APPENDIX L: INLAND WATERS SURVEY REPORTS

MEMORANDUM

TO:	Carl Paton – Senior Environmental Advisor
FROM:	Carmelo Bellia / Stephanie Watson
DATE:	2 May 2024
RE:	Test Pumping Results & Management of the Lamb Creek Water Supply and Dewatering Strategy

1 BACKGROUND

Mineral Resources Ltd (MinRes) is working towards developing the Lamb Creek Iron Ore Project (the Project), located on a tributary (herein referred to as Mine Creek) in the upper reaches of the Marillana Creek. The iron ore deposit at Lamb Creek is hosted in the Brockman Iron Formation, with mineralisation over a 1 km southwest to northeast strike length. Two previous studies (AQ2 2020, PSM 2021) have been carried out to understand the conceptual hydrogeological setting of the Project site and to develop water supply and dewatering strategies for the Project.

The main aquifer in the project area is the mineralised zone of the Brockman Iron Formation which has enhanced permeability and porosity, herein referred to as the orebody aquifer. Water supply for construction and mining will initially be met through groundwater abstraction from the orebody aquifer. A production bore (PB01) has therefore been installed on the north-western side of the proposed pit area (Figure 1) and two additional in-pit production bores are planned to meet the initial mine water demand.

Three production bores (PB02, PB03 and PB04) have been installed west and north of the proposed pit along Mine Creek (Figure 1) for additional water supply if the full water demand cannot be met from the orebody aquifer and a contingency production bore is planned to the north-east of the pit (near MB9).

Water demand for construction, dust suppression and processing requirements at Lamb Creek will be met through groundwater abstraction and is estimated to be about 30 L/s (~1GL/yr), based on data usage at similar sites in the Pilbara, as follows:

- Process water demand: ~12 L/s
- Camp water demand: ~3 L/s
- Dust suppression: ~15 L/s

Below water table (BWT) mining is scheduled to occur towards the end of the first year of mining, with the pit floor planned ~40 m below the pre-mining water table. Some passive dewatering of the pit is expected to occur through groundwater abstraction for water supply.

To understand potential production bore yields from existing bores, and further understand the groundwater system in the area, MinRes commissioned Pennington Scott (groundwater consultants) to carry out a test pumping program on the four production bores installed at Lamb Creek. This memo reports on the test pumping investigation and outlines the proposed water supply and dewatering strategy.

