Aqtesolv\BG_paleovalley\MPWB02\WB02_CJ.aqt	
Date: 02/08/17	Time: 16:36:56
PROJECT INFORMATION	
Company: GHD	
Client: TNG	
Project: 6129057	
Location: Stirling Station	
Test Well: MPWB02	
Test Date: 28/3/2015	
AQUIFER DATA	
Saturated Thickness: 45. m	Anisotropy Ratio (Kz/Kr): 0.1
WELL DATA	

Figure 4-1 Monitoring bore 15MPWB002 pump test interpretation



<u>WELL TEST ANALYSIS</u>					
Data Set: <u>G:\61\2905729\Tech\Design\data\Aqtesolv\BG_paleovalley\MPWB03\WB03_CJ.aqt</u>					
Date: <u>02/08/17</u>			Time: <u>16:39:08</u>		
<u>PROJECT INFORMATION</u>					
Company: <u>GHD</u>					
Client: <u>TNG</u>					
Project: <u>6129057</u>					
Location: <u>Stirling Station</u>					
Test Well: <u>MPWB03</u>					
Test Date: <u>28/3/2015</u>					
<u>AQUIFER DATA</u>					
Saturated Thickness: <u>40. m</u>			Anisotropy Ratio (Kz/Kr): <u>1.</u>		
<u>WELL DATA</u>					
Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
WB03	0	0	WB03	0	0
<u>SOLUTION</u>					
Aquifer Model: <u>Unconfined</u>			Solution Method: <u>Cooper-Jacob</u>		
T = <u>301. m²/day</u>			S = <u>2.013</u>		

Figure 4-2 Monitoring bore 15MPWB003 pump test interpretation



<u>MPWB04 CR</u>					
Data Set: <u>G:\61\2905729\Tech\Design\data\Aqtesolv\BG_paleovalley\MPWB04\WB04_Newman.aqt</u>					
Date: <u>02/08/17</u>			Time: <u>16:55:15</u>		
<u>PROJECT INFORMATION</u>					
Company: <u>GHD</u>					
Client: <u>TNG</u>					
Project: <u>6129057</u>					
Location: <u>Stirling Station</u>					
Test Well: <u>MPWB04</u>					
Test Date: <u>28/3/2015</u>					
<u>AQUIFER DATA</u>					
Saturated Thickness: <u>40. m</u>					
<u>WELL DATA</u>					
<u>Pumping Wells</u>			<u>Observation Wells</u>		
<u>Well Name</u>	<u>X (m)</u>	<u>Y (m)</u>	<u>Well Name</u>	<u>X (m)</u>	<u>Y (m)</u>
<u>WB04</u>	<u>0</u>	<u>0</u>	<u>WB04</u>	<u>0</u>	<u>0</u>
<u>SOLUTION</u>					
Aquifer Model: <u>Unconfined</u>			Solution Method: <u>Neuman</u>		
T = <u>191.2 m²/day</u>			S = <u>4.808</u>		
Sy = <u>0.15</u>			B = <u>0.6</u>		

Figure 4-3 Monitoring bore 15MPWB004 pump test interpretation

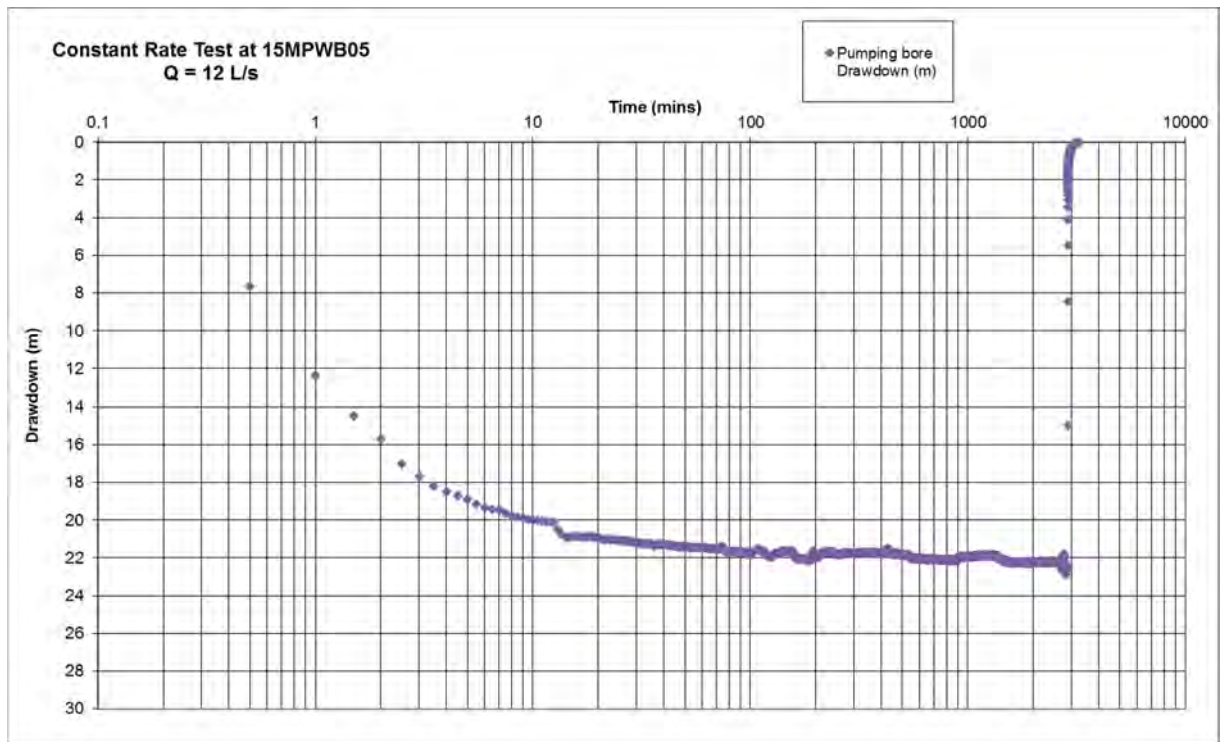


Figure 4-4 15MPWB005 Constant Rate Test drawdown in pumping bore

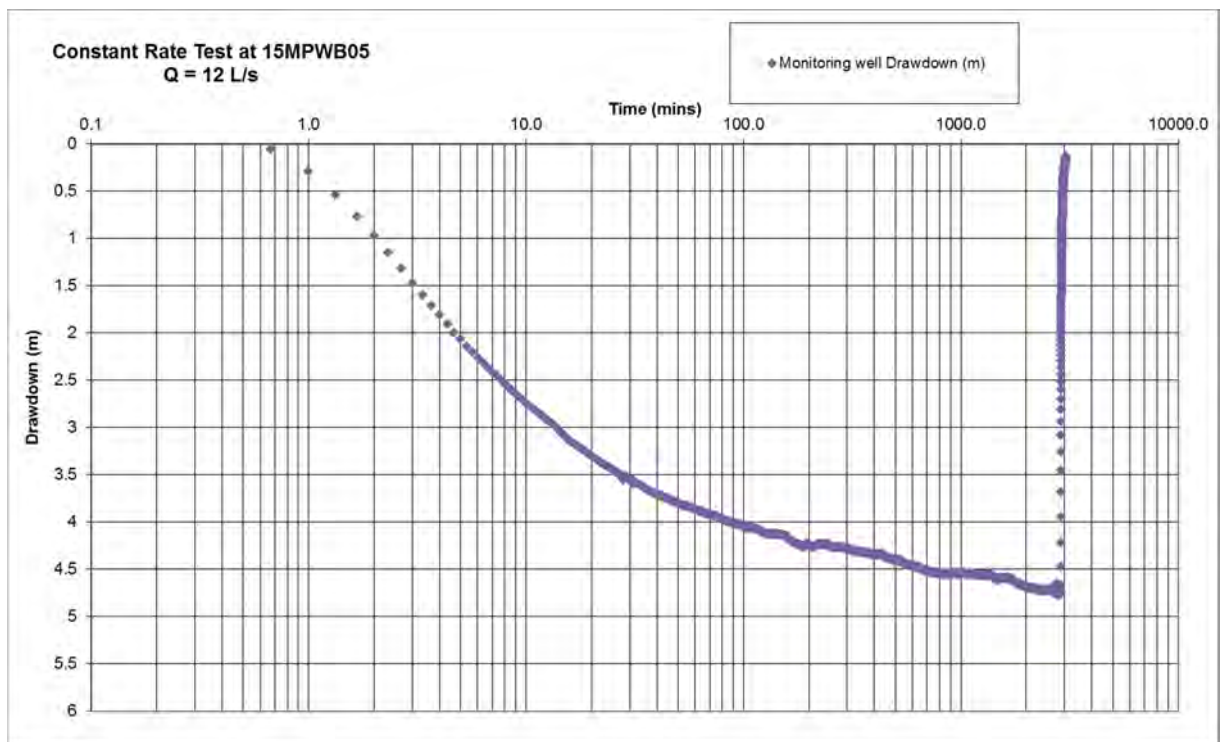
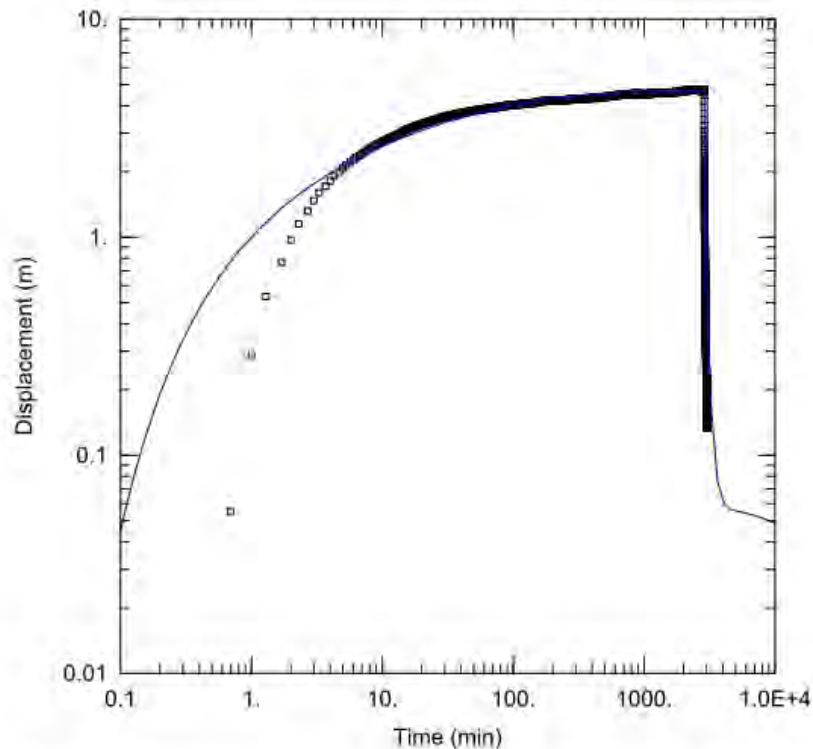


Figure 4-5 15MPWB005 Constant Rate Test drawdown in observation bore

The above presented data from the monitoring bore were used to estimate aquifer parameters initially using the Copper Jacob's Method (1946) and refined using Newman's Method (1974) (Figure 4-6). Based on this interpretation, recommended (bulk) aquifer parameters from the pumping test at this bore are:

- Transmissivity = 101 m²/d;
- Horizontal Hydraulic Conductivity = 2.2 m/d;
- Vertical Hydraulic Conductivity = 0.2 m/d;
- Specific Yield = 0.075; and
- Storage Coefficient= 0.0002.



TEST PRODUCTION BORE					
Data Set: G:\...\MPWB01_2017_inter Newman late BG.aqt					
Date: 02/08/17			Time: 15:57:45		
PROJECT INFORMATION					
Company: GHD					
Client: TNG					
Project: 6129057					
Location: Stirling Station					
Test Well: MPWB05					
Test Date: 28/3/2015					
AQUIFER DATA					
Saturated Thickness: 45. m					
WELL DATA					
Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
MPWB05	339557	7627846	MPWB01	339570	7627836
SOLUTION					
Aquifer Model: Unconfined			Solution Method: Neuman		
T = 101. m ² /day			S = 0.0002		
Sy = 0.075			B = 0.001		

Figure 4-6 Interpretation using Neuman's method at 15MPWB005

4.3 Testing and interpretation at 16MPWB015

In order to determine the appropriate pumping rate for the Constant Rate Test, step tests were undertaken at 16MPWB015 at rates of 5.5, 7.2, 9.3 and 11.2 L/s (each step pumped for 30 minutes). The maximum drawdown recorded at the end of 4th step (11.2 L/s) was 30.7 m. Following interpretation of the drawdown data from the step test, a pumping rate for a 48 hour- Constant Rate Test was determined to be 8.3 L/s.

