ROY HILL IRON ORE

SUPPLIER DOCUMENT REVIEW COVER SHEET

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Services provided:

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Water Management Studies - H3 Groundwater Report

Documentation Review Status

S1 No Comments. ☐

S2 Comments as Noted,
Revise & Resubmit Within 15 Working Days. ☐

S3 Not Reviewed, Information Only. ☐

S4 Not suitable for Review,
Revise & Resubmit Within 15 Working Days. ☐

Review of the document does not relieve the Contractor/Supplier of its responsibility for the due and proper performance of the Works in accordance with the Contract.

ADDITIONAL COMMENTS

Next Issue at Revision:

Signed: Date:

Name:

Position:

Roy Hill

McPhee Creek Iron Ore Project
Water Management Studies
H3 Groundwater Report

October 2021

Executive summary

Project description and scope

GHD Pty Ltd was commissioned by Roy Hill Iron Ore Pty Ltd to undertake water management studies for the proposed McPhee Creek iron ore mine site in the Pilbara region of Western Australia (the Proposal).

Atlas Iron (acquired by Hancock Group Pty Ltd in 2018) is jointly preparing a PFS for the proposed McPhee Creek Project.

The Proposal is in the Pilbara region of Western Australia, predominantly within mining tenement M45/1243-I. The Proposal is for the above and below water table mining of iron ore from five open cut pits, located approximately 30 km north of Nullagine. The Proposal includes the development of mine pits and associated infrastructure including but not limited to crushing and screening facilities, waste landforms, run of mine pad, access roads, solar field, administration, accommodation camp, stockpile and laydown areas, borrow pits, groundwater bores and transfer infrastructure, explosives magazine, fuel storage and landfill. The expected footprint of the Proposal is referred to as the Conceptual Footprint; however, the exact location of the footprint may change as mine planning progresses.

The Proposal is focused on a high-grade iron ore resource, to be mined over a mine life with a production rate of up to 14 Mtpa of ore. The ore body lies within a narrow syncline structure hosting banded iron formation (BIF) extending from south-east to north-west. Four open pits will be developed along the syncline to extract the iron ore. Although initially above water table, mining will proceed below water table in the year 2026 and will require dewatering. Dewatering volumes are predicted to exceed the site water requirements and disposal of excess water will be discharged to three creeks to the south-east of the mining area.

This H3 groundwater report presents the findings of the hydrogeological drilling and testing and hydrogeological conceptualisation of the Proposal and surrounding area. Numerical groundwater modelling was carried out to assess the potential impacts associated with mining, through assessment of dewatering requirements, excess water disposal during operations and groundwater recovery post closure.

Field investigations

Understanding of the hydrogeological conditions at the regional and mine site scales has been first collated from a variety of investigations, studies and datasets. This includes hydrogeological drilling, aquifer testing and sampling previously reported by other parties, including GHD’s investigation described in this report, as well as a review of the previous numerical modelling (FEFLOW) carried out in 2012 to 2013 (SKM 2013, SKM 2014). The hydrogeological investigation program carried out for this study comprised:

- A total of eight hydrogeological drilling locations identified by Atlas Iron. Most locations were across the strike of the deposit, with the dual purpose acting as dewatering points during mine life, and to collect information on aquifer properties. At the eight locations, five were used for installation of test production bores and six for monitoring bores.
- Pumping tests carried out for each production bore including a step test (SRT), constant rate test (CRT) and recovery test.
- Packer testing of geotechnical and metallurgical bores focused on low permeability formations (shale, quartzite) and confirmed low hydraulic conductivity values for these formations.

- Groundwater sampling – major ions, trace metals and elements, TSS

Key findings – hydrogeological conceptualisation

- The iron ore deposit is part of a geological syncline structure exposed in the elevated area of the catchment which forms an elongated basin running from south-east to northwest, approximately 7.5 km long and 0.5 km wide. Transmissive BIF zone containing the ore is encased in a low permeability package of shale (Footwall Shale), and partly quartzite of the Corboy Formation which dominates of the geology surrounding the Proposal footprint.
- The aquifer system of the BIF hosting the ore deposit was shown to demonstrate hydraulic connectivity along the basin, except for its southern part where sub-basins may have developed. In contrast, its connectivity with regional system surrounding the basin is limited and only viable where fracturing affects the integrity of shales.
- The CRT rates during aquifer testing in 2020 ranged from 28 to 116 L/s. Testing confirmed relatively high transmissivity of BIF units situated in the syncline structure, with values of up to 8,000 to 13,000 m^2/d for lower BIF, approximately 800 m^2/d for upper BIF. Specific yield varied in the range of 0.02 to more than 0.2 in BIF formations.
- Based on responses to pumping, the BIF aquifer system within the basin is unconfined.
- Packer testing of geotechnical and metallurgical bores confirmed low hydraulic conductivity values for shale and quartzite formations. Relatively consistent Lugeon ranges were obtained for test intervals completed on the shales. Except for MCDH050 (PSM002) which had an average value of 7, the average of the shales was less than 1. This is comparative to a very low hydraulic conductivity 10^{-11} m/d.
- Groundwater sampling confirms the fresh nature of groundwater at the Proposal footprint (median TDS 211 mg/L), and also regionally (median TDS 700 mg/L).
- Groundwater chloride content was used to estimate regional groundwater recharge rates between 4 to 11 mm/yr (1 to 3% of annual rainfall) which are consistent with previous estimates in e.g. AECOM (2013), SKM (2013, 2014). The proposed Project footprint is part of the recharge zone for the regional aquifer system.
- The identified receptors potentially affected by the Proposal include: licensed and unlicensed groundwater abstractions; permanent pools in the range; permanent and semi-permanent pools on creek lines; and potential presence of stygofauna and troglofauna.

Key findings – dewatering assessment

- Dewatering rates and drawdown were estimated using the new numerical groundwater flow model developed in MODFLOW-USG code for the Proposal:
  - The model was constructed to focus on the detail required for the mining area but allowing for examination of the effects of mining on the regional groundwater environment.
  - The model was developed following the principles in the Australian groundwater modelling guidelines, as a Class 2 model with elements of a Class 3 model.
  - The model was calibrated using observed regional water levels, as well as observed drawdowns from a number of pumping tests conducted in 2012 and 2020. Model parameters were based on site-specific data (pumping and packer tests) and conform with typical values for the geological units encountered in the area.
- Six predictive models were developed, using the calibrated model, to represent options for and uncertainty with the mine plan. Dewatering was represented using the DRAIN package in MODFLOW-USG.

- Highly varied dewatering rates will be required over the 15-year life of mine as a result of an initially fast vertical progression. The largest dewatering rates will be between 2026 and 2029, approximately 45 GL in total which constitutes 57% to 88% of the total dewatered volume removed over the life of mine (the variability is due to different dewatering options, primarily whether the Murray Pit would be allowed to partially fill once mining ceases in it). Peak dewatering rates (up to 15 GL/yr) are predicted in 2029 and up to 90% of the total dewatered volume is predicted be removed from Murray Pit. Estimated total dewater volume over the mine life is up to 80 GL – which can reduce to 51 GL if partial refilling of the Murray is considered.
- An option of dewatering using a network of highly productive dewatering rates was also evaluated by GHD in 2021. Two evaluated options (dewatering starting in 2023 or 2025) indicate the feasibility of effective dewatering achieved from a network of six dewatering bores, with peak flows required from these bores varying between 7 to 160 L/s (depending on the bore location and the dewatering start date and subject to bores achieving design rates). The total dewater volumes over life of mine are 86 GL for both starting options. Bore dewatering allows for smoother dewatering rates, for example peak annual rates are predicted to be up to 10 GL/yr in 2026 (for 2025 start) or even 7 GL/yr for the 2023 start, before they dissipate after 2032 to 3.1 GL/yr in 2032.
- Dewatering is predicted to create a south-west to north-east trending depression in the potentiometric surface primarily along the Avon and Murray Pits extending further north-east into the Ord and Nicholson Pits. The peak dewatering volumes will be removed between 2027 and 2029, during which the groundwater level is predicted to drop within the syncline structure but not necessarily in the surrounding fractured rock environment due to orebody aquifer’s encapsulation by low permeability shale.
- When mining ceases in 2040, the total drawdown footprint is predicted to extend to approximately 18 to 20 km^2. The extent of the drawdown is largely within the PDE but outspreading across the northern area of the Proposal footprint near Ord and Nicholson Pits. The drawdown footprint at the end of mining is predicted to include two natural surface water pools within the Proposal footprint. However, it is unlikely that these pools are connected to the regional groundwater. Other natural pools present on McPhee Creek, its tributary and Lionel Creek are not likely to be impacted by drawdown during operations.
- The dewatering required for the Proposal will generate excess water surplus to the mine requirements. The excess water disposal options evaluated in this study concentrated on surface discharge to three creek lines (McPhee Creek, McPhee Creek tributary, and Lionel Creek) that flow south-east of the mining area before joining the Nullagine River approximately 20 km from the mine site.
- The assessment of excess water disposal was based on the dewatering scenario that generated the largest volumes of excess water. The volumes were distributed across three creek lines. The downstream extent to which the excess water generates measurable surface flow along the creek lines before evaporating or infiltrating is referred to as the ‘wetting front’. The discharge rates to the three creeks were optimised so that the respective wetting front associated with excess water discharge and associated groundwater mounding remain upstream of the known pools.
- The typical depth to groundwater is estimated at approximately 7 to 8 metres below ground level at the creek lines. With excess water disposal, the water table is predicted to extend to the surface over the section of creek that sustains flow, which is estimated at approximately 18 km for McPhee Creek, 7 km for the McPhee Creek tributary, and 15.6 km for Lionel Creek.

- Surface flow and groundwater mounding based on existing assumptions is forecast to abate upstream of the mapped pools in each creek, and therefore upstream of the confluence with the Nullagine River, suggesting negligible impact.
- Additional modelling of excess water disposal has been subsequently completed by GHD (2021) which considers typical seasonal events consistent with climatic characteristics of the area.

Post closure assessment

- Permanent pit lakes will form in Avon and Murray Pits, with marginal lakes in parts of the Ord Pit. The Nicholson Pit is predicted to essentially remain dry, with the possibility of forming only small and intermittent accumulations of water following major rainfall events.
- Pit lake water levels are predicted to stabilise in Avon and Murray Pits within approximately 60 years of mining ceasing and are predicted to remain between 55 and 83 m below the pre-mining levels.
- The open pits will become terminal groundwater sinks with respect to the regional groundwater flow due to ongoing evaporation from the pit lake surfaces. Evaporation will also control the salinity of the pit. A separate study of pit lake quality (GHD, 2020a) indicates the potential for acidification and TDS rise in the pits. Due to the terminal sink nature of the pits during mining and post closure and their poor connectivity with the regional groundwater system it is considered unlikely that pit water quality would have any substantial deleterious effect on the regional groundwater system.
- The modelled water levels and the drawdown confirm the persistence of radial inflow of groundwater towards the Avon and Murray pit lakes post closure. The residual drawdown footprint is predicted to slowly extend following closure. The slow rate of footprint growth is related to low transmissivity and storativity of the fractured rock aquifer system (primarily Corboy Quartzite) surrounding the highly permeable syncline feature hosting the ore deposit.
- An assessment of the long-term stabilisation of drawdown identified that the time of maximum drawdown is dependent upon location, with areas within the high conductivity zones adjacent to the pits responding rapidly to water levels within the pits. The cone of depression is expected to migrate outwards from the pits at a slow rate within the regional fractured aquifer due its low hydraulic conductivity. Most of the drawdown is predicted to occur within 250 years of closure, and within the bedrock drawdown is predicted to stabilise within 1,000 to 2,000 thousand years if current climate conditions prevail.
- The drawdown footprint is predicted to cover an area of 58 km^2 in the year 2290, i.e. 250 years post closure. Groundwater will remain relatively deep in most parts of the tenement, similar to pre-mining conditions. There will be areas with smaller than 20 m bgl depth to groundwater within the Proposal footprint along sections of its perimeter and to the north and east of it, their long-term extent is predicted to cover 32 km^2.

Recommendations for licensing and groundwater management

Based on findings from the hydrogeological investigations and predictive assessment, recommendations have been developed for baseline and post-closure monitoring, trigger levels, monitoring reviews, model updates and development of groundwater licence operating strategy. The proposed monitoring design and trigger levels (where necessary) should be optimised, then consulted on and agreed with Department of Water and Environmental Regulation (DWER).

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.4 and the assumptions and qualifications contained throughout the Report.

Acronyms

AEP	Annual exceedance probability
AET	Actual evapotranspiration
AMD	Acid and metalliferrous discharge
ARI	Annual recurrence interval
BIF	Banded iron formation
BGL	Below ground level
BoM	Bureau of Meteorology
CRT	Constant rate test
DEM	Digital elevation model
DMIRS	Department of Mines, Industry Regulation and Safety
DR	Dual rotary
DWER	Department of Water and Environment Regulation
DoW	Department of Water
DRN	MODFLOW Drain package
EC	Electrical conductivity
EVT	Evapotranspiration
GDE	Groundwater dependent ecosystem
GWL	Groundwater licence
HSU	Hydrostratigraphic unit
KS	Kelly Subgroup
LG	Lower grade
MRD	Main range deposit
NAF	Non-acid forming
PAF	Potential acid forming
PDE	Proposal Development Envelope
PFS	Pre-Feasibility Study
RIV	MODFLOW River package
RIWI Act	Rights in Water and Irrigation Act 1914
ROM	Run of mine
SRMS	Scaled root mean square
TDS	Total dissolved solids
TVM	Time varying materials
VKA	Vertical anisotropy factor
WIN	Water Information
WIR	Water Information Reporting

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1. Introduction

1.1 Background

Atlas Iron Pty Ltd (Atlas Iron) acquired the McPhee Creek Mine iron ore deposit in 2010, with the view of developing it into a viable iron ore (magnetite) mine. The McPhee Creek project (the proposal) is situated approximately 30 km north of Nullagine, in the Pilbara region of Western Australia.

Atlas Iron conducted a pre-feasibility study (PFS) study in 2014 which comprised a number of water management studies to assess the impact of the mining proposal on surface water, groundwater, pit lake quality and a water balance. The 2014 assessment found that:

- Significant dewatering was required to enable mining of the ore below the watertable
- The proposal would have surplus water for a portion of its mine life that would require disposal
- Excess water disposal options identified discharge to a number of creek lines within the south and southeast of the mine area
- Pit lakes will form in Avon and Murray Pits and levels would stabilise at approximately 200 year after closure.

In late 2018 Atlas Iron joined the Hancock Group Pty Ltd and is jointly preparing a PFS for the proposed McPhee Creek mine. Since completion of the 2014 assessment, several updates have occurred which include changes to the mine plan.

The Proposal is for the above and below water table mining of iron ore from five open cut pits, located approximately 30 km north of Nullagine. The Proposal includes the development of mine pits and associated infrastructure including but not limited to crushing and screening facilities, waste landforms, run of mine pad, access roads, solar field, administration, accommodation camp, stockpile and laydown areas, borrow pits, groundwater bores and transfer infrastructure, explosives magazine, fuel storage and landfill.

Based on the findings of the 2014 PFS, the on-site water demand is estimated to be minimal resulting in the need for disposal of excess water associated with dewatering. Evaluation of disposal strategies is required to minimise the adverse effects of the abstraction and release of water on environmental, social and cultural values.

To this effect, Atlas Iron through Roy Hill Iron Ore Pty Ltd (Roy Hill) (part of Hancock Group Pty Ltd) engaged GHD Pty Ltd (GHD) on 3 January 2020, to address the gaps identified during previous investigations and by Atlas Iron, carry out additional hydrogeological investigations and water management assessments to assess the potential impact of the mining proposal (and specifically dewatering) on surface water, groundwater, pit lake quality and a water balance.

This H3 hydrogeological report presents the findings of the hydrogeological investigation, hydrogeological conceptualisation, groundwater modelling to assess dewatering impacts and recovery post closure, as well as an assessment of the discharge of excess water to creek lines.

To assess impacts and determine water management requirement, additional studies were undertaken which include surface water, mine water balance assessment, pit lake quality (acid mine drainage) assessment, water supply for proposed transport alignment, and a PFS-level cost estimate. These assessments are presented in separate reports (GHD, 2020a,b,c).

1.2 H3 level reporting

The Department of Water and Environment Regulation (DWER) is the lead authority with respect to dewatering and discharge related impacts and associated licensing, inclusive of mining operations.

Any dewatering from the mining pits as well as discharges from the mine have to include assessment and provision for dewatering and excess discharge impacts within the mine water management strategy. The DWER's objectives within the Pilbara mine guidelines (Department of Water, 2013) should form the basis of the Proposal's water management strategy.

Specific impacts to be addressed are discussed and specific discharge performance criteria are identified. The most important criteria are to minimise impacts on environmental receptors and third parties. The future activities at the mine will include in-pit and ex-pit dewatering which have to be licensed by the DWER through Section 5C, a licence to take water and manage its uses.

For excess discharge, the criteria are to discharge into a well-defined watercourse, with acceptable water quality, acceptable fauna and flora impacts and minimal erosion impacts.

Groundwater licence application (Section 5C) is accompanied by H3 level assessment – "detailed hydrogeological assessment including drilling, test pumping and a groundwater model" (DoW, 2009a) which is covered in this report.

1.3 Scope

The key objectives of the investigation program were to:

- Quantify the key water management risks associated with the Proposal including operational dewatering requirements and potential surface water and groundwater impacts
- Enable the development of a water management plan for the life of the Proposal
- Provide adequate information for project approvals.

To meet these objectives the following scope items were identified and covered as appropriate in this report:

- A field investigation program comprising the drilling, installation and testing of a series of production and monitoring bores, and completion of packer testing within selected geotechnical and metallurgical drill holes to enable estimation of potential mine dewatering requirements
- A review and update of the current excess water disposal options study, including surface water disposal (controlled release) and potential groundwater reinjection. Controlled surface water release was the preferred option
- Development of a new numerical groundwater model for dewatering and impact assessment
- Identification and assessment of water related impacts to support the relevant regulatory approvals required by the Proposal
- Preparation of a Prefeasibility Water Management Report (with a set of supporting reports), including pre-feasibility level capital and operating cost estimates (this report intends to inform the water management chapter of PFS and costs estimates).

1.4 Purpose of this report

This report is aligned with the H3 assessment level of reporting to fulfil the requirements for an application to the DWER for a Section 5 licence to abstract groundwater for the McPhee Creek Project.

Specifically this report documents the results of:

- a review of existing hydrogeological information pertinent to the McPhee Creek site
- the hydrogeological investigations carried out during this stage
- an update of hydrogeological conceptualisation
- the development of numerical groundwater flow model for:
  - dewatering assessment
  - impact on environmental receptors
  - assessment of excess disposal on groundwater and surface water receptors and
  - post-closure impact assessment.

1.5 Limitations

This report: has been prepared by GHD for Roy Hill Pty Ltd and may only be used and relied on by Roy Hill for the purpose agreed between GHD and the Roy Hill as set out in section 1.4 of this report.

GHD otherwise disclaims responsibility to any person other than Roy Hill 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.

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2. Project description

2.1 Introduction

The Proposal is located in the Pilbara region of Western Australia, predominantly within mining tenement M45/1243-I and includes the following key elements as well as any associated activities:

- Clearing of a Conceptual Footprint of up to 1,913 ha within a 4,465 ha Development Envelope (PDE)
- Above and below water table mining of five open cut pits
- Ore crushing and truck loading infrastructure
- Waste dumps, ore stockpiles, topsoil stockpiles and sub-soil stockpiles
- Support facilities: including small scale power generation at each of the mine facilities (including but not limited to workshops and crusher), telecommunications tower, solar field, workshops, hydrocarbon storage, explosive mixing and storage facilities, laydown areas and offices
- Linear infrastructure: including heavy and light vehicle access roads, conveyors, pipelines and power and communications distribution
- Infrastructure for surface water management: including diversion drains, levees and culverts
- Infrastructure for dewatering and groundwater abstraction for water supply
- Dewatering water management and associated infrastructure for discharge to surface water systems
- Construction and operation workforce accommodation camp/s
- Transport of the ore to the existing Roy Hill project or other third parties.

The McPhee Creek project area can be accessed via public road approximately 266 km drive southwest from the town of Port Hedland, or by public road approximately 220 km drive north from Newman. The location of the McPhee Creek project is shown in Figure 2-1.

2.2 Proposal exclusions

To date, various exploration and investigation activities have been completed in support of the Proposal. These include the clearing of access tracks and drill pads, for both resource and groundwater studies, and the construction of an accommodation camp to support these activities. Clearing of over 27 ha has occurred to date for these purposes, with clearing undertaken in accordance with the Mining Act 1978 (WA) (Mining Act).

The scope of the Proposal subject to assessment under Part IV of the Environmental Protection Act 1986 (EP Act) and the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) therefore excludes the following low impact activities:

- Utilisation and/or refurbishment of existing infrastructure including access tracks and accommodation camp.
- Ongoing low impact exploration and investigation activities to inform resource definition and the environmental impact assessment of the Proposal.
- Development and use of groundwater supplies to support the exploration and investigation activities described above.

Any new ground disturbance to support the above activities will be minimised and located to avoid significant habitat features. Approvals for the proposed ongoing exploration and investigation activities will be sought separately under the EP Act, Mining Act and Rights in Water and Irrigation Act 1914 (WA) (RiWI Act), as required.

2.3 Mining

Mining will use conventional drill and blast, load, and haul methods, with a production rate of up to 14 Mtpa of ore. A portion of the ore is located below the water table and as such dewatering will be required. It is anticipated that up to 16 GL/yr of dewatering will initially be required, which will decrease over the life of the mine.

Mining will be undertaken on a 24-hour basis, seven days a week. Clearing of up to 1,913 ha of vegetation will be required. The expected footprint of the Proposal is referred to as the Conceptual Footprint; however, the exact location of the footprint may change as mine planning progresses.

Where accessible, topsoil and vegetation will be removed during early development and stockpiled in adjacent well-drained areas. Topsoil stockpiles will be managed appropriately so that the material will be available for future rehabilitation operations.

The McPhee Creek iron ore may be subject to further processing off site, which does not form part of this application.

2.4 Processing

Once blasted, broken ore and waste rock will be loaded separately into haul trucks. Ore will be transported via the haul road network to the Run of Mine (ROM) pad. Crushing may be undertaken using a dry crushing and screening facility. Stockpiling of marginal ore material will also be undertaken to ensure maximum resource recovery. No tailings or wet waste product will be produced.

Following mining, the McPhee Creek iron ore will be stockpiled for transport via trucks off the McPhee Creek site.

2.5 Haulage

Ore will be transported by truck to third parties for processing or may be on sold as direct shipping ore. Any processing at third party locations is outside of the scope of this Proposal.

2.6 Waste rock management

Waste rock will initially be used to construct infrastructure (e.g. access roads and ramps, ROM and stockpile bases, drainage structures and safety bunds) with the remainder stored in above ground waste rock dumps or in-pit.

2.7 Additional infrastructure and support facilities

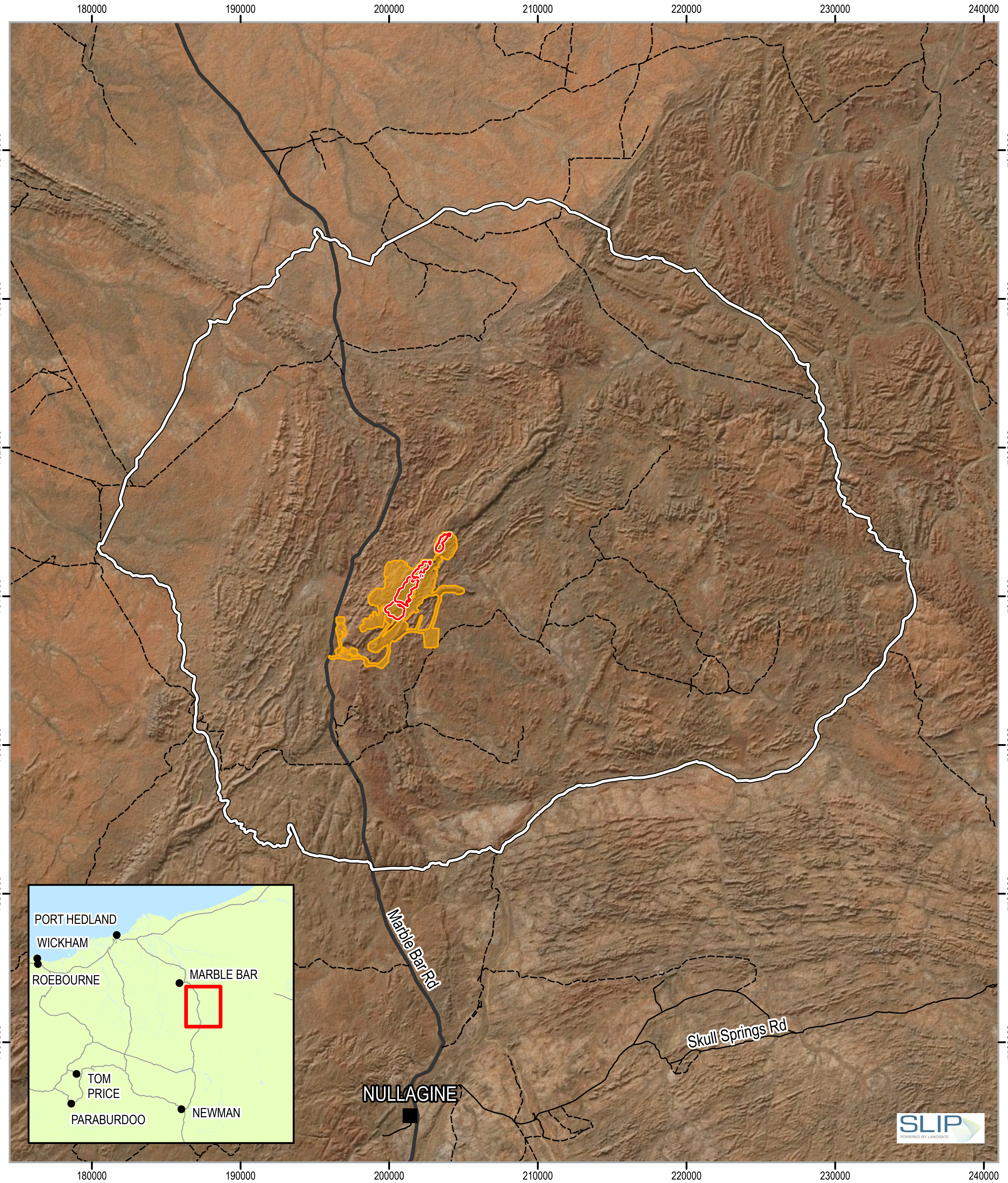
Bulk explosive materials will be located in a secure compound accessible from the main access route to provide safe and efficient access for bulk supplies. Initiating explosive will be stored in separate secure magazine compound located in excess of 1.5 km from mine workings and operations services, utilising bunding and the natural topography to assist in security and isolation.

To support the mine operation, offices, workshops, power generation, communication infrastructure and parking areas will also be constructed. A 200 person accommodation village will be constructed within the Development Envelope prior to implementation of the current proposal.

2.8 Water management

The Proposal's water supply will be sourced from local groundwater. All groundwater bores will be licensed under the Rights in Water and Irrigation Act 1914 (RIWI Act), as administered by the DWER. The dewatering strategy requires up to 15 GL per annum for initial dewatering, which will decrease over the life of the mine to around 2 GL/yr. Other water use (camp, dust suppression etc.) will total less than 2 GL per annum and will mostly be sourced from the dewatering supply.

The excess dewatering volume (i.e. that not utilised by the mine operations) will be discharged to a number of nearby creeks in a controlled manner. Discharge volumes will be up to approximately 15 GL per annum initially, decreasing over the life of the mine. The discharge location will be constructed with scour and erosion protection to minimise impact on the creek lines.



Legend

- Main Road
- Minor Road
- Track
- Assessment Domain
- Mine Disturbance Area
- Pit Footprint

Paper Size ISO A4

0 2.5 5 7.5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

GHD

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

Site Location (Regional)

Project No. 12548901
Revision No. 0
Date 04/10/2021

FIGURE 2-1

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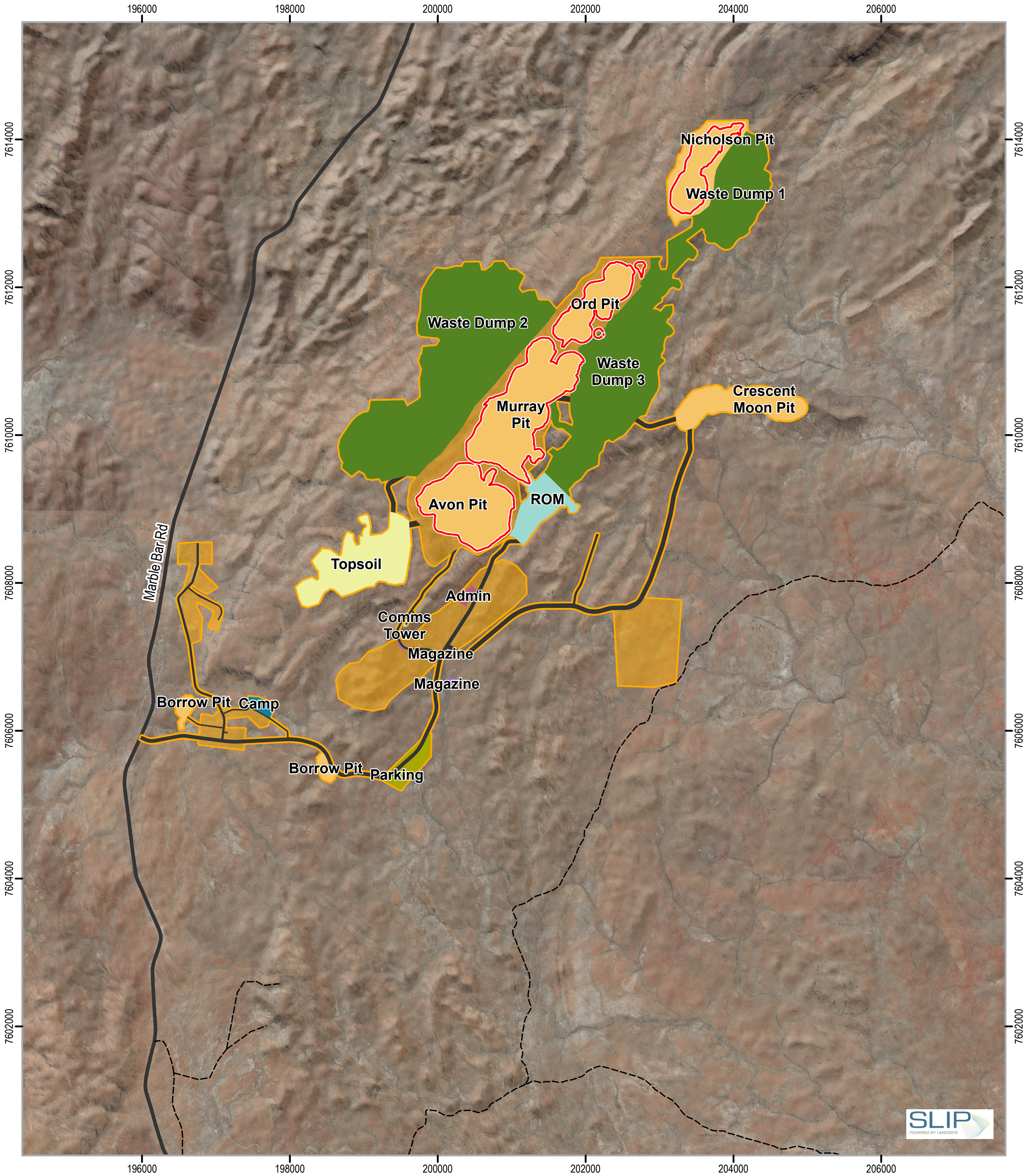
Print date: 04 Oct 2021 - 01:55

Data source: GHD: Pit Footprint - 20200828, Assessment Domain - 20191114, Project Development Envelope - 20201022; Landgate: Roads - 20171106 World Imagery: Earthstar Geographics. Created by: jabaygar



Legend

Main Road	Admin	Magazine	ROM	Waste Dump
Track	Camp	Parking	Roads	Mine Disturbance Area
Pit Footprint	Comms Tower	Pit	Topsoil	

Paper Size ISO A4

0 0.5 1 1.5 2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

GHD

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

Site Layout

Project No. **12548901**
Revision No. **0**
Date **04/10/2021**

FIGURE 2-2

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Print date: 04 Oct 2021 - 05:24

Data source: GHD: Pit Footprint - 20200828, Assessment Domain - 20191114, Project Development Envelope - 20201022, Site Layout - 20201005; Landgate: Roads - 20171106 WANow: Landgate / SLIP.
Created by: jabaygar

3. Previous investigations

The following hydrological and hydrogeological reports and data sources related to the McPhee Creek project were reviewed with summary of the review provided:

Hydrogeology:

- AECOM 2013a McPhee Creek Iron Ore Project Phase 2 Groundwater Investigation May 2013.
- SKM 2013 McPhee Creek Regional Groundwater Model, Model Report and Appendices Atlas Iron Contract Number C-OPR-0052.
- Jacobs (2014) McPhee Creek Groundwater Model, ATLAS IRON Groundwater Model Update, Document No. SOW 124-DEV-HY-SOW-0023, 8 August 2014.

Hydrology:

- AECOM (2011a) McPhee Creek Surface Water Hydrology Assessment
- AECOM (2011b) McPhee Creek Proposed Exploration Camp Flood Study
- AECOM (2012) McPhee Creek Flood Study Report (Draft)
- AECOM (2013b) Floodplain Mapping Report McPhee Creek Iron Ore Deposit
- GHD (2020b) McPhee Creek Surface Water Assessment, draft October 2020.

Excess water disposal to creeks:

- MWH (2012) McPhee Creek Excess Mine Water Disposal Options
- MWH (2014) McPhee Creek Excess Mine Water Discharge Refinement (Final McPhee Discharge Refinement.pdf)

Pit lake quality (AMD):

- SKM (2014) McPhee Creek AMD Investigation summary report

Ecology / subterranean fauna:

- Eco Logical Australia (2013) McPhee Creek Iron Ore Project Preliminary Environmental Impact Assessment.
- Biologic Environmental Surveys (2020) McPhee Creek Project: Aquatic Ecology Survey and Assessment July 2020

Geological mapping:

- Bagas (2005) Geological mapping, 1:100,000 Nullagine Geological Sheet

3.1 Field Investigations

McPhee Creek Iron Ore Project Phase 2 Groundwater Investigation (AECOM, 2013a)

According to AECOM (2013a) a number of groundwater field investigations have been carried out by Atlas Iron, starting from baseline water level, pH and EC monitoring in 60 exploration boreholes and laboratory analysis of a subset of samples for major ions and trace metals.

In 2011 AECOM undertook a Phase 1 desktop study of the McPhee deposit. Field investigations have been carried out by consultants including AECOM in 2011 and 2012 including down-hole electrical conductivity and temperature at nine sites and analysis of water samples from four locations in July 2011. In October 2011 groundwater levels and EC measurements were taken in 60 drill holes.

In 2012, six test production bores and three multi-piezometer monitoring bores were drilled and constructed, and 24 monitoring bores constructed in vertical resource drillholes, within Resource Zones 1 to 3. The AECOM 2013a scope included undertaking pump tests (including step draw down tests and 72 hour constant-rate tests), analysis of groundwater samples for ions and trace metals, monitoring of groundwater levels and measurement of downhole salinity at selected locations. Drilling and construction of one production bore and one monitoring bore for future camp water supplies was also undertaken.

AECOM (2013a) reported that several rock pools were present in the Proposal area; two near the south-eastern part of the MRD Aquifer and one near the camp. These were considered to be seasonal water holes fed only by rainfall runoff, as they were present well above the main water table elevation and had very fresh water chemistry considered to be consistent with likely runoff and not local groundwater.

Key findings from the AECOM 2013a study on the hydrogeology of the PDE are presented in Section 5.

3.2 Groundwater modelling

McPhee Creek Regional Groundwater Model (SKM, 2013)

The purpose of the modelling study was to determine the potential dewatering requirements for the mine and to estimate changes in groundwater levels, and potential impacts on existing users including groundwater dependent ecosystems. The assessment included constructing a groundwater model using FEFLOW software.

The outcome of the modelling was that total dewatering volume was approximately 60 GL, and that this value was relatively insensitive to mining duration or climate factors. T assessment also found that the regional groundwater table that will be influenced by dewatering was generally below the anticipated maximum rooting depth of native tree species. The report suggested that local vegetation must be reliant on surface water and stored soil moisture rather than the regional groundwater table, and that dewatering should not impact these plants.

The pit schedule modelled involved excavation of the deepest pit first (Murray Pit), which meant that the majority of dewatering occurred near the start of the mine life. The report stated that it might be possible to reduce dewatering rates and extend the dewatering through the life of the mine if mining at this particular pit was delayed, so that the dewatering provided the bulk of the mine water supply.

The assessment also identified that the mining schedule modelled would result in excess water requiring disposal during the first years of the mine, followed by a water deficit in later years.

McPhee Creek Groundwater Model Update (Jacobs, 2014)

In 2014, Jacobs updated the groundwater model to assess a revised 15 Mtpa mining schedule and to assess the impact of various dewatering scenarios.