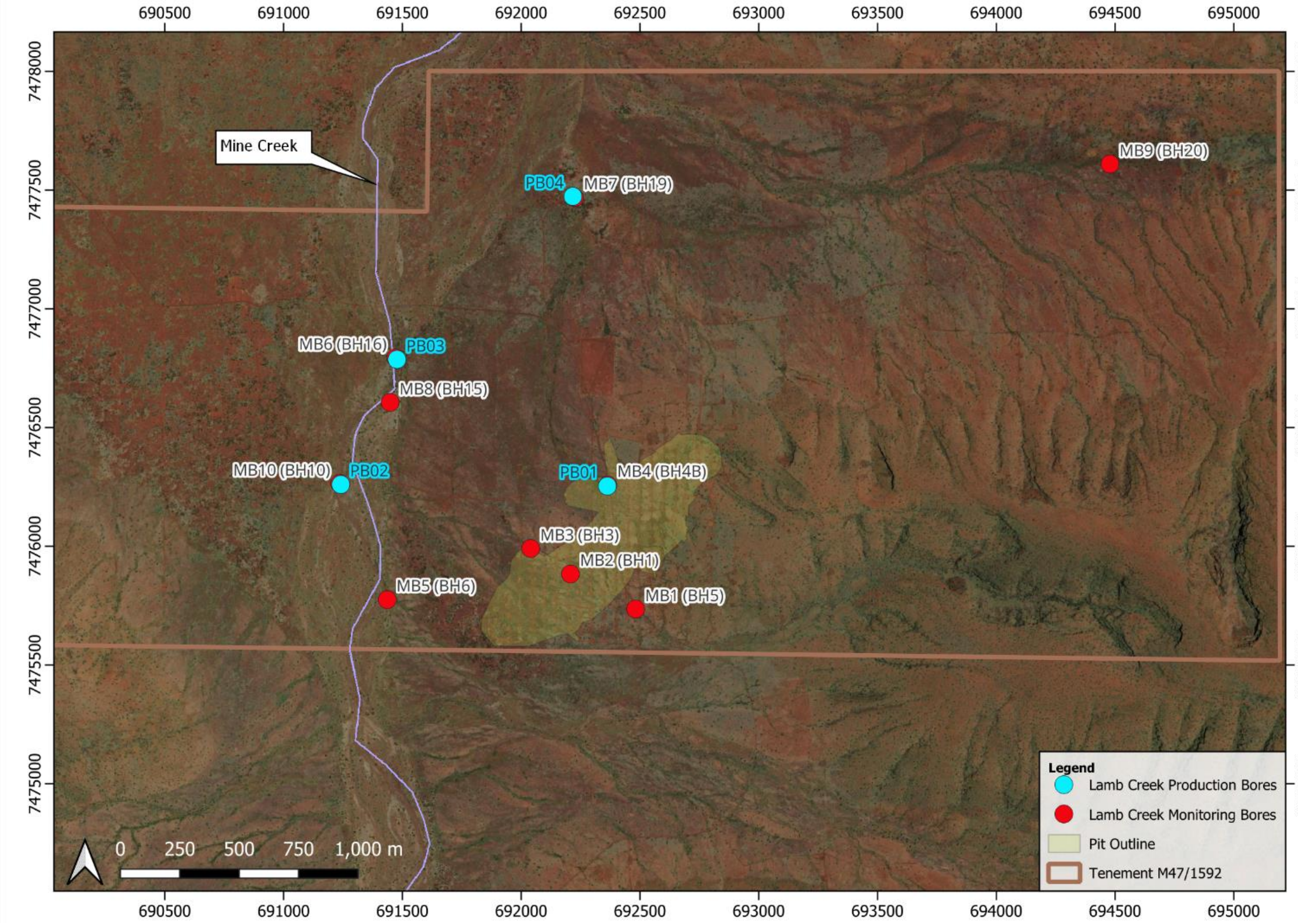

Figure 1: Overview of the Lamb Creek Iron Ore Project area, including the production bore and monitoring bore locations

2 HYDROGEOLOGICAL SETTING

The hydrogeological setting across the Project area can be summarised as follows:

- The mineralised zone of the Brockman Iron Formation hosts a localised orebody aquifer. An assessment by an independent consultant (AQ2, 2020) indicated the orebody aquifer can be considered a “bathtub” type aquifer with localised and enhanced porosity and permeability, but is surrounded by a more extensive lower porosity and permeability fractured rock aquifer (Figure 2).
- The measured water table is generally 44 to 60 mbgl in the proposed pit area and about 36 to 48 mbgl along Mine Creek.
- Tertiary detritals occur above the water table across the Project area and do not form part of any aquifer system in the area.
- Aerial lineament analysis has identified several faults across the Project area (Figure 3) which are inferred to provide some preferential groundwater flow between the orebody aquifer and its surrounds.

The independent consultant assessments concluded that mine dewatering would likely not meet the Project water demands over the life of mine (LOM), so additional water supply (3 production bores) was sourced for the Project along Mine Creek. In this context, mine dewatering will be the primary source of water supply for the Project, while the creek production bores will be used to supplement abstraction if/when needed.