During the 48 hour Constant Rate Test at 16MPWB015 (from 4/12/2016 to 6/12/2016), water levels were recorded manually and with data-loggers at the pumping bore (16MPWB015) and monitoring bore (16MPWB008) located 13 m away from the pumping bore.

Semi-log plot of the drawdown data versus the time from the Constant Rate Tests followed by recovery test for the pumping bore and observation bore is presented in Figure 4-7 and Figure 4-8 respectively. Recovery was almost instantaneous in the pumping bore, with relatively slow recovery at the observation bore.

During the pumping test, flow rate was measured at a logger on the pump outlet, as well as using a bucket and stop watch, at the discharge outlet (200 m from the bores). This indicated a consistent flow rate of 8.3 L/s throughout the test with the exception of the first 5 minutes, when the flow rate was adjusted to maintain the constant flow rate.

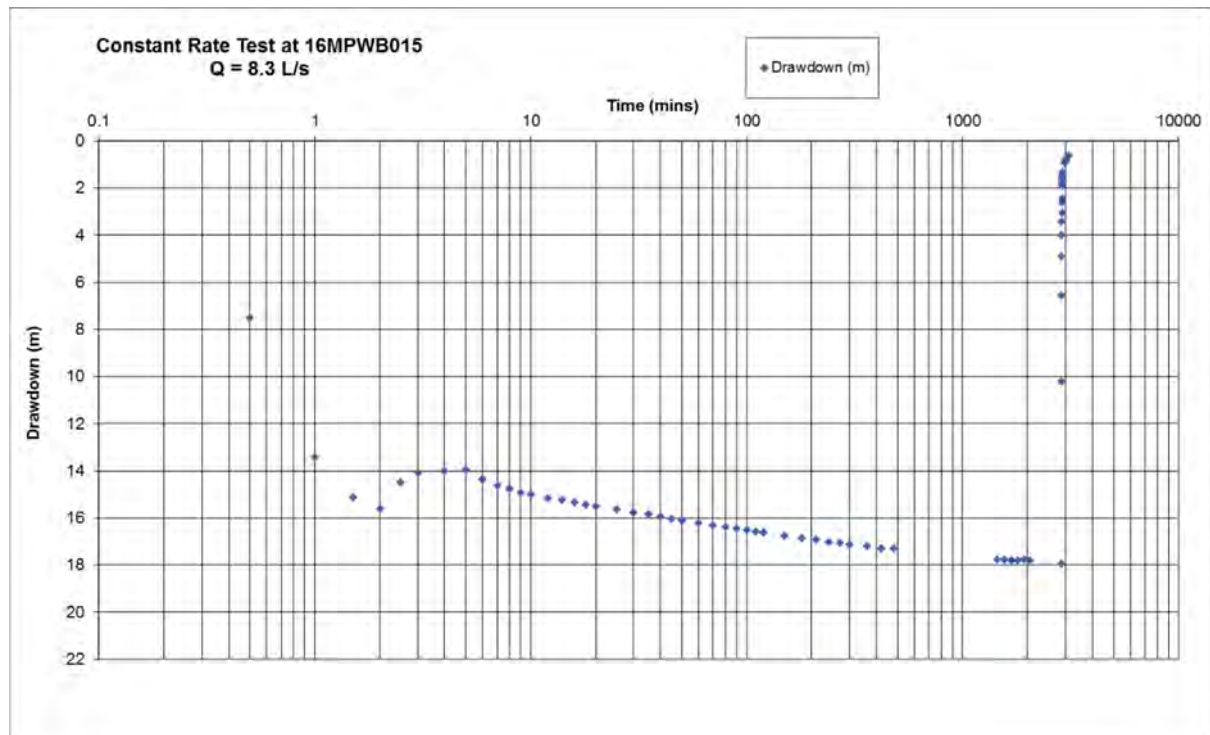


Figure 4-7 Drawdown data at 16MPWB015 during pumping test at the same bore

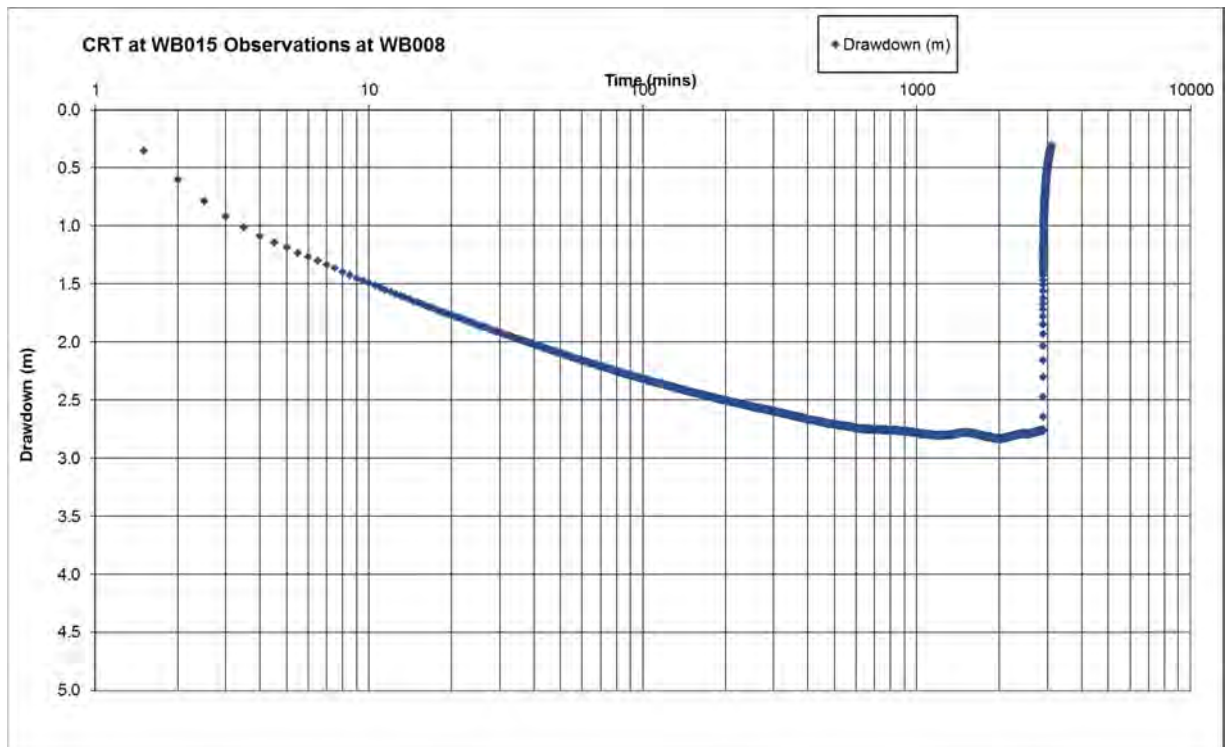
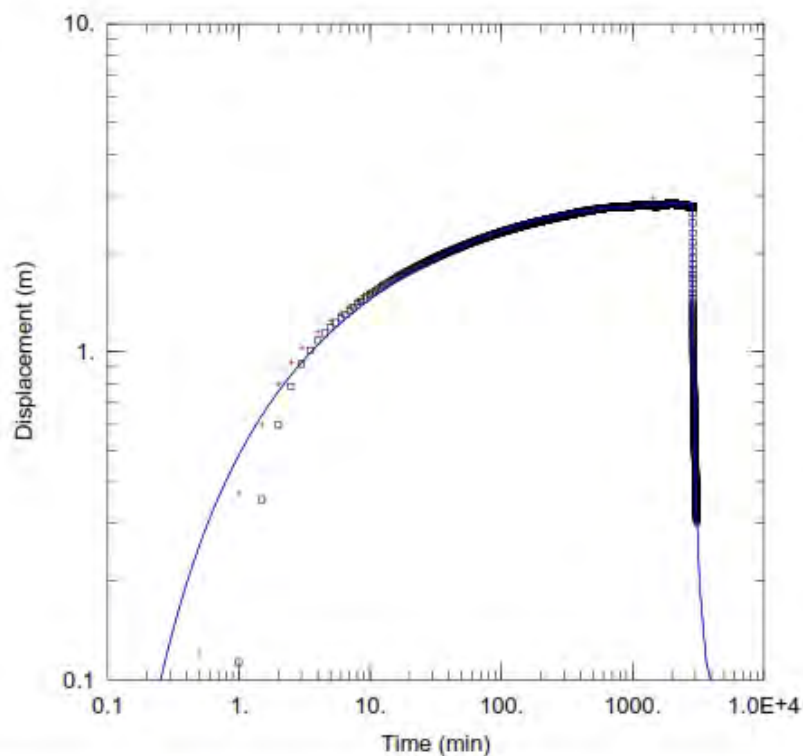


Figure 4-8 Drawdown data at 16MPWB008 during pumping test at 16MPWB015

Aquifer parameters have been estimated using data from the monitoring bore, initially using the Cooper Jacob's Method (1946) and refined using Newman's Method (1974) (Figure 4-9).

Based on this assessment, recommended (bulk) aquifer parameters from the pumping test at this bore are:

- Transmissivity = 115 m²/d;
- Horizontal Hydraulic Conductivity = 2 m/d;
- Vertical Hydraulic Conductivity = 0.04 m/d;
- Specific Yield = 0.05; and
- Storage Coefficient = 0.0002.



WELL TEST ANALYSIS

Data Set: G:\...\WB015_obs Newman.aqt

Date: 12/21/16

Time: 15:48:11

PROJECT INFORMATION

Company: GHD

Client: TNG

Project: 612905735

Location: Hansen River

Test Well: WB015

Test Date: 4/12/2016

AQUIFER DATA

Saturated Thickness: 56. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
WB015	0	0

Observation Wells

Well Name	X (m)	Y (m)
WB008_Manual	0	13
WB008_Logger	0	13

SOLUTION

Aquifer Model: Unconfined

Solution Method: Neuman

T = 115. m²/day

Sy = 0.05

S = 0.0005

Kz/Kr = 0.02

Figure 4-9 Interpretation using Neuman's method at 16MPWB015

4.4 Testing and interpretation at 16MPWB017

In order to determine the appropriate pumping rate for the Constant Rate Test, step tests were undertaken at 16MPWB017 at rates of 6, 8.1, 10.6 and 17.6 L/s (each step pumped for 60 minutes). A maximum drawdown was recorded at the end of 4th step (17.6 L/s) of 4.62 m. Due to the minimal drawdown recorded during the step test, the pump rate for the Constant Rate Test was determined to be the maximum available for the available submersible pump at 18 L/s.

At 16MPWB017 an 11-day¹ Constant Rate Test was undertaken (from 7/12/2016 to 18/12/2016) at 18 L/s to assess the long term viability of pumping at higher rate at this location as well as to provide higher confidence in interpreted aquifer parameter.

Semi-log plots of the drawdown data versus the time from the Constant Rate Tests followed by recovery test for the pumping bore (16MPWB017) and observation bore (16MPWB007) are presented in Figure 4-10 and Figure 4-11 respectively. Other bores (16MPWB006, 16MPWB011, 16MPWB012 and 16MPWB016) were also monitored during this long term pumping test. However, aquifer parameters interpretation was based on the observation data recorded for the bore 16MPWB007, as this bore is fully penetrating, located relatively short distance (13.5 m) from the pumping bore and is considered most appropriate while using conventional method of interpretation of aquifer parameters. Enhanced interpretation of aquifer parameters can be undertaken using numerical methods (MODFLOW with PEST).

During the pumping test, flow rate was checked at the gauge installed, as well as using a bucket and stop watch, at the discharge location 300 m from the pumping bore. The data indicated an average flow rate of 18.1 L/s, consistent throughout the test with minor fluctuation from 17.8 L/s to 18.4 L/s recorded during the test.