The outcome of the 2014 modelling included:

- Dewatering the Murray pits was relatively straightforward and achievable with dewatering bores placed outside the pits.
- Ord and Nicholson pits did not need dewatering bores as dewatering of the Murray pit was considered sufficient to achieve the required drawdown of groundwater at these locations.

- The estimated mine water demands could be met using water extracted from the aquifer.
- 88 GL of water would be produced during dewatering activities, while mine water demands would be 45 GL, leaving 43 GL of excess water requiring disposal.
- Recovery of groundwater levels after mining would be slow, with water levels stabilising in the Avon pits after 100 years and in the Murray pits after 200 years.
- Permanent pit lakes were not likely to form in Ord or Nicholson pits.

Previous groundwater modelling did not include the re-injection of extracted groundwater, although this was addressed in terms of excess disposal to surface creeks by (MWH, 2012).

3.3 Hydrology

Surface Water Hydrology Assessment (AECOM, 2011a)

A hydrological assessment was undertaken by AECOM (2011a) by using regional estimation of streamflow yield and floods. This regional assessment characterised the regional climate and annual, seasonal and daily flow regimes in the eastern Pilbara region based on Bureau of Meteorology (BoM) rainfall stations and Department of Water (DoW) streamflow gauging stations.

The assessment included attempting to develop a daily rainfall-runoff model of the McPhee Creek catchment, however, the report indicated that unsatisfactory attempts in calibration related to lack of local data (rainfall and streamflow). As an alternative approach, areal scaling of observed flows extracted from Nullagine streamflow gauge was undertaken. The outputs were considered to be acceptable for describing the local surface water regime, but stated that improved estimates could be developed with the establishment of local measurement sites to reducing uncertainty in the hydrologic regime.

Proposed Exploration Camp Flood Study (AECOM, 2011b)

A flood study was conducted by AECOM (2011b) to investigate the flood risk posed to the proposed exploration camp. The study was conducted using 1-dimensional hydraulic modelling software HEC-RAS with an assessment of the 100 average recurrence interval (ARI) flood event. Results show that proposed exploration camp location was located outside of the 100 year ARI floodplain.

Flood Study Report - Draft (AECOM, 2012)

A flood study report was produced by AECOM (2012) building on the 2011 assessment by constructing a two-dimensional (2D) hydrodynamic TUFLOW model to produce flood maps for 1%, 5%, and 20% annual exceedance probability (AEP) flood events.

The assessment was conducted by extracting flood hydrographs results and calibrated parameters from a RORB model as inputs to the TUFLOW hydraulic model. Calibration of the RORB model was based on a scaled observed hydrographs recorded at large catchment streamflow gauge on the Nullagine River. The TUFLOW model used a 10 m grid digital elevation model (DEM) extracted from Landgate.

Results showed that surface water flows were primarily directed towards three clearly defined channels to the southeast of the proposed mine site, McPhee Creek, branch (tributary) of McPhee Creek and an unnamed creek. The main creek lines were flagged as potentially posing restrictions on the location of infrastructure due to maximum water depths ≥1 m for the 1% AEP flood event. Flooding was shown to occur in areas away from the three main creek lines in areas of highly variable topography, though with shallower water depths than those within the main channels. This was flagged as potentially being a consequence to the accuracy of the topographical data available.

The study recommended that the model was refined using more detailed topographical data, such as LiDAR, if flood extents and depths were required for infrastructure design purposes. It also recommended the installation of rainfall and streamflow gauges in the vicinity of the Proposal area in order to refine the calibration of the hydrologic and hydraulic models.

Floodplain Mapping Report (AECOM, 2013b)

A floodplain mapping assessment was undertaken by AECOM (2013b) to refine the flood study done in 2012. The report updated the TUFLOW model through the use of a finer 5m grid size derived from LiDAR DEM data. Modelling was undertaken for the 1%, 5% and 20% AEP flood events.

The results were consistent with the 2012 results confirming that the surface water flows are directed primarily towards clearly defined channels by multiple tributaries and overland flow paths. Maximum water depth exceeded 3 m in some areas of the main channels for the 1% AEP flood event. Flooding occurred in areas of highly variable topography with water depths shallower than those within the main channels. The velocity of flows exceeded 3 m/second in the defined channels and generally less than 1 m/second in other areas.

Surface Water Assessment (GHD, 2020b)

GHD undertook a surface water assessment and produced a conceptual management plan for the revised mine plan for McPhee Creek. The assessment undertaken included understanding key surface water flow paths and flood risk at the Proposal site and identifying infrastructure required to manage the risk. Hydrologic and hydraulic modelling was undertaken to identify key flow paths and floodwater extents.

The assessment also included identifying potential impacts of the Proposal on environmental flows and surface water volumes in major creeks and the implications for identified receptors. This assessment of potential impact was determined by assessing the change in catchment areas due to the Proposal footprint.

3.4 Excess water disposal

McPhee Creek Excess Mine Water Disposal Options (MWH, 2012)

The study investigated potential strategies for environmental discharge of excess water from dewatering activities, including identification of potential discharge locations and preliminary scoping of associated environmental impacts.

The extent of potential plume length was modelled for the final three discharge rate scenarios (2 5 and 10 GL/annum), combined with three scenarios relating to the representation of the physical characteristics of the stream (bed material, stream width, width of riparian vegetation, seepage rates and storage). All of the watercourse discharge disposal options were determined as capable of containing the maximum discharge scenario of 10 GL/annum. The likelihood of erosion was assessed within each creek with flow velocities generally less than 1 m/second.

The outcome of the assessment was that the discharge into McPhee Creek was considered the most suitable as the assessment suggested that the discharge water would infiltrate prior to reaching any perennial pools.

Excess Mine Water Discharge Refinement (MWH 2014)

The purpose of the study was to refine the 2012 water balance model supported by a one-dimensional (HEC-RAS) hydraulic model and a conceptual groundwater model, in order to improve estimates of the dewatering discharge 'plume' length along the creeks. The length of the surface water plume were used to assess possible impacts on the creek environments and ecology and identify potential sensitive areas that may be at risk.

Atlas Iron had provided refined dewatering estimates (maximum discharge rate of 5.4 GL/annum) and selected preferred discharge locations (Options 2 and 3) into the branch of McPhee Creek.

The 1D HEC-RAS hydraulic analyses indicate that all assessed points in the creek channels were considered suitable for an environmental discharge up to 5.4 GL/annum and could potentially accept higher discharge volumes.

Groundwater modelling results indicated that surface water flow decreases downstream from the discharge point and eventually dissipates at approximately 9 to 10 km downstream.

The stream water balance model showed that the pessimistic, mid-range and optimistic dissipation lengths for the 5.4 GL/annum discharge scenario range from 26 to 9.5 km, with the mid-range length at 13.5 km. All models suggested a complete dissipation of the excess water discharge was feasible before the confluence of the McPhee Creek and Nullagine River

3.5 Pit lake quality

SKM (2014) carried out a pit lake quality (AMD) assessment which included the prediction of water quality during operations and closure by undertaking geochemical modelling/evaluation of the potential evolution of pit lake water chemistry for constituents of concern including total dissolves solids (TDS) and metals. The AMD study covered the pit voids only and excluded assessment of the external waste rock dumps and other potential sources. The mine plan did not include backfilling of pits with waste. The findings of the assessment included:

- pit lakes were estimated to take in the order of 200 years to reach a state of water balance equilibrium, at a level up to 60m lower than the pre-mining water table.
- during operations, runoff from the pit walls from potential acid forming (PAF) and non acid forming (NAF) rock would contribute to AMD and neutral pH saline and metalliferous drainage.
- the water quality in the pit voids would deteriorate over time post closure and the quality in each of the pits will be variable.
- the pH of the pit void water would be acid in Avon East and West. In the Murray pit the model output indicates neutral pH water due to the large proportion of groundwater relative to rainfall runoff from PAF material.
- all the pits would be dominated by sulphate due to the oxidation of sulphide minerals in the pits walls.
- TDS results showed increasing concentrations of major ions in the pit over time.
- the pits were determined to be terminal sinks to groundwater meaning that the metals, salts and acid in the pits will not seep into the local and regional groundwater, as long as the final void water level remains below the original pre-mining groundwater level.
- anticipated that there would be no adverse impact on surrounding groundwater quality.

3.6 Ecology

McPhee Creek Project Subterranean Fauna Survey (Subterranean Ecology, 2012)

According to Eco Logica (2013) Subterranean Ecology conducted baseline surveys of subterranean fauna across the McPhee Creek range in October-November 2011 and March-

May 2012 (within the ‘application area’). The sampling conducted captured both wet and dry season periods and reportedly exceeded the EPA minimum requirements for stygofauna and troglofauna sampling.

The Subterranean Ecology (2012) reportedly noted a very low diversity of stygofauna in the proposed mining areas and that troglofauna habitat appeared to have reasonable connectivity between the Main Range Deposit (MRD) and other iron formation areas. Further detail is provided in Section 6.2.2.

McPhee Creek Aquatic Ecology Survey and Assessment (Biologic Environmental Survey, 2020)

Biologic undertook a level 1 aquatic ecosystem survey and assessment for areas in proximity to the PDE, including three pools in the PDE and pools along the creek lines identified as potential locations for excess water disposal (McPhee Creek, Branch of McPhee Creek and an unnamed creek). Sampling was undertaken in April 2020 at 17 identified pools. Further detail is provided in Section 4.5.

4. Physical environment

4.1 Project area

The Proposal area is situated in the Pilbara region of Western Australia, approximately 32 km north of Nullagine and 58 km south-east of Marble Bar and four km east of the Marble Bar Road. The Proposal is situated within the M4501243 tenement of Giralia Resources Pty Ltd which covers an area of 6,379 ha.

4.2 Climate

4.2.1 Rainfall

The closest operating weather station is at Marble Bar (BoM Station 4106) which is approximately 60 km northwest of the site. The rainfall record at this station spans from 2000 to present. The mean and median monthly rainfall data for Marble Bar station (4106) and is presented in Figure 4-1 below. The mean annual rainfall is 393 mm/yr.

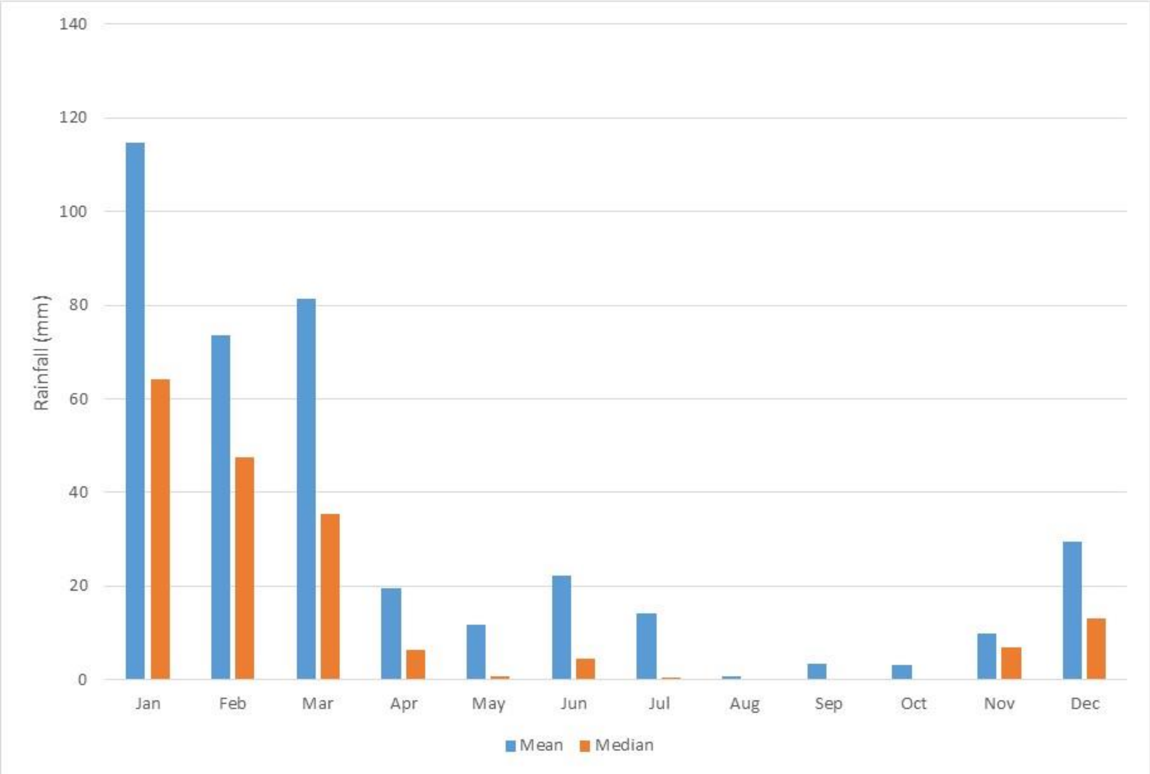


Figure 4-1: Marble Bar monthly rainfall 2000 to 2020 (BoM Station 4106)

The highest rainfall occurs between December to March, with the major events associated with tropical cyclones, monsoon lows and convective thunderstorms. Rainfall is typically decreases with distance from the coast. Tropical cyclones are a common feature of the region and have typically occurred between January and March with none between May to November (AECOM, 2013a).

To assess longer term rainfall trends, a longer rainfall record (1907 to present) is available for Bonney Downs Station (BoM 4006) located approximately 65 km south-west of the McPhee Creek PDE. Monthly rainfall is presented along with the annual rainfall and cumulative rainfall departure (CRD) plots in Figure 4-2 and Figure 4-3. CRD plots present the cumulative difference of monthly rainfall from the mean monthly rainfall, in this case the mean for the standard Bureau of Meteorology (BoM) period of 1961 to 1990. Periods of below average rainfall show a descending CRD trend, whereas periods of above-average rainfall show an ascending trend.

The plot of 1900 to 2020 data (Figure 4-2) shows a long period of relatively stable rainfall from the start of records in 1907 until around 1950, followed by short periods of below or above average rainfall from 1950 to about the end of 1994. Since 1995, there has been a relatively consistent period of significantly above-average rainfall. The 10-year moving average of annual rainfall (dashed line in Figure 4-3) has decreased slightly since 2003 but it is still above the baseline (1961-1990) average of 302 mm/annum. This is consistent with regional rainfall trends produced by the BoM (2020), which indicates an increase of 20 to 40 mm/decade since 1970.

CRD plots are useful for assessing potential groundwater trends as they tend to be an indicator for long-term groundwater levels, other than in areas influenced by significant surface water interaction or abstraction. Based on these relationships, current groundwater levels are likely to be at the higher end of their historical range, subject to the influences noted above.

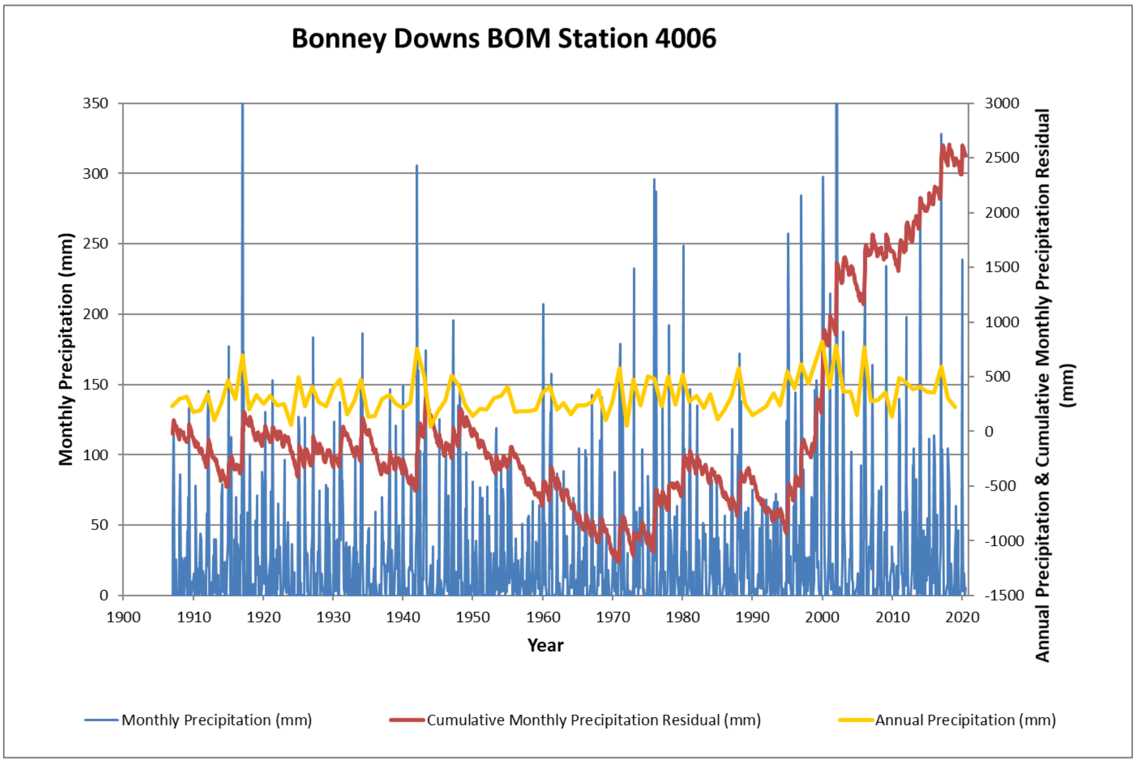


Figure 4-2: Cumulative rainfall departures, Bonney Downs, 1900 to 2020

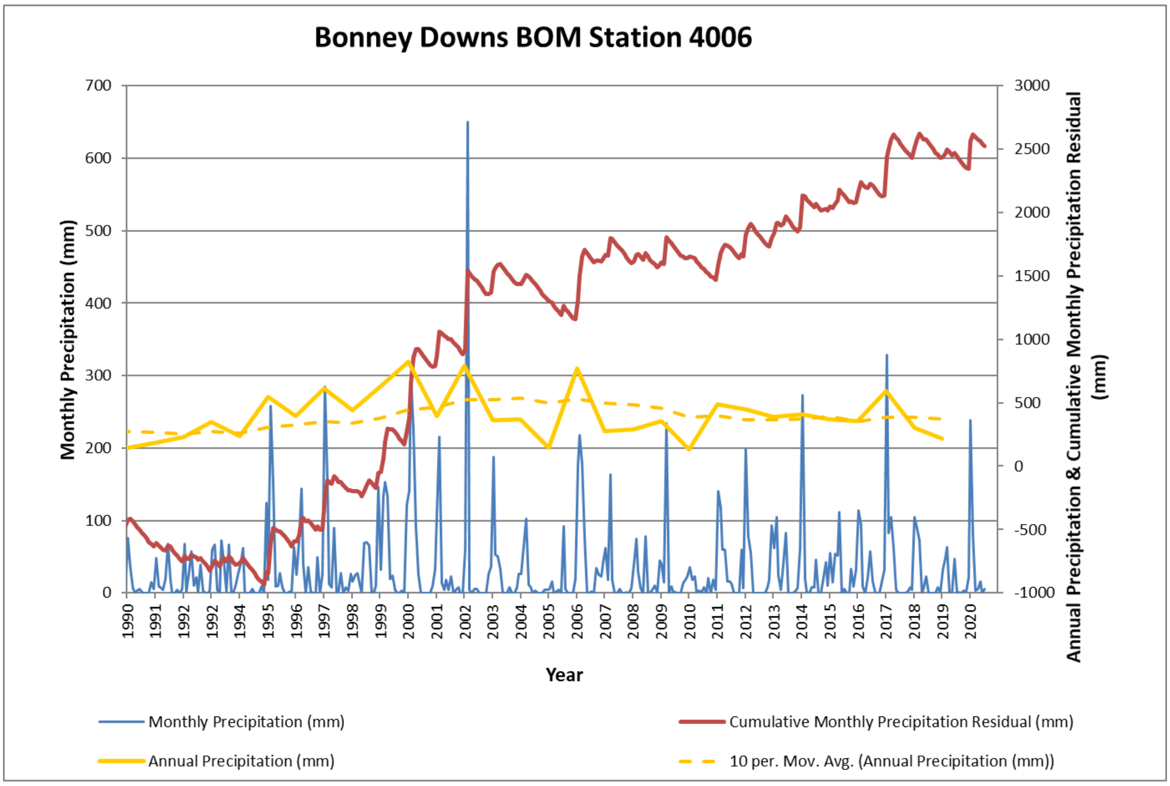


Figure 4-3: Cumulative rainfall departures, Bonney Downs, 1990 to 2020

4.2.2 Temperature and evaporation

At Marble Bar BoM station (4106), the average (2000 to 2020) monthly mean maximum temperature ranges from 27.1° in June to 42° in December, with an annual average of 35.6° (Figure 4-4). The monthly average minimum ranges from 12.2 in July to 26.5 in January (Figure 4-5).

Across the region, potential evaporation rates significantly exceed rainfall. Mean annual (pan) evaporation rates range from 3,000 to 4,000 mm (based on national BoM mapping, Figure 4-6) which is around an order of magnitude greater than the mean annual rainfall range of between 392 mm for Marble Bar station (4106). Annual pan evaporation at Marble Bar averaged 3,312 mm from 1968 to 1988, with typical daily rates of 11 to 13 mm (AECOM, 2013a).

The annual "point potential evapotranspiration", that which would take place under the condition of unlimited water supply such as from a small body of water, is shown on Figure 4-6 and reflects the pan evaporation value from Marble Bar, at around 3,200 mm (BoM, 2020).

The "areal actual evapotranspiration" is the evapotranspiration that actually takes place, under the condition of existing water supply, from an area large enough that the effects of any upwind boundary transitions are negligible and local variations are integrated to an areal average. For example, this represents the evapotranspiration which would occur over a large area of land under existing (mean) rainfall conditions. It is lower than the potential evapotranspiration, being approximately 300 mm (Figure 4-7) (BoM, 2020). Unlike rainfall, total pan evaporation has not changed significantly since 1970 Figure 4-8 (BoM, 2020).

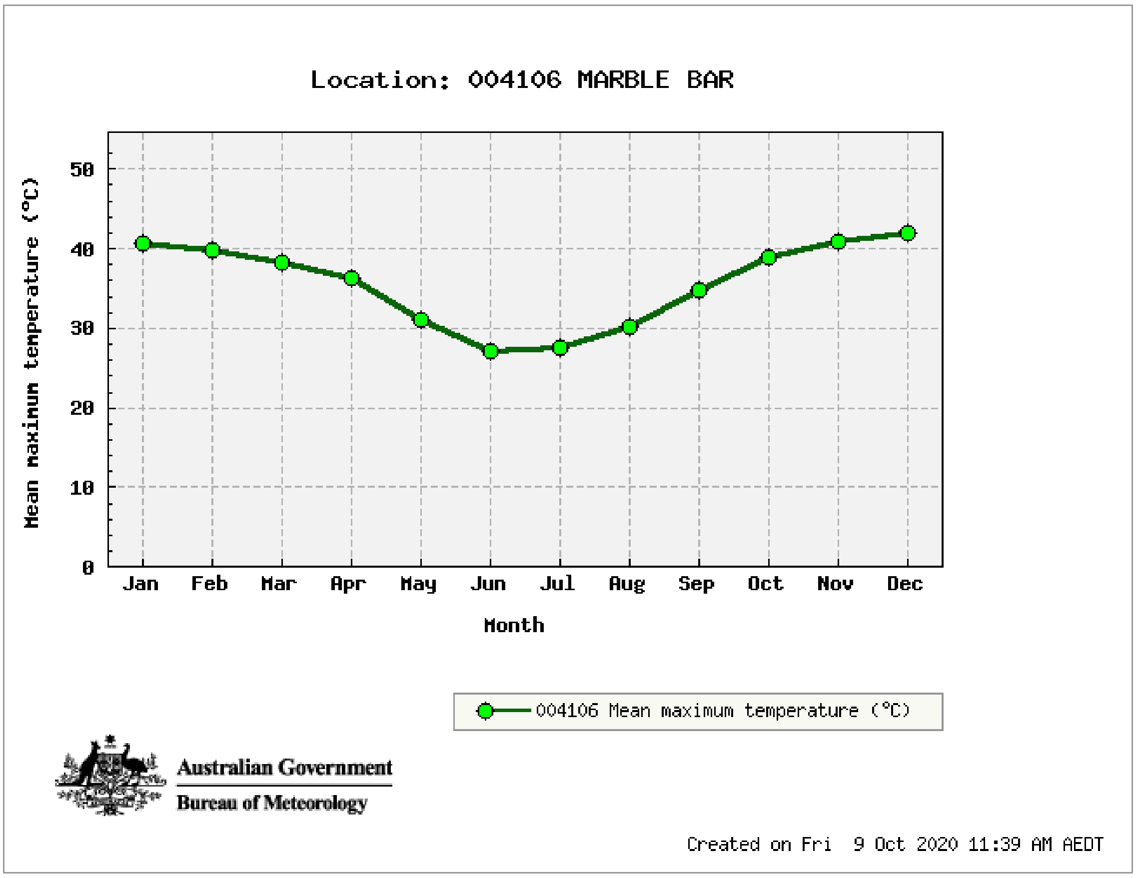


Figure 4-4: Mean maximum temperature at Marble Bar (BoM, 2020)

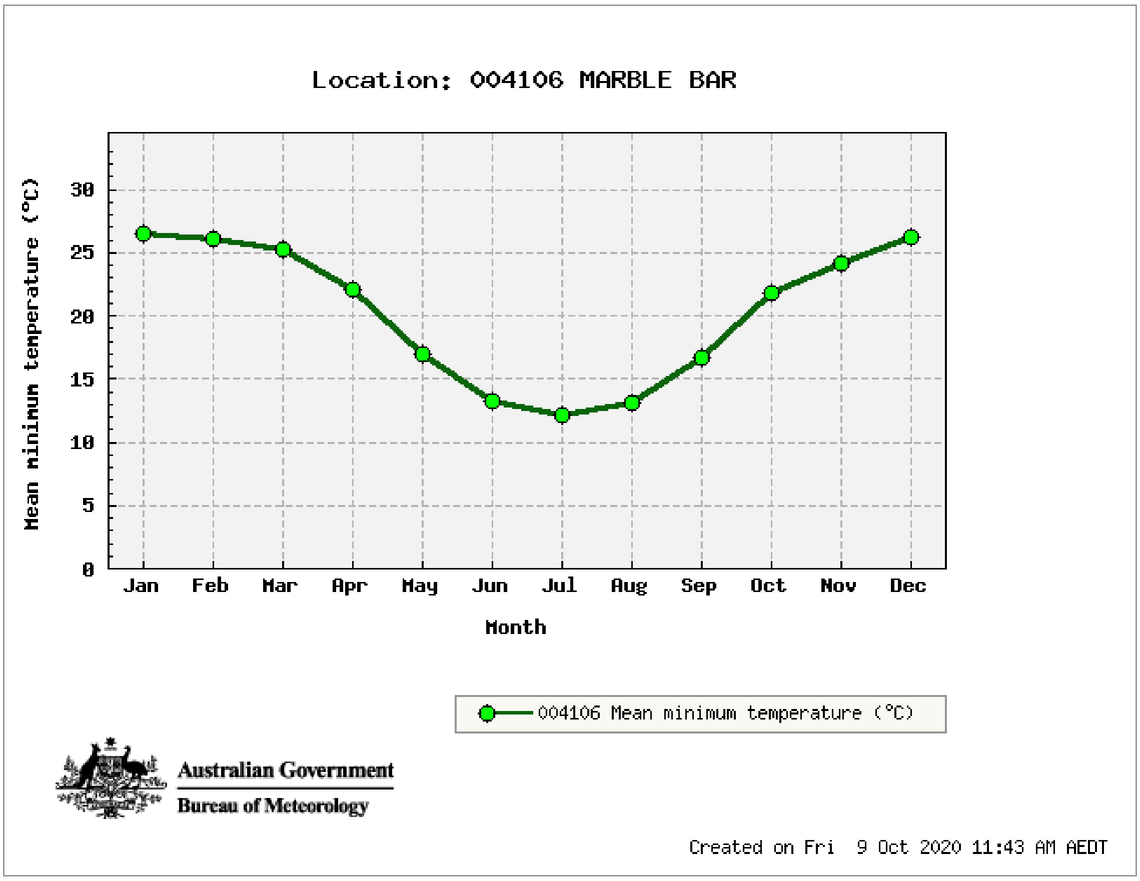


Figure 4-5: Mean minimum temperature at Marble Bar (BoM, 2020)

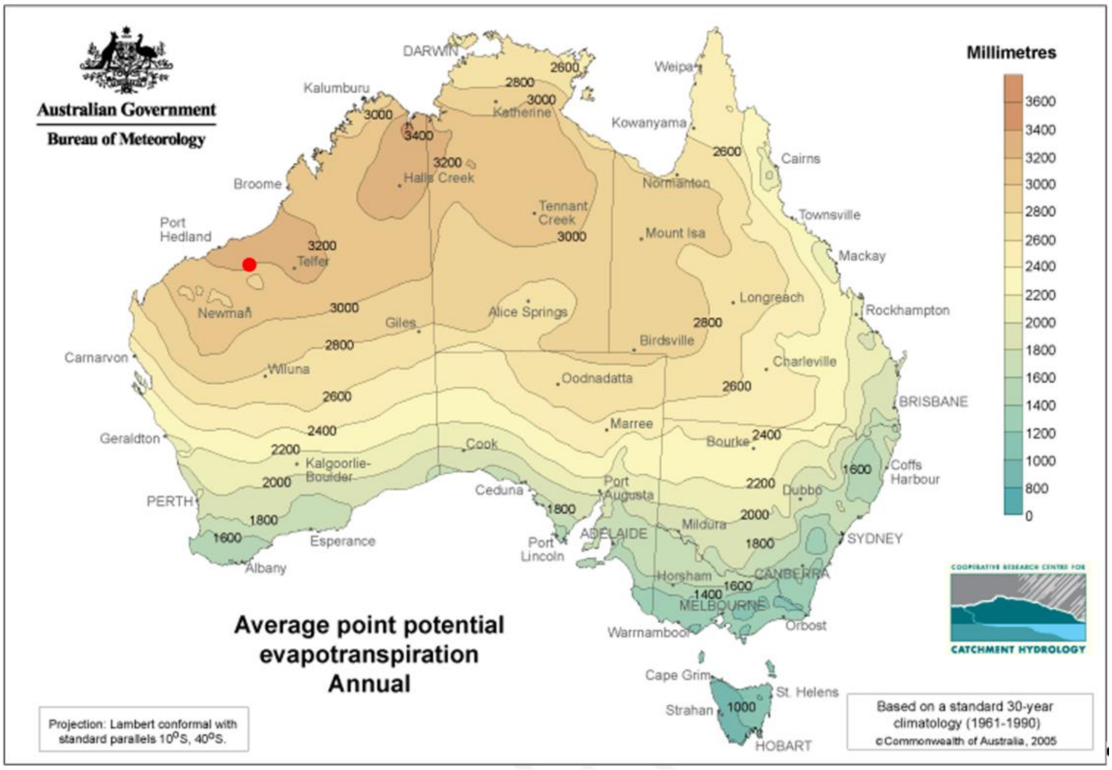


Figure 4-6: Average annual point potential evapotranspiration (BoM, 2020)

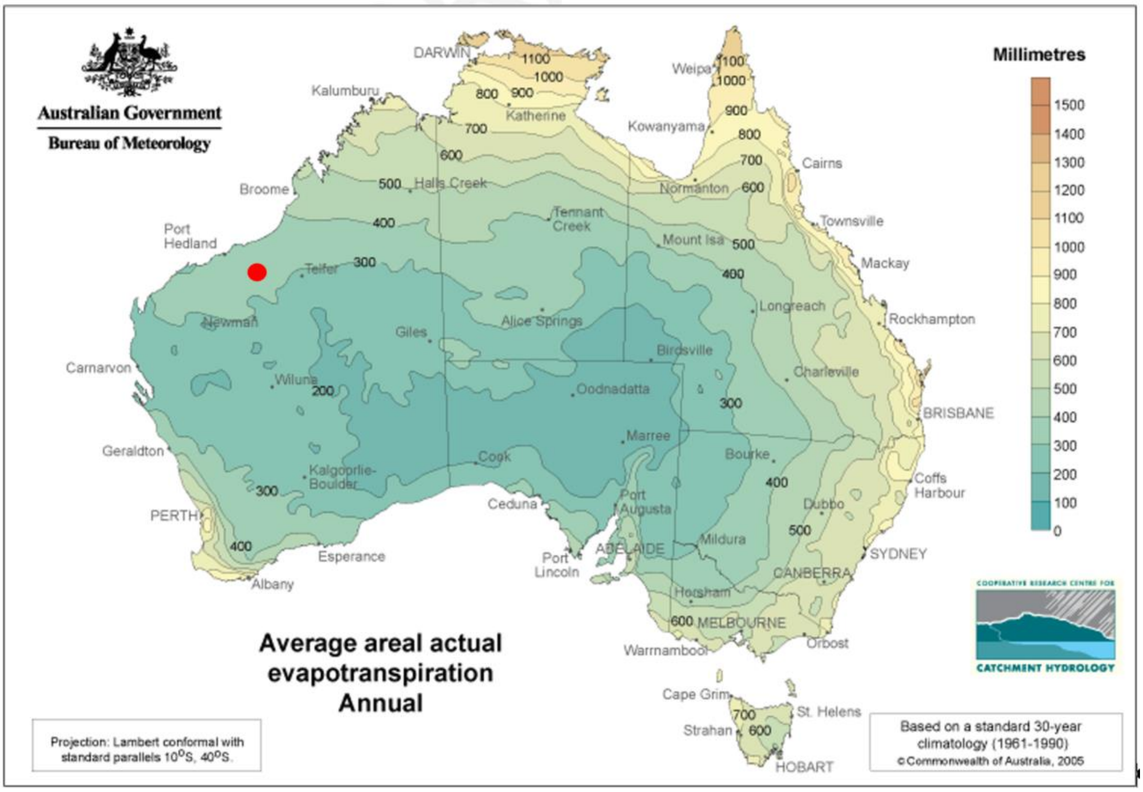


Figure 4-7: Average areal actual evapotranspiration (BoM, 2020)

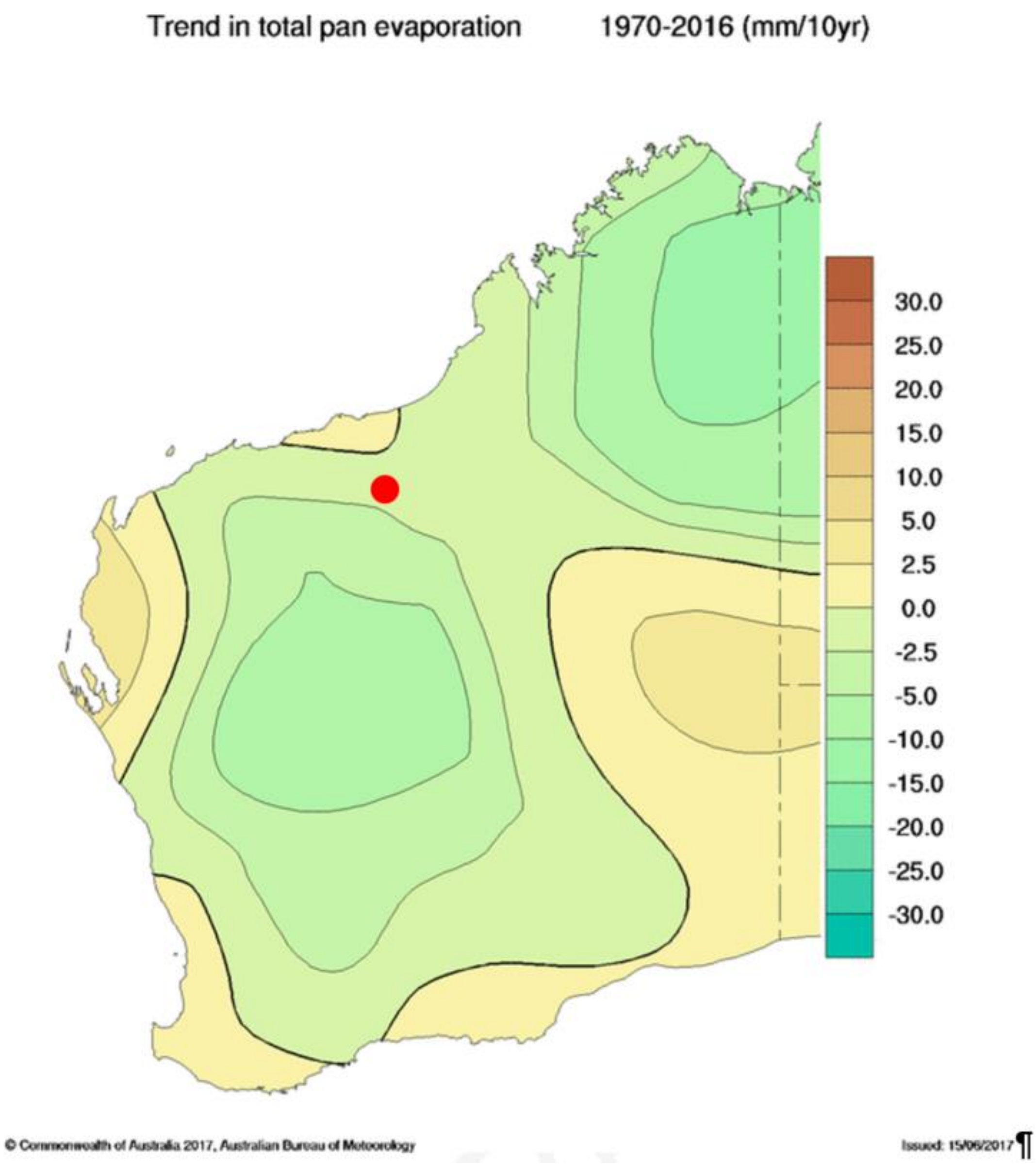


Figure 4-8: Trend in total pan evaporation (BoM, 2020)

4.2.3 Future climate

Commander et al.(2015) summarised the various climate change models for the region and noted that recharge was not expected to change significantly under the wet or dry scenarios considered, despite significant changes in runoff. Of the six modelled scenarios, one showed an increase in recharge of between 1 and 5 %, two showed changes of less than ±1%, one showed a decrease of between 1 and 5% and one showed a decrease of between 5 and 10%. They summarised the findings as follows:

4.3 Physiography

4.3.1 Ground elevations

The Proposal area comprises an elevated ridge shape that strikes northeast-southwest as largely defined by the exposed local syncline and banded iron lithology. To the east and south-east of the ridge-defined structure, the topography is lower and undulating and drains to the south-east (Figure 4-9).