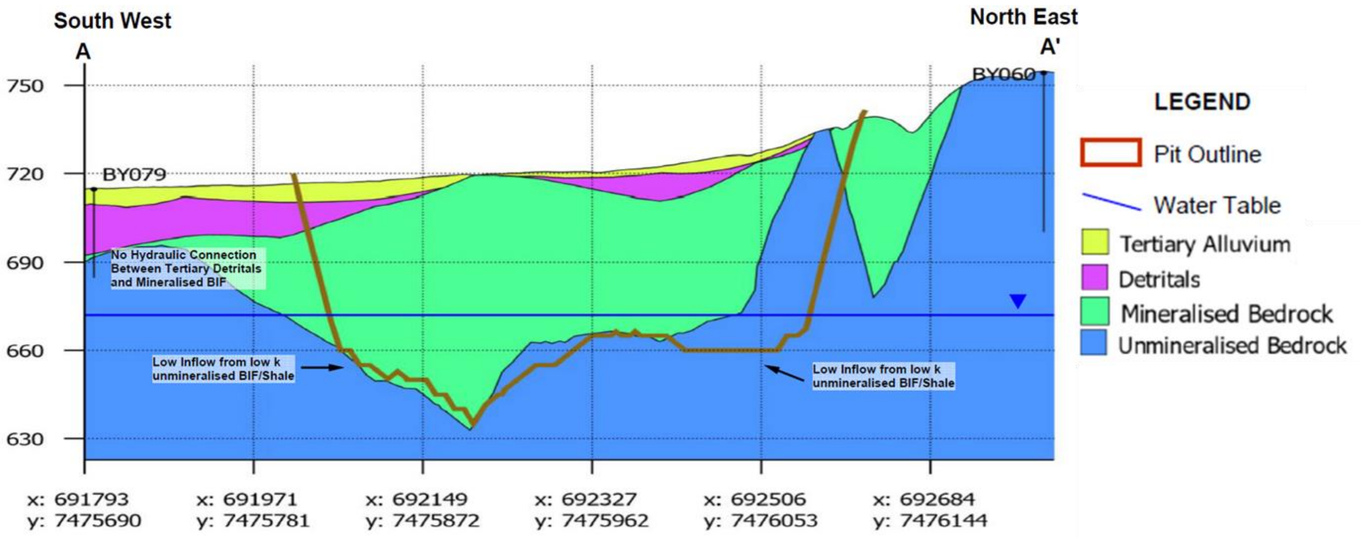

Figure 2: Schematic hydrogeological cross-section through Lamb Creek deposit (after AQ2, 2020)