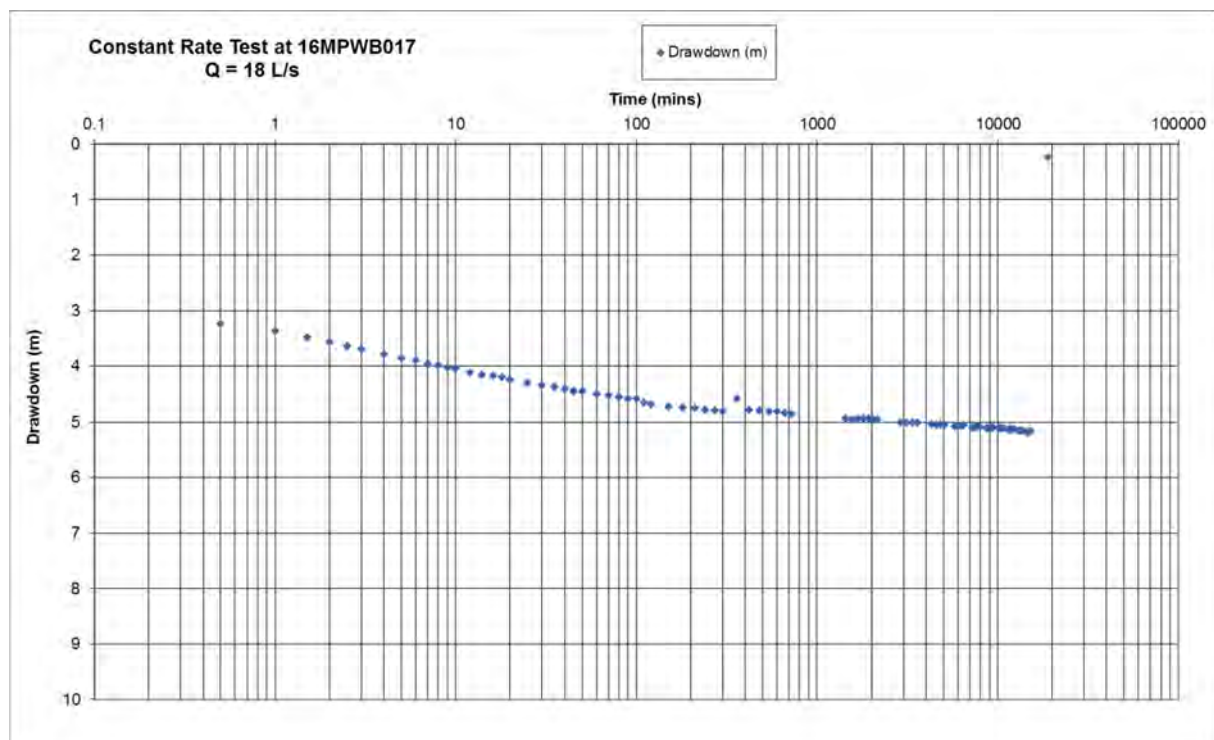


Figure 4-10 Drawdown data at 16MPWB017 during pumping test

¹ Initially a 14-day test was planned at this location, however, due to weather and safety conditions prevailing at the site, the test was reduced to 11-day.

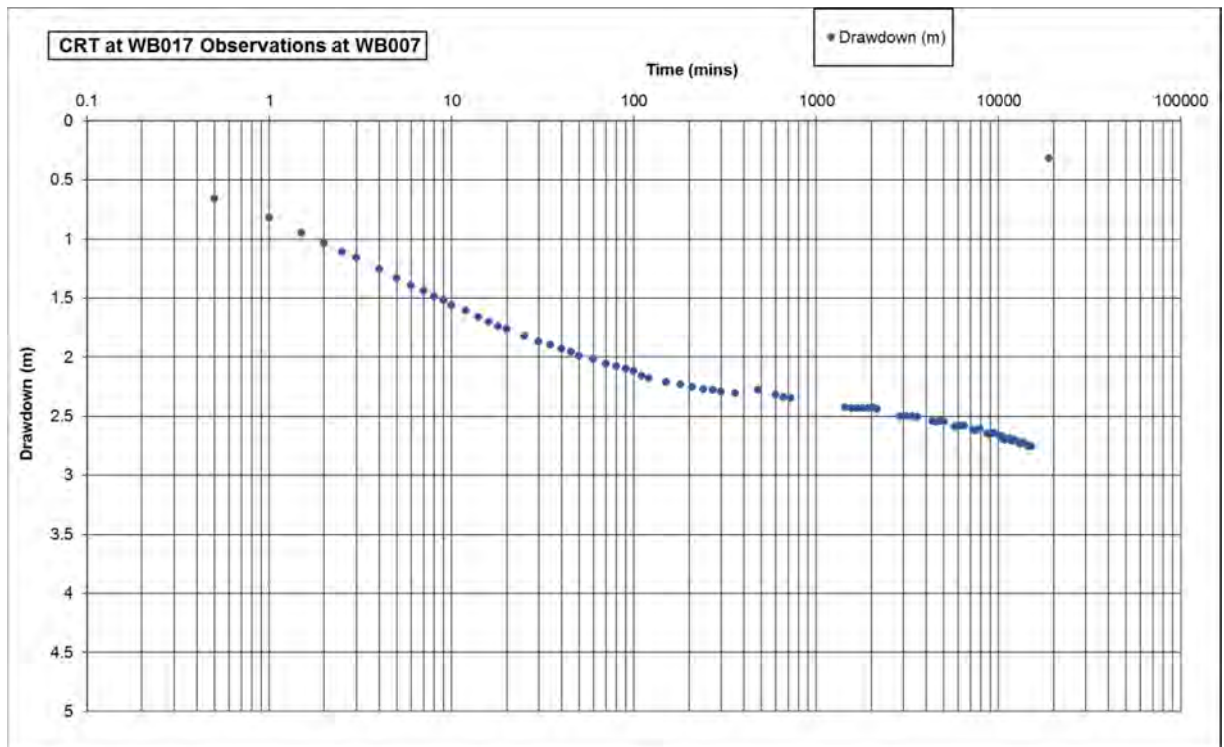


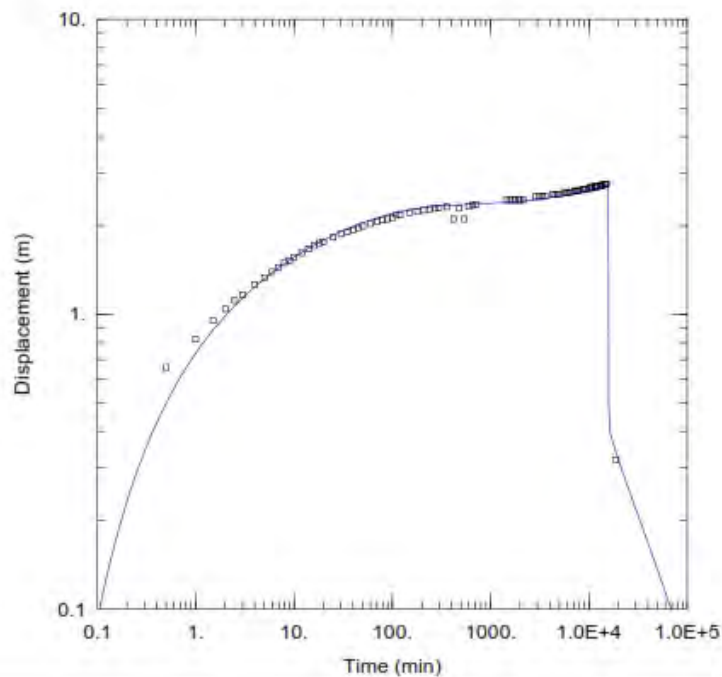
Figure 4-11 Drawdown data at 16MPWB007 during pumping test at 16MPWB017

Aquifer parameters have been estimated using data from the monitoring bore (16MPWB007), using the drawdown data record using Newman's Method (1974). These are presented in Figure 4-12.

Recommended (bulk) aquifer parameters from the pumping test at this bore (MPWB017) are

- Transmissivity = 300 m²/d (range 300 to 400 m²/d)
- Horizontal Hydraulic Conductivity = 7 m/d (range 7 to 10 m/d)
- Vertical Hydraulic Conductivity = 0.07 m/d (range 0.07 to 0.1 m/d)
- Specific Yield = 0.075 (range 0.05 to 0.15); and
- Storage Coefficient = 0.0002 (range 0.0002 to 0.004)

Two other nearby bores (16MPWB011 located 560 m to the east and 16MPWB012 located 1026 m to the west) of the pumping bore recorded water level decline of less than 0.2 m during the test. While this level of drawdown is not considered appropriate to be used in the interpretation of the aquifer parameters, a cross-check (validation) of predicted drawdown from the interpreted parameters from bore 16MPWB007 at these two locations is presented in Figure 4-13 for bore 16MPWB011.



WELL TEST ANALYSIS

Data Set: G:\...WB017_obs_at_WB007_Newman_V1.aqt

Date: 01/09/17

Time: 10:21:02

PROJECT INFORMATION

Company: GHD

Client: TNG

Project: 612905735

Location: Hansen River

Test Well: WB017

Test Date: 7/12/2016

AQUIFER DATA

Saturated Thickness: 43. m

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
WB017	0	0	WB007	0	13.5

SOLUTION

Aquifer Model: Unconfined

Solution Method: Neuman

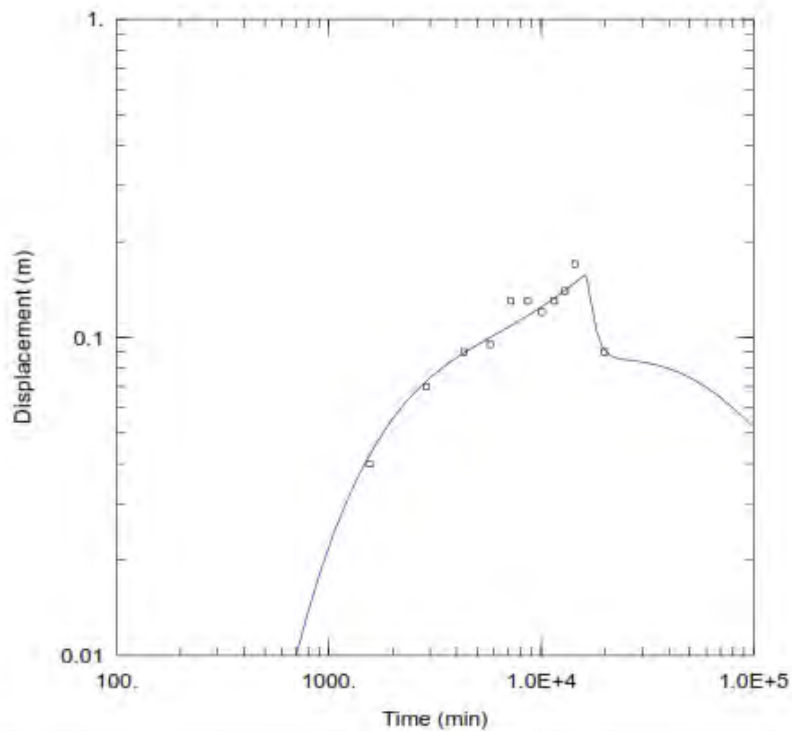
$T = 300. \text{ m}^2/\text{day}$

$S = 0.00045$

$S_y = 0.075$

$B = 0.001$

Figure 4-12 Interpretation using Neuman's method at 16MPWB007



WELL TEST ANALYSIS

Data Set: G:\...WB017_obs_at_WB011_Newman.aqt

Date: 01/10/17

Time: 16:29:26

PROJECT INFORMATION

Company: GHD

Client: TNG

Project: 612905735

Location: Hansen River

Test Well: WB017

Test Date: 7/12/2016

AQUIFER DATA

Saturated Thickness: 43. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
WB017	0	0

Observation Wells

Well Name	X (m)	Y (m)
WB011	0	560

SOLUTION

Aquifer Model: Unconfined

T = 300. m²/day

Sy = 0.05

Solution Method: Neuman

S = 0.004

β = 1.5

Figure 4-13 Interpretation using Neuman's method at 16MPWB011

5. Water quality data

Groundwater quality data has been collected from the drilling and testing programs completed in 2015 and 2016. This has included collection of field data during drilling of the bores (pH and TDS), collection of field data during the pump testing of the production bores, and collection of samples for comprehensive laboratory analysis at the completion of the pump tests. The below sections summarise the data from these investigations.

5.1 Field data

The data presented in the below figures shows the field data collected from the final air-lift of each completed bore. For comparative purposes, laboratory data is also presented for the field parameters. Data is presented for the 2015 and 2016 drilling programs.