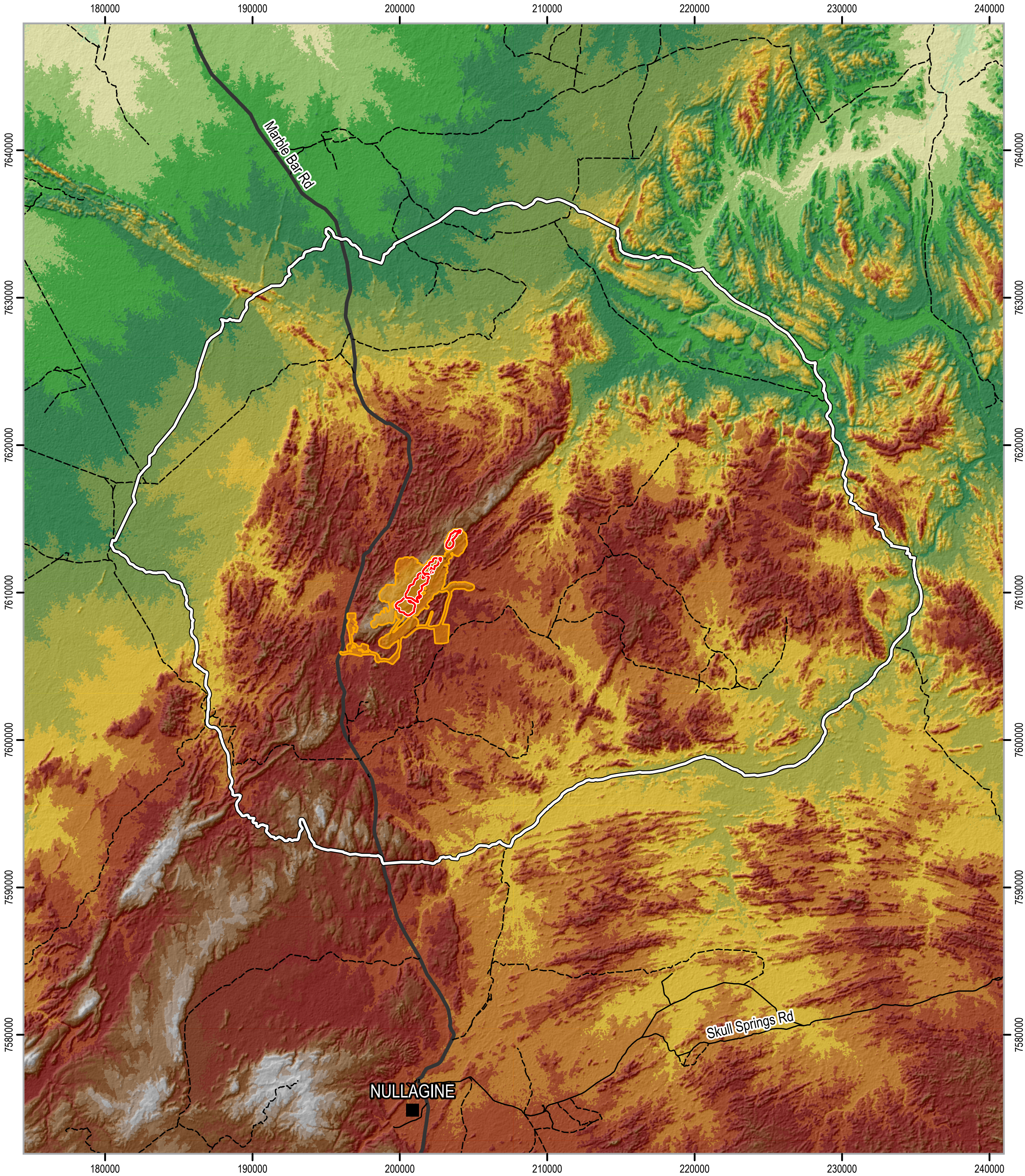
The ground elevations vary between a maximum of 560 m AHD along the ridges within the PDE and minimum of 240 m AHD along the Nullagine River to the south east. The slope gradient over the plains to the south-east averages approximately 0.5 to 0.75%.

4.3.2 Soils and land systems

The land cover of the catchment is typically spinifex grass and sparse trees on rock outcrop and colluvial or thin alluvial soils. The intermittent watercourses that cross the catchment consist of clear gravel channels with treelined banks, which can be readily distinguished from the surrounding vegetation and identified on the Proposal aerial imagery. The majority of the McPhee PDE is situated on several similar land systems (Figure 4-10, DPIRD, 2019) which are broadly correlated with the underlying geology:

- Capricorn System covering the western side of the PDE, characterised by rugged sandstone hills, ridges, stony footslopes and interfluves supporting low acacia shrublands or hard spinifex grasslands with scattered shrubs.
- Rocklea system in the eastern part of the PDE. Includes basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex and occasionally soft spinifex grasslands with scattered shrubs.
- Taylor System in small patches on the western side. Stony plains and isolated low hills of sedimentary rocks supporting hard and soft spinifex shrubby grasslands.
- Robe System, forming a narrow ridge in the mid-eastern part of the PDE. It describes low plateaux, mesas and buttes of limonite supporting soft spinifex and occasionally hard spinifex grasslands.

The drainages to the south-east run mainly through the stony plains of the Rocklea System. The Nullagine River on the eastern boundary of the study area cuts into the Mosquito System, also characterised as stony plains and prominent ridges of schist and other metamorphic rocks supporting shrubby hard spinifex grasslands.



Legend

Freeway	Laneway	Assessment Domain	221 - 240	321 - 340	421 - 440	521 - 540
National Highway	Mall	**Ground Elevation (m AHD)**	241 - 260	341 - 360	441 - 460	541 - 560
State Highway	Track	166 - 180	261 - 280	361 - 380	461 - 480	561 - 580
Main Road	Pit Footprint	181 - 200	281 - 300	381 - 400	481 - 500	581 - 600
Minor Road	Mine Disturbance Area	201 - 220	301 - 320	401 - 420	501 - 520	

Paper Size ISO A4

0 2.5 5 7.5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

Ground Elevations

Project No. **12548901**
Revision No. **0**
Date **04/10/2021**

FIGURE 4-9

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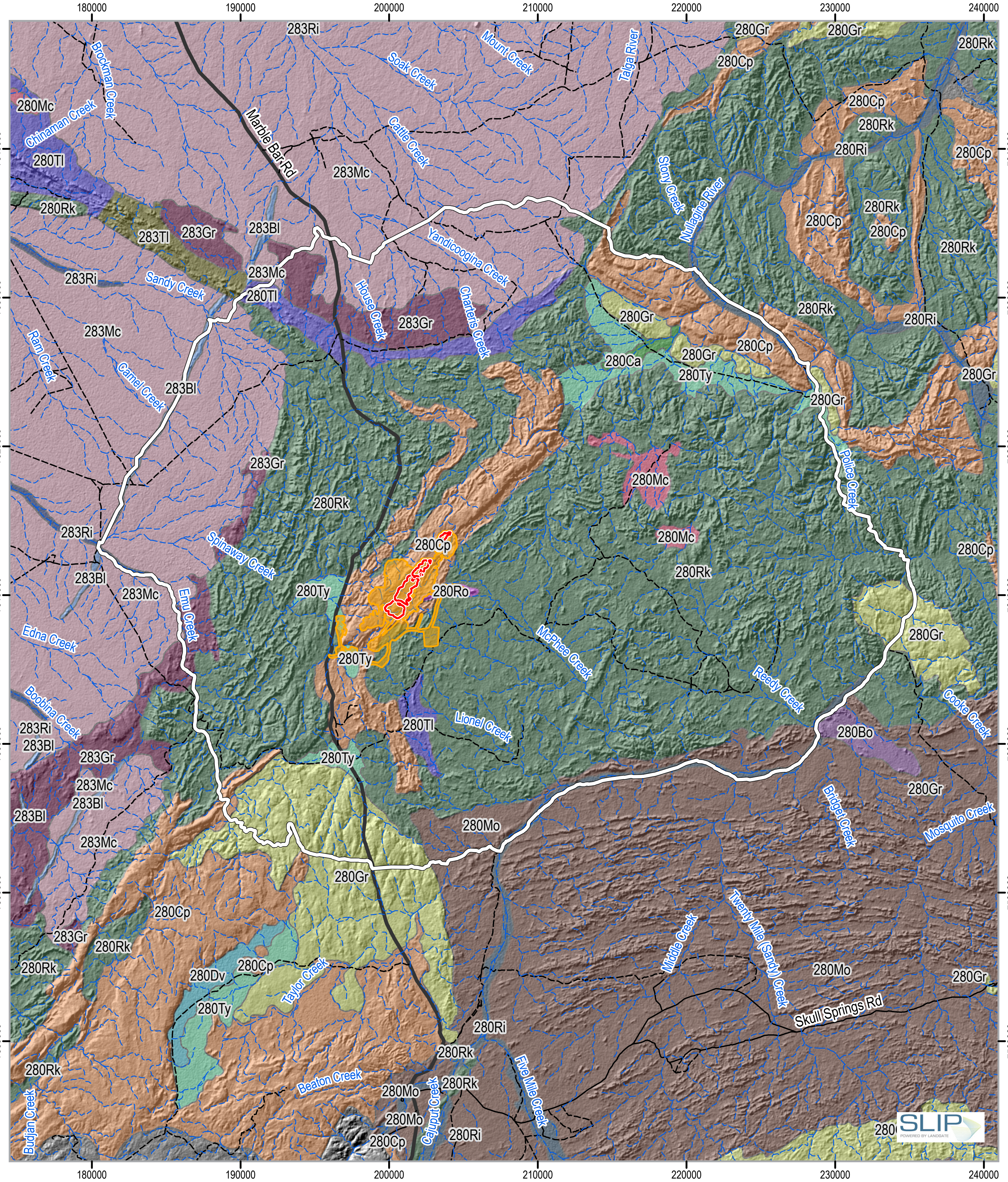
Data source: Roy Hill: DTM- 20200918; GHD: Pit Footprint - 20200828, Assessment Domain - 20191114, Project Development Envelope - 20201022, Site Layout - 20201005; Landgate: Roads - 20171106 .
Created by: jabaygar



Legend

- Main Road
- Minor Road
- Track
- Stream
- Assessment Domain
- Pit Footprint
- Mine Disturbance Area

Soil Landscape System

- 280Bo - Boolaloo System
- 280Ca - Calcrete System
- 280Cp - Capricorn System
- 280Dv - Divide System
- 280Gr - Granitic System
- 280Mc - Macroy System
- 280Mo - Mosquito System
- 280Ri - River System
- 280Rk - Rocklea System
- 280Ro - Robe System
- 280Tl - Talga System
- 280Ty - Taylor System
- 283Bl - Black System
- 283Gr - Granitic System
- 283Mc - Macroy System
- 283Ri - River System
- 283Tl - Talga System

Paper Size ISO A4

0 2.5 5 7.5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

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McPhee Iron Ore Project
Water Management Studies

Land Systems

Project No. **12548901**
Revision No. **0**
Date **04/10/2021**

FIGURE 4-10

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Data source: GHD: Pit Footprint, Assessment Domain- 20201016, Landgate: Roads - 20171106, Land Systems - 20180622, . Created by: jabaygar

4.4 Surface drainage

The area of iron ore mineralisation lies between the catchments of Nullagine River and the Coongan River. The PDE is located at the top of four major tributaries to the Nullagine and Coongan Rivers, comprising McPhee Creek, Spinaway Creek, Sandy Creek and an unnamed creek.

The majority of the mine infrastructure footprint is situated in the upper reaches of McPhee Creek and a main tributary that drains to the south-east into McPhee Creek and subsequently into the Nullagine River (Figure 4-11) (MWH, 2014). The McPhee Creek tributary joins McPhee Creek around 20 km downstream of the proposed mine site. McPhee Creek joins the Nullagine River approximately 30 km downstream of the McPhee Creek mineralisation area (MWH, 2014).

An unnamed creek to the south-west of McPhee Creek also drains a proportion of the PDE and flows in a south-easterly direction from the mineralised area discharging to the Nullagine River. This unnamed creek is referred to as Lionel Creek in this study, to distinguish it from other unnamed drainage lines in the region.

The Nullagine River flows north for approximately 200 km before entering the De Grey River which in turn flow for approximately another 200 km before discharging to the Indian Ocean (MWH, 2014).

The headwaters of the Sandy and Spinaway Creeks are in the northwest of the PDE. Two branches of the upper catchment of Sandy Creek are located north and north-west of the mineralisation body. The two branches cross Marble Bar Road as floodways extending approximately 50 km north-west to Camel Creek then joining Coongan River, continuing north to Talga River and finally the De Grey River. Spinaway Creek is located approximately 2 km west of the mineralisation body flowing west across Marble Bar Road to Emu Creek also entering Coongan River, Talga River and the De Grey River further downstream.

Headwaters of Charteris Creek originate approximately 2.5 km north of the McPhee Creek mineralisation body (outside of the PDE), continuing north for approximately 30 km to Yandicoogina Creek entering Talga River approximately 70 km north of the Proposal area. Further downstream this enters Coongan River joining the confluence of the De Grey River approximately 140 km north-west of the site.

4.5 Pools

Biologic (2020) surveyed 17 pools during their aquatic ecology survey undertaken in April 2020. The survey identified the following:

- McPhee Creek supported numerous semi-permanent and permanent pools with some potentially connected to groundwater (pools McPC2 and McPC4). All sites were characterised by pH of 8.2 to 8.8, clear waters and generally low dissolved metals but high nutrient concentrations. Most sites reportedly comprised potential groundwater dependent vegetation such as *Eucalyptus camaldulensis* and *Eucalyptus victrix* along the banks.
- Branch of McPhee Creek also supported numerous pools some of which were considered likely to be permanent and connected to groundwater (i.e. pool BMcPC1). Water quality within Branch of McPhee Creek was characterised by pH of 8.1 to 9.3, brackish to saline EC, adequate dissolved oxygen, and clear waters with generally high nutrient concentrations. Potential groundwater dependant vegetation, such as *Eucalyptus camaldulensis* and *Eucalyptus victrix*, were reported to be present at all sites.
- Unnamed creek was considered highly ephemeral supports several semi-permanent pools along the most downstream stretch of the Creek, with only two pools remaining at

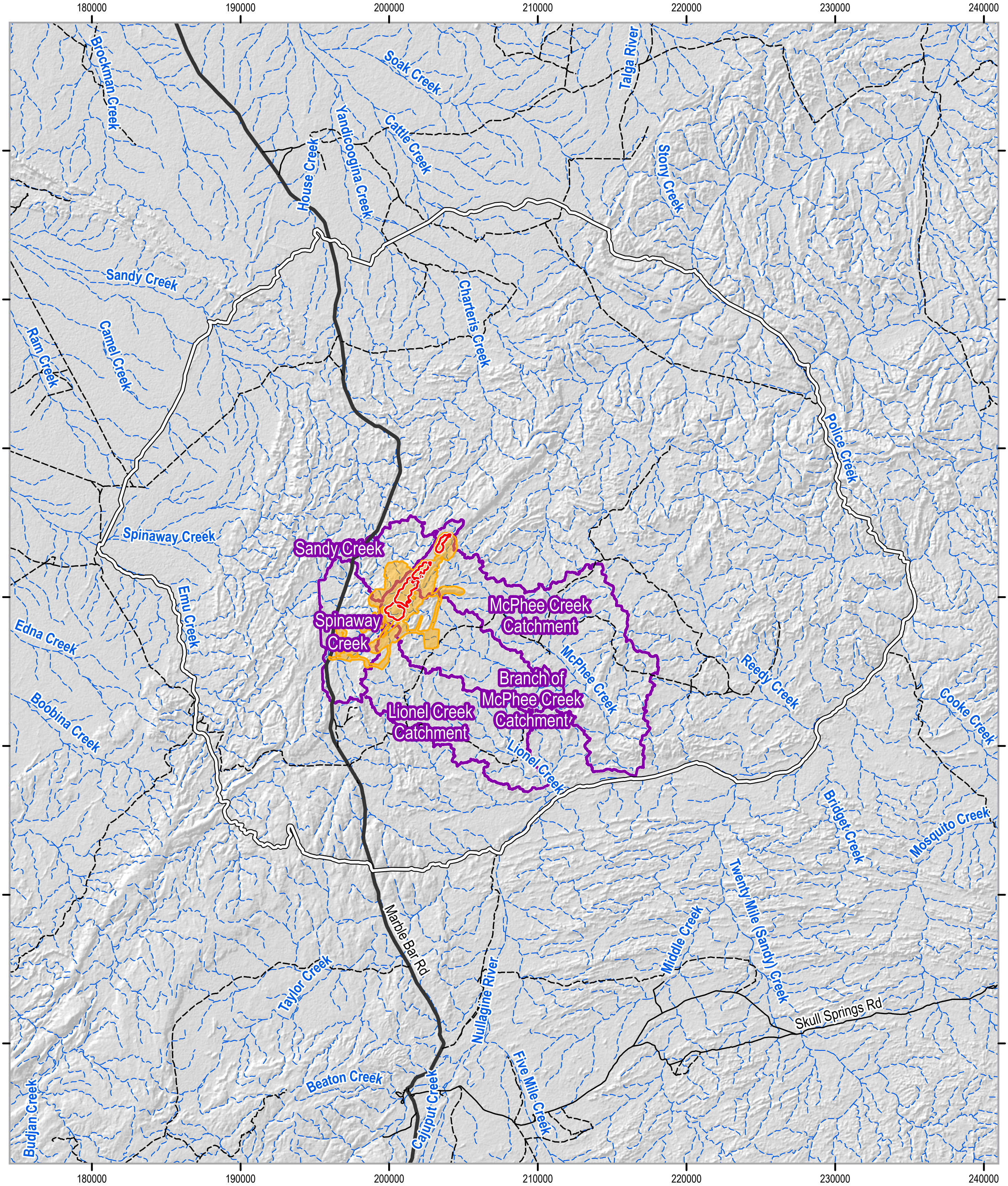
the time of survey. Water quality was characterised by pH of 8.9 and clear waters, with generally low dissolved metal concentrations and high nutrients. Other than these similarities, pool UN3 was fresh with adequate DO, while UN4 was brackish with notably low dissolved oxygen. Potential groundwater dependant vegetation were reported to be present, with *Eucalyptus victrix* being recorded at all sites and *Eucalyptus camaldulensis* at pool UN4.

- The Range pools were located in the upper most reaches of the catchment within the PDE and were not connected to other surface water systems (creeks).

McPhee Creek and Branch of McPhee were reported to support a diverse range of aquatic flora, habitats and aquatic fauna values, including conservation significant and range restricted species. The unnamed creek comprised considerably less semi-permanent and permanent pools than either McPhee Creek or Branch of McPhee.

However, UN3 was found to provide important habitat for macroinvertebrate fauna, recording the highest overall macroinvertebrate taxa richness, a high richness of Pilbara endemic and sensitive taxa, and conservation significant species. All three of the creeks provided nursery habitat for one or more species of freshwater fish, and the Branch of McPhee was considered important for freshwater turtles.

Based on the Biologic report (2020) it is possible that some of the identified pools may potentially be sensitive to changes in the surface water or groundwater regime as a consequence of the proposed mining activities. The extent to which the pools are surface water or dependent on regional groundwater is uncertain, therefore all the surveyed pools have been considered in the assessment.



Legend

- Main Road
- Minor Road
- Track
- Stream
- Assessment Domain
- Mine Disturbance Area
- Pit Footprint
- Catchment

Paper Size ISO A4

0 2.5 5 7.5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

Area Hydrology

Project No. **12548901**
Revision No. **0**
Date **04/10/2021**

FIGURE 4-11

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Data source: GHD: Streams - 20191113, Pit Footprint - 20200828, Assessment Domain - 20191114, Project Development Envelope - 20201022; Landgate: Roads - 20171106 . Created by: jabaygar

4.6 Geology

4.6.1 Regional geology

The McPhee Creek PDE occurs within the Kelly Subgroup (KS) in the south-eastern part of the East Pilbara Granite-Greenstone Terrane (Bagas, 2050) as shown on Figure 4-12. The KS consists of Archaean intrusive and extrusive igneous and sedimentary sequences including the Euro Basalt, Wyman Formation, and Charteris Basalt.

The McPhee Creek iron ore deposit is hosted within the north-east to south-west trending Paddy Market Formation which, together with the underlying Corboy Formation, forms the core of the Sandy Creek Syncline, faulted against the Wyman Formation and Euro Basalt of the Kelly Subgroup to the SE.

The Paddy Market Formation is thinly bedded iron formation interbedded with ferruginous chert, often comprising white and black laminae of ferruginous shale, and variably ferruginized or silicified chert. The Corboy Formation comprises sandstones (silicified quartzites) and basal polymictic conglomerates with interbedded shales and cherts.

To the east of the PDE is the domal structure consisting of the Strelley Pool Chert and Panorama Formations which belong to the Salgash Subgroup. The Panomara Formation (felsic volcanoclastic rocks) is intruded by greenstone gabbro, ultramafics (e.g. Dalton Suite, Apex Basalt) and various dolerite dykes.

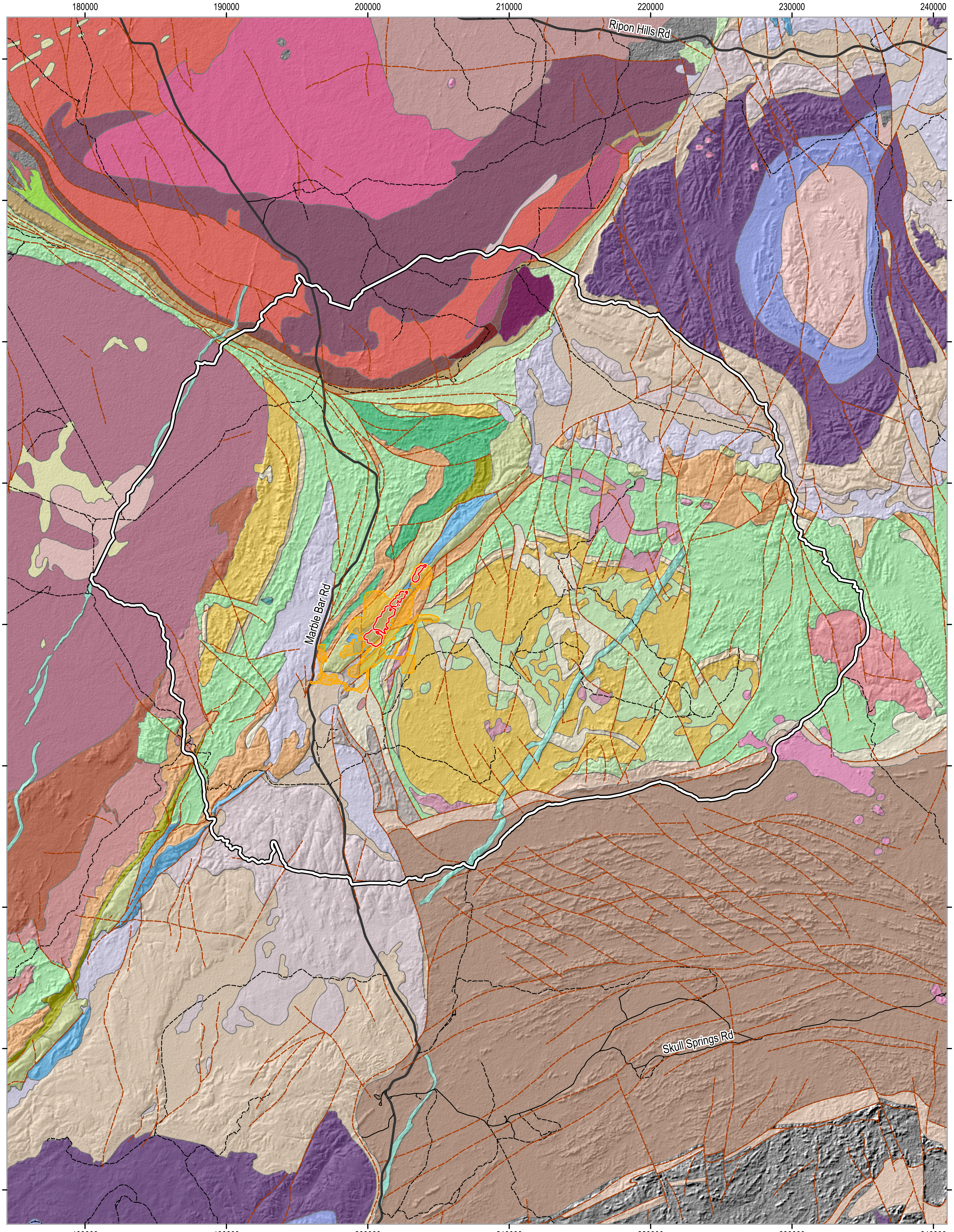
To the south of the domal structure lie the sediments of the Mosquito Creek Formation of the De Grey Group, comprising interbedded conglomerate and coarse-grained sandstone, with interbedded sandstone, siltstone, and shale.

A series of steeply dipping north-northeast faults occurs in the Kelly Greenstone Subgroup.

Cainozoic deposits are common on granite and sparsely distributed in areas of greenstones and metasedimentary rocks. Older deposits include consolidated alluvial, colluvial, and residual material. Later, unconsolidated Quaternary material includes alluvial, colluvial, eluvial, and eolian deposits.

In the mining area, ferruginous duricrust occurs that includes massive, pisolitic, and nodular laterite with some transported material. These units expose local underlying dissected bedrock. The ferricrete grades downward into leached and kaolinized deeply weathered rock. Ferricrete deposits are several metres thick, include massive, pisolitic and nodular ironstone

Residual calcrete consists of dissected, massive, nodular, and cavernous carbonate that overlies, and is derived from, altered carbonate-rich ultramafic rocks, and covers large areas bordering rivers or creeks over granitic rocks. The calcrete forms as sheets, encrustations, and joint-fills, and is either massive or nodular. Calcrete sheets are mapped in the upstream parts (close to the PDE) of surface drainages, McPhee Creek to the south-east and Spinaway Creek to the west.



Legend

- Main Road
- Minor Road
- Track
- Fault
- Assessment Domain
- Mine Disturbance Area
- Pit Footprint
- Bishop Creek Monzogranite
- Owens Gully Diorite
- Underwood Gneiss
- Dalton Suite
- Emu Pool Supersuite
- Boobina Porphyry
- Carbana Monzogranite
- Chessman Granodiorite
- Davitt Syenogranite
- Gobbos Granodiorite
- Joorina Granodiorite
- Kennell Granodiorite
- Wilina Granodiorite
- Hardey Formation
- Bamboo Creek Member
- Kylena Formation
- Maddina Formation
- Mount Roe Basalt
- Tumbiana Formation
- Cleaverville Formation
- Farrel Quartzite
- Charteris Basalt
- Euro Basalt
- Wyman Formation
- Coondamar Formation
- Mosquito Creek Formation
- Strelley Pool Formation
- Budjan Creek Formation
- Corboy Formation
- Cookes Creek Monzogranite
- Mondana Monzogranite
- Fig Tree Gneiss
- Lady Adelaide Orthogneiss
- Warrawoona Group
- Apex Basalt
- Duffer Formation
- Mount Ada Basalt
- Panorama Formation
- Black Range Dolerite
- Pilbara Craton Greenstones
- Bridget Suite

Paper Size ISO A3

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

Regional Geology

Project No. **12548901**
Revision No. **0**
Date **04/10/2021**

FIGURE 4-12

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Print date: 04 Oct 2021 - 11:53

Data source: GHD: Pit Footprint - 20200828, Assessment Domain - 20191114, Project Development Envelope - 20201022, USG Model Grid- 20201026; Landgate: Roads - 20171106 . Created by: jabaygar

4.6.2 Geology of orebody

The Paddy Market Formation that hosts the ore body is characterised by thinly bedded banded iron formation (BIFs) interbedded with ferruginous chert (Bagas, 2005). Atlas Iron, based on the interpretations presented in “An Updated Stratigraphy for the McPhee Creek Iron Ore Deposit” (Warner and Potter, 2012), has subdivided the Paddy Market Formation into eight stratigraphic subunits (Figure 4-13), comprising from bottom to top:

- MC1 - Footwall Shale, a distinctive black, fissile shale with an obvious geophysical signature. The unit is characteristically carbonaceous, sulphidic and considered to be the lowest stratigraphic unit. Its full thickness is as yet untested by deep drilling.
- MC2 – Footwall BIF, identified from logging with a larger chip size and a weaker geophysical signature. It is characterised by hard hematite – goethite mineralisation, low phosphorous content and is typically 10 to 15 m thick.
- MC3 – BIF with interbedded shales, identified from logging as a lower strength unit with moderately hard to friable goethite, moderate phosphorous content and a thickness of 20 to 30 m.
- MC4 – Shale with thin BIF, easily identifiable due to its shale content (high alumina >10%), typically low/sub grade friable goethite (44 to 54% Fe) and 30 to 40m thick.
- MC5 – BIF, contains hard to moderate goethite, low to medium grade iron 53.8 to 57.0% Fe, this unit contains moderate levels of phosphorous and is 10 to 15m thick
- MC6 – Chert horizon, highly siliceous and extends for much of the strike length of the deposit with a consistent thickness of 10 to 20 m. This unit has been used as a valuable marker to confirm drilling progression through the stratigraphy.
- MC7 – BIF, hard to moderate goethite with high iron (up to 61.1%) and high phosphorous (0.1 to 0.5%) content. The unit is typically 15 to 30 m thick and primarily identified due to its high phosphorous content.
- MC8 – BIF with shale interbeds, containing moderately hard to friable goethite, with high iron and phosphorous levels. This unit is 40 to 60m thick and is currently being further subdivided.

Figure 4-14 shows typical cross sections through the deposit, showing significant folding and the separation of the ore into distinct synclinal ‘pods’. Figure 4-15 presents surface geology mapping as presented in AECOM (2013a).

A geological model has been developed by Atlas Iron for the resource from the resource drilling programs and interpretations of the structural features identified within the resource area.

Within the geological model the subunits of the Paddy Market Formation have been broadly grouped together into three units. A summary of the model units is provided below as Table 4-1. The geological model structure (i.e. geometry and units) forms the basis of the groundwater numerical model as presented in Section 9.

Table 4-1: Geological model units summary

ID	Description	Equivalent stratigraphical model unit
MP7	Upper BIF	Paddy Market Formation - incorporating MC7 and MC8
MP6	Chert zone	Paddy Market Formation - incorporating MC6
MP2	Lower BIF	Paddy Market Formation - incorporating MC2, MC3, MC4 and MC5

ID	Description	Equivalent stratigraphical model unit
MP1	Footwall shale	Paddy Market Formation - Incorporating MC1
fqz	Corboy Formation / quartzite background	Corboy Formation i.e. underlying Paddy Market Formation

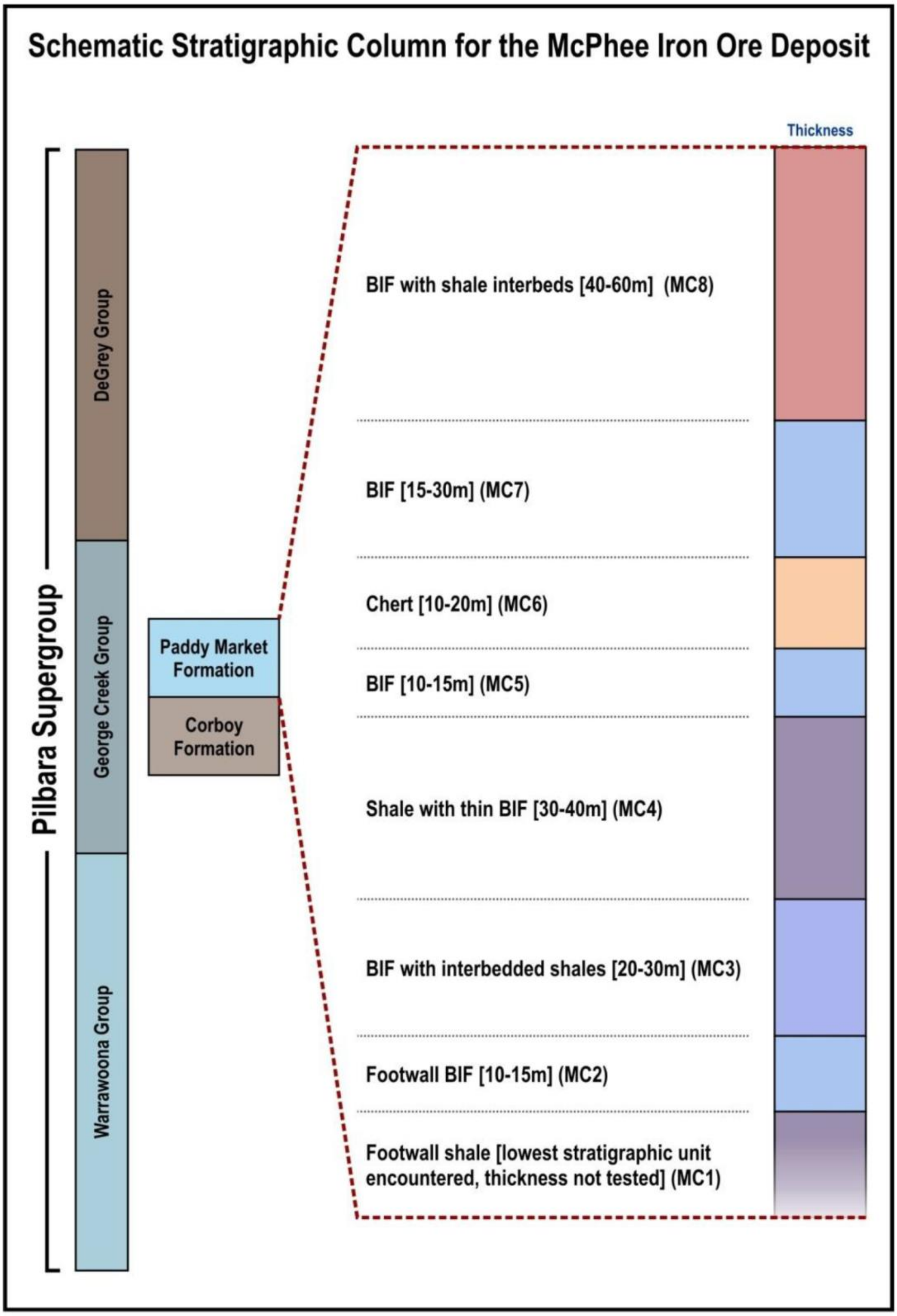
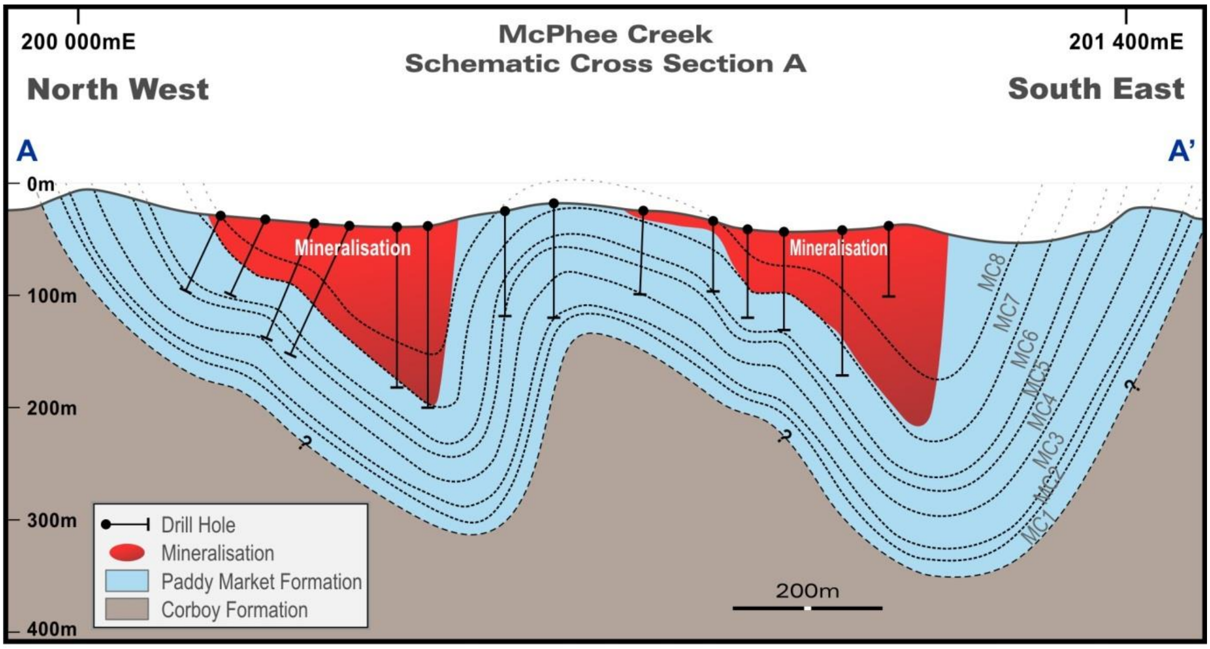