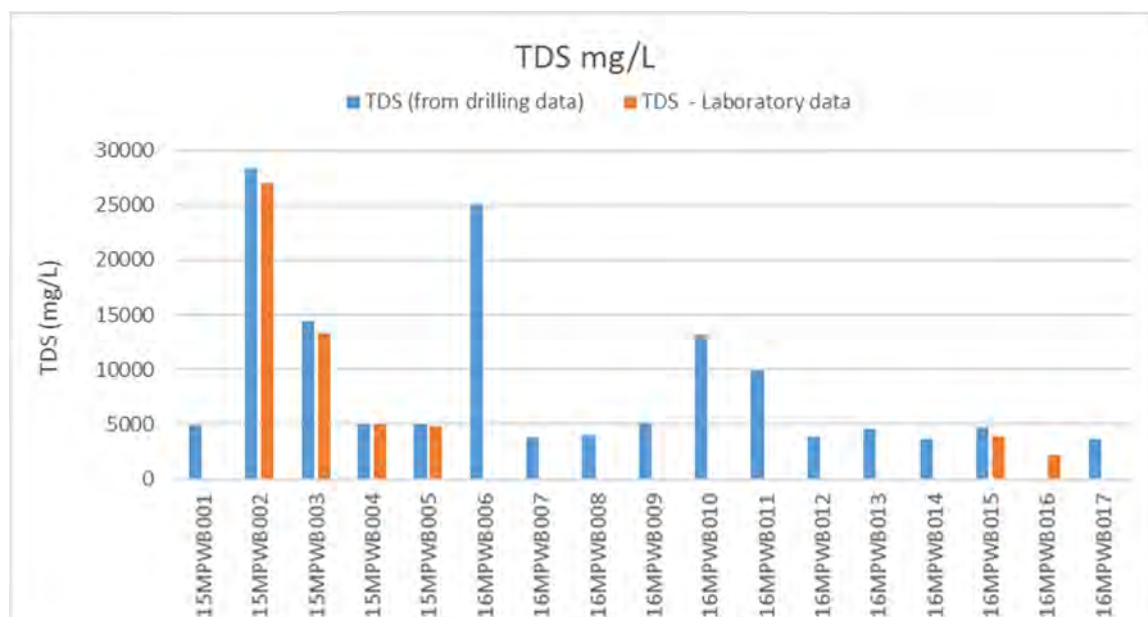


Figure 5-1 Field data for bores – TDS from final airlifting of bore

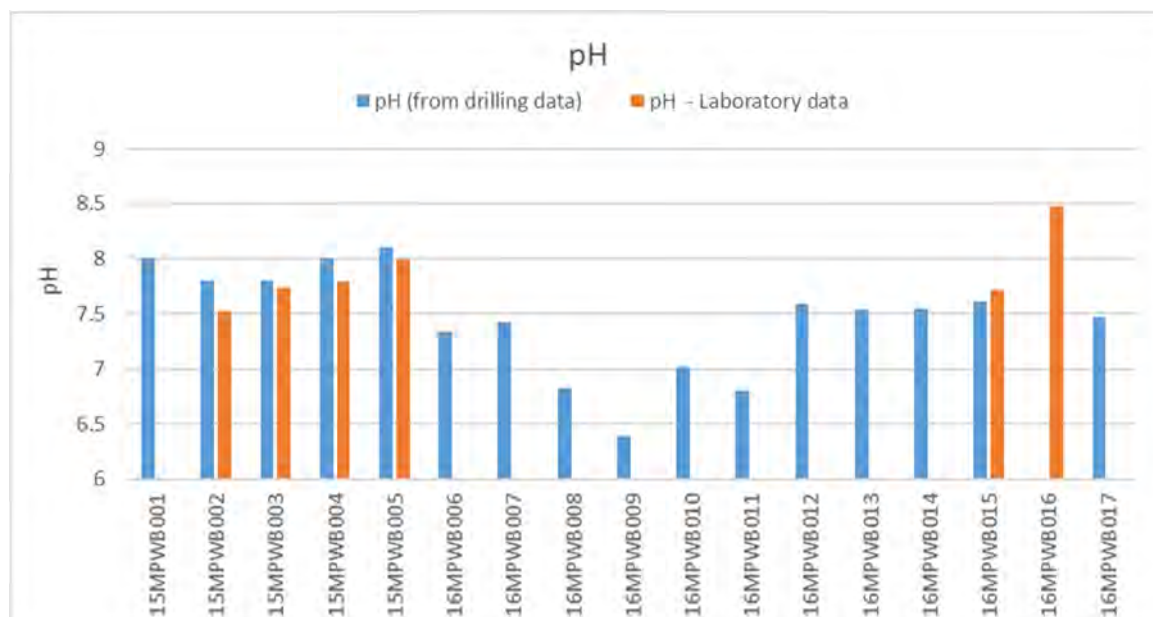


Figure 5-2 Field data for bores – pH from final airlifting of bore

5.2 Constant Rate Test field data

During the Constant Rate Test of MPWB015 and MPWB017, field water quality data, together with the recorded pump rate was measured at various intervals. The below plots illustrate this data.

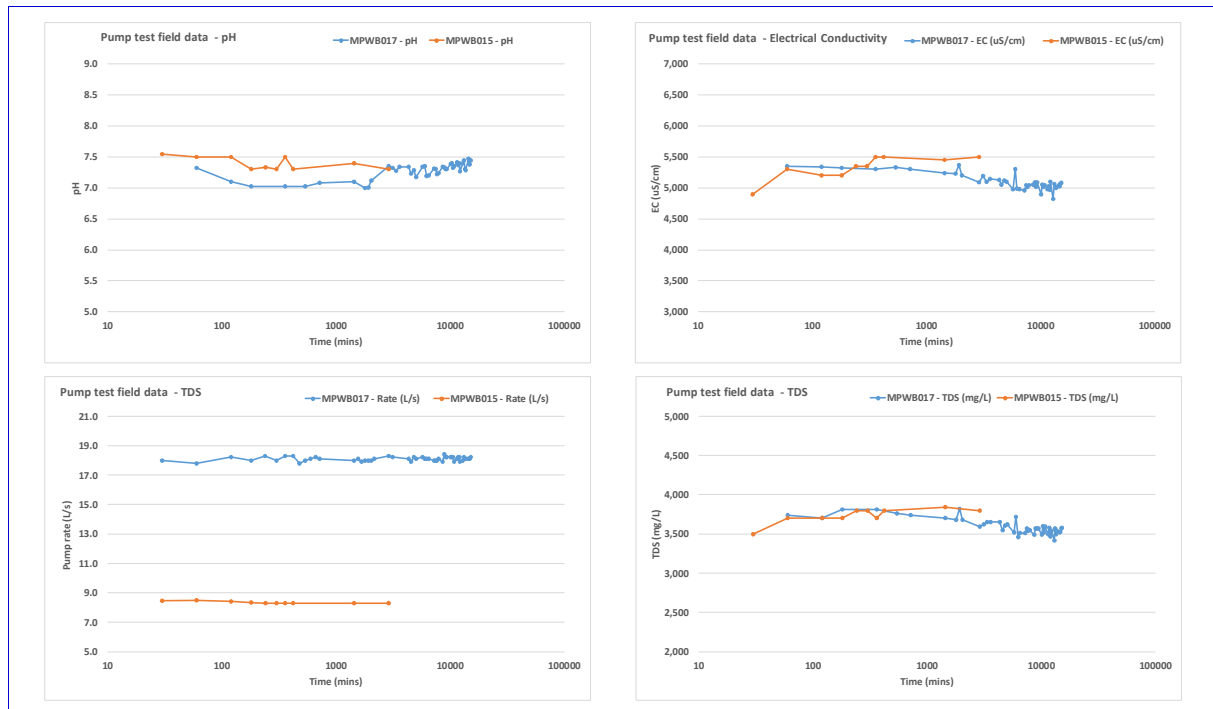


Figure 5-3 Field data during pumping test of MPWB017

5.3 Laboratory data

Samples were taken at the end of the pump tests on the monitoring bores and test production bores. The samples were submitted for laboratory analysis for a general water quality suite. The results for the analyses are presented below as Table 5-1.

Table 5-1 Laboratory results for monitoring bore and test production bores

		MPWB02	MPWB03	MPWB04	MPWB05	WB015	WB017
		24/03/2015	24/03/2015	24/03/2015	27/05/2015	23/12/2016	23/12/2016
ChemName	output unit						
Inorganics							
Sulfate as SO4 - Turbidimetric	mg/L	-	-	-	-	705	343
Electrical conductivity (lab)	µS/cm	41,600	20,400	7710	7200	6020	3380
Hydroxide as CaCO3	mg/L	<1	<1	<1	-	-	-
pH (Lab)	pH Units	7.52	7.73	7.79	7.8	7.71	8.47
Silica	µg/L	-	-	-	33,000	-	-
Total Dissolved Solids (calculated from EC)	mg/L	27,000	13,300	5010	4200	3910	2200
Metals							
Arsenic	mg/L	-	-	-	-	<0.001	<0.001
Barium	mg/L	-	-	-	<0.02	0.022	0.004
Beryllium	mg/L	-	-	-	-	<0.001	<0.001
Boron	mg/L	-	-	-	1.2	1.22	0.93
Cadmium	mg/L	-	-	-	-	0.0001	<0.0001
Chromium (III+VI)	mg/L	-	-	-	-	0.002	<0.001
Cobalt	mg/L	-	-	-	-	<0.001	<0.001
Copper	mg/L	-	-	-	-	0.039	<0.001
Iron	mg/L	-	-	-	5.7	-	-
Lead	mg/L	-	-	-	-	<0.001	<0.001
Manganese	mg/L	-	-	-	0.52	0.049	0.412
Mercury	mg/L	-	-	-	-	<0.0001	<0.0001
Nickel	mg/L	-	-	-	-	0.012	<0.001
Selenium	mg/L	-	-	-	-	0.01	<0.01
Strontium	mg/L	-	-	-	2.9	-	-
Uranium	mg/L	-	-	-	<0.05	-	-
Vanadium	mg/L	-	-	-	-	0.02	<0.01
Zinc	mg/L	-	-	-	-	0.143	<0.005
Alkalinity							
Alkalinity (Carbonate as CaCO3)	mg/L	<1	<1	<1	<10	<1	19
Alkalinity (Hydroxide as CaCO3)	mg/L	-	-	-	-	<1	<1
Alkalinity (total as CaCO3)	mg/L	491	515	315	-	338	311
Bicarbonate Alkalinity as CaCO3	mg/L	491	515	315	350	338	292
Hardness as CaCO3	mg/L	3620	2770	1040	940	1020	342
Major Ions							
Fluoride	mg/L	0.7	1.1	1	0.8	0.9	1.3
Calcium	mg/L	387	300	137	98	132	30
Chloride	mg/L	11,400	5140	1930	1600	1430	749
Magnesium	mg/L	645	491	169	170	167	65
Anions Total	meq/L	439	205	82.4	-	61.8	34.5
Potassium	mg/L	720	367	123	72	90	74
Sodium	mg/L	9010	3570	1320	1000	1040	625
Cations Total	meq/L	483	220	81.3	-	67.9	35.9
Sulphate	mg/L	5150	2410	1040	-	-	-
Ionic Balance	%	4.77	3.42	0.67	-	4.7	2.05
Nutrients							
Ammonia as N	mg/L	-	-	-	2.5	0.08	1.66
Nitrate (as N)	mg/L	-	-	-	7.4	14.7	7.18
Nitrite (as N)	mg/L	-	-	-	2.5	<0.01	0.76
Nitrite + Nitrate as N	mg/L	-	-	-	-	14.7	7.94
Phosphate total (P)	µg/L	-	-	-	<50	-	-
Reactive Phosphorus as P	µg/L	-	-	-	-	10	<10
Sulphate as S	mg/L	-	-	-	290	-	-

6. Conclusions

The drilling and testing completed has identified that the Hanson River Palaeochannel aquifer offers a suitable groundwater supply for the TNG Mount Peake Project. Groundwater salinity was found to be brackish to saline in all locations drilled. Due to the use of the majority of groundwater for ore processing, the high salinity is not a limiting factor for its use for the project.

In general the aquifer has been identified at the majority of locations drilled, with only one location indicating a lack of suitable aquifer thickness, attributable to the presence of a local basement high. The aquifer was generally found to be most productive towards its base where coarse gravels were found to correlate with higher groundwater flow. Due to the variable depth of these gravel layers, there was a considerable range in groundwater's yields found during drilling and testing.

Based on the drilling and testing completed, the key parameters and recommended pumping rates of the three constructed pumping bores are presented in Table 6-1. The below data should be considered in groundwater model development.

Table 6-1 Aquifer testing summary – production bores

Bore	Step test rates (L/s)	Constant Rate Test (L/s)	Recommended pump rate (L/s)	Bulk Kv (m/d)	Transmissivity (m ² /d)
15MPWB005	8, 10, 12, 15	12 (48 hour)	8.5	5	100-200
16MPWB015	5.5, 7.2, 9.3, 11.2	8.3 (48 hour)	8.5	2	115
16MPWB017	6, 8.1, 10.6, 17.6	18 (11 days)	18	7	300 - 400

Appendices

Appendix A - Bore logs

BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN19336, Hansen River Paleo Channel

HOLE No. 16MPWB006**SHEET 1 OF 1**

Position : 340042.2 E 7619180.7 N MGA94 53 **Surface RL:** 446.32m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : Atlas Copco T3 **Mounting:** Truck **Contractor :** Tomlin Drilling **Driller :** Murray Tomlin **Checked :**
Date Started : 8/7/2016 **Date Completed :** 9/7/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL								Note: * indicates signatures on original issue of log or last revision of log WELL PIEZOMETER	
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	Comments/ Observations	WELL PIEZOMETER Log	Components	
5	Downhole Hammer	PVC casing	7.18 mbgl 		3.00 (449.32)		SM	Sandy SILT, dark brown, with some gravel and pebbles (Alluvium) Silty GRAVEL, light gray, with clay and pebbles (Aluvium)	D	S	water and foam introduced during drilling <			

See standard sheets for details of abbreviations & basis of descriptions

**GHD**

GPO Box 668, Brisbane Qld 4001
T: 61 7 3316 3000 F: 61 7 3316 3333 E: bnemail@ghd.com
CLIENTS | PEOPLE | PERFORMANCE

Job No.**612905735**

BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN19337, Hansen River Paleo Channel

HOLE No. 16MPWB007**SHEET 1 OF 1**

Position : 340316.3 E 7622132.9 N MGA94 53 **Surface RL:** 442.37m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : Atlas Copco T3 **Mounting:** Truck **Contractor :** Tomlin Drilling **Driller :** Murray Tomlin **Checked :**
Date Started : 9/7/2016 **Date Completed :** 10/7/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL				Comments/ Observations	WELL PIEZOMETER	
SCALE (m)	Drilling Method	Hole Support Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	Components
5	Downhole Hammer	PVC casing 150mm	7.93 mbgl				SW	Gravelly SAND, light brown to gray, with silt (Alluvium)	D	L	150mm PVC casing with cement grout Blank PVC Slotted Screen Bottom Sump Bottom End Cap
10											
15					12.00 (454.37)		GW	Sandy GRAVEL, gray, traces of silt (Alluvium)	M	L-MD	
20					18.00 (460.37)		GW	Sandy GRAVEL, light brown, with silt (Alluvium)	W	L-MD	
25					24.00 (466.37)		GW-GC	sandy GRAVEL, brown to gray, with silt and clay (Alluvium)	W	L-MD	
30					30.00 (472.37)		GP	GRAVEL (coarse and clean), brown, with sand (Alluvium)	W	MD	
35					36.00 (478.37)		GC	Clayey GRAVEL, brown, fine to coarse (Alluvium)	W	L-MD	
40					42.00 (484.37)		GP	Sandy GRAVEL, gray, medium to coarse, traces of silt (Alluvium)	W	L-MD	
45					51.00 (493.37)			SANDSTONE, gray, fine to coarse grained, fresh to slightly weathered			
50											
55											Yield>10 L/s Good aquifer (42-51m)
60											Final reading after airlift Yield ~ 10 L/s pH~7.8 EC~5.6 mS/cm Temp 29 degree C TDS~3.1 ppt
65					66.00 (508.37)			End of borehole at 66 metres.			
70											8" drilling, 6" pvc casing, 0-12m blank 12-54m slotted 54-66m blank
75											
80											

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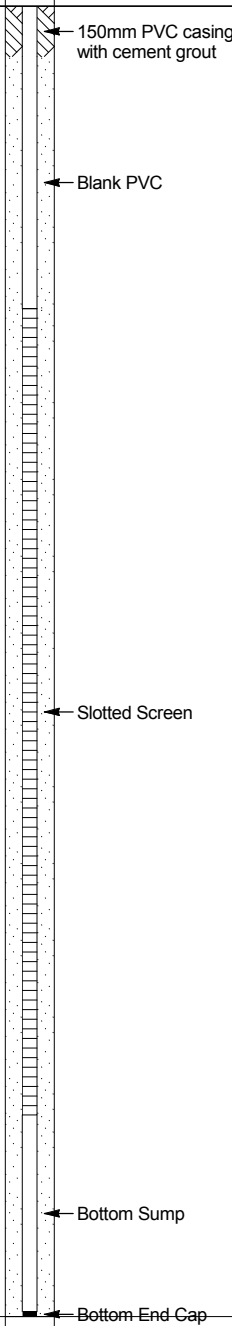
Job No.**612905735**

BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN19338, Hansen River Paleo Channel

HOLE No. 16MPWB008**SHEET 1 OF 1**

Position : 339894.4 E 7624268.0 N MGA94 53 **Surface RL:** 442.87m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : Atlas Copco T3 **Mounting:** Truck **Contractor :** Tomlin Drilling **Driller :** Murray Tomlin **Checked :**
Date Started : 10/7/2016 **Date Completed :** 10/7/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL				Comments/ Observations	WELL PIEZOMETER	
SCALE (m)	Drilling Method	Hole Support Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	Components
5	Downhole Hammer	PVC casing 150mm	9.03 mbgl		3.00 (445.87)		SM		D	L- MD	 150mm PVC casing with cement grout Blank PVC Slotted Screen Bottom Sump Bottom End Cap
10							SM	Silty SAND, dark brown to gray, with some gravel (Alluvium)	D	L- MD	
15											
20					18.00 (460.87)		GW	Sandy GRAVEL, light brown, little to no fine (Alluvium)	W	L- MD	
25					24.00 (466.87)		GC	Gravelly CLAY, brown, with silt (Alluvium)	W	L- MD	
30					27.00 (469.87)		GW	Sandy GRAVEL, brown, little to no fine (Alluvium)	W	L	
35					30.00 (472.87)		GC	Clayey GRAVEL, brown, with silt (Alluvium)	W	L- MD	
40					33.00 (475.87)		GW	Sandy GRAVEL, brown, little to no fine (Alluvium)	W	L	
45					36.00 (478.87)		GC	Sandy GRAVEL, brown, with clay (Alluvium)	W	L- MD	
50											
55											
60											
65					66.00 (508.87)			SILTSTONE, gray, fine grained, moderately to highly weathered, weak at the top and strong at the bottom.	W		42-66 m good aquifer.
70											Final Airlift Yield ~ 10 L/s EC ~ 6.1 mS/cm TDS ~ 3.3 ppt
75											
80					78.00 (520.87)			End of borehole at 78 metres.			
85											8" drilling, 6" casing 0-18m blank, 16-66m slotted, 66-78m blank
90											

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Job No.**612905735**

BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN19339, Hansen River Paleo Channel

HOLE No. 16MPWB009**SHEET 1 OF 1**

Position : 338815.0 E 7627527.9 N MGA94 53 **Surface RL:** 438.91m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : Atlas Copco T3 **Mounting:** Truck **Contractor :** Tomlin Drilling **Driller :** Murray Tomlin **Checked :**
Date Started : 11/7/2016 **Date Completed :** 11/7/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL				Comments/ Observations		WELL PIEZOMETER Log	
SCALE (m)	Drilling Method	Hole Support Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index		Components
5	Downhole Hammer	PVC casing 150mm	9.3 mbgl				SM	Silty SAND, brown, with some gravel (Alluvium)	D	L-MD		150mm PVC casing with cement grout
10												Blank PVC
15					12.00 (450.91)		GW-GM	Sandy GRAVEL, brown, with silt and clay (Alluvium)	W	L-MD	minor seepage at 13m	
20											Airlift yield ~ 0.5 L/s	
25					24.00 (462.91)		GW	Sandy GRAVEL, brown, minor silt and clay (Alluvium)	W	D	Airlift yield ~ 2.5 L/s EC ~ 7.1 mS/cm	
30												
35											Airlift yield ~ 4 L/s	Slotted Screen
40												
45												
50					48.00 (486.91)		GW-GM	Sandy GRAVEL, gray, with silt and clay (Alluvium)	W	L-MD	Airlift yield ~ 5 L/s	
55												
60												
65					63.00 (501.91)			SILTSTONE/SANDSTONE, brown with some pink shade, moderately weathered, fine grained	W		Final airlift yield (after casing) ~ 4 L/s pH 8 EC 7.5 mS/cm TDS 4.1 ppt	Bottom Sump
70												
75					72.00 (510.91)			End of borehole at 72 metres.				Bottom End Cap
80											8" drilling 6" pvc casing 0-12m blank 12-60m slotted 60-72m blank	

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Job No.**612905735**

BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN19340, Hansen River Paleo Channel

HOLE No. 16MPWB010**SHEET 1 OF 1**

Position : 340558.0 E 7619307.9 N MGA94 53 **Surface RL:** 446.12m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : Atlas Copco T3 **Mounting:** Truck **Contractor :** Tomlin Drilling **Driller :** Murray Tomlin **Checked :**
Date Started : 12/7/2016 **Date Completed :** 12/7/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL				Comments/ Observations	WELL PIEZOMETER Log	
SCALE (m)	Drilling Method	Hole Support Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	Components
0	Downhole Hammer	PVC casing 50mm	8.51 mbgl		6.00 (452.12)		SM	Silty SAND, light gray, trace of travel (Alluvium)	D		50mm PVC casing Blank PVC Slotted Screen Blank PVC Slotted Screen Bottom End Cap
10					12.00 (458.12)		CH	CLAY, gray, high plasticity (Alluvium)	M	S-F	
20					24.00 (470.12)		CI	Gravelly CLAY, with gray, Alluvium		S	
30					33.00 (479.12)		CI	Gravelly CLAY, brown, sticky (Alluvium)		S	
40					66.00 (512.12)			SANDSTONE, gray, medium grained, moderately to highly weathered			
50					81.00 (527.12)			SANDSTONE, gray, medium grained, fresh with quartz			
60					84.00 (530.12)			End of borehole at 84 metres.			
70											
80											
90											
100											8" drilling 2" casing 0-12m blank 12-30m slotted 30-66m blank 66-84m slotted

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Job No.**612905735**

BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN19341, Hansen River Paleo Channel

HOLE No. 16MPWB011**SHEET 1 OF 1**

Position : 340883.0 E 7622041.1 N MGA94 53 **Surface RL:** 458.66m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : Atlas Copco T3 **Mounting:** Truck **Contractor :** Tomlin Drilling **Driller :** Murray Tomlin **Checked :**
Date Started : 12/7/2016 **Date Completed :** 13/7/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL						WELL PIEZOMETER			
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	Comments/ Observations	WELL PIEZOMETER Log	Components	
5	Downhole Hammer	PVC casing 150mm	7.83 mbgl				SW	SAND, gray, traces of silt and gravel (Alluvium)	D	L	Water strike at 13m, (12-21m Good aquifer)		150mm PVC casing with cement grout	
10													Blank PVC	
15														
20							12.00 (470.66)		SW	Gravelly SAND, brown, traces of silt (Alluvium)	W	L- MD	at 18m, Airlift yield ~ 5 L/s	
25							18.00 (476.66)		GW	Sandy GRAVEL, gray, minor silt (Alluvium)	W	MD		
30							21.00 (479.66)		CL	Gravelly CLAY, brown, medium plasticity (Alluvium)	W	Soft		
35													21-30m Aquitard with low Kv	
40							30.00 (488.66)		GP	GRAVEL, brown, coarse granined (Alluvium)	W	MD		
45							33.00 (491.66)		GC	Clayey GRAVEL, brown (Alluvium)	W	MD		
50							36.00 (494.66)		GW	Sandy GRAVEL,	W	MD	at 42m, Airlift yield ~ 10 L/s EC 18 mS/cm pH 7.8 Temp 28	
55							42.00 (500.66)		GP-GC	Sandy GRAVEL, brown, with clay (Alluvium)	W	MD		
60							51.00 (509.66)		GW	Sandy GRAVEL, gray, little to no fine (Alluvium)	W	MD		
65					54.00 (512.66)			SILTSTONE, gray, fined grained, moderately weathered, weak to strong (crushed by drilling)	W		After casing final airlift yield ~ 7L/s EC 23 mS/cm TDS 16.2 ppt pH 7.9 Temp 28 degree C			
70					60.00 (518.66)			End of borehole at 60 metres.					Bottom Sump	
											8" drilling 6" casing 0-12m blank 12-54m slotted 54-60m blank		Bottom End Cap	

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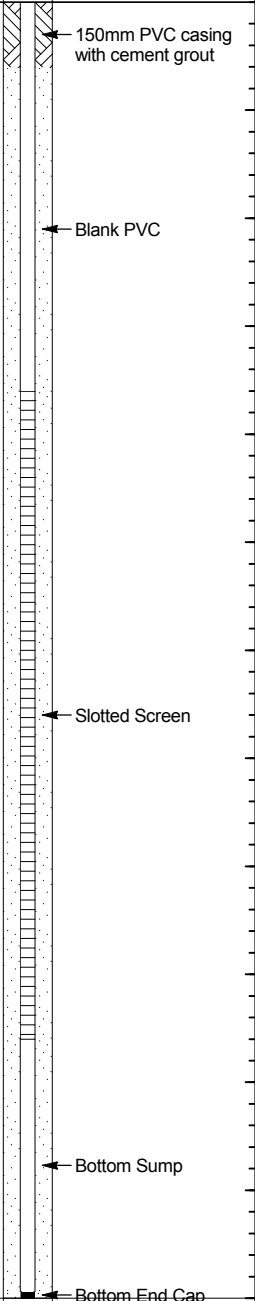
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BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN19342, Hansen River Paleo Channel