Figure 4-13: Local geology (Warner and Potter, 2012)



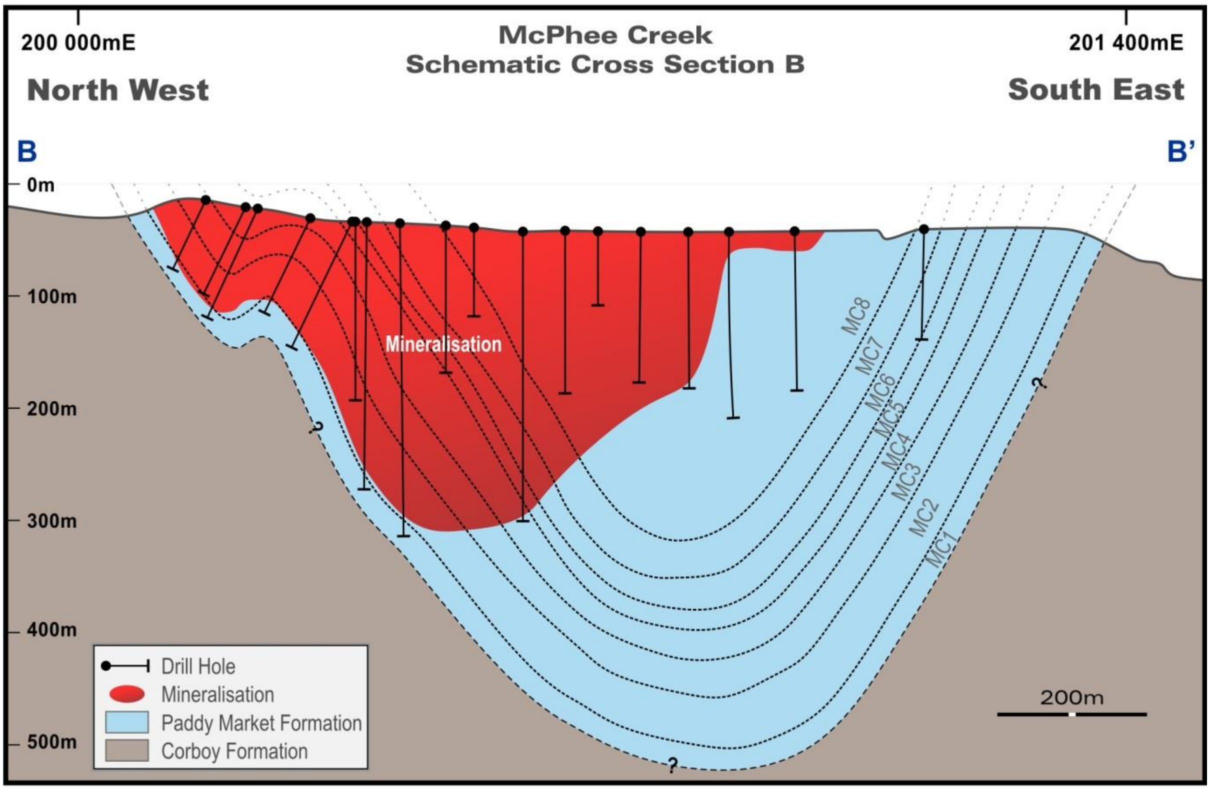


Figure 3: Schematic Cross Sections

Figure 4-14: Ore deposit cross sections (Warner and Potter, 2012)

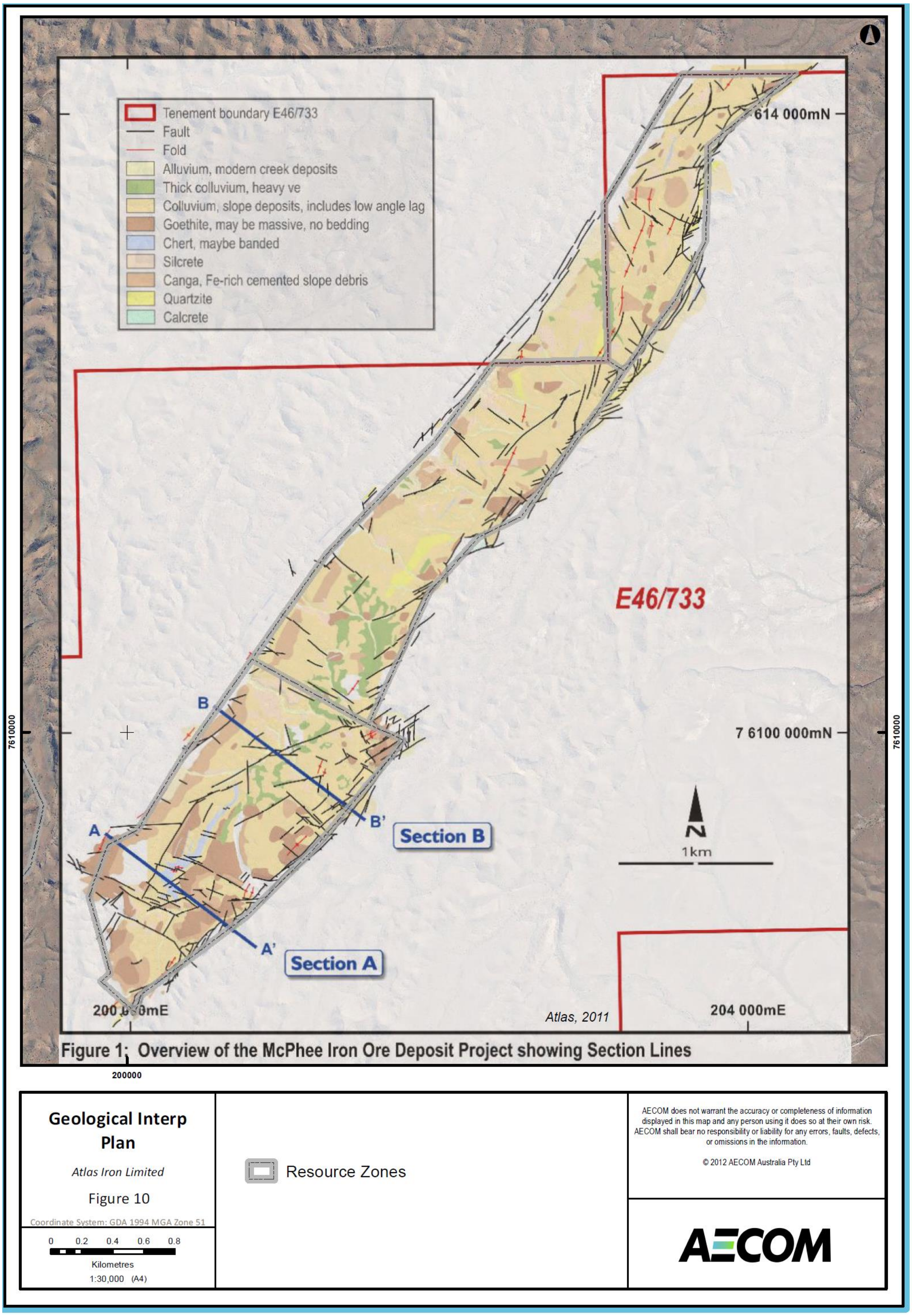


Figure 4-15: Surface geology (AECOM, 2013a)

5. Hydrogeological setting

5.1 Introduction

The broad regional hydrogeological setting is outlined in this section. Details and learnings from hydrogeological investigation carried out for this project are described and discussed in Section 7 and hydrogeological conceptualisation is described in Section 8.

5.2 Regional hydrogeology

The mine site and surrounds are contained within the Pilbara Fractured Rock Aquifer (DoW, 2009b). CSIRO place the site within the Granite Greenstone Terrain (Commander et al., 2015). It comprises multiple disconnected fractured rock aquifers with some areas of higher permeability unconsolidated sedimentary or chemically deposited aquifers.

The fractured rock aquifers exist in many different rock formations in the more highly fractured or weathered zones or zones of intensive bedding pane partings (Johnson and Wright, 2001), . The most significant fractured rock aquifers tend to be in the more brittle, hence more intensely fractured, units such as quartz veins, cherts, Banded Iron Formations (BIF), dolomite and quartzite sandstones (Commander et al., 2015).

Yields in the order of 1,000 to 2,000 kL/day, relatively fresh water (100 to 1,500 mg/L as TDS) have been obtained from BIF, dolomite and sandstone fractured rock aquifer aquifers (Johnson and Wright, 2001). Commander et al (2015) noted that although the fractured rock aquifers tend to be localised, they form important mine and construction water supplies and can be locally significant for springs and rockpools supporting GDEs.

Commander et al. (2015) summarises key groundwater balances for the Granite Greenstone Terrain as:

- Median rainfall 345 mm/r
- Median runoff 24 mm/y or 6.8% or rainfall
- Median recharge 3.4 mm/y or 0.99% of rainfall
- Evaporation 92.2% of rainfall

The mine site is part of the proclaimed Pilbara Groundwater Area under RIWI Act 1914, Section 26B(1).

5.3 Aquifer and aquitard units

Previous studies by AECOM (2013a) and SKM (2014) defined the local hydrogeology. The aquifers hosting the ore deposits comprise secondary porosity dominated fractured units within the Paddy Market Formation. They are contained within the elongated Sandy Creek Syncline.

The Footwall Shale of the Paddy Market Formation and quartzite of the underlying Corboy Formation are considered to form an aquitard, so that the Paddy Market Formation in the mine area acts as an isolated, unconfined elongated basin aquifer approximately 7,500 m long by 700 m wide and up to 250 m deep (AECOM, 2013a).

This has been informally referred to as the Main Range Deposit Aquifer or MRD Aquifer. The aquifer forms a basin from the northern parts of Zone 1 to Zone 3, however, within much of Zone 1, the aquifer forms separate and discrete sub-basins due to faulting and secondary folding.

5.4 Aquifer parameters

Aquifer properties differ considerably within the PDE, especially for the syncline feature that hosts the deposit and the surrounding crystalline basement that encapsulates the syncline.

Previous aquifer testing results and relatively flat measured groundwater levels within the syncline structure suggest the prevalence of comparatively high hydraulic conductivity and possibly also increased storage when compared to typical fractured rock environments (AECOM, 2013a).

Aquifer hydraulic properties estimated from historical pumping tests conducted within the PDE (AECOM, 2013a) as well as recent testing by GHD (the latter discussed in Section 7.3) are presented and discussed in Section 7.9.

5.5 Groundwater levels and flow directions

SKM (2013) compared the pre-mining groundwater levels against ground surface elvations which showed groundwater was within around 10 to 20 m of the surface in lower-lying areas adjacent to drainage lines but was significantly deeper in elevated ridge areas, at 40 to 100 m below surface (Figure 5-1). This subdued reflection of the surface topography in the groundwater level is typical of fractured rock aquifers.

AECOM (2013a) contoured the 2011 data, which indicated an elevated groundwater divide along the ridgeline marking the McPhee Creek catchment, radially sloping to all directions (Figure 5-2).

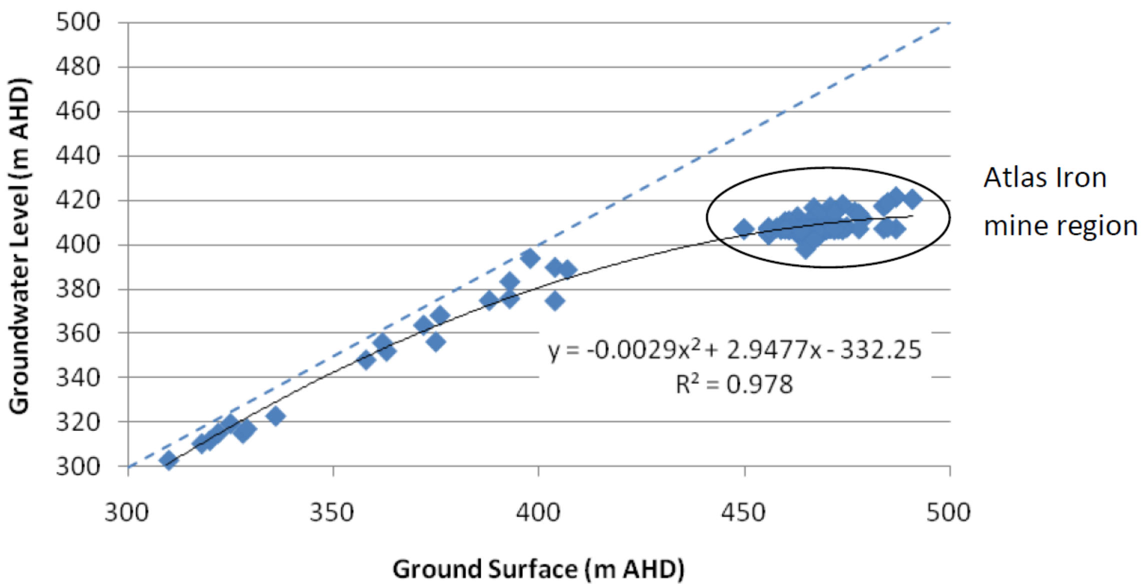


Figure 5-1: Measured pre-mining groundwater elevations vs ground elevations (after SKM, 2013)

5.6 Groundwater salinity and chemistry

Based on 2011 sampling, AECOM (2013) reported that within Zones 1 to 3 of the MRD, groundwater was fresh (80 to 500 mg/L TDS based on a EC conversion factor of 0.6) and near-neutral to slightly alkaline.

Based on limited major ion data, groundwater within the MRD is typical for an active recharge zone, with elevated magnesium and bicarbonate. Paddy's Bore to the south-west of the MRD was a Ca-Mg-HCO_3 type, along the flow paths towards Paddys Bore.

5.7 Surface water groundwater connectivity

SKM (2013) noted that as the McPhee Creek deposit is located above the elevation of the Nullagine River and located at a distance of 17 km from the mine site, it was considered unlikely that the Nullagine River would affect groundwater flow within the McPhee Creek deposit. However, the relatively fresh salinity of groundwater at the site suggests relatively dynamic through flow and ultimately any groundwater at the site will either discharge directly to the Nullagine River alluvium or its tributaries or evapotranspire.

Although a significant proportion of groundwater within alluvial deposits adjacent to the river is likely to be lost via evapotranspiration, the relatively low salinity of groundwater suggest there is some active discharge of groundwater into the river, at least during or immediately after the wet season.

A number of pools discussed in sections 4.5 and 6.2.1 are permanent features and potentially groundwater-fed and areas of riparian vegetation may also potentially be dependent on groundwater, , it is not known if they are hydraulically connected to regional or perched groundwater. However, AECOM (2011a) estimated median stream flows based on scaling of Nullagine River flow data from 1997-2010, which showed flow only occurring in February and March.

Recharge to alluvial and more permeable areas of the fractured rock aquifers could be significant during the brief periods of surface water flow as recharge and water recirculation was noted in previous pumping tests (AECOM, 2013a).

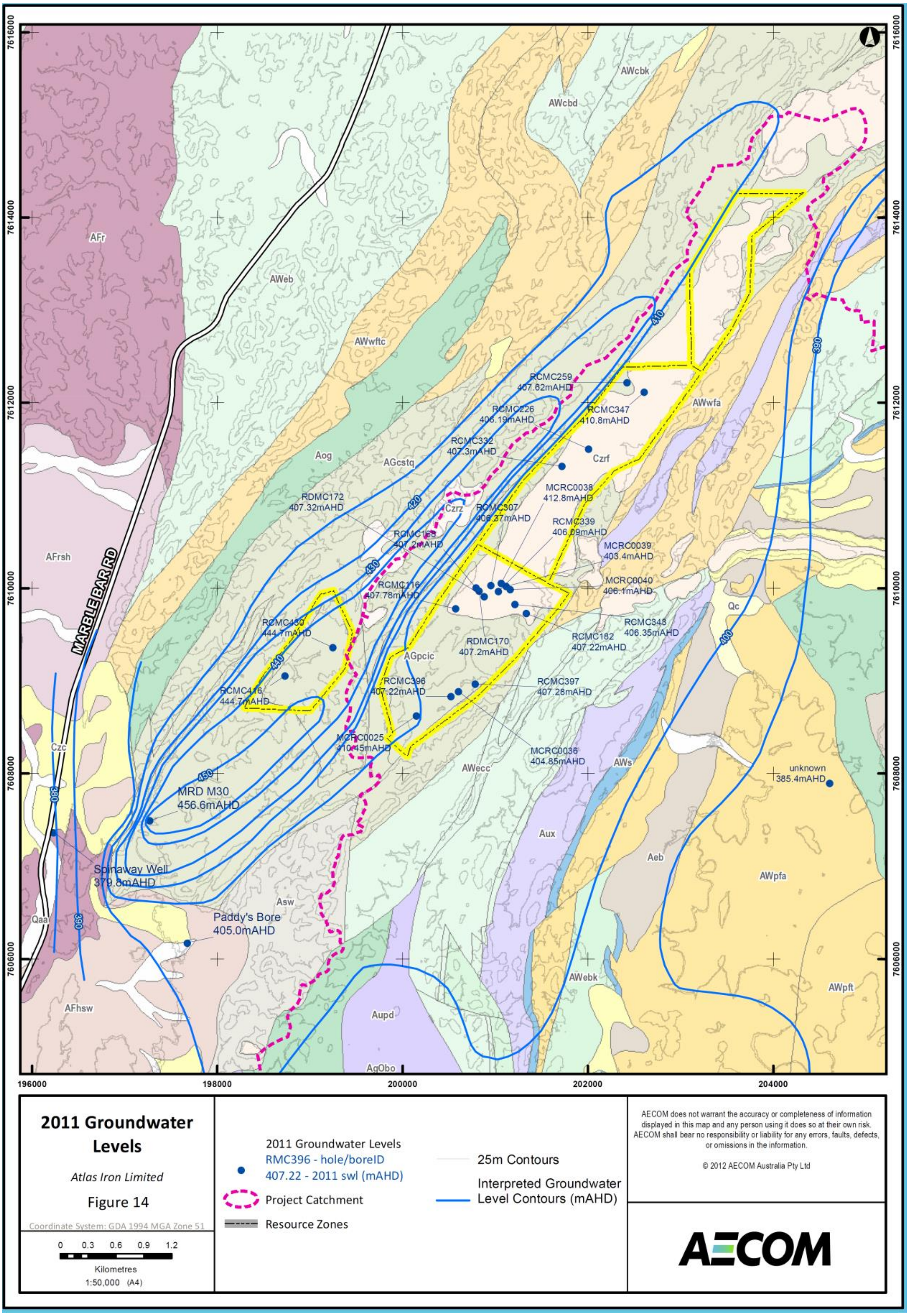


Figure 5-2: Groundwater level contours at the PDE (from AECOM, 2013a)

6. Groundwater use

6.1 Licensed and unlicensed abstraction

The Proposal is with in the area covered by the Pilbara Groundwater Allocation Plan (2013), which sets out the licensing requirement for the regions. Water used for mining is further managed by the DoW's Pilbara Water in Mining Guideline (DoW, 2009b).

The DWER Water Information Reporting (WIR) database shows 24 bores or mine shafts within a 20 km radius of the mine centre (presented in Table 6-1 and Figure 6-1). The groundwater levels are relatively shallow, at 5.3 to 18.5 m below ground level, and typically fresh, with median TDS of 800 mg/L, although some brackish samples (up to 7,600 mg/L) bring the average up to around 1,600 mg/L.

The database does not provide the current status or use of these abstraction points, but AECOM (2013a) noted they were mostly used for pastoral supplies, are old mine workings or exploration bores drilled by Main Roads WA.

A search of the DWER Water Register website on 2 October 2020 produced details of 14 groundwater and 2 surface water licences within a 20 km radius of the mine centre. Licence details are provided in Table 6-2 and Figure 6-2. The total groundwater allocation is 4,946,750 kL/y and the total surface water allocation 160,000 kL/y (total 5.1 GL/y). Included in the groundwater figure is the 80,000 kL/y allocated to the Nullagine town water supply (65335) and 1,295,000 kL/y allocated to Atlas Iron.

Station pastoral bores and wells for stock and domestic supplies are not typically licensed.

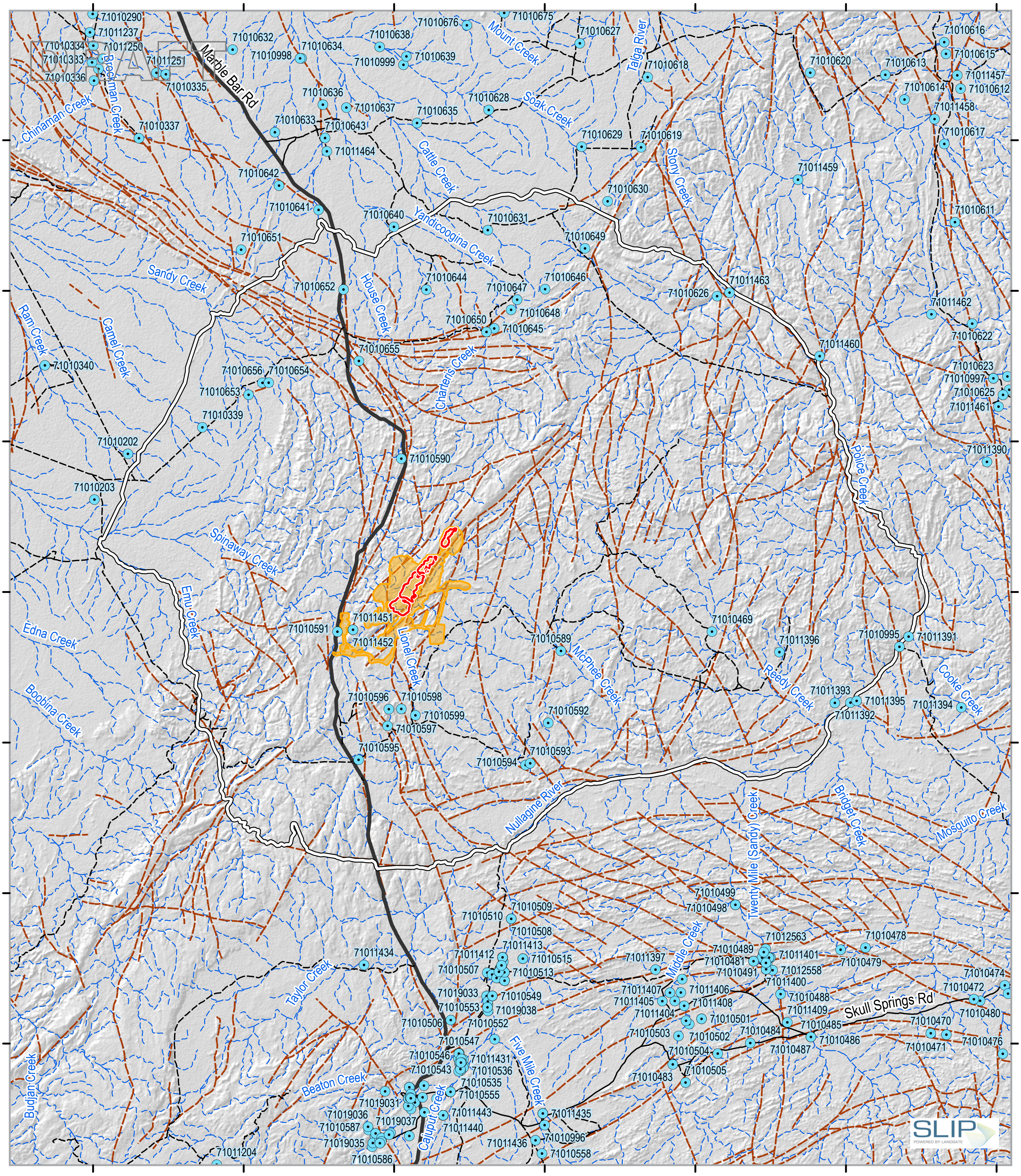
Table 6-1: Registered bores/wells

Site Ref	Site Name	Easting (mMGA)	Northing (mMGA)	Date Installed	Drilled Depth (m)	SWL (mbgl)	SWL Date	TDS (mg/L)	TDS date
71010339	Links Well	808968*	7620996*	-	-	5.30	22/06/1997	800	22/05/1997
71010589	McPhee Creek Well	211123	7606114	30/06/1900?	12.11	5.3	09/02/2012	1,200	02/0/8/1996
71010590	Gallops Well	200521	7618888	-	14.75	12.84	-	500	21/11/1977
71010591	Spinaway Well	196196	7607338	-	9.99	9.40	-	555	-
71010592	Quartz Circle D.H.I.	210271	7601279	30/06/1976	76.2	18.46	30/06/1976	1,078	30/06/1976
71010593	Quartz Circle Camp	209022	7598669	30/06/1976	28	9.60	30/06/1976	7,620	30/06/1976
71010594	Lionel	208697	7598503	-	-	7.60	02/08/1996	1,000	02/08/1996
71010595	Hales Gravel Well	197672	7598811	-	1.87	3.90	02/08/1996	430	02/08/1996
71010596	Mineshaft	199686	7602176	-	12.56	-	-	-	-
71010597	Mineshaft	199575	7601120	-	15.63	13.95	-	7800	-
71010598	Mineshaft	200427	7602283	-	18.03	18.03	-	-	-
71010599	Mineshaft	201440	7601791	-	19.16	17.00	-	561	-
71010644	No 19 Well	202158	7630042	-	21.11	6.79	-	587	-
71010645	Yandacoogina (Trig)	206666	7627514	-	14.5	12.88	-	650	17/11/1997
71010647	Battery Shaft	208206	7629392	-	12.74	12.64	-	1,447	-
71010648	Uncle Tom Mineshaft	207816	7628726	-	15.28	11.69	-	2,738	-
71010650	Trig Well	206083	7627306	-	-	7.90	18/06/1997	850	18/06/1997
71010652	Underwood Well	196663	7630136	-	9.81	7.74	-	583	-
71010653	Old Well	190303	7623088	-	7.3	-	-	-	-
71010654	Well	191637	7623909	-	11.38	6.58	-	1,179	-
71010655	Unnamed	197692	7625343	15/08/1998	33	9.91	09/02/2012	670	15/08/1997
71010656	Tony Well	191282	7623842	-	-	7.30	22/05/1997	700	22/05/1997
71011451	Unnamed	197217	7607506	15/08/1986	100	-	-	-	-
71011452	Unnamed	197217	7607506						

All locations in Grid Zone 51 except as indicated * in Zone 50, SWL = static water level, 2012 SWL recorded by Atlas and reported in AECOM (2013a)

Table 6-2: Water licence summary

WRI Number	Instrument Type	Issue Date	Expiry Date	Licence Allocation (kL/y)	All Parties	Sub Area	Aquifer
65335	Groundwater	17/10/2018	29/11/2027	80,000	Water Corporation	East Pilbara	Pilbara - Fractured Rock
161702	Groundwater	22/01/2019	21/01/2029	2,000,000	Millennium Minerals Limited	East Pilbara	Pilbara - Fractured Rock
171278	Groundwater	5/10/2017	4/10/2027	1,009,000	FMG Nullagine Pty Ltd	East Pilbara	Hamersley - Fractured Rock
175352	Groundwater	14/02/2017	13/02/2027	95,000	Atlas Iron Pty Ltd	East Pilbara	Pilbara - Fractured Rock
176665	Surface Water	8/04/2014	7/04/2024	80,000	Millennium Minerals Limited	NA	NA
176960	Groundwater	3/04/2020	2/04/2030	1,100,000	Atlas Iron Pty Ltd	East Pilbara	Pilbara - Fractured Rock
178635	Groundwater	3/05/2016	2/05/2026	90,000	Beatons Creek Gold Pty Ltd	East Pilbara	Pilbara - Fractured Rock
179086	Groundwater	28/03/2014	27/03/2024	50,000	Atlas Iron Pty Ltd	East Pilbara	Pilbara - Fractured Rock
179423	Groundwater	28/07/2014	27/07/2024	50,000	Atlas Iron Pty Ltd	East Pilbara	Hamersley - Fractured Rock
179633	Groundwater	7/08/2020	7/08/2030	81,500	Main Roads	East Pilbara	Hamersley - Fractured Rock
182493	Groundwater	22/06/2016	21/06/2026	210,000	Beatons Creek Gold Pty Ltd	East Pilbara	Pilbara - Fractured Rock
183394	Surface Water	21/09/2016	20/09/2026	80,000	Beatons Creek Gold Pty Ltd	NA	NA
201457	Groundwater	20/06/2018	19/06/2028	20,000	John Edward Telfer	East Pilbara	Pilbara - Fractured Rock
203581	Groundwater	27/11/2019	10/11/2029	1000	Main Roads	East Pilbara	Pilbara - Fractured Rock
204411	Groundwater	9/06/2020	8/06/2030	160,000	Calidus Resources Limited	East Pilbara	Pilbara - Fractured Rock
204507	Groundwater	7/07/2020	6/07/2030	250	Nimble Resources Pty Ltd	East Pilbara	Pilbara - Fractured Rock



Legend

- Existing Bore (AGE, 2019)
- Main Road
- Minor Road
- Track
- Stream
- Fault
- Assessment Domain
- Pit Footprint
- Mine Disturbance Area

Paper Size ISO A4

0 2.5 5 7.5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

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GHD

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McPhee Iron Ore Project
Water Management Studies

Registered Bores/Wells

Project No.	12548901
Revision No.	0
Date	04/10/2021

FIGURE 6-1

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Data source: GHD: Bore Locations - 20191031; Streams - 20191113, Pit Footprint - 20200828, Assessment Domain - 20191114, Project Development Envelope - 20201022; Landgate: Roads - 20171106 .
Created by: jabaygar

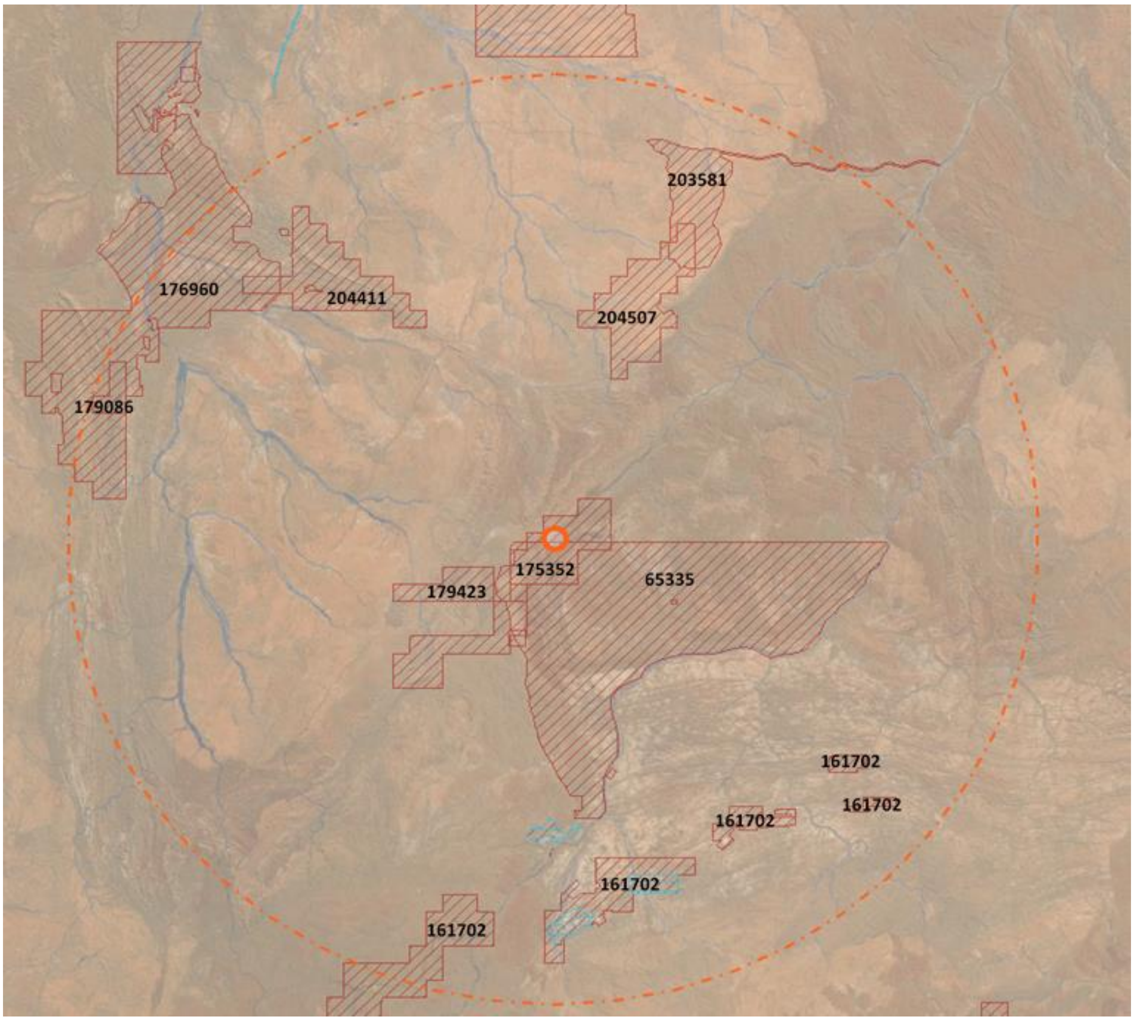


Figure 6-2: Licensed allocations within 20 km

6.2 Groundwater dependent ecosystems, stygofauna and troglofauna

6.2.1 Groundwater Dependent Ecosystems

The BoM GDE Atlas shows potential GDEs within approximately 20 km of the mine centre, shown on Figure 6-3, comprising:

- Moderate potential Terrestrial GDE
  - Active flood plains, major rivers and banks supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands.
  - Hills and ridges of sandstone and dolomite supporting low shrublands or shrubby spinifex grasslands. (Dark green)
- Low potential Terrestrial GDE – Various soil types and vegetations (Light green)
- Moderate potential Aquatic GDEs - Yandicoogina Creek and Emu Creek
- High potential Aquatic GDE - Nullagine River
- Unclassified potential Aquatic GDE - Unnamed pool

No subterranean GDEs were noted on the atlas.

Eco Logical (2013) noted "*While two phreatophytic flora species occur within the drainage lines within the Application Area (Eucalyptus victrix and Atalaya hemiglauca), the vegetation types* *containing these species are not considered to be GDEs… Given the depth of the water table (50-60 m depth) it is unlikely that lowering of the water table would impact existing vegetation. While several rock pools occur on stream lines near the south-eastern extent of the MRD aquifer, these pools are considered to be seasonal and fed by rainfall runoff only. They occur well above the main water table elevation and freshwater chemistry is consistent with runoff*."

The survey conducted by Biologic (2020) included semi-permanent and permanent pools which may potentially be connected to groundwater, including McPC2, McPC4 and BMcPC1. The locations of these pools are presented in Figure 6-3.

6.2.2 Stygofauna and Troglofauna

Eco Logical (2013) noted that the area comprised many disconnected fractured rock aquifers that were likely to restrict the movement of stygofauna but that movement would potentially be unrestricted in the alluvial aquifers. They reported 13 species of stygofauna had been observed within or surrounding the proposed mine pit areas.

Eco Logical (2013) reported "*Twenty species of troglofauna were recorded during the survey comprising spiders, centipedes, millipedes, pauropods, diplurans, cockroaches, beetles, silverfish, planthoppers and isopods. The troglofauna assemblage was primarily recorded in the Gorge Creek BIF (proposed pit area) (Subterranean Ecology 2012*[1])".

Fifteen of the species were recorded only inside the proposed pit area and none had been recorded elsewhere in the Pilbara. Reportedly no subterranean fauna species listed under the *Environment Protection and Biodiversity Conservation Act* or the *Wildlife Conservation Act* were recorded during surveys of the McPhee Creek Application Area.

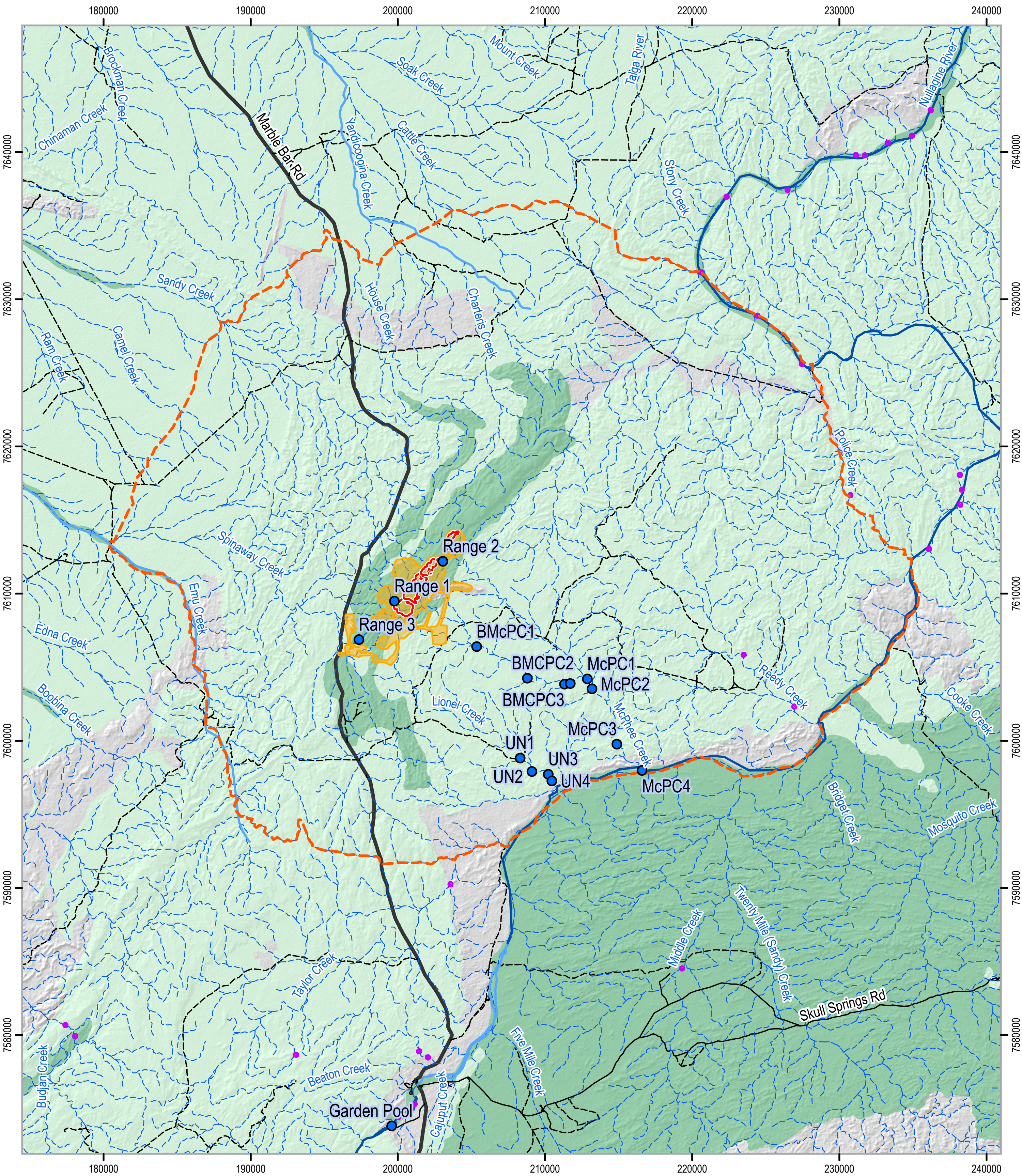
In terms of key values Eco Logical (2013) noted "*One species of stygofauna and 15 species of troglofauna are known only from the footprint area and may be of concern for the Proposal; however, further habitat assessment may reduce the number of species of interest.*"

In terms of impact, Eco Logica (2013) noted:

"*The Proposal has the potential to significantly impact subterranean fauna as a result of:*

- *Loss of stygofauna and troglofauna habitat through excavation of mine pits.*
- *Loss of stygofauna habitat through extraction of groundwater (potentially mitigated through reinjection of surplus dewater).*
- *Alteration of the humidity of troglofauna habitat through exposure of cavities to the external environment, alteration of air currents, and extraction of groundwater.*
- *Loss of troglofauna habitat if water levels increase to a point where the air-filled rock cavities become saturated (e.g. through disposal of excess mine water, either by direct injection into the aquifer, or from seepage through surface strata if water is released into drainage lines).*
- *Habitat degradation through changes to water quality (e.g. increased acidity caused by black shale, including percolation of leachates beneath waste dumps; increased salinity levels; increased levels of nutrients and organic matter; or introducing other pollutants).*
- *Impacts to any alluvial aquifer fauna connected to McPhee Creek due to surface discharge of excess dewater."*

[1] Reference for Subterranean Ecology (2012) not provided in Eco Logical 2013



Legend

- Pool
- Main Road
- Minor Road
- Track
- Stream
- Assessment Domain
- Pit Footprint
- Mine Disturbance Area

Terrestrial GDE

- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment
- Low potential GDE - from national assessment

Aquatic GDE

- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment
- Low potential GDE - from national assessment
- Unclassified potential GDE - from regional studies

Paper Size ISO A4

0 2.5 5 7.5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

GHD

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

GDEs and Pools

Project No. **12548901**
Revision No. **0**
Date **04/10/2021**

FIGURE 6-3

\\ghdnet\ghd\AU\Perth\Projects\61\12548901\GIS\Maps\Working\12548901_Figures.aprx
Print date: 04 Oct 2021 - 16:54

Data source: GHD: Bore Locations - 20191031, Streams - 20191113, Pit Footprint - 20200828, Assessment Domain - 20191114, Project Development Envelope - 20201022; BOM: GDEs - 20201104; Landgate: Roads - 20171106 . Created by: jabaygar

6.3 Proposed groundwater use

6.3.1 Dewatering

Dewatering will be necessary to secure dry mining conditions in the open cut pits. Dewatering will be achieved through a combination of pumping from near- and in-pit dewatering bores and from in-pit sumps.

Pre-feasibility estimates of up to around seventeen dewatering bores have been identified, the number will depend on site-based achieved yields. The dewatering bores range in depth from around 120 m to up to 280 m. In-pit bores are primarily required on the northwest side of Avon and Murray pits as the BIF units that require dewatering are present largely only within the pit footprints i.e. the shale and Corboy units are at or near the surface in locations immediately northwest of the pit. On the south-east side of the resource, the BIF units extend outside of the pit footprints thus allowing near-pit dewatering bores.

The dewatering bore locations are concentrated around Avon and Murray Pit (fourteen bores), with two bores required for Nicholson Pit and one for Ord Pit. The reduced number of bores for the north-eastern pits reflects their limited depths and mining occurring later in the life of mine period i.e. the resource is already partly dewatered by the preceding dewatering of Avon and Murray Pits. The dewatering bores and sumps will be connected to a water reticulation pipeline.

6.3.2 On-site water use

Water demand for construction and operational phase will be relatively modest. The current estimates are that up to 6,700 kL/d of water will be needed for the operation phase. Water for ore processing will not be required since ore will be processed off site.

Water will be sourced from production (dewatering bores) on site.

6.3.3 Water discharge

The water balance assessment (GHD, 2020a) identified that the Proposal will have surplus water during the early stage of the life of mine. Excess dewatering volumes from the year 2026 onwards will be disposed of to the existing creek lines to the southeast of the mine development envelope. These creek lines form tributaries of the Nullagine River which flows approximately 17 km south-east of the PDE.

The locations of the proposed discharge points are based on proximity to the PDE, maximisation of depth to groundwater and minimisation of infrastructure required to reticulate the discharge from the dewatering bores.

Part of the dewatering volume can also be potentially disposed of via aquifer injection, as managed aquifer recharge (MAR), however this option, if chosen, is subject to further assessment. At this stage, excess water disposal needs are covered by creek discharge.

As a preliminary guidance, the injection bore sites for MAR can be situated in the southwestern part of the PDE. Approximately five to seven bores are estimated to be able to provide a total recharge capacity of around 3 GL/yr during the 2026 to 2028.

Areas outside of PDE are not considered prospective for large-volume re-injection.

6.3.4 Water infrastructure

Mining below the water table will start in approximately 2026. Construction and on-site water use between 2021 and 2025 can be met from the existing production bores which have sufficient capacity to meet demand.

Dewatering infrastructure for mining below the water table will include near-pit bores. The largest dewatering volumes are expected to be within the first three years of mining below water table due to the proposed schedule of progression of Avon and Murray pits, which are the deepest pits in the PDE. These pits will be dewatered up to a depth of 240 m below ground level or about 160 m below the pre-mining water level.

Compliance with 5C licence and groundwater operating strategy will comprise groundwater level monitoring and groundwater sampling from a network of on-site and regional monitoring bores. It is estimated that 20 to 30 monitoring bores will be used to monitor the mining impacts. The recommended monitoring strategy is presented in Section 11.

7. Groundwater investigation

7.1 Overview

Atlas Iron developed a scope for a groundwater investigation to address hydrogeological data gaps that were identified in the 2013 AECOM Phase 2 Groundwater Investigation and were subject to third party review by Jurassic Groundwater (2019), based on which the scope of works was prepared by Atlas Iron. Field components of the GHD 2020 groundwater investigation included installation of additional test production bores and monitoring bore, aquifer testing including groundwater quality sampling, and processing data from packer testing of geotechnical and metallurgical diamond cored bore sites.

The following sections provide a summary of the site investigation aspects that relate specifically to the hydrogeological scope.

7.2 Hydrogeological drilling

7.2.1 Overview

The purpose of the 2020 hydrogeological drilling campaign was to address data gaps surrounding the aquifer properties of the main ore deposit, following the previous hydrogeological investigation field work completed in 2012 (AECOM, 2013a).

The overview of existing approvals with regards to hydrogeological drilling are presented in Table 7-1:

Table 7-1: Existing regulatory approval documents for hydrogeological drilling

Approval	Detail	Dates
Programme of Work Approval *Department of Mines, Industry Regulation and Safety*	Equipment on M45/1243-I Registration ID: 83008 Programme of work approval for use of ground disturbing equipment.	Issued 6 November 2019, valid for 4 years
Licence to Construct or Alter Well (26D licence) *Department of Water and Environmental Regulation*	Instrument No. CAW203556(1) Location of activity: M45/1243 Licence to "Construct as many as required non-artesian well(s) for mining or public supply"	From 4 November 2019 to 3 November 2021

A total of eight drilling locations were identified by Atlas Iron, with the rationale for each location summarised below in Table 7-2 and presented in Figure 7-1. Most locations were across the strike of the deposit, with the dual purpose acting as dewatering points during mine life, and also to collect information to inform the groundwater model calibration by providing refined aquifer properties. Of the eight locations, five were test production bores and three were drilled for monitoring bores purposes only. Two of the test production bore locations ("P" and "R") had existing monitoring bores therefore only test production bores were needed.

Table 7-2: Rationale for bore locations

Location name	Bores and target depths*	Rationale
D-alt & n-alt	MCP0151 (PB) &MCP0155 (MB) 180 m	New test production bore and monitoring bore. Test fault and shale between Avon and Murray pits. No existing hydraulic data on properties of the shale. Geological model units MP2 (lower BIF) and MP1 (basement shales).
L-alt & e-alt	MCP0152 (PB) & MCP0156 (MB) 250 m	New test production bore and monitoring bore. Test dewatering and deep aquifer. Located perpendicular to the deepest part of Murray pit. Test for dewatering feasibility. Also possible fault to the west. Geological model units MP2 (lower BIF) and MP1 (basement shales)
O-alt & t-alt	MCP0153 (PB) & MCP0154 (MB) 150 m	New test production bore and monitoring bore. Test aquifer properties in area of northern Ord pit and area between Ord and Nicholson pits. Geological model units MP6 (chert units) and MP7 (lower BIF)
P	MCP0103 (PB) 150m	New test production bore at location of existing monitoring bore (MCRC0448). Test aquifer properties in area of Nicholson pit. Geological model units MP7 (upper BIF) and MP6 (chert zone)
R	MCP0105 (PB) 150 m	New test production bore at location of existing monitoring bore (RCMC430). Test aquifer properties in BIF units west of MRD, possibility of reinjection. Geological model units MP7 (upper BIF), MP6 (chert zone) and MP2 (lower BIF)
c	MCP0157 (MB) 30 m	New monitoring bore in area of no previous drilling. North-eastern regional monitoring. Geological model units MP1 (basement shales)
k	MCP0116 (MB) 100 m	New monitoring bore. Northern regional monitoring. Geological model units MP7 (upper BIF).
m-alt	MCP0158 (MB) 250 m	New monitoring bore. Murray drawdown monitoring east pit wall. Geological model units MP6 (chert zone) and MP2 (lower BIF)

* Bore names – PB = test production bore, MB = Monitoring bore

7.2.2 Drilling methodology

Following the experience of the previous groundwater drilling program in 2012, a dual rotary (DR) air hammer methodology was selected as the most appropriate to complete the required drilling. The DR method offers the benefit of advancing a large diameter outer steel casing to seal off unconsolidated/fracture zones. These zones are common within the BIF and chert units of the MRD Aquifer and, without the employment of a DR method, can lead to bore collapse resulting in compromised casing installations.

Pentium Hydro Pty Ltd (Pentium Hydro) was engaged by Roy Hill to complete the drilling program, under the technical supervision of GHD Hydrogeologists. Pentium Hydro used the DR air hammer method with a Foremost DR24HD drilling rig, mounted on an 8x8 Mercedez Benz Actros. In addition to an on-board compressor, three auxiliary Sullair compressors were utilised to achieve the drilling target depth.

During drilling, lithological samples were taken every 2 m for logging by the supervising GHD hydrogeologist. During drilling below the water table, groundwater yield was estimated either measuring flow into a container (flows less than 2 L/s), using a V-notch weir (flows 2-20 L/s) or through a visual estimate of flow (flows greater than 20 L/s). In groundwater flow zones, field water quality (pH, electrical conductivity (EC) and total dissolved solids (TDS)) was also recorded.

On-pad sumps were dug at the beginning of the program to contain the water generated during the drilling process. However, at some locations the encountered flows were high and the sumps filled quickly and overtopped. Notches were dug in the corner of the sumps, allowing them to drain in a controlled manned into existing drainage lines. As the host aquifer over much of the site is fractured rock, there was very little suspended load within the discharge water, and combined with the previous groundwater quality data (Section 5.6) the environmental impact of the discharge was considered to be negligible.

Detailed methodologies, results and analysis of the field investigations are presented in the section below. A summary of the bore drilling and installations is presented as Table 7-3. Bore logs are included in Appendix A and chip tray photography in Appendix B.

Test production bores

The general approach for test production bores was to drill using a 15” down-hole hammer bit, inside 16” dual rotary (DR) steel, equipped with a 17” casing shoe. The DR drilling method was employed until the ground conditions became too hard for the DR casing to advance further, or until the ground conditions were deemed competent enough, after which conventional open-hole hammer drilling was used to complete the hold to target depth.

For bores’ MCP0152 [L] and MCP0105 [R] it was necessary to telescope from an initial larger drill diameter in order to achieve their target depth. This was necessary due to alternating zones of broken and competent ground and high groundwater flows which made the drilled formation unstable. The telescoped holes were first started at 20” DR, then reduced to 18” DR, then to conventional open-hole hammer.

Once drilled to the required target depth, the productions bores were specified to be constructed using 12” machine slotted steel casing (304.8 mm internal diameter). At MCP0103 [P] and MCP0151 [D] the bores were constructed using 10” steel (254 mm internal diameter). This was due to installation difficulties (tight annulus) that prevented installation of 12” casing.

The bores were screened and gravel packed across the water-table, using 3.2-6.4 mm washed gravel. A bentonite seal was placed above the top of the gravel, and backfilled to surface. A 500 x 500 mm concrete block was installed as headworks, along with a lockable steel bore cover.

Once installation was complete, each production bore was developed via airlifting for several hours, until discharge water was clear and free of sediment.

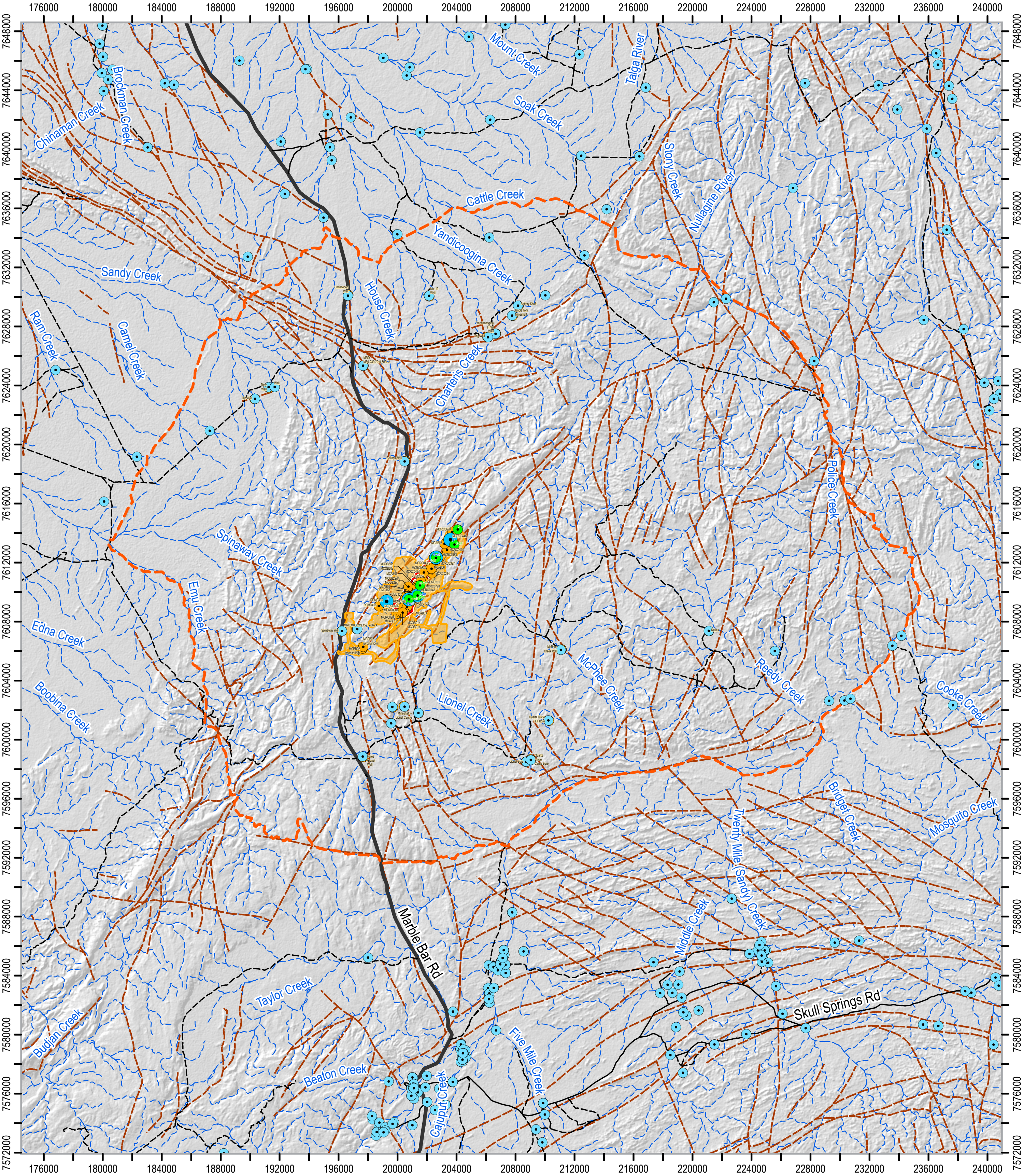
Monitoring bores

Monitoring bores were drilled using a combination of the DR method, and conventional down-hole-hammer. The general approach for monitoring bores was to drill using 10” steel DR casing that was advanced until refusal in consolidated material, after which conventional hammer drilling was continued to reach target depth. In most locations, the monitoring bore was drilled prior to the production bore. At site MCP0156 [e] telescoping from 12” to 10” was required due to variable ground conditions.

The monitoring bores were constructed with Class 18 50 mm internal diameter PVC, screened and gravel packed across the water table, using 3.2-6.4mm washed gravel. A bentonite seal was placed above the top of the gravel and backfilled to surface. The bores were finished with a steel monument riser and 500 x 500mm concrete block.

Once installation was complete, each monitoring bore was developed via airlifting for several hours until discharge water was clear and free of sediment. Only MCP0155 [n-alt], screened in a shale unit, required a considerable amount of development.

These monitoring bores were not sampled for laboratory water quality analysis during this program, however field parameters were recorded during drilling and development.



Legend

- Production (GHD, 2020)
- Monitoring (GHD, 2020)
- Existing Bore (AGE, 2019)
- Existing Bore (AECOM)
- Main Road
- Minor Road
- Track
- Stream
- Fault
- Assessment Domain
- Mine Disturbance Area
- Pit Footprint

Paper Size ISO A4

0 2.5 5 7.5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

GHD

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

Hydrogeological Bore Locations (Mine Site)

Project No. **12548901**
Revision No. **0**
Date **04/10/2021**

FIGURE 7-1

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Print date: 04 Oct 2021 - 17:01

Data source: GHD: Bore Locations - 20191031, Streams - 20191113, Pit Footprint - 20200828, Assessment Domain - 20191114, Project Development Envelope - 20201022; Landgate: Roads - 20171106 .
Created by: jabaygar

Table 7-3: Bore installation summary

Bore	Site ID	Date completed	Easting (m MGA94 Z51)	Northing (m MGA94 Z51)	Ground elevation (m AHD)	Depth drilled (m)	Casing diameter (mm)	Casing type	Slotted interval (m bgl)	SWL (m btoc)*
Test production bores										
MCP0153	O-alt	6-03-20	202,608	7,612,331	466.77	150	304.8	Steel	58-148	58.2
MCP0103	P	27-03-20	203,583	7,613,544	477.74	154	254	Steel	70-148	70.4
MCP0151	D-alt	31-03-20	200,758	7,609,502	479.45	180	254	Steel	72-180	71.4
MCP0152	L-alt	12-06-20	201,350	7,609,744	458.28	203	304.8	Steel	57-201	50.6
MCP0105	R	17-05-20	199,257	7,609,364	491.01	126	304.8	Steel	46-106	45.6
Monitoring bores – paired with new production bores										
MCP0145	t-alt	29-02-20	202,603	7,612,321	465.74	148	50	PVC	64.7-148	58.2
MCP0155	n-alt	4-04-20	200,766	7,609,502	480.06	106	50	PVC	76-106	72.8
MCP0156	e-alt	30-04-20	201,357	7,609,757	455.61	204	50	PVC	36-200	50.7
Monitoring bores – new regional monitoring bores										
MCP0158	m-alt	16-04-20	201,519	7,610,458	461.26	210	50	PVC	33.5-177.5	55.1
MCP0116	k	18-06-20	204,083	7,614,245	462.98	106	50	PVC	36-93	55.2
MCP0157	c-alt	20-06-20	203,855	7,613,223	411.45	28	50	PVC	10-28	5.4

* Static water level, measured as metres below top of casing 20 June 2020

7.2.3 Hydrogeological drilling summary – lithology and hydrogeological conditions

The following sections provide a summary of the lithology and hydrogeological conditions encountered at each drill location. Detailed geological logs and chip tray photography for each locations are included as Appendix A and Appendix B.

MCP0153 "O-alt"(PB) & MCP0154 "t-alt"(MB)

The lithology of MCP0153 and MCP0154 was broadly consistent, with a separation distance between the two drill sites of approximately 11m.

A relatively shallow colluvial surface layer was present up to a depth of around 6 m, including some minor calcrete. This was underlain by a narrow BIF rich band to a depth of up to 28 m, possible consistent with sub-unit MC7 of the Paddy Market Formation (see Section 4.6.2 for sub-unit descriptions). This upper BIF was underlain by a chert dominant unit from around 28 m to up to 80m, inferred as the MC6 unit. The chert become less dominant from around 80 m with heavily fractured goethite and haematite rich BIF becoming more dominant from around 80 m to the base of drilling at up to 150 m. This lower BIF unit is inferred MC5.

The inferred geology broadly aligns with the current geological model that has been developed by Atlas Iron as a Leapfrog model. The current model divides the Paddy Market BIF into four units (MP1, MP2, MP6 and MP7) which align with the subunit descriptions summarised in Section 4.6.2.

During drilling groundwater was intersected at a depth of 51 to 52 m. Groundwater flow generally increased with depth up to a maximum flow of around 40 L/s. Given that the entire depth of the bore was drilled with DR techniques, flow in an open hole would be expected to be significantly greater (i.e. water ingress would come from the entire aquifer face, not just the open area below the outer casing cutting shoe). There was no significant change in groundwater quality with depth, with a consistent EC of around 300 µS/cm.

MCP0151 "D-alt" (PB) & MCP0155 "n-alt" (MB)

The lithology of MCP0151 and MCP0155 was broadly consistent, with a separation distance between the two drill sites of approximately 8 m.

A shallow laterite was present up to a depth of around 4 m. This was underlain by a cherty BIF unit to around 60 m, possible consistent with unit MC2. This BIF was underlain by a chert dominant unit from around 28 m to up to 80m, inferred as the MC6 unit. A generally competent carbonaceous shale was presented from around 80 m to the base of drilling, up to a depth of 180 m. This shale unit is possibly consistent with MC1. The inferred geology broadly aligns with the current geological model, however the geological model predicted that the underlying Corboy Formation would be intersected towards the base of drilling, whereas the shale unit was found to extend to the total depth of drilling (up to 180 m).

During drilling groundwater was intersected at a depth of 76 m. Groundwater flow was consistently minor from the first water strike to the base of the bore, with a maximum flow of around 3 L/s. There was no notable change in groundwater quality with a consistent EC value of around 500 µS/cm.

MCP0152 "L-alt" (PB) & MCP0156 "e-alt" (MB)

The lithology of MCP0152 and MCP0156 was broadly consistent, with a separation distance between the two drill sites of approximately 10 m.

A shallow laterite was present up to a depth of around 4 m. This was underlain by an alternating sequence of hematite and goethite rich BIF and cherty BIF. This unit was present to the base of the drilling to a depth of up to 204 m. It was generally heavily fractured, however there were various areas of more competent BIF. This BIF unit is possibly consistent with MC3 and MC2.

The inferred geology broadly aligns with the current geological model which predicted MC2 for the majority of the depth of drilling. However the geological model predicted that the underlying shale (unit MP1) would be intersected towards the base of drilling, whereas the base of drilling was in the BIF.

During drilling groundwater was intersected at a depth of 60 m. Groundwater flow increased significantly with depth in both the monitoring bore and production bore drilling. Maximum flows of up to 100 L/s were estimated at MCP0152, with the volume of groundwater inflow causing some drilling issues such as difficulties getting the hammer to work effectively. There was no significant change in groundwater quality with a consistent EC of around 500 µS/cm.

MCP0103 “P” (PB)

A lateritic profile was present up to a depth of around 8 m. This was underlain by a hematite rich BIF to the base drilling at 154 m. It was generally quite fractured but was able to be drilled open-hole from a depth of 78 m. This BIF unit is possibly consistent with MC7. The inferred geology broadly aligns with the current geological model which predicted MP7 (Upper BIF) for the majority of the depth of drilling with MP6 (Chert unit) at the base. The actual drilling did not encounter the chert dominant zone, although the BIF did include between 10-30% of chert.

During drilling groundwater was intersected at a depth of 76 m. Groundwater flow increased significantly with depth with a maximum flow of 40 L/s. There was no significant change in groundwater quality with a consistent EC of around 500 µS/cm.

MCP0105 “R” (PB)

MCP0105 is the only production bore site located outside of the MRD Aquifer, albeit in the neighbouring syncline, with the consistent geological sequence to the MRD. No mining is currently planned for this area, with the drilling aimed at assessing potential for aquifer reinjection.

A lateritic sequence up to 12 m was encountered from the surface. This was underlain by a generally haematite rich BIF to a depth of 56 m, inferred as possibly unit MC7. This BIF was underlain by a chert dominant unit from 56 m to up to 90 m, inferred as the MC6 unit. A lower BIF with a high proportion of chert was then present from 90 to 122 m (inferred as possibly MC5). This was then underlain by a carbonaceous shale in which the drilling was terminated at 126 m. This shale unit is possibly consistent with MC1.

The inferred geology broadly aligns with the current geological model which predicted upper BIF (MP7) over chert (MP6) over lower BIF (MP2). The model did not predict shale at the drilled depth, but the nearby resource holes did encounter the same shale at a similar depth.

During drilling groundwater was intersected at a depth of 46 m. Groundwater flow increased steadily with depth with a maximum flow of 45 L/s. Groundwater EC increased slightly with depth from an initial concentration of 410 µS/cm at 46 m, increasing to 932 µS/cm at 100 m.

MCP0157 “c-alt” (MB)

MCP0157 was drilled to offer a monitoring bore outside of the MRD in the area east of the Nicholson Pit. There had been no previous drilling in this area. The upper 8 m were alluvials that were underlain by a schist. This is possibly a contact area between the Wyman Formation and the Corboy Formation. The Wyman Formation is described as a “felsic agglomerate and minor tuff”. The Corboy Formation is described as “quartz sandstone, fuchsitic quartz sandstone, banded chert, sandstone, basal cobble to pebble polymictic conglomerate; weakly metamorphosed”. The location is within the unit of the Leapfrog model representing basement shale, however the encountered units appear more aligned to the “fqz” background geology unit of the geological mode.

During drilling groundwater was intersected at a depth of 12 m. Groundwater flow was generally low and did not exceed 2 L/s. Groundwater EC was higher than in the area of MRD at a concentration of up to 2,470 µS/cm.

MCP0116 “k” (MB)

MCP0116 was drilled to offer a monitoring bore outside of the MRD in the area north of the Nicholson Pit. A lateritic sequence of 4 m was encountered from the surface. This was underlain by a generally chert rich BIF to a depth of 70 m, inferred as possibly unit MC7. This cherty BIF was underlain by a more mineral rich BIF up to the final the depth of 106m, possibly also MC7. There was some clay content throughout this BIF profile. The geological model for the area predicted that the entire drilled depth would be MP7 (upper BIF) which is broadly consistent with encountered geology.

During drilling groundwater was intersected at a depth of 60 m. Groundwater flow was generally low and did not exceed 3 L/s. Groundwater EC was stable at around 500 µS/cm.

MCP0158 “m” (MB)

MCP0158 was drilled to offer a monitoring bore outside of Murray Pit to assess dewatering. A lateritic sequence of 4 m was encountered from the surface. This was underlain by a BIF unit that became more chert rich from 66 m to the base of drilling at 210 m. This BIF unit is possibly all MC2. The geological model for this area predicted that the upper 100 m would be MP6 (chert) underlain by MP2 (lower BIF) to the base of the bore.

During drilling groundwater was intersected at a depth of 59 m. Groundwater flow increased significantly with depth with a maximum flow of over 40 L/s. Groundwater EC was stable at around 500 µS/cm.

7.3 Aquifer testing - summary

Aquifer testing was completed by Resource Water Group, and McArthur Drilling and Test Pumping (only bore MCP0103 [P]). Each production bore was first subjected to a step test (SRT), comprising four 30 or 60 minute steps of varying rates, without recovery between steps. Once completed, a suitable pumping rate, for the constant rate test (CRT) was selected. A nominal period of 72 hours was selected for each CRT.

Discharge water generated during the pumping tests was moved as far from the bore as possible via lay-flat tubing. This was done to limit the likelihood of recirculation during testing.

During the CRTs, up to six monitoring bores were equipped with data loggers to record groundwater levels. Manual dip measurements were also recorded during the pumping and recovery phases.

A summary of the pump tests is provided in Table 7-4, with descriptions for each bore test and analysis provided in the following sections.

Table 7-4: Pumping test details

Test bore	Step tests	Constant rate tests	Inferred geological test unit
MCP0103 [P]	Steps 35 – 50 L/s	28 L/s	MP7 – Upper BIF
MCP0105 [R]	Steps 65 – 100 L/s	95 L/s	MP6 – Chert and MP2 lower BIF (upper BIF largely unsaturated)
MCP0151 [D]	No steps*	1.35 L/s	MP1 – base shales
MCP0152 [L]	Steps 80 – 114 L/s	110 L/s	MP2 – lower BIF
MCP0153 [O]	Steps 65 – 95 L/s	90 L/s	MP6 – Chert and MP2 lower BIF
* Calibration test demonstrated limited drawdown at maximum pumping rate available, therefore testing proceeded straight to CRT.			

7.4 Bore MCP0103 [P]

7.4.1 Bore locations

A summary of the bores included in the testing program at this site is provided in Table 7-5 and the relative positions are shown in Figure 7-2.

Table 7-5: MCP0103 - Bores used in testing

Hydro ID	Co-ordinates (MGA94 Z51)		Radial Distance (m)	Total Drilled depth (m)	Screen	
	Easting	Northing			From	To
MCP0103 (Bore P)	203,583	7,613,544	0	154	70	148
MCRC0448	203612.4	7613595	59	160	53.8	102.58
MCRC0698	203707.7	7614075	546	136	53.7	71.7
MCRC0464	202888.8	7612392	1,345	136	53.7	125.7
MCP0153 (Bore O)	202,608	7,612,331	1,556	150	58	148

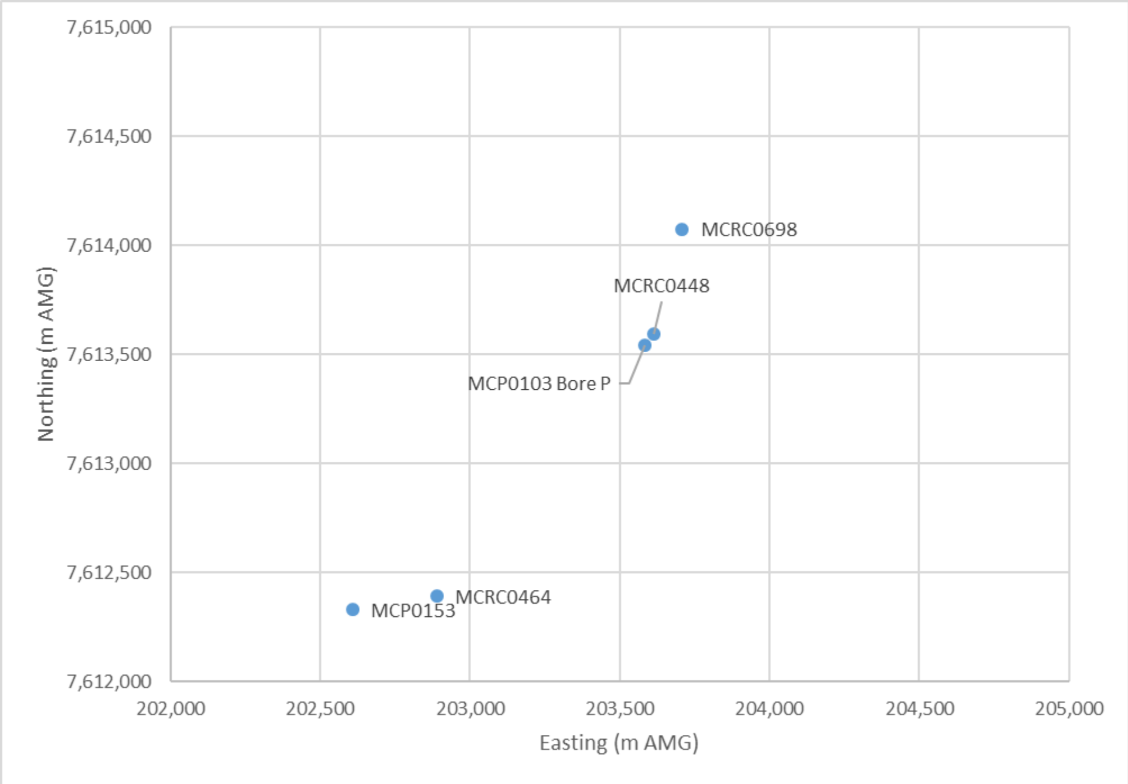


Figure 7-2: Bore MCP0103 [P] test layout

7.4.2 Testing program

Bores were subject to constant rate testing as summarised in Table 7-6.

Table 7-6: Bore MCP0103 [P] testing program

Stage	Start	End	Total Time (min)*	Flow Rate (L/s)
Pumping	3/5/2020 09:00	5/5/2020 09:00	4,320 (4,320)	28.1
Recovery	5/5/2020 09:00	7/5/2020 07:00	2,760 (7,080)	0
Note: Recovery duration based upon production bore monitoring. * cumulative time in parenthesis				

7.4.3 Observations

Water level

Monitoring bore responses are shown in Figure 7-3. Bore MCP0103 [P] and its nearest observation bore, bore MCRC0448 exhibited an obvious response to pumping. In terms of the more remote bores, bores MCP0153 showed no obvious response to pumping and bore MCP0153 recorded a drawdown of 0.2 m. The drawdown in bore MCRC0698 was considered spurious in the sense that it dropped at the commencement of pumping and then remained relatively stable, therefore it was not included in the analysis. Both bore MCRC0448 and Bore P (MCP0103) recovered over 90%.