HOLE No. 16MPWB012**SHEET 1 OF 1**

Position : 339324.4 E 7622344.3 N MGA94 53 **Surface RL:** 445.81m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : Atlas Copco T3 **Mounting:** Truck **Contractor :** Tomlin Drilling **Driller :** Murray Tomlin **Checked :**
Date Started : 13/7/2016 **Date Completed :** 13/7/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL								WELL PIEZOMETER	
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	Comments/ Observations	WELL PIEZOMETER Log	Components	
5	Downhole Hammer	PVC casing 150mm	9.3 mbgl				SM	Silty SAND, brown, with some gravel (Alluvium)	D	L-MD	water strike at 13m at 18m, Airlift yield ~ 3.5 L/s at 24m, Airlift yield ~ 5 L/s at 30m, Airlift yield ~ 5 L/s EC 4.9 mS/cm Temp 28 degree pH 7.6 Good aquifer interval (24-33m) at 36m, Yield ~ 7.5 L/s at 48m, Yield ~ 8-10 L/s EC 5.3 mS/cm Temp 28 degrees pH 7.8 Final Airlit (after casing) Yield 5 L/s pH 7.56 EC 5.84 mS/cm TDS 4.15 ppt			
10														
15							12.00 (457.81)	GC	Sandy GRAVEL, brown, fine to coarse grained, with clay (Alluvium)	W		L-MD		
20							18.00 (463.81)	GW	Sandy GRAVEL, brown, medium to coarse, with clay (Alluvium)	W		L-MD		
25							24.00 (469.81)	GW	Sandy GRAVEL, gray, little to no fine (Alluvium) Good aquifer interval	W		L-MD		
30														
35							33.00 (478.81)	GW	Sandy GRAVEL, brown, with silt (Alluvium)	W		L-MD		
40														
45							42.00 (487.81)		SANDSTONE (Ferrigenous), brown, fine to coarse, modelrately weathered. Broken by drilling	W				
50														
55														
60					60.00 (505.81)			End of borehole at 60 metres.			8" drilling, 6" casing 0-18m blank 18-48m slotted 48-60m blank			
65														
70														

Note: * indicates signatures on original
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BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN19343, Hansen River Paleo Channel

HOLE No. 16MPWB013**SHEET 1 OF 1**

Position : 338330.4 E 7622422.8 N MGA94 53 **Surface RL:** 445.96m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : Atlas Copco T3 **Mounting:** Truck **Contractor :** Tomlin Drilling **Driller :** Murray Tomlin **Checked :**
Date Started : 14/7/2016 **Date Completed :** 14/7/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL				Comments/ Observations	WELL PIEZOMETER	
SCALE (m)	Drilling Method	Hole Support Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	Components
5	Downhole Hammer	PVC casing 150mm	9.78 mbgl				SM	Silty SAND, brown, with some gravel (Alluvium)	D	L- MD	
10											
15											
20					18.00 (463.96)		GC	Clayey GRAVEL, gray (Alluvium)	W	L- MD	
25					24.00 (469.96)		GW	Sandy GRAVEL, brown, medium to coarse, traces of silt (Alluvium)	W	L- MD	
30					30.00 (475.96)		SP	SAND, brown, medium to coarse, (Alluvium)	W	L	
35					33.00 (478.96)		GW	Sandy GRAVEL, brown, with some clay (Alluvium)	W		
40					39.00 (484.96)		GC	Clayey GRAVEL, brown (Alluvium)	W		
45					42.00 (487.96)		GW	Sandy GRAVEL, dark brown (ferrigenous), traces of silt and clay, (Alluvium)	W		
50					48.00 (493.96)			SILTSTONE, gray, fine grained, moderately to highly weathered.	W		
55											
60					60.00 (505.96)			End of borehole at 60 metres.			
65											
70											

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BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN19344, Hansen River Paleo Channel

HOLE No. 16MPWB014**SHEET 1 OF 1**

Position : 337310.4 E 7622606.9 N MGA94 53 **Surface RL:** 447.27m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : Atlas Copco T3 **Mounting:** Truck **Contractor :** Tomlin Drilling **Driller :** Murray Tomlin **Checked :**
Date Started : 14/7/2016 **Date Completed :** 15/7/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL				Comments/ Observations	WELL PIEZOMETER Log	
SCALE (m)	Drilling Method	Hole Support Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	Components
5	Downhole Hammer	Steel casing 150mm	11.3 mbgl		6.00 (453.27)		SM	Silty SAND, brown, traces of gravel, Alluvium	D	L	150mm steel casing with cement grout at 7m driller introduced water during drilling at 21m, first water strike at 24m, yield~0.5 L/s at 30m, yield ~2 L/s Hole collapsed/caved in at 30m, hence steel casing introduced for this hole at 36m, yield~5 L/s EC 5.5 mS/cm TDS 3.8 ppt pH 7.5 Temp 26 degrees After casing airlift Yield ~ 5 L/s EC 5.35 mS/cm TDS 3.75 ppt Temp 26 degrees
10					9.00 (456.27)		GC	Clayey GRAVEL, dark brown, Alluvium	M	MD	
15							CL	Silty CLAY, brown, traces of sand, Alluvium	M	S	
20					21.00 (468.27)		GC	Clayey GRAVEL, dark brown, Alluvium	W	MD	
25					24.00 (471.27)		GW	Sandy GRAVEL, dark brown, ferruginous, with clay, Alluvium	W	D	
30											
35					36.00 (483.27)			SANDSTONE/SILTSTONE, brown and gray mixed, moderately to highly weathered, porous, light, broken by drilling, possibly of low strength	W		
40											
45											
50											
55											
60					60.00 (507.27)			End of borehole at 60 metres.			Bottom End Cap
65											
70											

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BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN19345, Hansen River Paleo Channel

HOLE No. 16MPWB015**SHEET 1 OF 1**

Position : 339884.0 E 7624270.0 N MGA94 53 **Surface RL:** 442.90m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : Atlas Copco T3 **Mounting:** Truck **Contractor :** Tomlin Drilling **Driller :** Murray Tomlin **Checked :**
Date Started : 16/7/2016 **Date Completed :** 17/7/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL						WELL PIEZOMETER				
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	Comments/ Observations	WELL PIEZOMETER Log	Components		
5	Downhole Hammer	Steel casing 200mm	9.3 mbgl				SM	Silty SAND, brown, traces of gravel, Alluvium	D	L	at 9m, water and foam introduced during drilling.				
10													200mm steel casing with cement grout		
12.00 (454.90)							GM	Sandy GRAVEL, brown, with silt, Alluvium	M	MD			Bentonite		
15															
18.00 (460.90)								GW	Sandy GRAVEL, gray, coarse, traces of silt, Alluvium	W	MD	at 18m, first water strike (yield ~ 0.5 L/s)		Steel casing	
20															
24.00 (466.90)								GW to GM	Sandy GRAVEL, gray (30-33m) to brown (33-36m), with silt and clay, Alluvium	W	MD	at 24m, yield ~ 3 L/s		Bentonite	
25															
30													at 30m, yield ~ 4 L/s EC 5.7 mS/cm TDS 4.1 ppt		
35															
36.00 (478.90)									GC	Clayey GRAVEL, brown, fine to coarse, with silt, Alluvium	W	MD	increased rig vibration (36 to 39m)		Slotted Screen
40															
45.00 (487.90)							GW	Sandy GRAVEL, brown, with minor silt, Alluvium	W	MD	at 42m, yield ~ 4 L/s EC 5.8 mS/cm				
45															
50											at 48m, yield ~ 5 Ls EC 5.9 mS/cm TDS 4.2 ppt				
54.00 (496.90)															
55															
57.00 (499.90)															
57.00 (499.90)							GW	Sandy GRAVEL, dark brown, with minor silt and clay, Alluvium	W	MD					
60											at 60m, yield ~ 8 L/s EC 6.3 mS/cm TDS 4.6 ppt		Screen (Johnson 54 to 66m)		
65															
66.00 (508.90)											at 66m, yield ~ 8-10 L/s EC 6.5 mS/cm TDS 4.6 ppt				
70															
72.00 (514.90)								SILTSTONE, gray, fine grained, highly weathered, weak (broken by drilling)	W				Bottom Sump		
75								End of borehole at 72 metres.			Final yield after screen ~ 8-10 L/s EC 6.6 mS/cm TDS 4.68 ppt pH 7.61		Bottom End Cap		
80											12" drilling, 8" steel casing.				
85											0-18m blank 18-54m slotted 54-66m screen (johnson)				
90											66-72m blank				

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BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN019424, Hansen River Paleo Channel

HOLE No. 16MPWB016**SHEET 1 OF 1**

Position : 340322.0 E 7622133.0 N MGA94 53 **Surface RL:** 442.40m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : RIG008- 685 SH **Mounting:** Truck **Contractor :** Silver City Drilling **Driller :** Hamish Beach **Checked :**
Date Started : 1/12/2016 **Date Completed :** 1/12/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL						WELL PIEZOMETER		
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	Comments/ Observations	WELL PIEZOMETER Log	Components
5	Downhole hammer	PVC Casing	7.9 mbgl 		3.00 (445.40)		SW	Gravelly SAND with silt, Brown, Alluvium	D		Foam introduced Water strike at 18-20 m		150mm PVC casing with cement grout Blank PVC Slotted Screen Bottom End Cap
							SW	Gravelly SAND with silt, Gray, Alluvium	D				
10					9.00 (451.40)		SW	Gravelly SAND with silt, Brown, Alluvium	D				
					12.00 (454.40)		SW	Silty SAND with gravel, Brown, Alluvium	SM				
15					15.00 (457.40)		SW	Silty SAND, minor gravel, mosit, Alluvium (foam introduced)	M				
20					18.00 (460.40)		GP	Sandy GRAVEL, with some pebbles, brown, Alluvium	W				
					21.00 (463.40)			End of borehole at 21 metres.					
25													
30													
35													
40													
45													
50													
55													
60													

See standard sheets for details of abbreviations & basis of descriptions

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GPO Box 668, Brisbane Qld 4001
 T: 61 7 3316 3000 F: 61 7 3316 3333 E: bnemail@ghd.com
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Job No.**612905735**

BOREHOLE LOG SHEET WITH WELL PIEZOMETER

Client : TNG
Project : Mount Peak Water Supply
Location : RN019425, Hansen River Paleo Channel

HOLE No. 16MPWB017**SHEET 1 OF 1**

Position : 340327.0 E 7622126.0 N MGA94 53 **Surface RL:** 442.40m **Angle from Horiz. :** -90° **Processed :** BG
Rig Type : RIG008- 685 SH **Mounting:** Truck **Contractor :** Silver City Drilling **Driller :** Hamish Beach **Checked :**
Date Started : 1/12/2016 **Date Completed :** 2/12/2016 **Logged by :** BG **Date:**

DRILLING					MATERIAL					Comments/ Observations	WELL PIEZOMETER	
SCALE (m)	Drilling Method	Hole Support Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition Consistency / Density Index		WELL PIEZOMETER Log	Components
5	Percussion downhole hammer	Steel Casing	7.95		6.00 (448.40)		SW	Gravelly SAND with silt, Brown, Alluvium	D	foam introduced during drilling from 9 to 60 m Yield ~ 2 L/s Sampling from 21 to 40 is not done properly by the driller Yield ~ 10- 12 L/s EC 5.6 mS/cm TDS 3.1 ppt pH 7.9 Yield ~ 10- 15 L/s (Sampling was difficult due to high water pressure)		200mm steel casing with cement grout
10					21.00 (463.40)		GW	Sandy GRAVEL with some silt, Brown, Alluvium	W			Bentonite
15					15.00 (457.40)		GP	Sandy GRAVEL, minor silt, Gray, Alluvium	W			Bentonite
20					30.00 (472.40)		GP	Sandy GRAVEL, Coarse, little to no fine, Brown, Alluvium	W			Slotted Screen
25					36.00 (478.40)		GC	Sandy GRAVEL with Clay, Gray (36-39) to Brown (39-42), Alluvium	W			Screen (Johnson 42 to 54 m)
30					42.00 (484.40)		GP	Sandy GRAVEL, Brown, Coarse, Little to no fine, Alluvium	W			Bottom Sump
35					51.00 (493.40)			Sandstone/SILTSTONE, Gray, fine to coarse, slightly weathered	W			Bottom End Cap
40					60.00 (502.40)			End of borehole at 60 metres.				
45												
50												
55												
60												
65												
70												