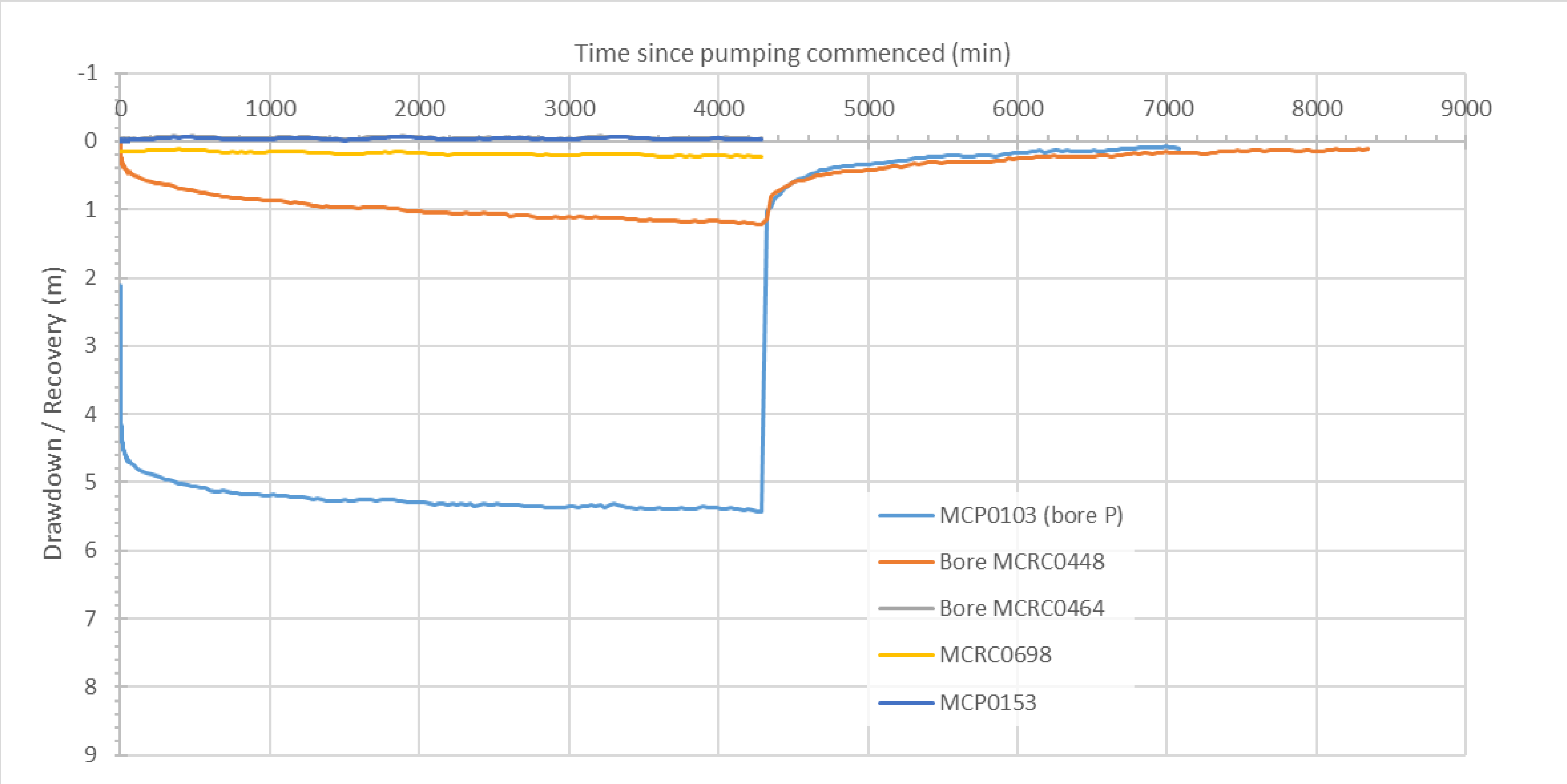


Figure 7-3: Bore MCP0103 [P] aquifer response to pumping

7.4.4 Analysis

The pumping test data was analysed using a number of numerical and graphical solutions to the transient well equation, with the objective of determining representative aquifer hydraulic parameters of transmissivity and storativity for the aquifer system. Derivative analysis is a commonly applied diagnostic tool and has been applied to groundwater flow at the borefield.

Review of flow diagnostic plots indicates that observation bore data exhibits a unit slope in late time which is characteristic of bilinear groundwater flow, i.e. finite conductivity fracture or a closed aquifer system.

The pumping test data from both the step drawdown and constant rate tests was analysed using a variety of curve matching techniques. Initially the confined Theis approach was applied, however, the curve match was poor, indicating that the aquifer response deviated from the underlying Theis assumptions. Unconfined analytical methods were subsequently applied and the results have been summarised in Table 7-7 for the nearest production bore. Selected output has been attached as Appendix C.

Recovery data was manipulated using the Agawal transformation and analysed using unconfined analytical methods.

Table 7-7: Summary of MCP0103 [P] test analysis

Stage	Model	Bores	Transmissivity (m^2/day)	Storage Coefficient	Comment
Pumping	Theis	MCRC0448	1,691	$7x10^{-5}$	Poor match to derivative data. Method not appropriate
	Cooper-Jacob		982	$5x10^{-3}$	Match to late time only
	Neuman		981	S: $5x10^{-4}$ S_y: $4x10^{-3}$ K_z/K_r: 0.03	Good match to both drawdown and derivate data.
	Tartakovsky-Neuman		981	S: $5x10^{-4}$ S_y: $4x10^{-3}$ K_z/K_r: 0.056	
Recovery	Neuman	MCRC0448	740	S: $1.5x10^{-3}$ S_y: $8x10^{-3}$ K_z/K_r: 0.02	Good match to both drawdown and derivate data.
	Tartakovsky-Neuman		740	S: $1.5x10^{-3}$ S_y: $8x10^{-3}$ K_z/K_r: 0.04	

7.5 Bore MCP0105 [R]

7.5.1 Bore locations

A summary of the bores included in the testing program at this site is provided in Table 7-8 and the relative positions are shown in Figure 7-4.

Table 7-8: MCP0105 - bores used in testing

Hydro ID	Co-ordinates (MGA94 Z51)		Radial distance (m)	Total drilled depth (m)	Screen	
	Easting	Northing			From	To
MCP0105	199,257	7,609,364	0	126	46	106
RCMC430	199247.1	7609361	10	132	42	84
RCMC416	198729.8	7609053	612	84	42	78
RCMC120	200501	7609702	1,289	124	53.7	95.7
RCMC122	200544.1	7609659	1,320	100	93.8	97.7

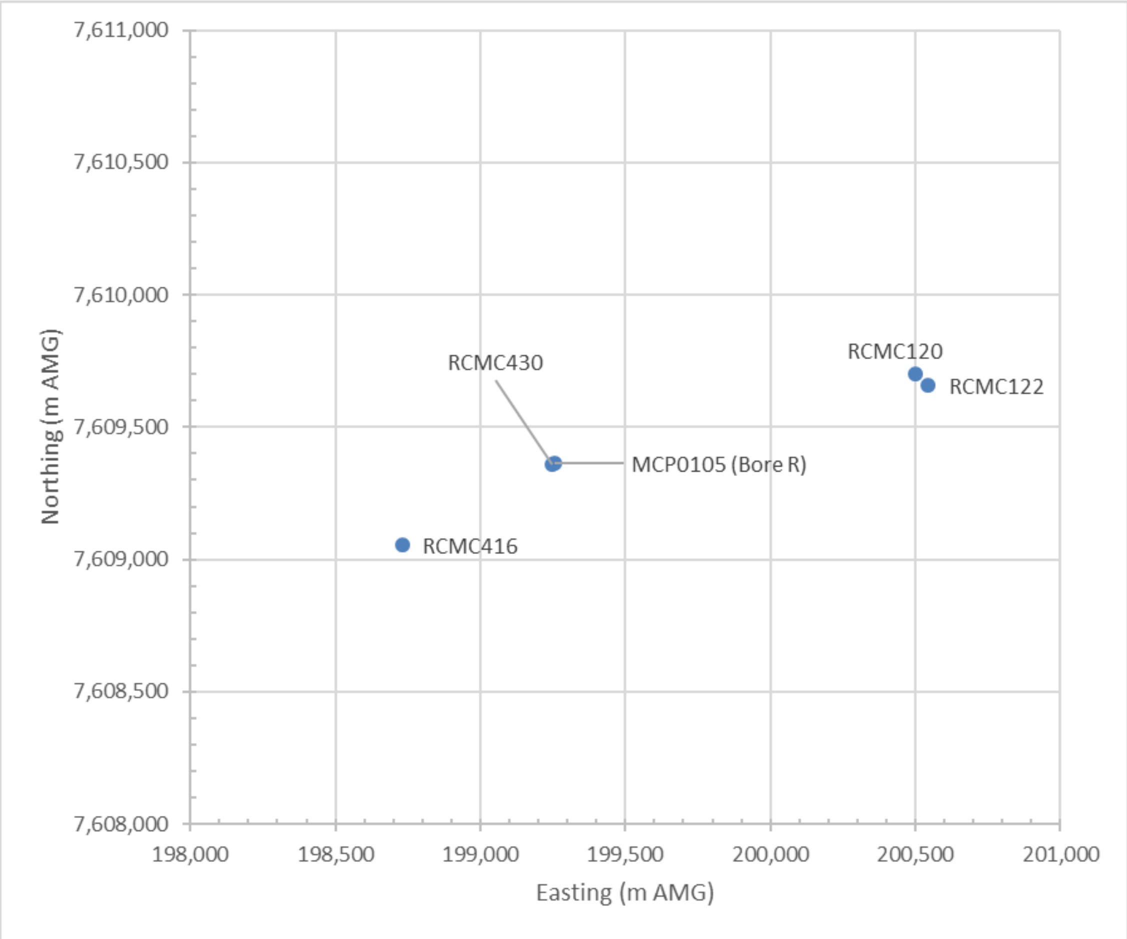


Figure 7-4: MCP0105 [R] test layout

7.5.2 Testing program

Bores were subject to a step drawdown and constant rate test as summarised in Table 7-9.

Table 7-9: MCP0105 [R] testing program

Stage	Start	End	Total time (min)*	Flow rate (L/s)
Step 1	12/7/2020 11:26	12/7/2020 12:26	60 (60)	61.3
Step 2	12/7/2020 12:26	12/7/2020 13:26	60 (120)	76.1
Step 3	12/7/2020 13:26	12/7/2020 14:26	60 (180)	85.8
Step 4	12/7/2020 14:26	12/7/2020 15:26	60 (240)	101.3
Recovery	12/7/2020 15:26	13/7/2020 11:00	1,174 (1,414)	0
Pumping	13/7/2020 11:00	16/7/2020 11:00	4,320 (4,320)	95
Recovery	16/7/2020 11:00	17/7/200 17:00	1,800 (6,120)	0
Note: Recovery duration based upon production bore monitoring. * cumulative time in parenthesis				

7.5.3 Observations

Water level

The aquifer response to the constant rate pumping, as gauged by the monitoring bores has been provided in Figure 7-5. Obvious movement was identified in the pumping bore MCP0105 (Bore R) and the nearest monitoring bore, bore RCMC430. Logged data was not available from bore RCMC416.

At the close of the pumping period, outlying monitoring bores RCMC122 and RCMC120 had drawdown 0.09 m and 0.19 m respectively.

Water quality

Water quality monitoring was undertaken during the constant rate test which included field pH, temperature and EC. The field monitoring data has been graphically presented in Figure 7-6 and shows that the water quality with respect these parameters remained relatively stable. The water was observed to be clear during the constant rate pumping phase.

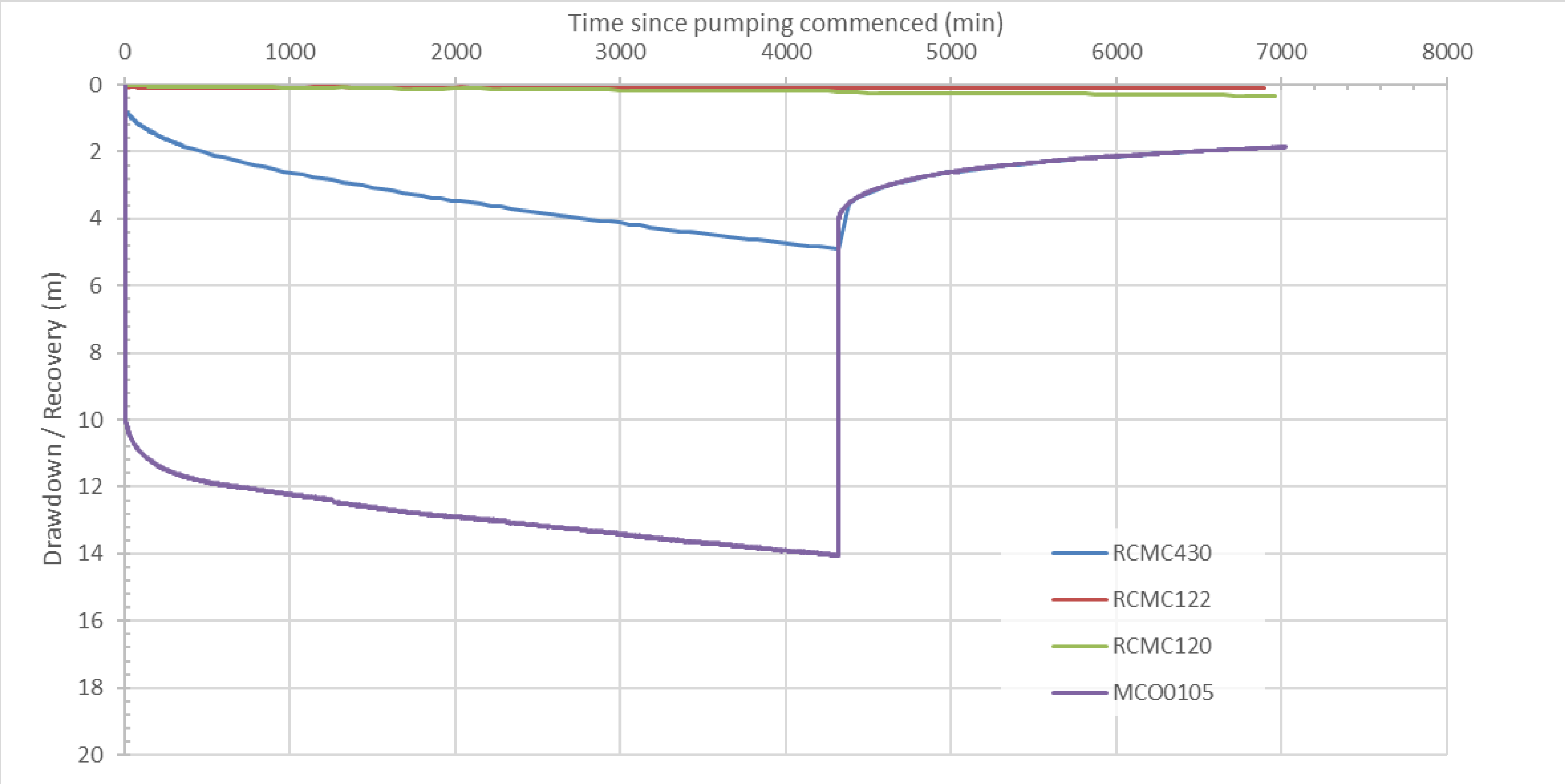


Figure 7-5: MCP0105 [R] test response to pumping

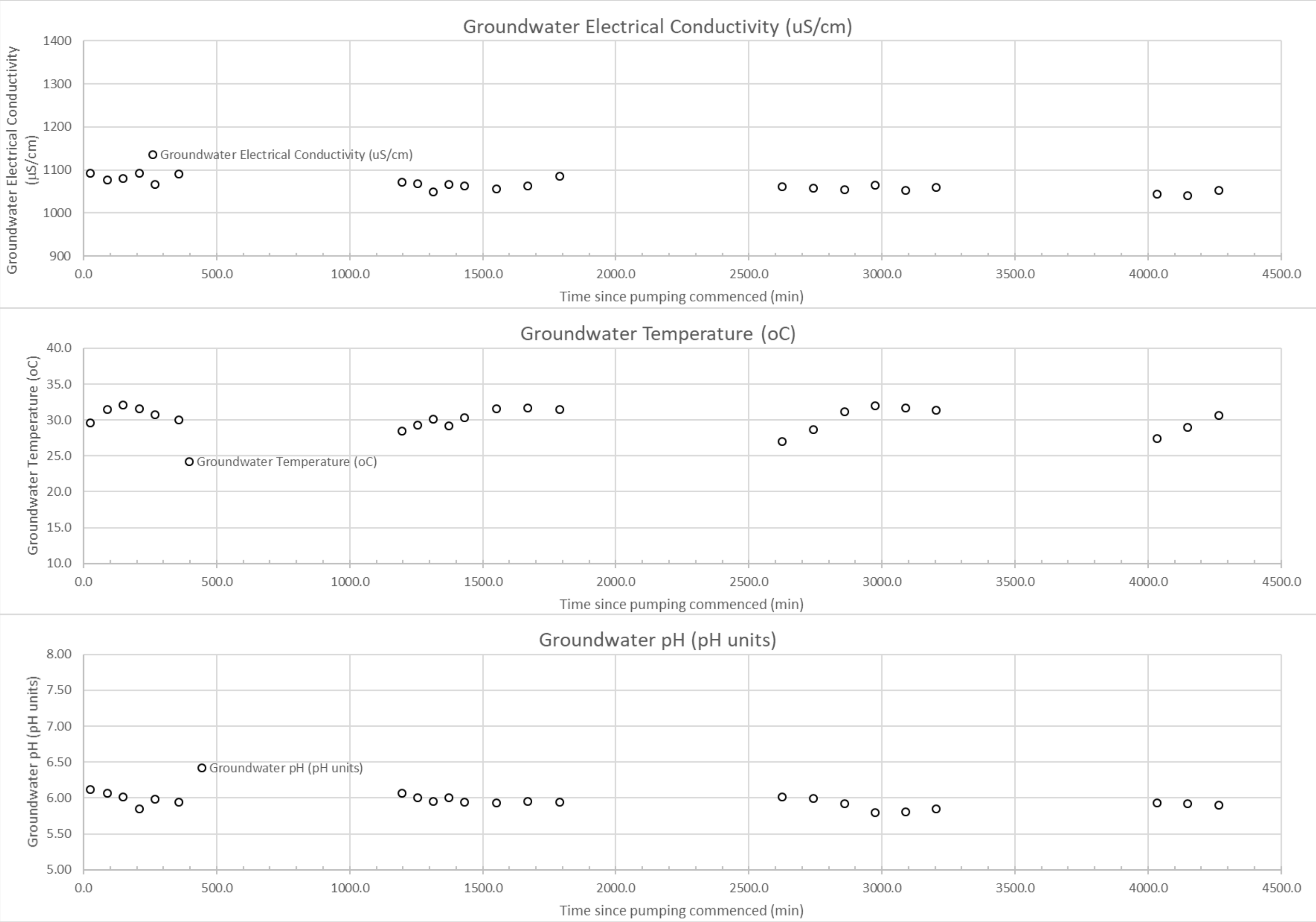


Figure 7-6: MCP0105 [R] water quality monitoring

7.5.4 Analysis

Analysis was as per the approach outlined in section 7.4.4 and a summary of the analysis has been presented in Table 7-10.

On a linear flow diagnostic plot, the drawdown data exhibits a unit slope at late time which is characteristic of a closed or strip aquifer.

The Theis model was unsuitable based upon attempts to match to both drawdown and derivative data and therefore unconfined methods were applied to the data from the nearest observation bore, RCMC430. The Neuman model provided the best match to both drawdown and derivative data, however, it is recognised that the match is incomplete to all data.

Table 7-10: Summary of MCP0105 [R] test analysis

Stage	Model	Bores	Transmissivity (m^2/day)	Storage coefficient	Comment
Pumping	Theis	RCMC430	1,325	0.025	Poor match to drawdown and derivative data.
	Neuman		618	S: 0.01 K_z/K_r: 0.25	Match to form of drawdown and derivative
Recovery	Neuman	RCMC430	778	S: 0.06 K_z/K_r: 0.05	Match to form of drawdown and derivative

7.6 Bore MCP0151 [D]

7.6.1 Bore locations

A summary of the bores included in the testing program at this site is provided in Table 7-11 and the relative positions are shown in Figure 7-7.

Table 7-11: MCP0151 [D] - bores used during testing

Hydro ID	Co-ordinates (MGA94 Z51)		Radial distance (m)	Total drilled depth (m)	Screen	
	Easting	Northing			From	To
MCP0151	200758	7609502	0	180	72	180
MCP0155	200,766	7,609,502	8	106	76	106
RCMC132	200906.6	7609387	187	106	72	90
RCMC122	200544.1	7609659	265	100	93.8	97.7
RCMC337	200925.4	7609883	416	258	47.8	71.8
MCP0156	201357	7609767	655	204	36	200

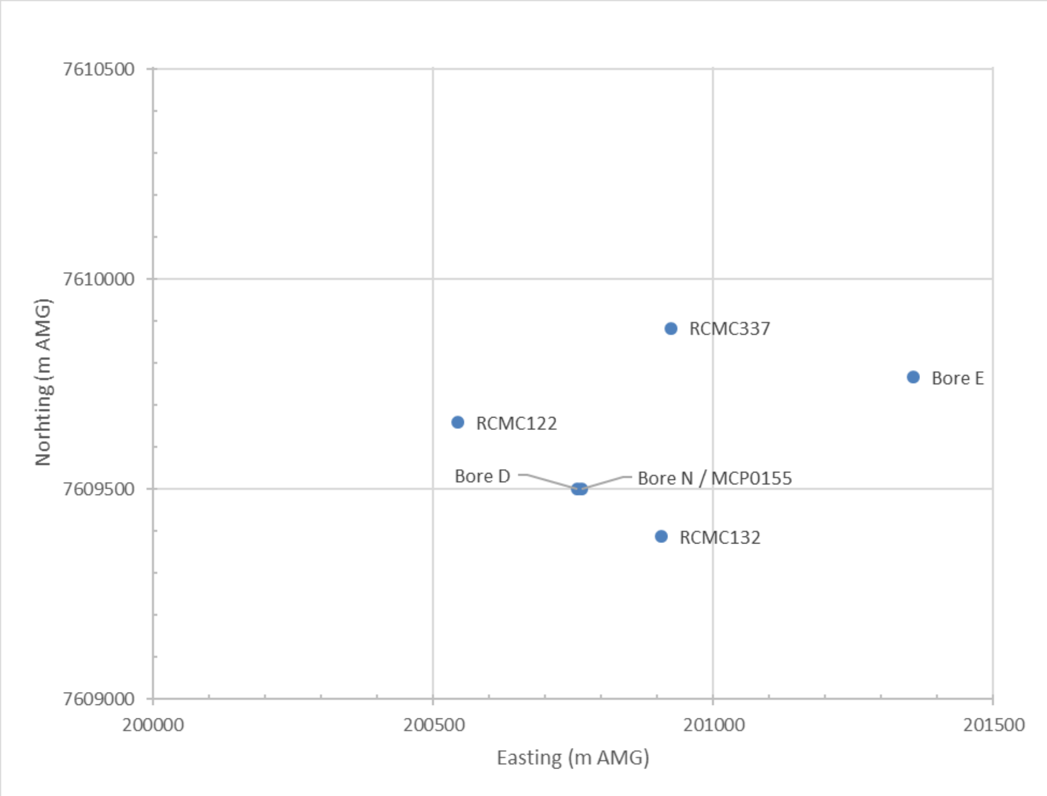


Figure 7-7: MCP0151 [D] test layout

7.6.2 Testing program

Bores were subject to a constant rate testing as summarised in Table 7-12.

Table 7-12: MCP0151 [D] testing program

Stage	Start	End	Total Time (min)*	Flow Rate (L/s)
Pumping	30/6/2020 15:35	2/7/2020 15:35	2,880 (2,880)	1.32 – 1.38
Recovery	2/7/2020 15:35	4/7/2020 13:17	2,742 (5,622)	0
Note: Recovery duration based upon production bore monitoring. * cumulative time in parenthesis				

7.6.3 Observations

Water level

The step drawdown test drawdown response have not been shown.

The water level response for the pumping bore MCP151 and the observation bores MP0155, MCRB1312 and RCMC122 have been shown in Figure 7-8. Bores MCRB132 and RCMC122 did not show an obvious response to pumping.

Manual water level measurements were also taken in bores RCMC337 and Bore E, however, these bores did not show an obvious drawdown response to pumping.

Water quality

Water quality monitoring was undertaken during the constant rate test which included field pH, temperature and EC. The field monitoring data has been graphically presented in Figure 7-9 and shows that the water quality with respect these parameters remained relatively stable. The water was observed to be clear during the constant rate pumping phase.

7.6.4 Analysis

Analysis was as per the approach outlined in section 7.4.4 and a summary of the analysis has been presented in Table 7-13 .

Review of the bilinear diagnostic flow plot indicated a unit slope both during early and late time, suggesting fracture flow in a closed aquifer system.

Best matches to both drawdown and derivative data were obtained from using the recovery data. Whilst the flow rate was low relative to other bores testing in the program, it did show some variability during the pumping phase. Based upon the quality of the matches, the recovery data is considered more reliable. Selected output has been attached as Appendix C.

Table 7-13: Summary of MCP0151 [D] test analysis

Stage	Model	Bores	Transmissivity (m^2/day)	Storage coefficient	Comment
Pumping	Theis	MCP0155	65	$4x10^{-4}$	Poor match to drawdown and derivative data.
	Neuman		58	S: $5x10^{-5}$ S_y: $4x10^{-3}$	Improved match to drawdown and derivative. Match to late time not as good (underestimates drawdown.
	Tartakovsky-Neuman		65	S: $3.5x10^{-3}$ S_y: $1x10^{-3}$ K_z/K_r: 0.004	
Recovery	Neuman	MCP0155	13	S: $2x10^{-3}$ S_y: 0.08 K_z/K_r: 0.08	Reasonable match to both drawdown and derivative data.
	Tartakovsky-Neuman		15	S: $2x10^{-3}$ S_y: 0.08 K_z/K_r: 0.08	

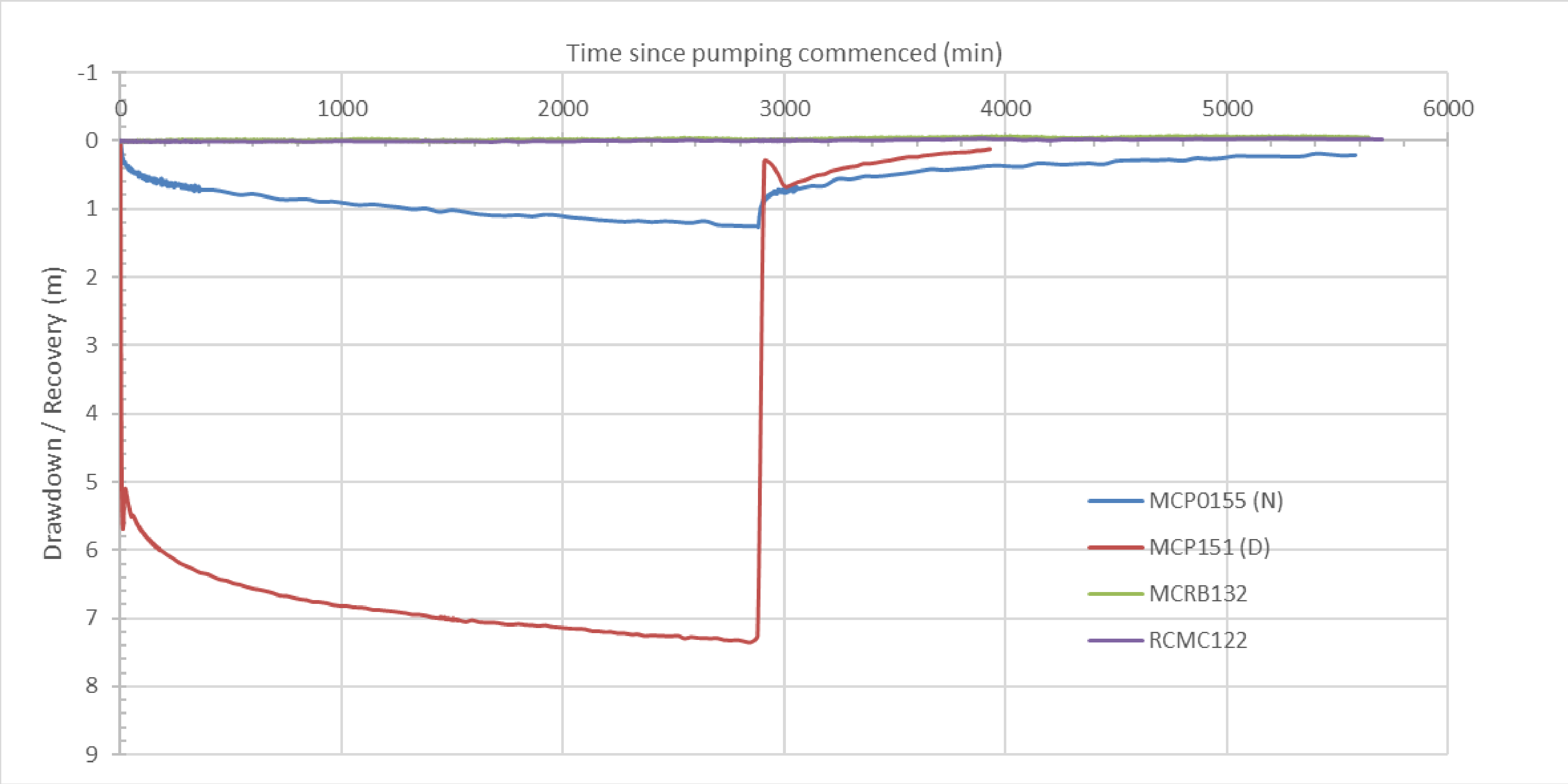


Figure 7-8: MCP0151 [D] test - aquifer response to pumping

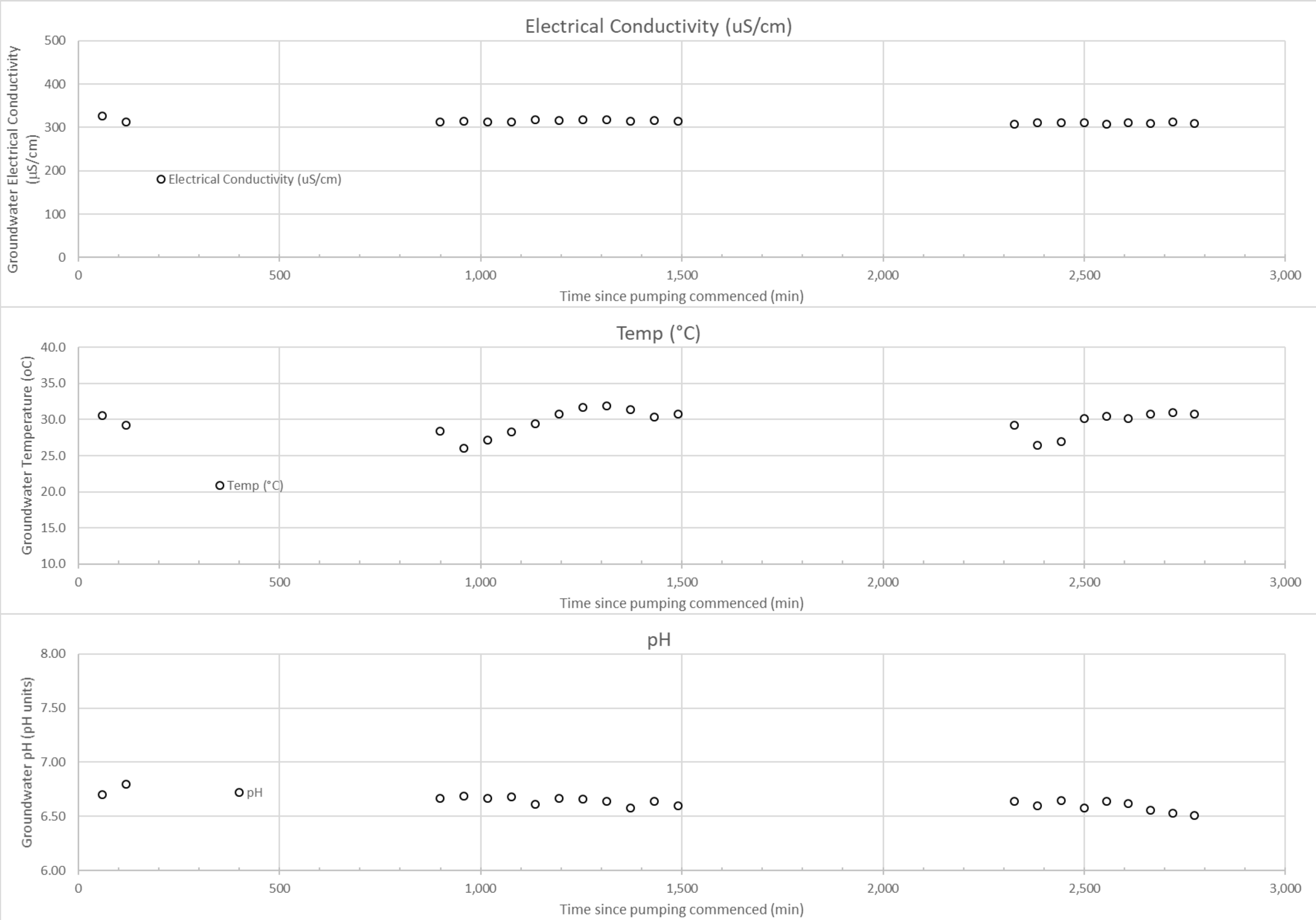


Figure 7-9: MCP0151 [D] test - water quality monitoring

7.7 Bore MCP0152 [L]

7.7.1 Test bore locations

A summary of the bores included in the testing program at this site is provided in Table 7-14 and the relative positions are shown in Figure 7-10.

Table 7-14: MCP0152 [L] - bores used during testing

Hydro ID	Co-ordinates (MGA94 Z51)		Radial distance (m)	Total drilled depth (m)	Screen	
	Easting	Northing			From	To
MCP0152	201,350	7,609,774	0	203	57	201
MCP0156	201,357	7,609,767	10	204	36	200
MCRC0148	201378.5	7609972	200	106	90	102
MCAB05	201306.8	7610352	580	142	56.5	140.5
RCMC168	200792.7	7610003	603	160	59.6	119.5
MCP0155	200,766	7,609,502	644	106	76	106
MCP0158	201,519	7,610,458	705	210	33.5	177.5

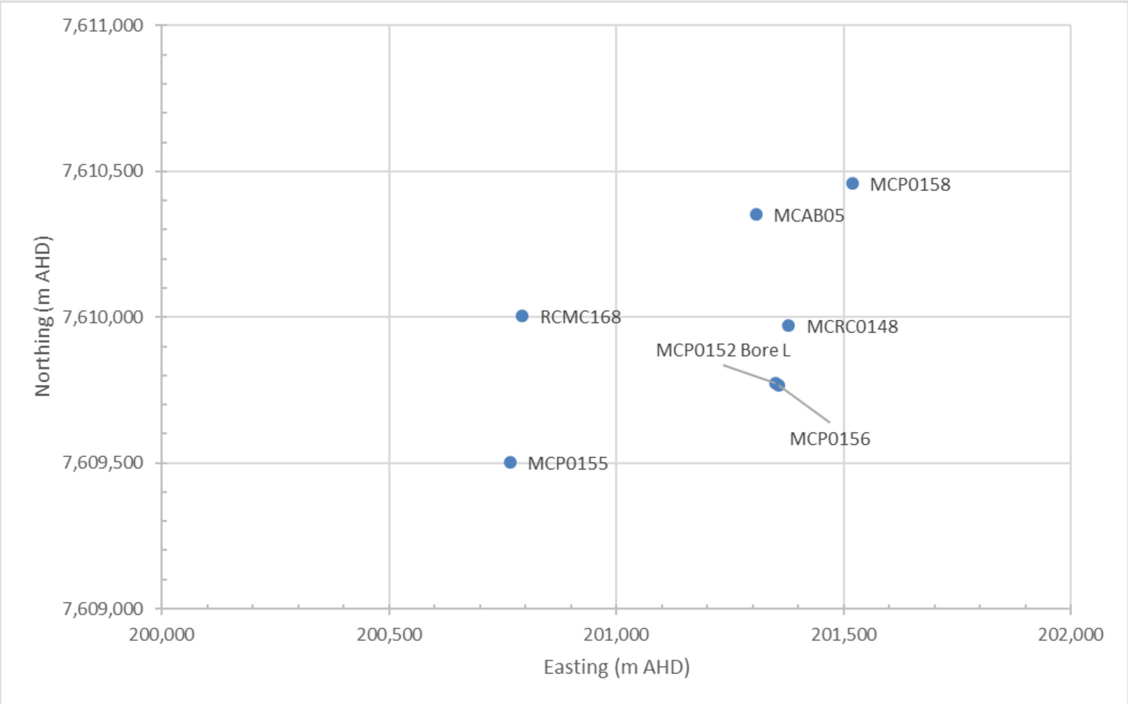


Figure 7-10: MCP0152 [L] test layout

7.7.2 Testing program

Bores were subject to a step drawdown and constant rate testing as summarised in Table 7-15.

Table 7-15: MCP0152 [L] testing program

Stage	Start	End	Total time (min)*	Flow rate (L/s)
Step 1	20/7/2020 09:15	20/7/2020 10:15	60 (60)	79.5
Step 2	20/7/2020 10:15	20/7/2020 11:15	60 (120)	90.5
Step 3	20/7/2020 11:15	20/7/2020 12:15	60 (180)	100.7
Step 4	20/7/2020 12:15	20/7/2020 15:15	180 (360)	114.8
Recovery	20/7/2020 15:15	21/7/2020 08:00	1,005 (1,365)	0
Pumping	21/7/2020 08:00	24/7/2020 14:00	4,680 (4,680)	110
Recovery	24/7/2020 14:00	26/7/2020 07:30	2,490 (7,170)	0
Note: Recovery duration based upon production bore monitoring. * cumulative time in parenthesis				

7.7.3 Observations

Water level

The step drawdown test data has not been shown.

Water level drawdowns for the pumping bore (MCP0152) and observation bores is shown in Figure 7-11. Apparent drawdown is identified in a number of the observations. Drawdowns are shown spatially at the close of pumping in Figure 7-12 and as a distance drawdown plot in Figure 7-13.

Water quality

Water quality monitoring was undertaken during the constant rate test which included field pH, temperature and EC. The field monitoring data has been graphically presented in Figure 7-14 and shows that the water quality with respect these parameters remained relatively stable. The water was observed to be clear during the constant rate pumping phase.

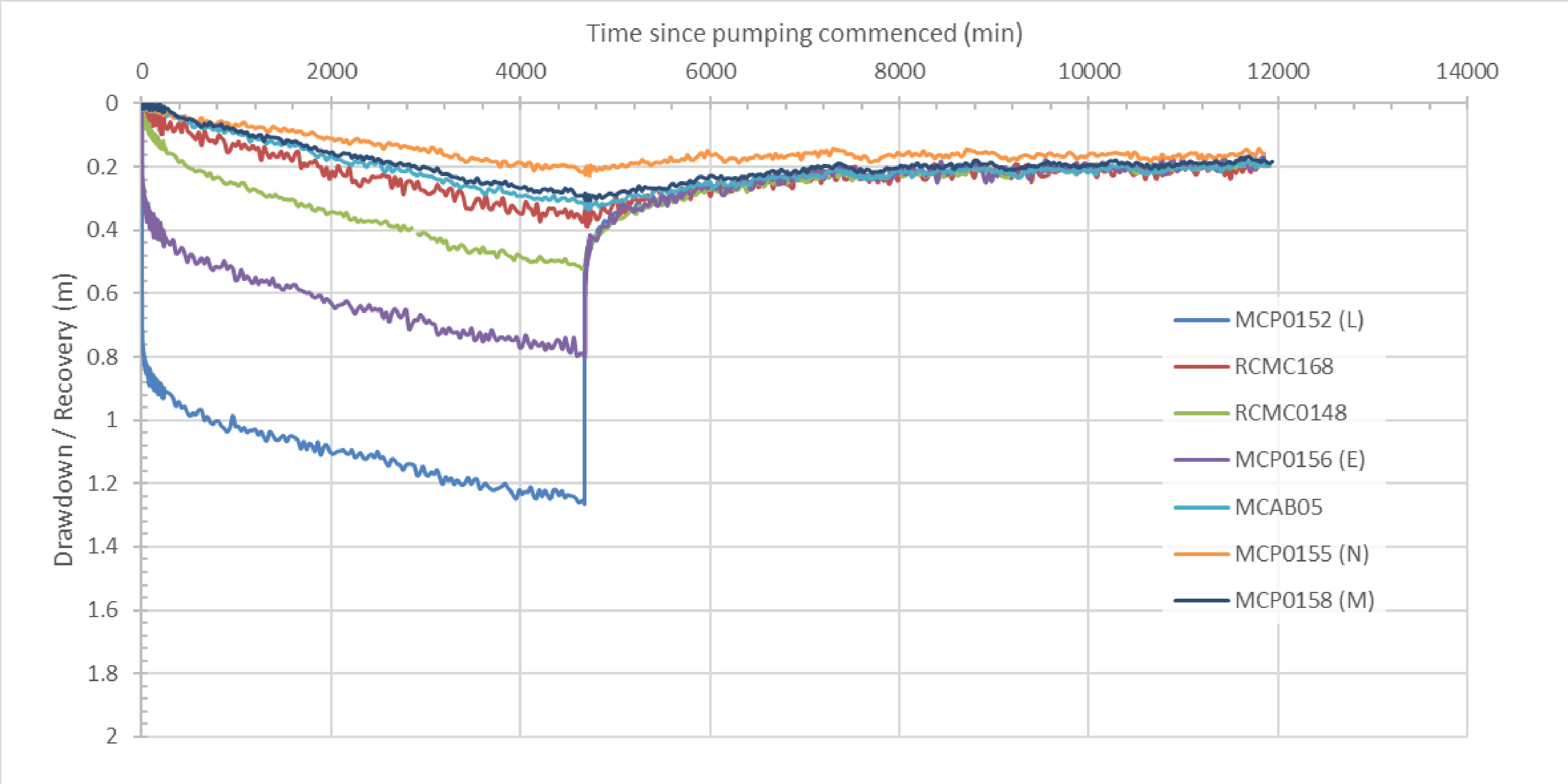


Figure 7-11: MCP0152 [L] testing - aquifer response to pumping

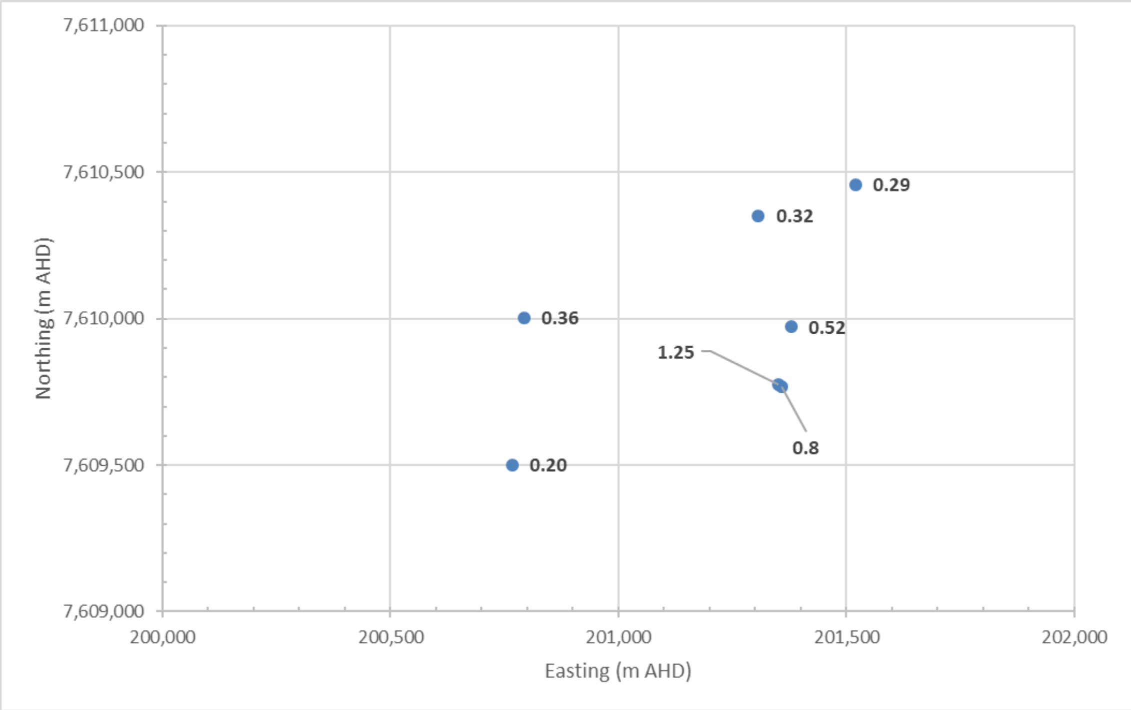


Figure 7-12: MCP0152 [L] test - spatial response to pumping

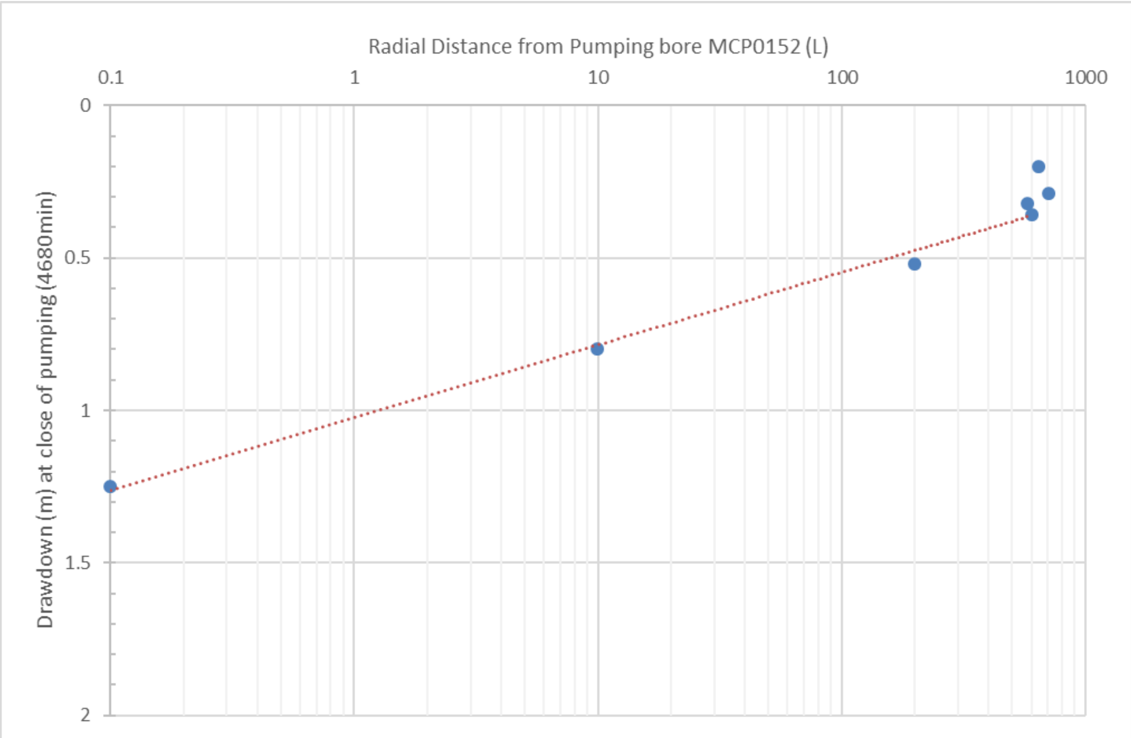


Figure 7-13: MCP0152 [L] test - distance drawdown response

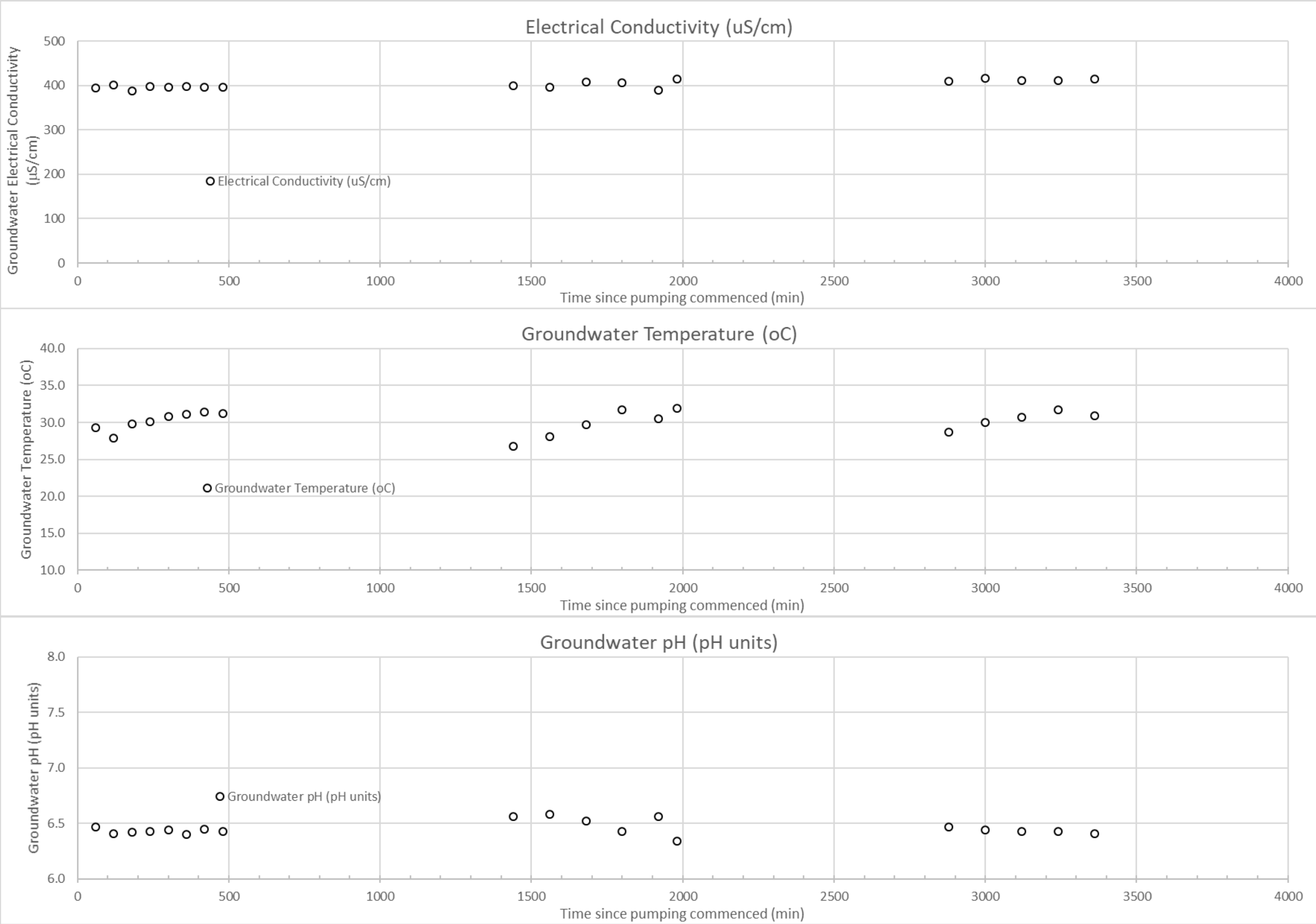


Figure 7-14: MCP0152 [L] test - water quality monitoring

7.7.4 Analysis

Analysis was as per the approach outlined in section 7.4.4 and a summary of the analysis has been presented in Table 7-16. Selected analytical output has been attached as Appendix C.

Table 7-16: Summary of MCP0152 [L] testing - analysis

Stage	Model	Bores	Transmissivity (m^2/day)	Storage coefficient	Comment
Pumping	Theis	MCP0156 (E)	12,000	$3.3x10^{-2}$	Match to early time data only. Poor match to derivative
	Neuman		11,000	S: $2.3x10^{-2}$ Sy: 0.1	Match to early time data only. Poor match to derivative.
	Tartakovsky-Neuman		10,008	S: $3.4x10^{-2}$ Sy: $3.5x10^{-2}$ K_z/K_r: 0.2	
	Theis	MCRC0148	6,800	$1.9x10^{-2}$	Poor match to drawdown and derivative. Low confidence
	Neuman		3,300	S: $7.5x10^{-3}$ Sy: $6.0x10^{-2}$	
	Tartakovsky-Neuman		3,050	S: $6.4x10^{-3}$ Sy: $6.4x10^{-2}$	
Recovery	Neuman	MCP0156 (E)	13,520	S: $1.1x10^{-2}$ Sy: $8.9x10^{-3}$	Reasonable match to drawdown and derivate, but subjective match.
	Neuman	MCRC0148	8,073	S: $3x10^{-3}$ Sy: $2x10^{-2}$ K_z/K_r: 0.3	

7.8 Bore MCP0153 [O]

7.8.1 Test bore locations

A summary of the bores included in the testing program at this site is provided in Table 7-17 and the relative positions are shown in Figure 7-15.

Table 7-17: MCP0153 [O] –bores used in testing

Hydro ID	Co-ordinates (MGA94 Z51)		Radial distance (m)	Total drilled depth (m)	Casing diameter (mm)	Screen	
	Easting	Northing				From	To
MCP0154	202,603	7,612,321	0	148	50	64.7	148
MCP0153	202,608	7,612,331	11.1	150	304.8	58	148
MCRC0464	202888.8	7612392	287	136	150	53.7	125.7
MCRC0327	202695.1	7611919	420	112	150	59.7	101

Hydro ID	Co-ordinates (MGA94 Z51)		Radial distance (m)	Total drilled depth (m)	Casing diameter (mm)	Screen	
	Easting	Northing				From	To
MCRC0410	203356.8	7612866	920	136	150	53.7	102.7

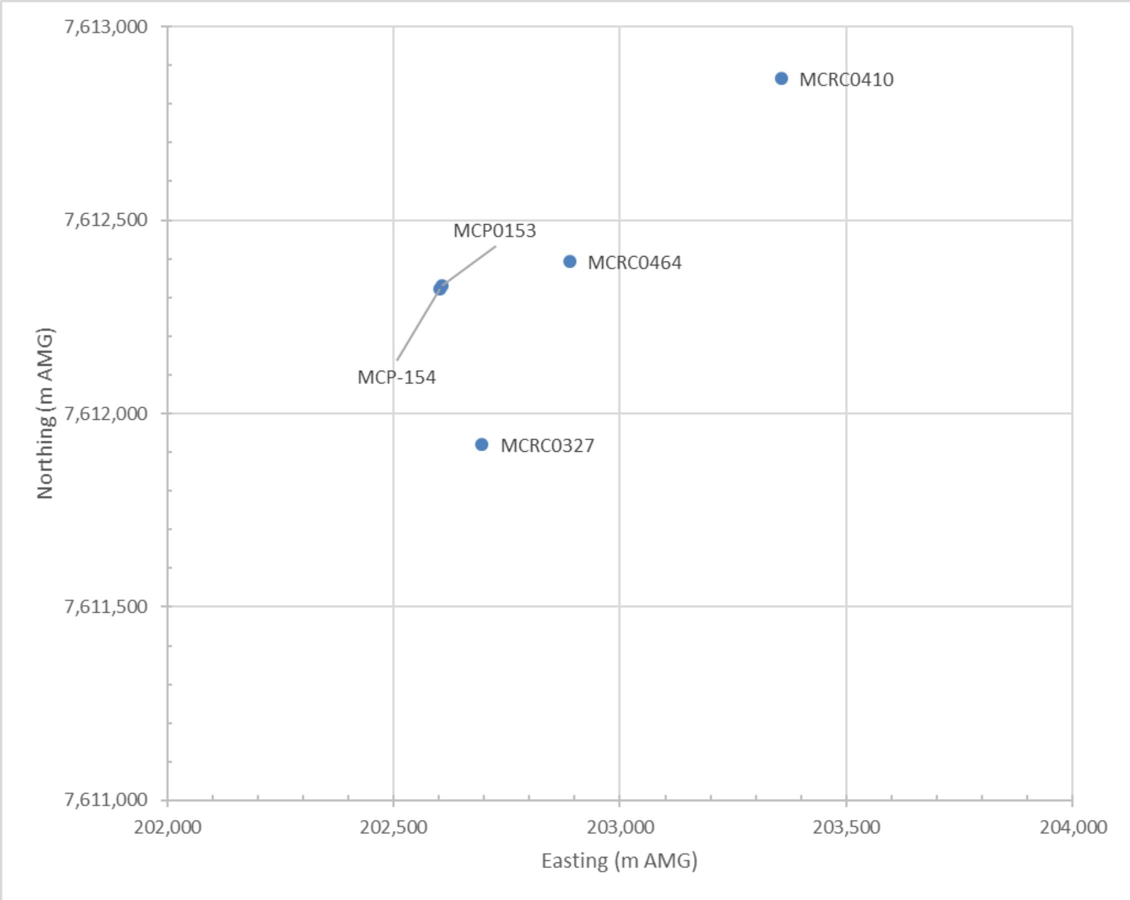


Figure 7-15: MCP0153 [O] test layout

7.8.2 Testing program

Bores were subject to step drawdown and constant rate testing as summarised in Table 7-18.

Table 7-18: MCP0153 [O] aquifer testing program

Stage	Start	End	Total Time (min)	Flow Rate (L/s)
Step 1	30/7/2020 06:45	30/7/2020 07:45	60 (60)	65
Step 2	30/7/2020 07:45	30/7/2020 08:45	60 (120)	75
Step 3	30/7/2020 08:45	30/7/2020 09:45	60 (180)	85
Step 4	30/7/2020 09:45	30/7/2020 12:45	180 (360)	95
Recovery	30/7/2020 12:45	30/7/2020 13:30	45 (405)	0
Pumping	30/7/2020 13:30	2/8/2020 13:30	4,320 (4,320)	89.6
Recovery	2/8/2020 13:30	4/8/2020 06:15	2,445 (6,765)	0

Note: Recovery duration based upon production bore monitoring.

7.8.3 Observations

Water level

Water level drawdowns for the pumping bore (MCP0154) and observation bores are shown in Figure 7-16 that were data logged.

Water quality

Water quality monitoring was carried out during the constant rate test which included field pH, temperature and electrical conductivity (EC). The field monitoring data has been graphically presented in Figure 7-17 and shows that the water quality with respect these parameters remained relatively stable. The water was observed to be clear during the constant rate pumping phase.

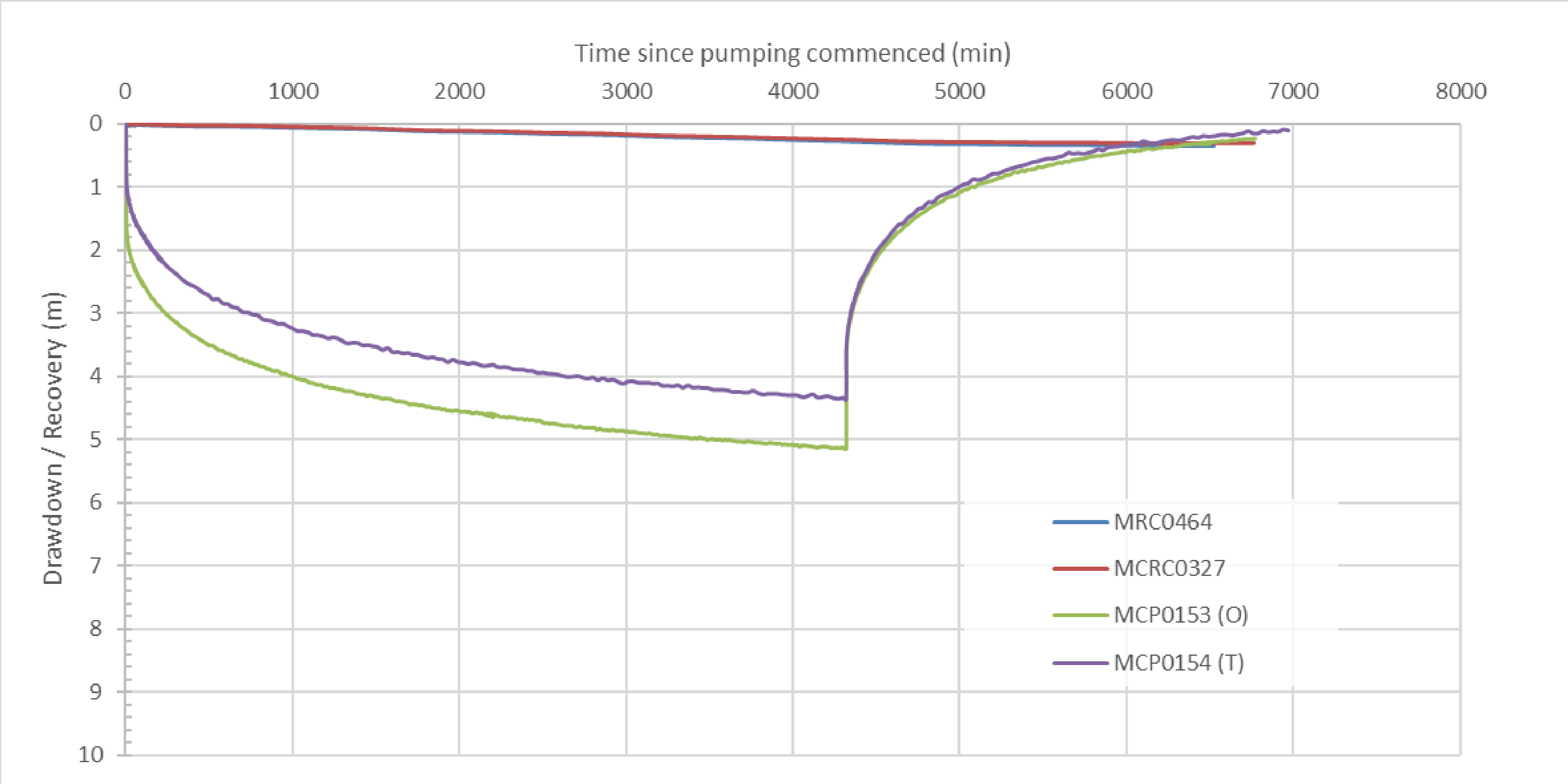


Figure 7-16: MCP0153 [O] test - aquifer response to pumping

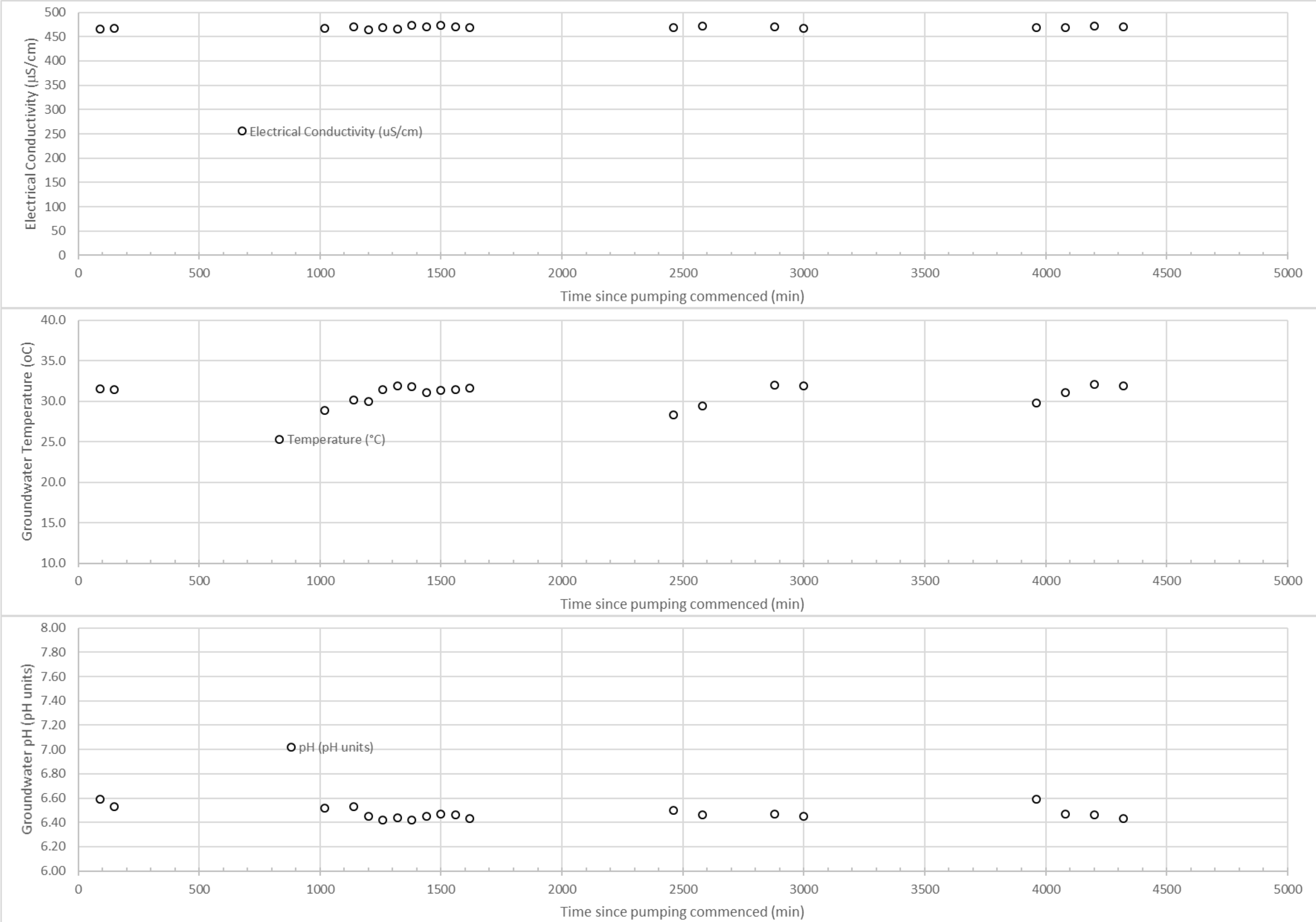


Figure 7-17: MCP0153 [O] test - water quality monitoring

7.8.4 Analysis

Analysis was as per the approach outlined in section 7.4.4 and a summary of the analysis has been presented in Table 7-19. Selected analytical output has been attached as Appendix C.

Table 7-19: Summary of MCP0153 [O] test analysis

Stage	Model	Bores	Transmissivity (m^2/day)	Storage coefficient	Comment
Pumping	Theis	MCP0154 (T)	1,019	0.06	Match to late time drawdown and derivative data only
	Neuman		868	S: $4.6x10^{-3}$ S_y: 0.1	Reasonable match to both drawdown and derivative data
	Tartakovsky-Neuman		959	S: $8.7x10^{-3}$ S_y: 0.07	
Recovery	Neuman	MCP0154 (T)	690	S: $7.5x10^{-3}$ S_y: 0.1	Reasonable match to both drawdown and derivative data

7.9 Summary of analytical parameters from aquifer testing

A summary of calculated aquifer hydraulic parameters is provided in Table 7-20.

Table 7-20: Estimated aquifer parameters

Test Site	Bore	Geological unit	Transmissivity	Specific yield	Storativity
Bore P	MCRC0448	MP7 – Upper BIF	(740 to 980) 860 Ave	0.004 to 0.008	0.0005 to 0.008
Bore R	RCMC430	MP6 – Chert & MP2 lower BIF	(618 to 778) 700 Ave	>0.2	0.01 to 0.06
Bore D	MCP0155	MP1 – base shales	13 to 15	0.08	0.002
Bore L	MCP0156	MP2 – lower BIF	8,000 to 13,000	0.009 to 0.03	0.01
	MCRC0148	MP2 – lower BIF	8,000	0.02	0.003
Bore O	MCP0154	MP6 – Chert and MP2 lower BIF	(690 to 960) 812 Ave	(0.07 to 0.1) 0.1	(10-3 to 10-1) 0.02

7.10 Packer testing

Atlas Iron identified a selection of geotechnical and metallurgical diamond cored bores for packer testing. The main purpose of the packer testing was to test the hydraulic properties of the geological units which have low hydraulic conductivity and would have limitations in responding to pumping tests. A summary of the packer testing is provided below as Table 7-21, with the packer tests analyses included in Appendix E. A summary of test data is presented as Figure 7-18.

Key observations from the packer tests are as follows:

- Relatively consistent Lugeon ranges were calculated for those test intervals completed on the shales. With the exception of MCDH050 (PSM002) which had an average value of 7, the average of the shales was less than 1. This is equivalent to a hydraulic conductivity being less 0.0086 m/d. It should be noted that these tests were completed in competent shales, whereas the shale test at MCDH050 may have been tested on an interval with some minor fracturing.
- The two tests that included quartzite zones, likely parts of the Corboy Formation, also had very low Lugeon values, slightly lower than the shales.
- The two intervals that were logged as BIF had quite variable tests, reflective of the varying degree of fracturing found with the BIF units. Both tests were completed in relatively competent sections of BIF, noting that the more fractured zones were not suitable for testing. The average values for the two BIF tests ranged between 5 and 20.
- Valid tests could not be completed at some target intervals. This was predominately due to problems inflating the packer in broken BIF, or the rate of injection being too high for the testing methods. An issue with the bean-pump on the rig also negated the test completed on MCDH054 (PSM011).

Table 7-21: Packer test details

Bore ID	Location	Lithology	Test interval (mbgl)	Lugeon values (range)
MCDH046	MH9	BIF	108 - 111	16.98 - 28.79
MCDH045	MH7	BIF	125 - 130	3.88 - 6.89
MCDH046	MH9	Shale	167 - 170	1.4 - 5.98
MCDH047	MH8	Shale	249 - 253	0.65 - 1.68
MCDH050	PSM002	Shale	127 - 130	1.84 - 12.04
MCDH051	PSM013	Shale	139 - 142	0.19 - 2.94
MCDH052	PSM012	Shale	153 - 156	0.09 - 0.3
MCDH056	PSM008	Shale	70 - 73	0.17 - 0.39
MCDH052	PSM012	Shale / quartzite	187 - 190	0.12 - 0.23
MCDH051	PSM013	Banded quartzite and shale laminations	180 - 183	0.35 - 0.82
MCDH056	PSM008	Ultra Mafic	157 - 160	NA

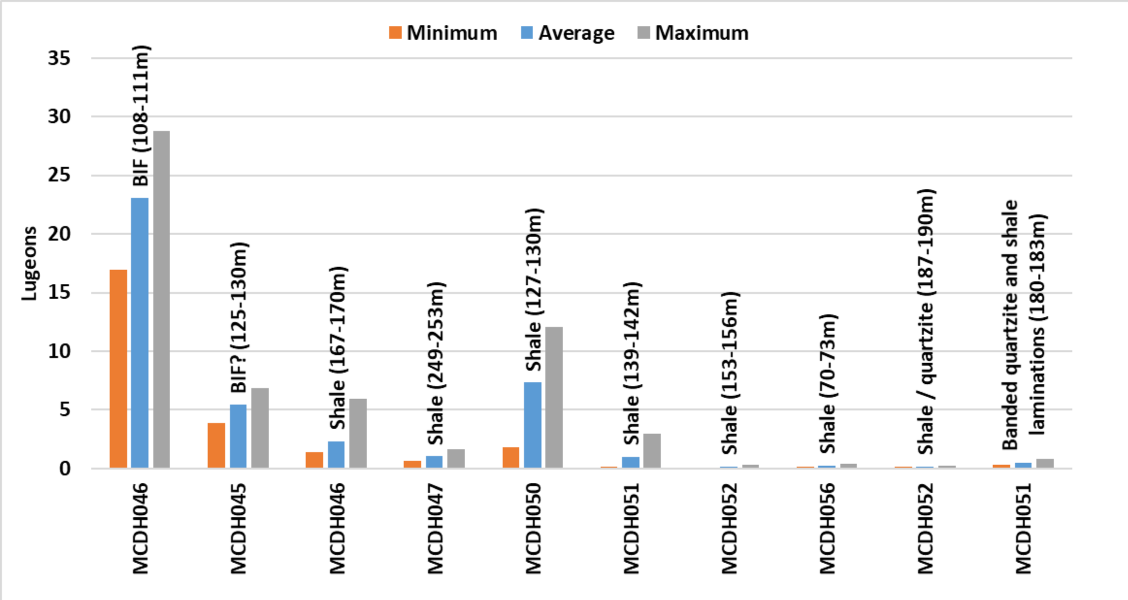


Figure 7-18: Packer test summary

7.11 Groundwater quality sampling

Field groundwater quality sampling for pH, TDS and EC was undertaken during drilling. The sampling was undertaken at multiple depths within the aquifer. The data from this is included on the bore logs presented as Appendix A.

Groundwater samples were taken for laboratory analysis from the test production bores that were subject to test pumping. The data from these bores is presented in Appendix E and the laboratory reports are included as Appendix F.

The laboratory results show a broad consistency between the bores. A slight difference is noted for MCP0105, which shows a slightly higher salinity of 660 mg/L compared to less than 300 mg/L for the remaining four bores. Other parameters, includes some metals are also marginally elevated at this site.

Whilst bore MCP0105 is within the same chert and lower BIF units as bores MCP0152 and MCP0153, it is located within the neighbouring syncline to the main resource area. This suggests that there may be some degree of disconnect between these two synclinal systems. The similarity of data between the upper BIF (MCP0103) and lower BIF (MCP0152 and MCP0153) suggest connection of these units, which would be expected based on their consistently fractured nature.

Of interest is that MCP0151, installed within the basal shale, has groundwater chemistry consistent with the BIF units.

8. Hydrogeological conceptualisation

8.1 Introduction

The hydrogeological conceptual model is based on data interpretation of combined findings from the previous and current (2020) hydrogeological investigations. It builds on the concepts previously developed by AECOM (2013a), SKM (2013, 2014) and MWH (2012, 2014).

8.2 Project domain

The area selected for hydrogeological conceptualisation and inclusion in the groundwater model includes the region surrounding the PDE and the extent is aligned principally with surface water catchments or other natural (geological) boundaries. Since the PDE is situated of the catchment divide it includes catchments radially spreading from the PDE in all directions.