See standard sheets for
 details of abbreviations
 & basis of descriptions



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Job No.**612905735**

Appendix B – Borefield cross sections

TNG LIMITED

MOUNT PEAKE PROJECT

Borefield Tenure and Section Locations

Author: C.W.
ENIGMA MINING LTD
Date: 5/11/2016
Mount Peake Tenure.mxd

LEGEND

- Waterbore Locations
- TNG Exploration Licences
- TNG Ancillary Mining Leases



Kilometers
0 2 4 6 8

Projection: GDA94 MGA Zone 53
1:250,000

Mount Peake
Resource

LONG SECTION

CROSS
SECTION

HANSON

DARWIN
ALICE
SPRINGS

133°20'E

133°30'E

133°20'E

133°30'E

21°40'0"S

21°30'0"S

21°20'0"S

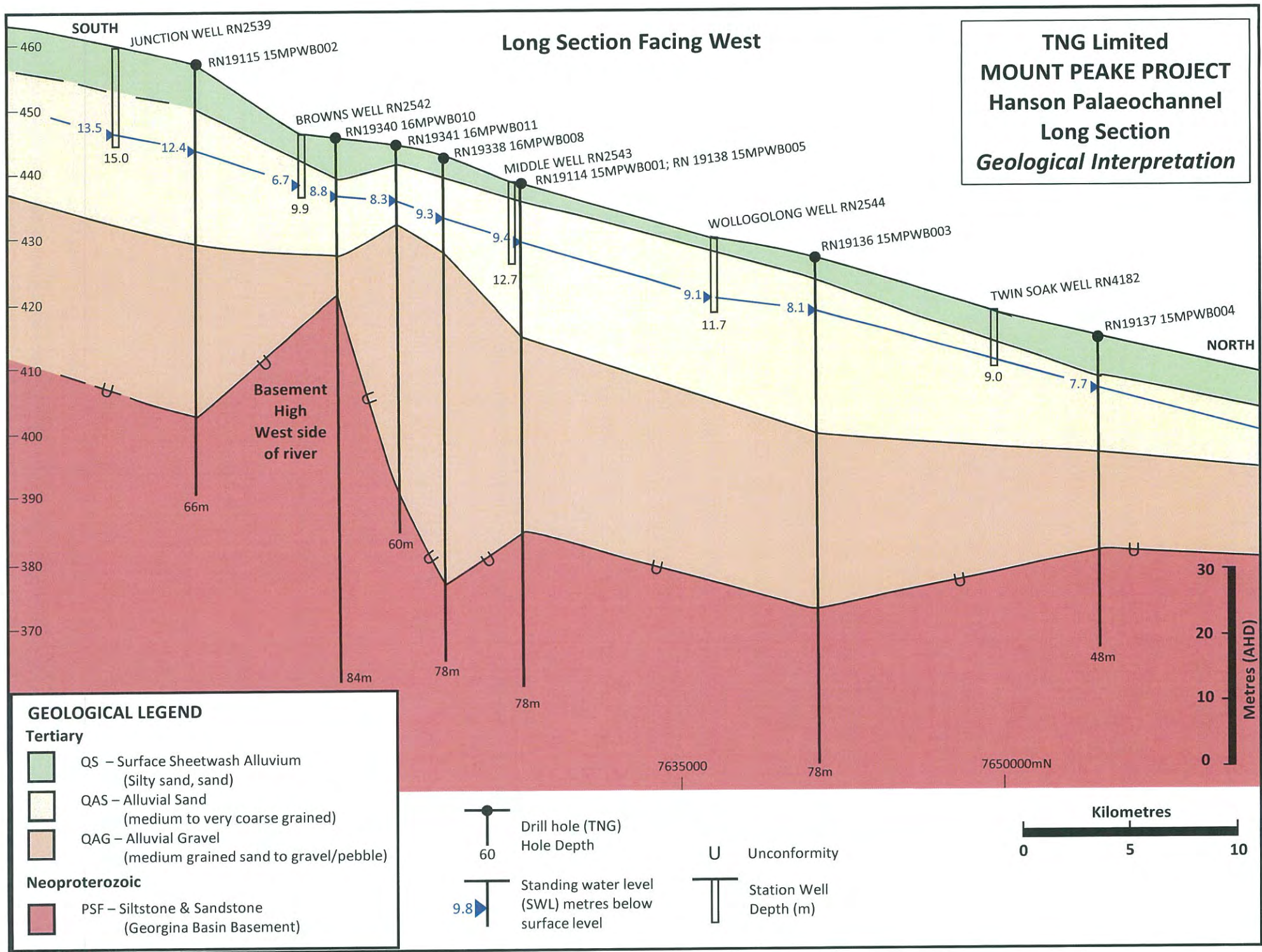
21°10'0"S

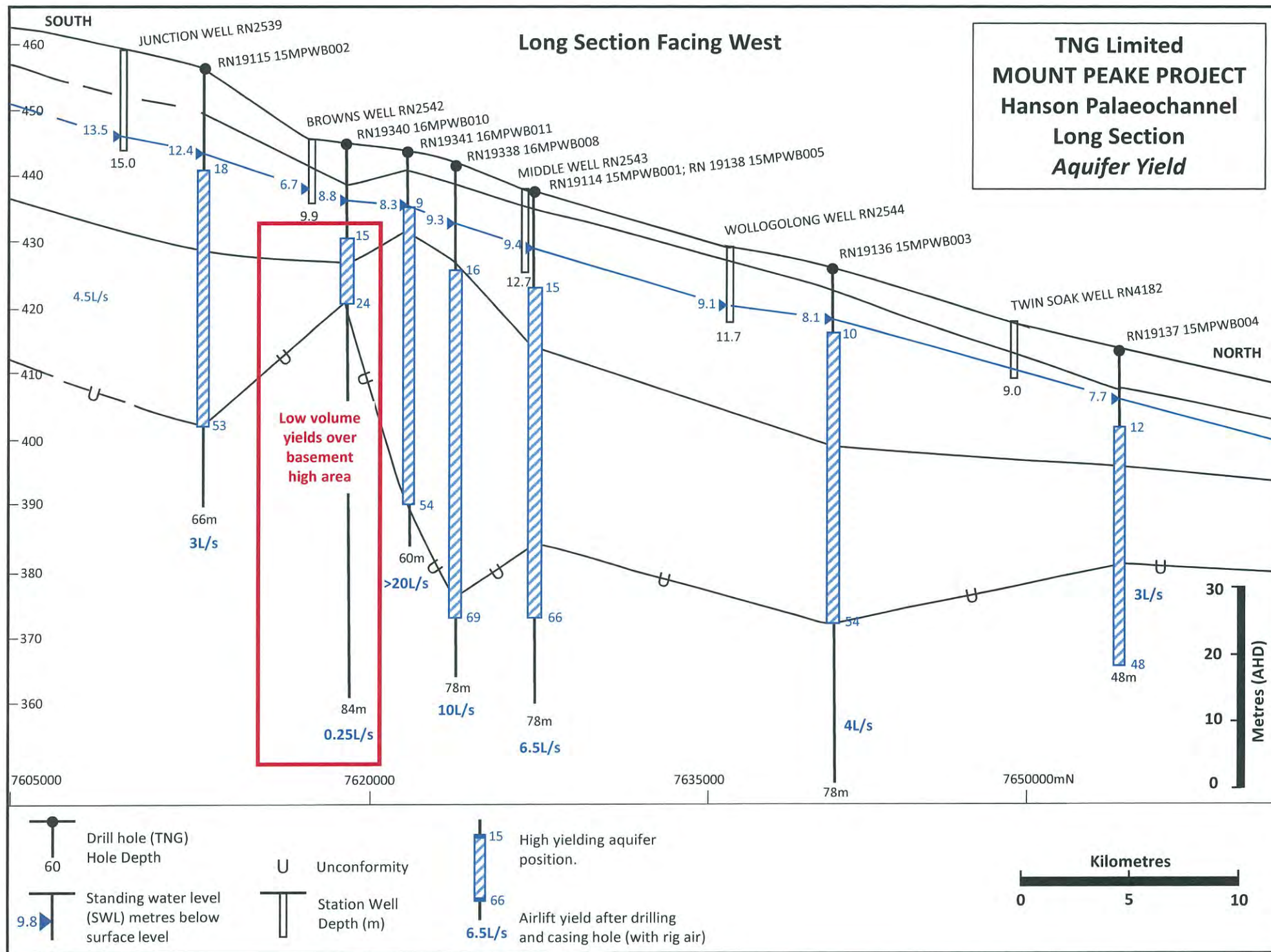
21°40'0"S

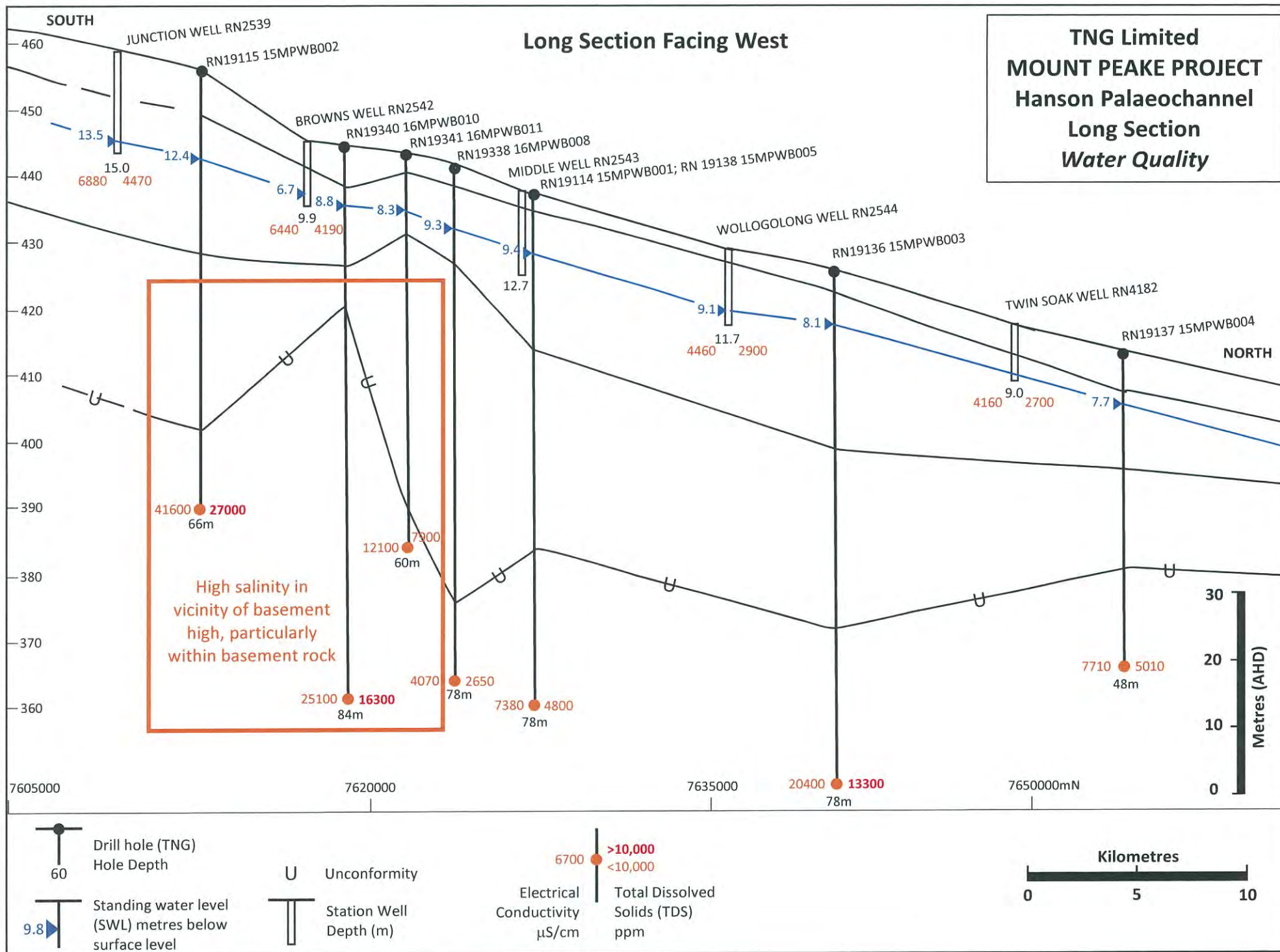
21°30'0"S

21°20'0"S

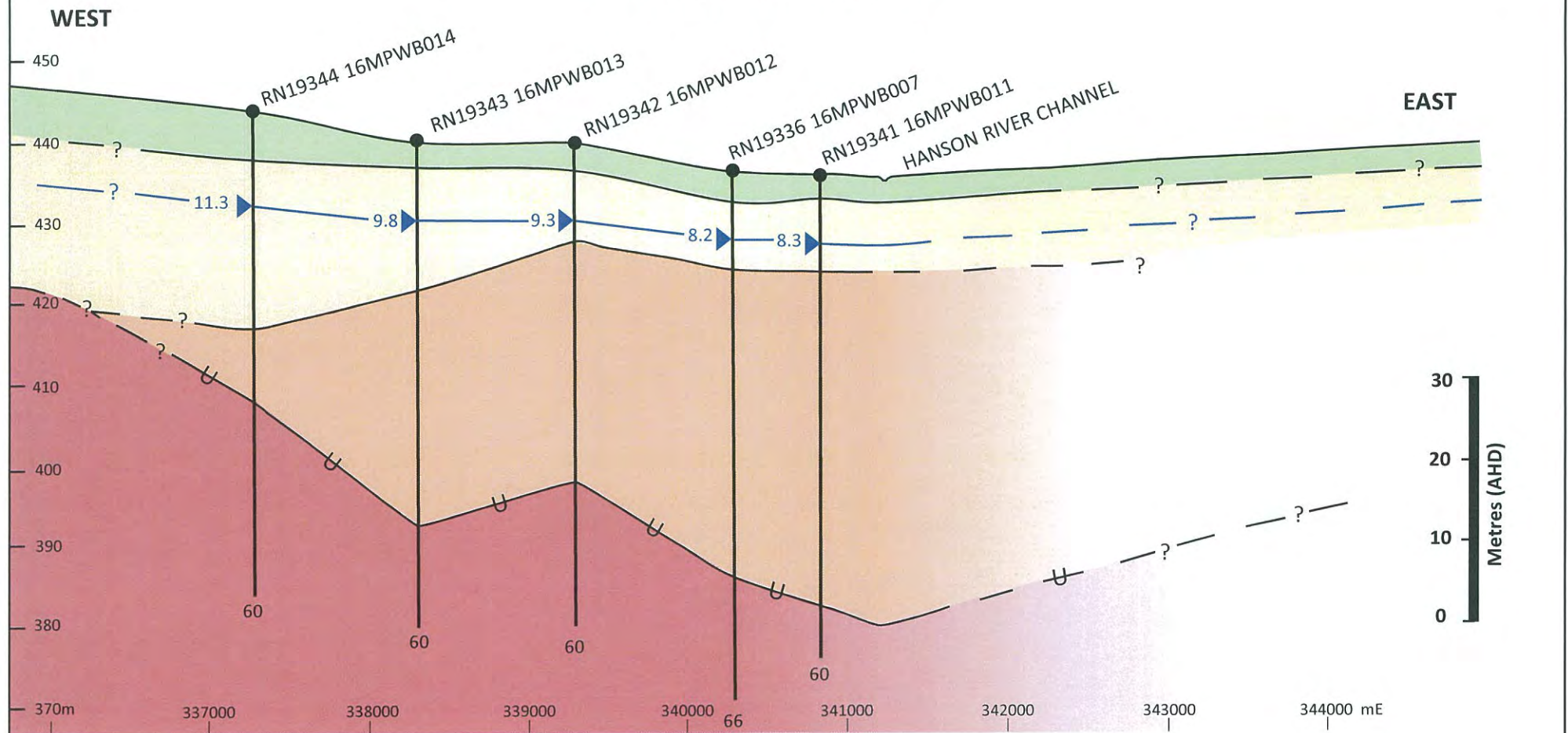
21°10'0"S







Cross Section Facing North



GEOLOGICAL LEGEND

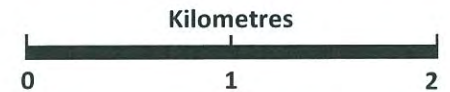
Tertiary

- QS – Surface Sheetwash Alluvium (Silty sand, sand)
- QAS – Alluvial Sand (medium to very coarse grained)
- QAG – Alluvial Gravel (medium grained sand to gravel/pebble)

Neoproterozoic

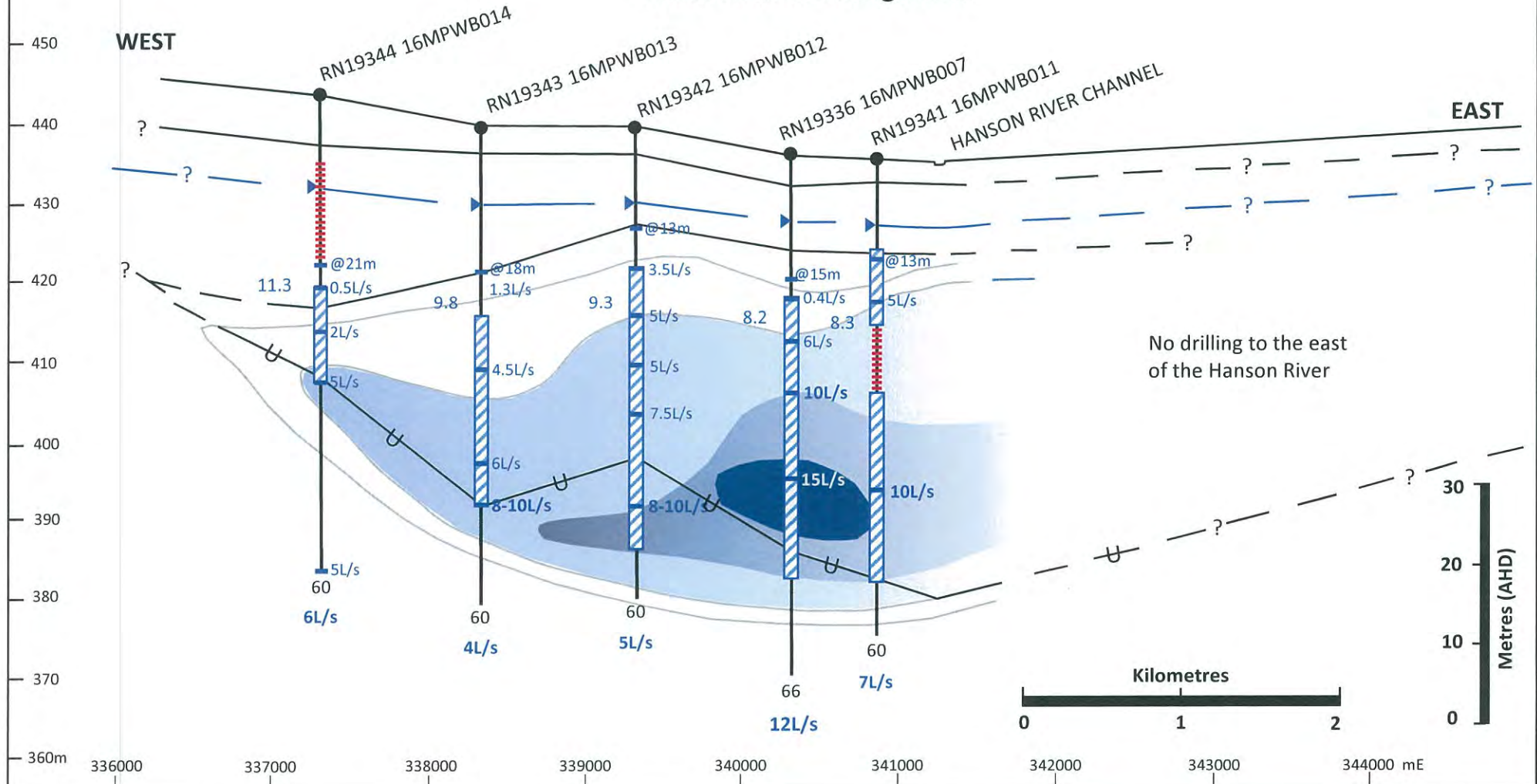
- PSF – Siltstone & Sandstone (Georgina Basin Basement)