The main groundwater impacts anticipated with project operations include dewatering and disposal of excess water into creeks. Other groundwater ‘stresses’ such as potential unregistered abstractions associated with stock watering are negligible on the regional groundwater. The model domain was selected such that the boundaries of the domain were sufficiently remote from the potential extent of simulated impacts to minimise the likelihood of modelled impacts on model boundaries (and vice versa).

The area of the model domain is 1,687 km^2, shown as ‘assessment domain’ in Figure 2-1.

8.3 Hydrostratigraphic units

The hydrostratigraphic units used in this study are based on Atlas Iron’s 3D geological block model of mine geology (Atlas Iron, 2020a) with the geology outside of the block model simplified to basement and regolith. The units are summarised below in Table 8-1. Note that “waste” refers to in-situ material below ore grade, rather than excavated waste rock.

A representation of the geological model, produced in Leapfrog, is shown as Figure 8-1. This figure includes the model units summarised in Table 8-1. Cross sections from the model are presented as Figure 8-2 (Murray Pit) and Figure 8-3 (full length of the resource). The final pit elevations and the hydrogeological test bores are also included on these cross sections.

Table 8-1: Interpreted hydrostratigraphic units

Hydrostratigraphic unit	Leapfrog model unit	Unit description	Spatial occurrence
Upper BIF Min	MP7	Upper banded iron formation ore. Aquifer	Within ore body
Upper BIF Waste		Upper banded iron formation waste. Aquifer	Within ore body
Chert	MP6	A chert layer separating the upper and lower BIF. Aquifer	Within ore body
Lower BIF min	MP2	Lower banded iron formation ore. Aquifer	Within ore body
Lower BIF waste		Lower banded iron formation waste. Aquifer	Within ore body
Shale	MP1	Underlying shale at the base of the Paddy Market Formation. Aquitard	Beneath ore body
Fractures	NA	Fault-induced fracturing, assumed to be 30 m wide, with increased hydraulic conductivity and storativity.	Within orebody and immediately surrounding aquitards

Hydrostratigraphic unit	Leapfrog model unit	Unit description	Spatial occurrence
Quartzite	Fqz	Corboy Formation quartzite. Aquitard	Beneath ore body

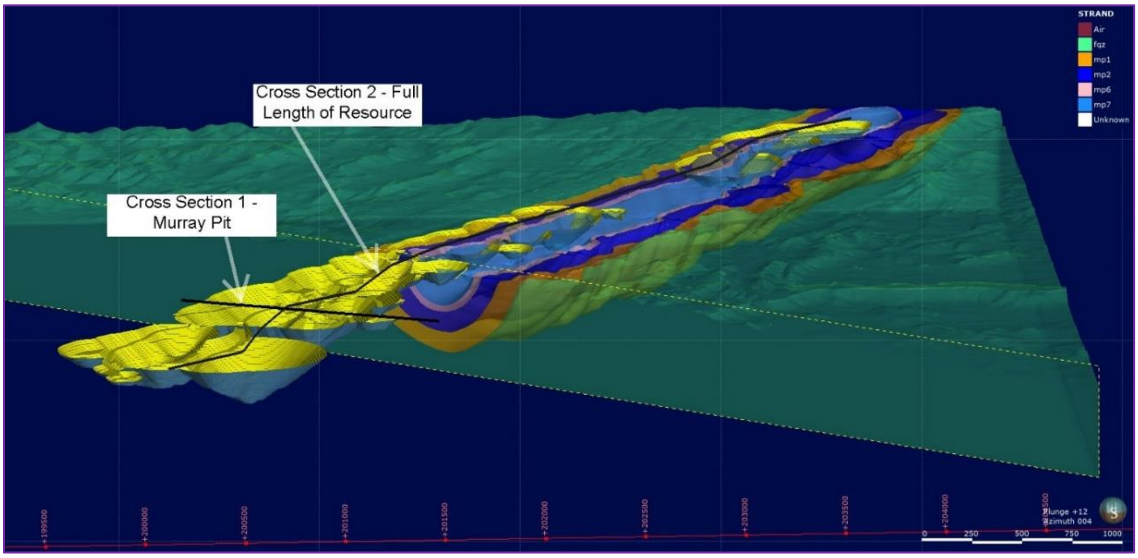


Figure 8-1: Leapfrog model including cross section alignments

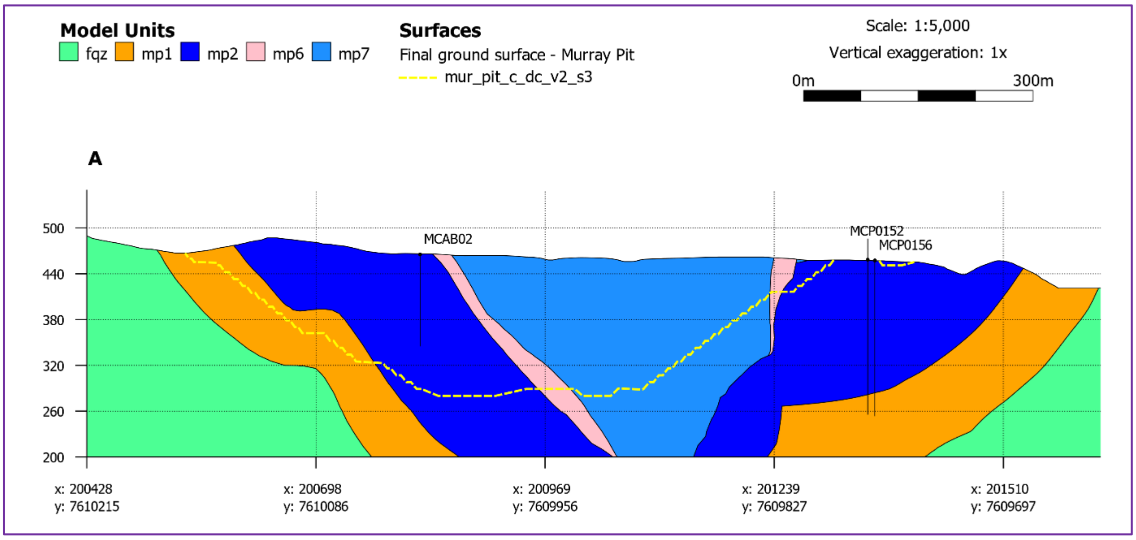


Figure 8-2: Cross section 1: Murray Pit

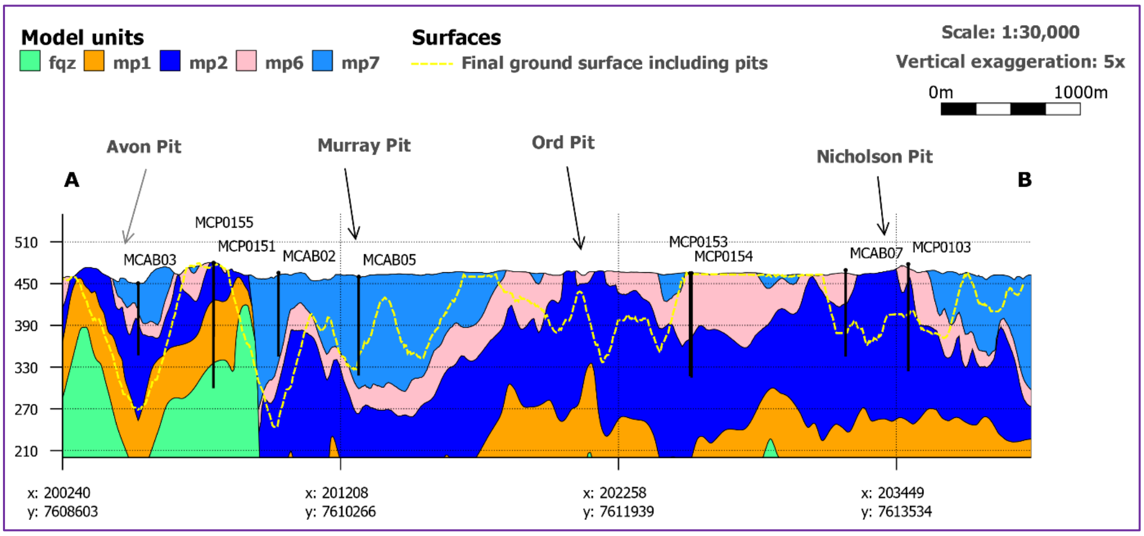


Figure 8-3: South-north cross section 2: full length of resource

8.4 Aquifer geometry and boundary conditions

The aquifer forms a syncline or basin of BIF and chert aquifer within the underlying shale and quartzite. The underlying shales and quartzite are generally less fractured and have a significantly lower permeabilities than the BIF and chert aquifer. The 'basin' structure of this aquifer is clearly visible on the 3D geological model shown in Table 8-1 and the cross sections presented as Figure 8-2 (Murray Pit) and Figure 8-3 (full length of the resource).

Based on the data collected to date all aquifers in this study are considered to be unconfined. Permanent rock pools are present within and in proximity to the PDE at elevations significantly above the regional water table. It has not been determined if these pools are a result of connectivity with discontinuous perched aquifers which may potentially be present, or supported by surface runoff. One historical bore was artesian when first drilled (Paddys Bore), possibly due to intersecting a sub-horizontal fracture zone of higher permeability rather than being confined by an aquitard.

8.5 Hydraulic properties

A summary of the tested properties of the hydrostratigraphic units is presented below as Table 8-2. The presented hydraulic properties include the range of values from the various studies completed for the McPhee Creek project. The properties demonstrate the significantly more permeable BIF and chert units in comparison to the underling shales and quartzite.

The high permeability of the BIF and cherts is largely attributable to their brittle and fractured nature. Evidence from drilling programs highlights that significant fracturing can often occur for the entire depth of these units (hence the need for them to be drilled with DR methods). Conversely, in some areas the BIF and cherts can be more competent and include less abundant fracturing. This variability is demonstrated by the wide range of hydraulic conductivities shown in Table 8-2, i.e. ranging between 9 to 93 m/d.

Vertical hydraulic conductivities are considered to be lower than the horizontal hydraulic conductivity due to the more intensive jointing along bedding planes although the ratio depends on the dip of the folder beds.

Table 8-2: Hydraulic parameters

Unit	Subunit	K	Sy	Source / comment
BIF	Upper BIF	15 to 22	0.12	SKM - includes units "Upper BIF Waste, Upper BIF Hyd, Upper BIF Min"
		10 to 20	0.03 to 0.07	AECOM - upper and lower BIF the same.
		9 to 12	0.004 to 0.008	GHD - from Bore P
	Chert	11	0.12	SKM
	Lower BIF	15 to 22	0.07	SKM - includes units "Lower BIF Waste, Lower BIF Hyd, Lower BIF Min"
		10 to 20	0.03 to 0.07	AECOM - upper and lower BIF the same.
		6.9 to 92.9	0.01 to 0.1	GHD - from Bores R, L and O. Includes chert units.
Shale[1]		0.075	0.054	SKM
		0.0001 to 0.01	0.001-0.02	AECOM
		0.1	0.08	GHD - from Bore D
Quartzite		0.0075	0.3	SKM
Fault zone		25	0.3	SKM

[1] – Packer testing by GHD indicated very low K based on Lugeon values (generally less than 1, i.e. K less than 0.0086 m/d)

8.6 Groundwater flow regime

Groundwater at the regional scale flows radially from the PDE in all directions due to the elevated topographic position of the PDE and based on available records of regional water levels. The syncline structure that hosts the deposit acts as a localised 'bath tub' due to its high permeability, storing relatively fresh groundwater. Groundwater level within the syncline is deep, being actively recharged through outcropping rocks.

The permeable part of the syncline is surrounded by low permeability shale which functions as an aquitard and reduces the exchange or outflow from the structure to the surrounding fractured rock aquifer. The permeability distribution in the syncline structure has been well investigated through aquifer testing (as presented in Section 7.3).

The fractured rock aquifer beyond the PDE has not been subject to aquifer testing but is considered to have comparatively lower (several orders of magnitude) permeability and storage consistent with other similar regions and geologies.

Depth to groundwater is generally more than 50 m bgl within the PDE, notably in its western part (Figure 8-4). Shallow groundwater occurs along surface drainages (including in small areas of the eastern part of the PDE) and possibly in flat areas along the northern perimeter of the model domain (Figure 8-5). Groundwater discharges through surface drainage areas either through evapotranspiration processes or as an occasional baseflow component of the creek flow after heavy rainfall events.

The existing groundwater level data indicates that groundwater responds to sporadic variations in rainfall. These have been considered in model parameterisation.

Current groundwater loss through groundwater abstraction within the model domain is negligible.

8.7 Groundwater recharge and regional throughflow

Groundwater recharge occurs via widespread direct infiltration to the fractured BIF and chert during periods of heavy rainfall complemented with stream flow infiltration during short wet season flows.

Low chloride values in the groundwater suggests that the recharge regime is dynamic, with relatively low residence times in the mining area which is considered to be the regional recharge zone. Average chloride concentration of groundwater in the PDE is 44 mg/L and reported rainfall chloride concentrations for the inland Pilbara region vary between 0.5 to 1.4 mg/L (e.g. Skrzypek et al., 2013).

Based on the chloride values the average area recharge rates are in the range of 1.1 to 3.2% of rainfall, i.e. 4 to 11 mm/yr. In terms of the hydrogeological conceptual model input, these rates theoretically represent an annual contribution to the groundwater system of 8.4 to 23.6 GL/yr over the model domain.

When considering the same recharge rates over the PDE footprint, the annual groundwater recharge volume ranges between 0.2 to 0.6 GL/yr.

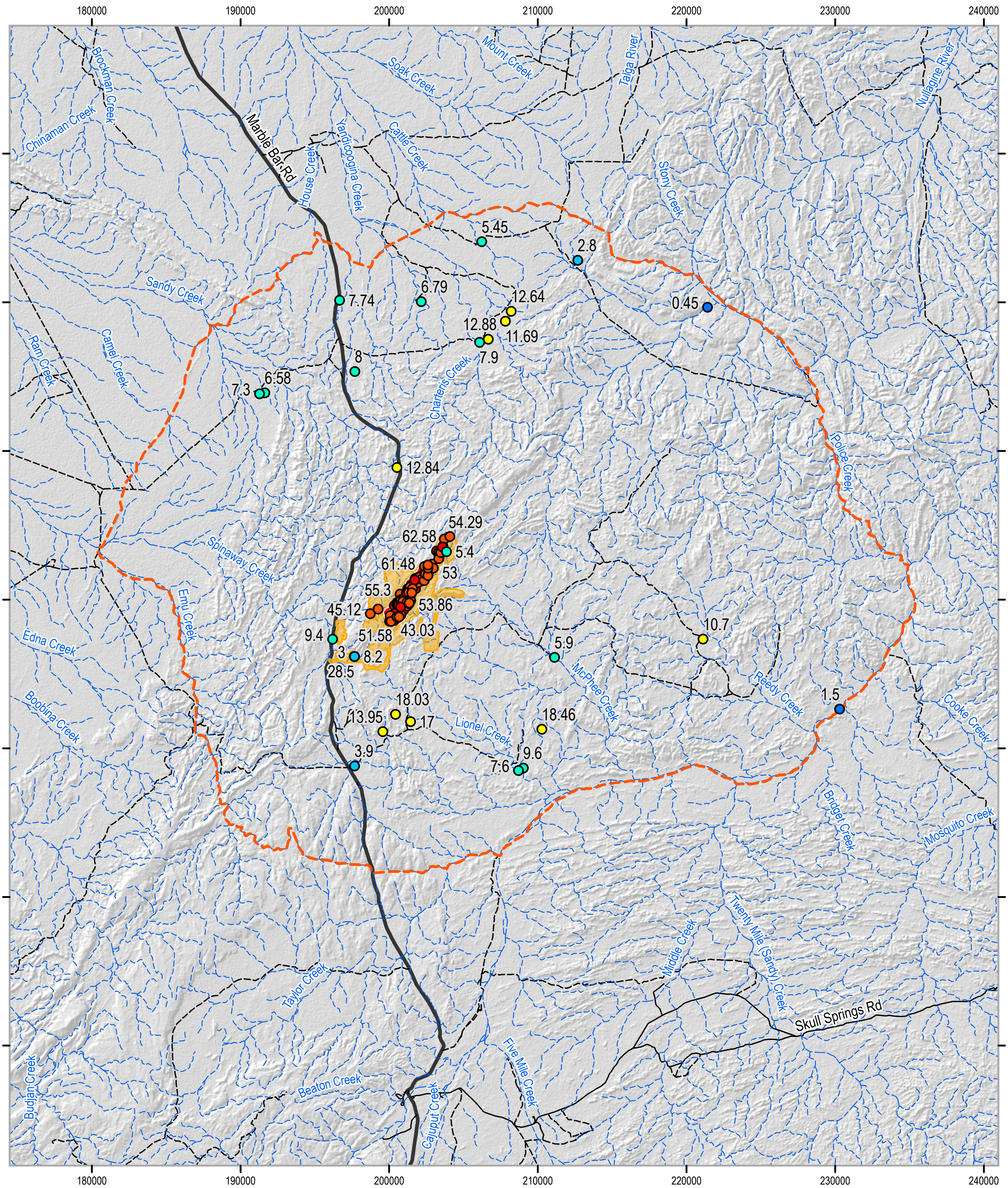
Groundwater throughflow is deemed to be minor. The outward radial flow radiating from the ridgeline in the centre in the PDE is equivalent to received recharge over the PDE, i.e. 0.2 to 0.6 GL/yr. Over the model domain, outside of the PDE, generally in low-lying areas, groundwater contributes to occasional baseflow or discharges as evapotranspiration or minor losses at the model domain perimeter.

8.8 Surface water

The model domain does not have any permanent surface water features. There are a number of creeks and drainages which only flow intermittently after periods of high rainfall. There are no useable surface flow records to allow estimation of baseflow during such events or stream losses to the subsurface.

When surface flows are generated during and after rainfall events there is the potential for limited creek recharge to the underlying fractured aquifer system. When surface water flows are generated they eventually contribute to the Nullagine River to the south and east of the model domain and to the Coongan River to the west of the model domain.

A number of pools are known to occur within the model domain, both within the PDE and also along the downstream sections of the McPhee and Lionel Creeks. As discussed in section 8.4, the pools within the PDE do not appear to be connected to the regional groundwater system and are either surface runoff fed or associated with perched groundwater.



Legend

Depth to Groundwater Meters Below Ground Level (BGL)

- <2
- 2.1 - 5
- 5.1 - 10
- 10.1 - 20
- 20.1 - 40
- 40.1 - 60
- 60.1 - 80
- Main Road
- Minor Road
- Track
- Stream
- Assessment Domain
- Mine Disturbance Area
- Pit Footprint

Paper Size ISO A4

0 2.5 5 7.5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

GHD

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

Depth To Groundwater (BGL)

Project No. 12548901
Revision No. 0
Date 04/10/2021

FIGURE 8-4

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Print date: 04 Oct 2021 - 17:04

Data source: GHD: Bore Locations - 20191031, Streams - 20191113, Pit Footprint - 20200828, Assessment Domain - 20191114, Project Development Envelope - 20201022; Landgate: Roads - 20171106 .
Created by: jabaygar

8.9 Evapotranspiration

Groundwater outflow from the model domain is primarily through evapotranspiration in areas of shallow groundwater along the existing creek lines. Evapotranspiration losses are significant in areas of shallow groundwater, to the extent that surface expression of groundwater is almost non-existent.

Phreatophyte vegetation along creek lines are likely to have deep rooted systems, consequently an extinction depth of 2 to 10 m has been adopted for modelling purposes.

A potential evapotranspiration rate that applies to the model domain, is considered in the range of 1,600 to 2,000 mm/yr (Bureau of Meteorology). The actual evapotranspiration (AET) rates, based on the BoM data values of just over 300 mm/yr apply to the model domain. Within the model domain only a very small part is thought to have active evapotranspirative processes due to depth to the regional groundwater (generally in low-lying areas on the fringes of the model domain).

When the actual evapotranspiration rate is applied to an estimated 5% to 10% of the total model domain area, it would represent a groundwater loss of approximately 27 to 54 GL/yr, respectively. In comparison to the recharge rates stated in previous sections) this indicates that the total area affected by evapotranspiration is likely to be less than 5%, i.e. areas with sufficiently shallow groundwater constitute less than 5% of the total model domain.

The total AET output from the majority of the PDE is estimated be minor due to the depth to groundwater being more than 20 m, i.e. groundwater leaves the PDE area as throughflow.

8.10 Groundwater chemistry and salinity

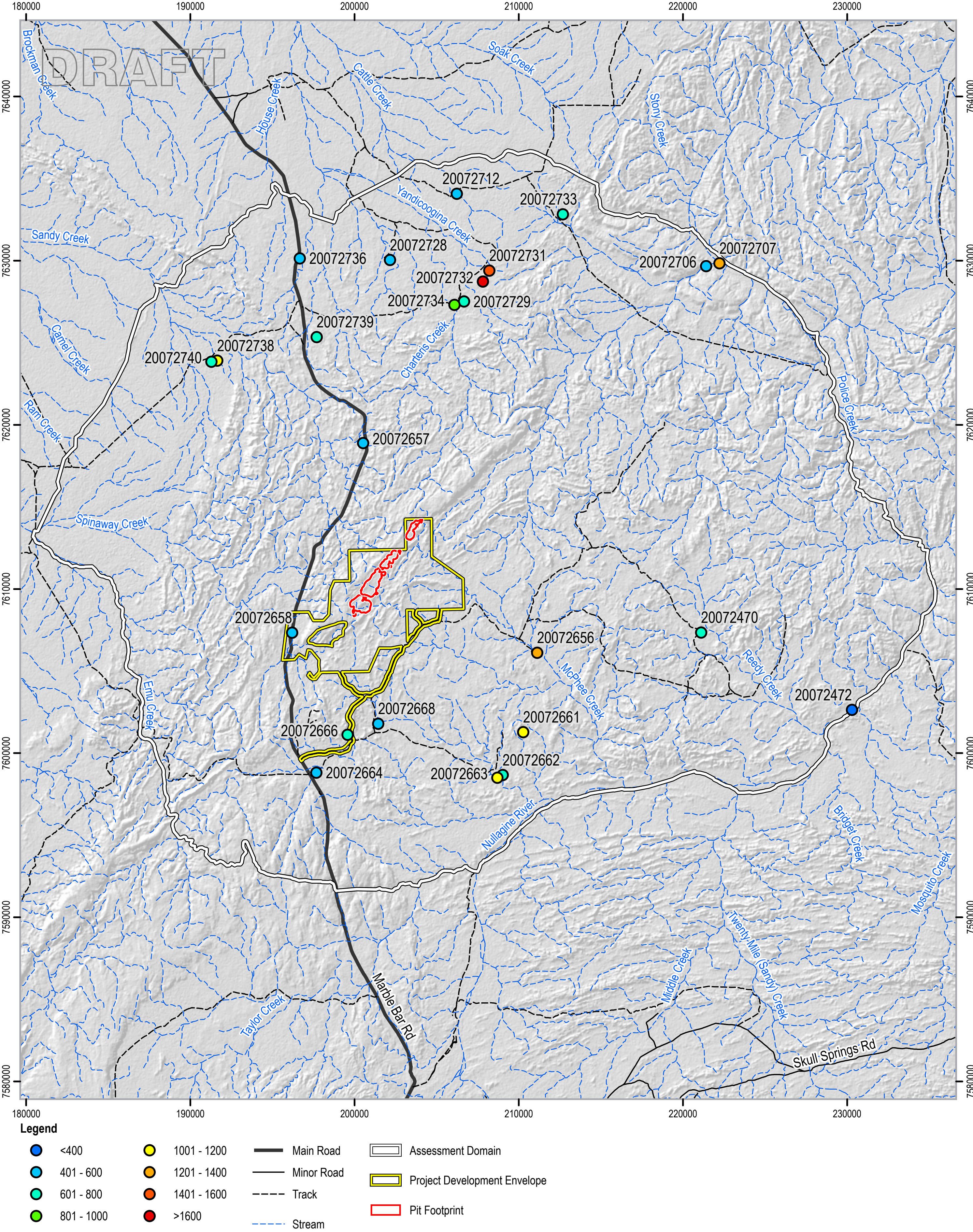
Groundwater salinity and quality in the model domain is controlled by topographic elevation, location in the landscape, occurrence of the drainage features and associated groundwater residence time. Groundwater is generally fresh in the elevated areas (Figure 8-6) including in the PDE (typically less than 500 mg/L).

Outside of the PDE information on groundwater chemistry is sparse and limited to TDS or EC. Available records from DWER’s WIN database suggest minor increases in salinity in areas outside of the PDE although the majority of samples were recorded as still fresh with TDS below 1000 mg/L. Salinities to the south-east of the PDE exceed 1,000 mg/L and there are three other locations with salinities higher than 1,000 mg/L within the model domain.

The median salinity within the PDE is 211 mg/L as TDS while areas outside of the PDE are characterised by the median TDS value of 700 mg/L (Figure 8-6).

Groundwater chemistry in the PDE is dominated by magnesium bicarbonate type, with some samples showing magnesium chloride-bicarbonate (Figure 8-7). This is typical of the recharge regime within the greenstone terranes.

The south-west part of the ore deposit (bores MCP0105, RCMC416, MCRC0088) has minor bicarbonate content, replaced by chloride and elevated sulphate and elevated chloride, suggesting possibly longer residence times for groundwater in this portion of the PDE or depletion of available carbonate in the rock matrix.



Paper Size ISO A4

0 3 6 9 12

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

GHD

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

Groundwater Salinity (as TDS)

Project No. 12520160
Revision No. A
Date 07/11/2020

FIGURE 8-6

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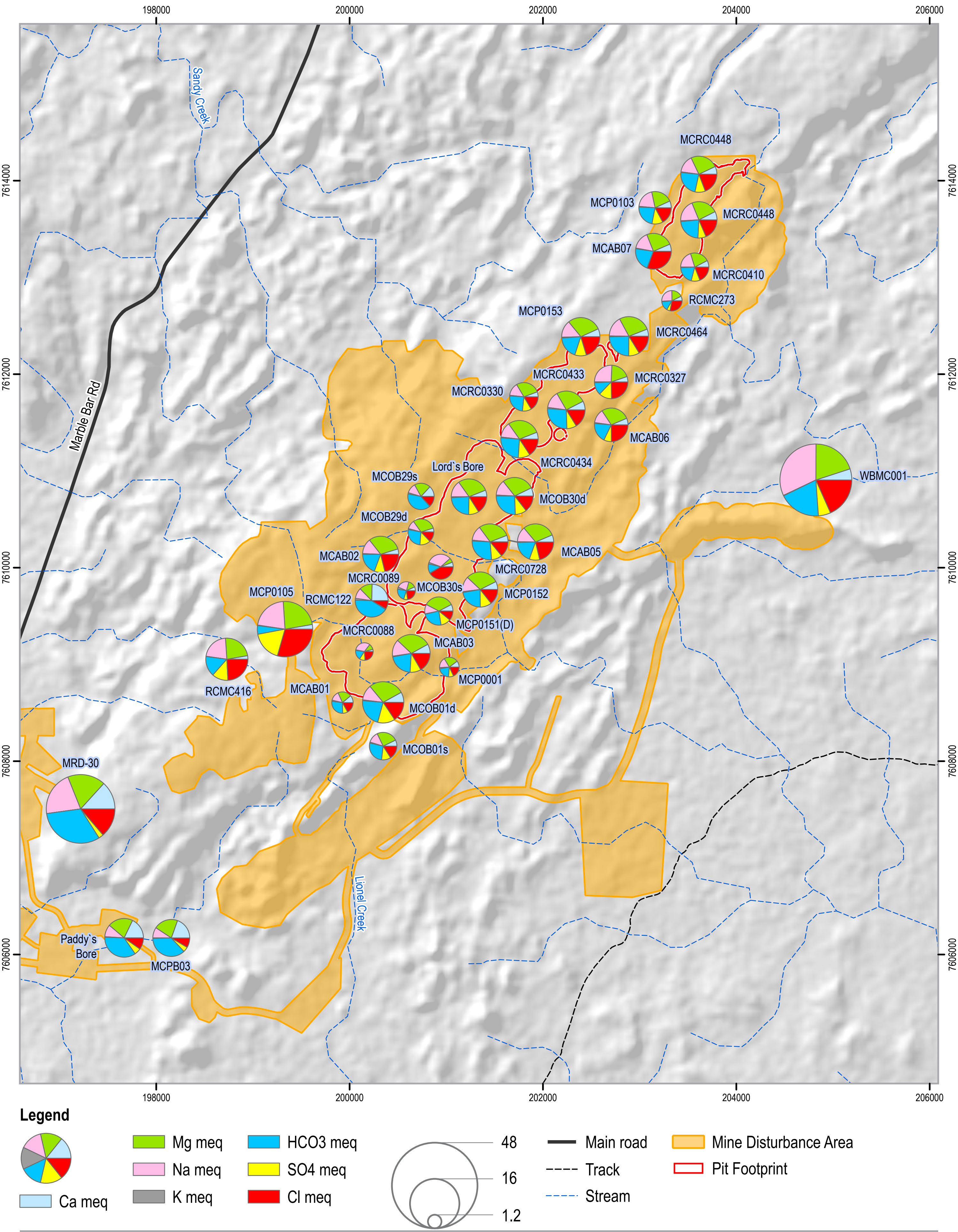
Print date: 07 Nov 2020 - 01:09

Data source: GHD: Bore Locations - 20191031, Streams - 20191113, Pit Footprint - 20200828, Assessment Domain - 20191114, Project Development Envelope - 20201022; Landgate: Roads - 20171106 .
Created by: pjhernandez



Paper Size ISO A4

0 0.5 1 1.5 2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

GHD

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

Groundwater Hydrochemical Types

Project No. **12548901**
Revision No. **0**
Date **04/10/2021**

FIGURE 8-7

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Print date: 04 Oct 2021 - 17:09

Data source: GHD: Bore Locations - 20191031, Streams - 20191113, Pit Footprint - 20200828, Assessment Domain - 20191114, Project Development Envelope - 20201022; Landgate: Roads - 20171106 .
Created by: jabaygar

8.11 Conceptual water and salt balance

The conceptual (volumetric) water balance represents regional-scale input and output components of the groundwater flow within the model domain. These conceptual water balances are considered to be representative of a quasi-steady state, with negligible changes in groundwater system storage and aquifer throughflow through model boundaries during long periods of time.

Flooding events following high rainfall events represent a relatively short-term deviation for the model domain’s volumetric water balance. That contribution is considered short-lived, having a top-up function and probably of minor significance to the model domain volumetric balance and the existing groundwater storage.

Over the long term, the groundwater system within the Proposal ‘domain’ is considered to have not been affected by any large-scale groundwater abstraction. This signifies undisturbed and balanced groundwater flow conditions.

Groundwater recharge is the main contributor to groundwater in the model domain. It is estimated to be within 8.4 to 23.6 GL/yr based on the chloride levels in the groundwater. Groundwater losses in the model domain are via the process of evapotranspiration in flat areas around the domain perimeter and mainly along the creek lines where groundwater is closer to the ground surface.

The groundwater losses are likely to occur from a small portion of the model domain in which evapotranspiration from groundwater is active. This proportion, estimated at less than 5% to 10% of the model domain area, would require an actual evapotranspiration rate of between 50 to 280 mm/yr which is within the BoM actual evapotranspiration value for this region (approximately 300 mm/yr). This is supported by elevated TDS (due to evapoconcentration) in low-lying areas closer to the perimeter of the model domain (Figure 8-6).

Since the majority of the model domain boundaries are along main surface drainages the outflow component through the subsurface is considered minor and recharge and evapotranspiration are the principal water balance components under current, undisturbed conditions.

8.12 Project-anticipated changes to hydrogeological setting

Given that mining will extend below the water table in 2026 dewatering will be required. The high permeability of the orebody aquifer and its moderate to high specific yield mean that significant volumes water will require extraction and drawdown will be significant.

The extent of drawdown will likely be limited by the encapsulation of the aquifer by the underlying and surrounding shale and quartzite. Although groundwater use within the area of likely significant drawdown is negligible, the area contains stygofauna that could be impacted by rapid drawdown or recovery of the regional groundwater.

After cessation of mining recovered groundwater levels within the PDE would be expected to be lower than pre-mining levels.

If disposal of excess water is discharged into creek lines this will locally raise groundwater levels, although the significance of the impact will likely be lowest in areas where groundwater level are already near surface.

If excess water is infiltrated along creeks where the water table is currently deep, water level rises (mounding) could occur. While this potentially has the benefit of preserving groundwater resources, the effect on stygofauna of the rate of groundwater level rise, and the rate of post mining fall, will need to be assesed.

The mine water chemistry is currently fresh and there is no evidence of contamination. Mining activities may contribute elevated ammonia and nitrate from blasting residue and hydrocarbons from fuel and lubricant spills. This may require testing and treatment prior to water disposal to the environment and will need to be managed through management plans and spill response procedures.

9. Numerical groundwater flow model

9.1 Introduction and objectives

The McPhee Creek Iron Ore project will involve the construction of large open cut pits which will require dewatering to lower the existing water table. Dewatering will create hydraulic head differences with the surrounding water table, resulting in the horizontal movement of groundwater towards the open cut pits.

It is also likely that most of the water collected through dewatering activities will be disposed to the environment, with the currently evaluated options comprising creek disposal (preferred option while managed aquifer recharge (MAR) was considered as not feasible due to lack of suitable injection conditions. Due to the shallow natural water table along creeks at their downstream reaches, the mounding associated with creek disposal has the potential to cause groundwater expression at the surface and temporarily create zones with shallow groundwater levels.

Following cessation of mining, the water level in the open cut pits will recover to the level where inflows (mainly groundwater) will match the evaporative flux from the pit lake surface. Evaporation is likely to keep the water levels in the pits below their pre-mining levels resulting in a residual cone of depression with the pits acting as a groundwater sink. Evaporation will also increase solute concentrations in the pit water over time.

The purpose of the numerical modelling is to quantify the potential project-induced changes to groundwater levels and fluxes to assist with the assessment of groundwater impacts and risks, particularly to sensitive ecological receptors. Groundwater flow modelling outputs are also used to support the assessment of changes in pit lake quality post closure.

The objectives of numerical modelling have been specified as assessing and providing estimations for:

- Optimised mine dewatering scenarios during the life of mine with recommended placement and sizing of proposed dewatering bores
- Maintenance of a secure water supply to meet project demands during the life of mine
- Assessment of impacts to the groundwater system, the environment, and any identified other groundwater users
- Input constraints to manage the vertical advance of mining should abstraction rates be constrained – this can be used to manage the mining schedules. It may be required to review mining scheduled as they are developed to ensure a practical dewatering strategy can be associated with the mine plan(s).

To meet this intended model use, the modelling is required to:

- Simulate the existing hydrogeological conditions, including the distribution groundwater levels, flow directions and components of water balance, informed by the findings of field investigations and hydrogeological conceptualisation.
- Simulate groundwater flow processes, at a regional scale commensurate with the large spatial extent of the PDE and disposal of excess water to selected creek lines in the region.
- Quantify the magnitude, extent and duration of project-induced changes to groundwater levels, at a level of accuracy appropriate for the scale and complexity of the model, and for assisting with the assessment of impacts on sensitive ecological receptors i.e.

groundwater level changes and potential surface water flows at the location of ecosystems.

9.2 Overall modelling approach

9.2.1 Staged approach

Groundwater modelling described in this report has been undertaken in a staged manner, consistent with the recommendations of the Australian Groundwater Modelling guidelines (Barnett et al., 2012).

The hydrogeological conceptualisation that underpins the development of the numerical model is described in the preceding section, followed by descriptions of model design and construction (Sections 9.5 to 9.9), calibration (Section 9.10), and prediction (Section 9.11).

9.3 Target confidence level

The Australian Groundwater Modelling Guideline (Barnett et al., 2012) recommends setting out a target confidence level at the start of the modelling process. While the actual confidence level achieved is not known until the outcomes of predictions are considered within the context of model calibration performance and data, the target confidence level provides a useful point of reference for setting out the modelling expectations.

As outlined in the guidelines, groundwater modelling is an iterative process with feedback expected between conceptualisation and numerical modelling. Insights obtained during numerical modelling may identify areas of deficiencies in the conceptual model or gaps in data. Aspects of conceptualisations that have been revised or enhanced through numerical groundwater modelling are highlighted in this section of the report.

According to the guidelines, the confidence in a model’s ability to simulate potential future effects depends primarily on whether or not:

- Future stresses to be predicted by the model are similar to those of the past;
- Predictions are required for a period of time similar to that of historical observations;
- Available data sufficiently characterises hydrological features of most relevance to model predictions; and
- The model is capable of simulating the key hydrological processes and can be calibrated to available data.

As outlined in the hydrogeological conceptual model, the existing hydrogeological conditions are likely to have evolved over a very long period, responding to hydrological and salinity changes such as flushing/dilution from periodic inland flow and rainfall recharge and evapotranspiration.

Historical data is available to enable these processes to be simulated in detail in the PDE, and with lower confidence elsewhere within the model domain. Instead, the focus of the modelling (or more appropriately, this model’s calibration) is to simulate the net effect of the processes that would produce water levels that are consistent with those observed, at the end of a realistic simulation period.

The period of available historical observations used to inform the past behaviour remains smaller compared to the period of predictive simulation. Similarly, the future hydraulic stresses imposed by dewatering and excess water disposal, in terms of the magnitude, extent and duration, would be large compared to those observed to date (such as localised drawdown imposed during pumping tests).