- U Unconformity
- Drill hole (TNG)
Hole Depth
60
- Standing water level (SWL) metres below surface level
9.8



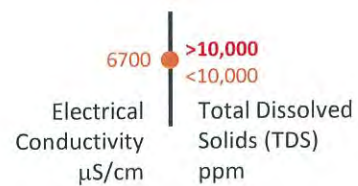
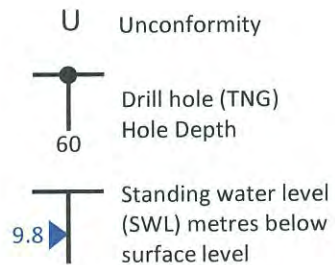
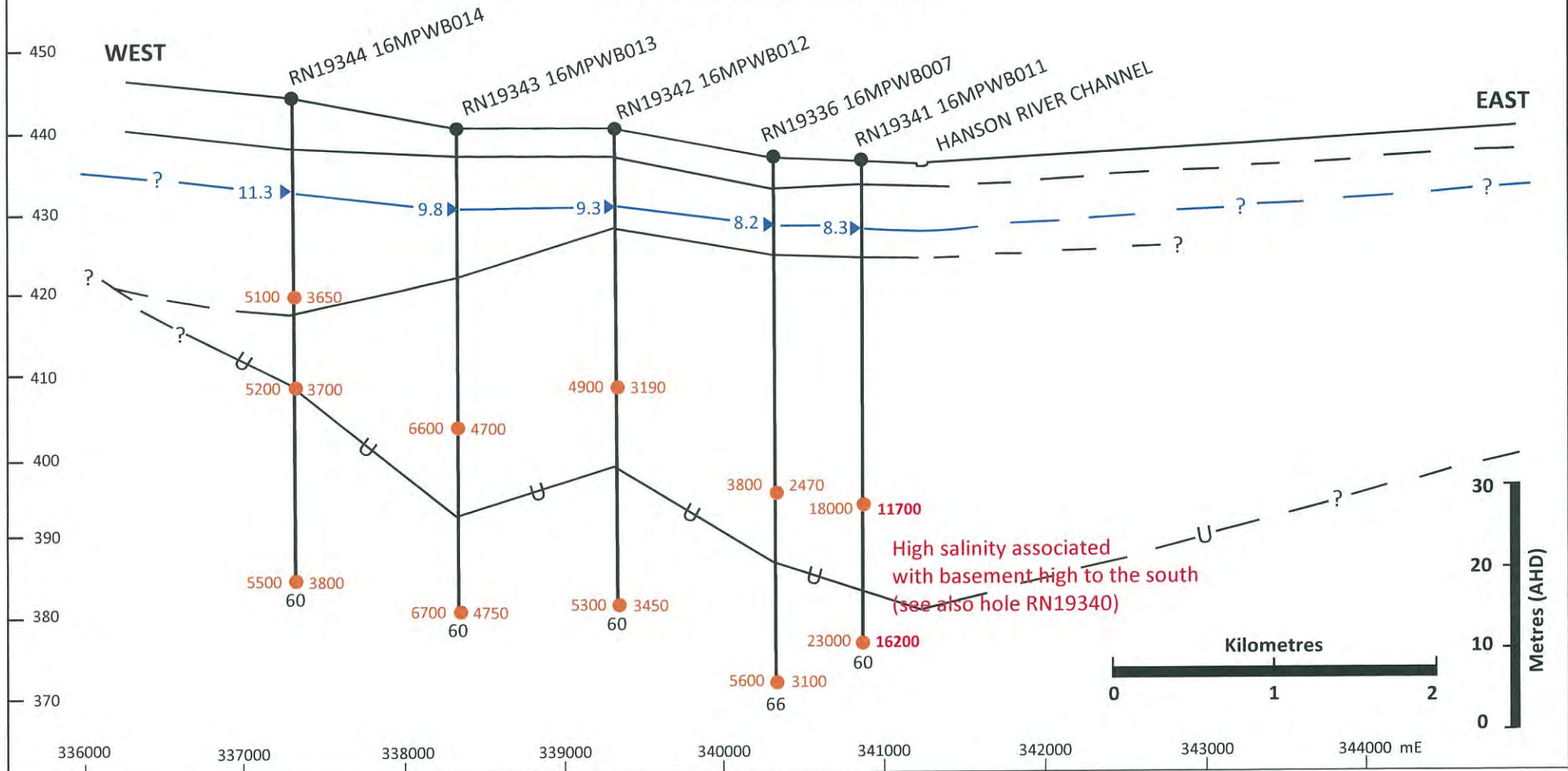
TNG Limited
MOUNT PEAKE PROJECT
Hanson Palaeochannel
Cross Section
Geological Interpretation

Cross Section Facing North



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Hanson Palaeochannel
Cross Section
Aquifer Yield

Cross Section Facing North



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Hanson Palaeochannel
Cross Section
Water Quality

GHD

GHD, 999 Hay Street, Perth, WA 6000

P.O. Box 3106, Perth WA 6832

T: OfficeTelephone F: 61 8 6222 8555 E: permail@ghd.com.au

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Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	B Gautam	A Osbaldeston	ON FILE	I McCardle	ON FILE	10/3/17

www.ghd.com



GHD

GHD, 999 Hay Street, Perth, WA 6000

P.O. Box 3106, Perth WA 6832

T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

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		Name	Signature	Name	Signature	Date
	Adam Osbaldeston	Ian McCardle	On file	Ian McCardle	On file	24/03/2017

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