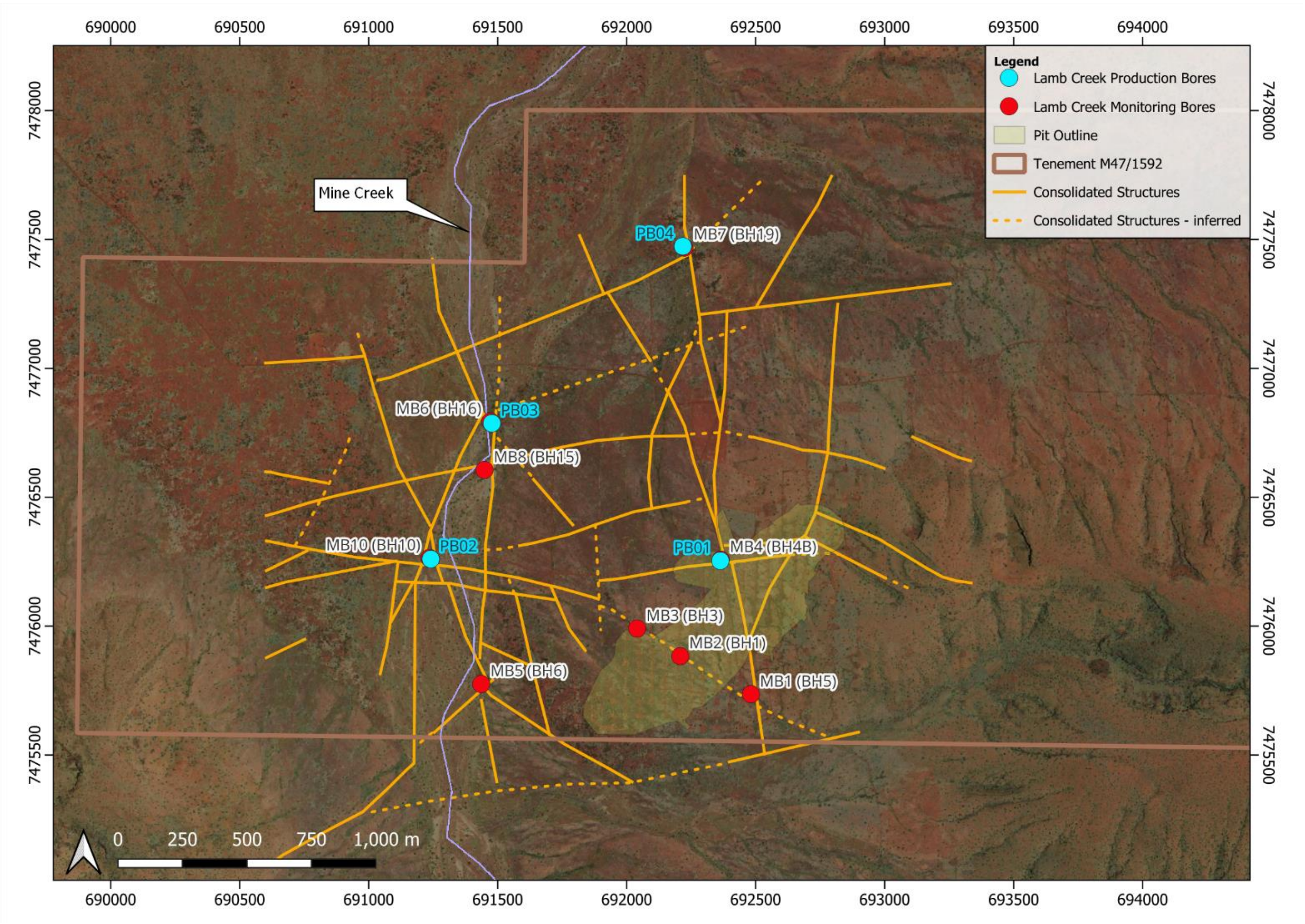

Figure 3: Faults identified across the Project area through the aerial lineament analysis

3 TEST PUMPING OVERVIEW

Pennington Scott carried out a test pumping program and associated analysis (Pennington Scott, 2022) on the four production bores installed at Lamb Creek (Appendix A). Production and monitoring bore water levels were logged during the investigation at locations shown in Figure 1. The objectives of the test pumping investigation were to:

- estimate bore yields
- provide data on the groundwater system
- inform the water supply and dewatering strategies.

Test pumping was successfully conducted in three of the four bores, PB01, PB02 and PBO3, however in PB03 the displacement data was erratic at times which may have impacted the results. Test pumping of PB04 was aborted due to a build-up of sediment within the bore column.

Where completed, each test comprised the following:

- Step Test (SRT):
  - Five (5) steps of forty (40) minutes each to inform the constant rate test
- Constant Rate Test (CRT):
  - A twenty-four (24) or forty-eight (48) hour CRT
- Recovery Phase:
  - Water level recovery in each production bore was monitored for a minimum of two hours upon completion of the CRT.

3.1 CRT Pumping Results

Each CRT was run for 24 to 48 hours at rates between 16 to 32 L/s. Tests in PB01 and PB02 showed an initial high rate of drawdown due to bore loss effects followed by a period of straight-line logarithmic drawdown. Groundwater level recovery within all pumped bores showed a rapid recovery to 80% before stabilising at a water level that was lower than the pre-test level.

Analysis of the test pumping results by Pennington Scott (2022), indicated the following:

- Transmissivity values adjacent to the Lamb Creek orebody of 92 and 81 m^2/day, based on the Radflow and Cooper-Jacob analysis methods, respectively.
- Transmissivity values at Mine Creek ranging from 256 to 449 m2/day, based on the Radflow analysis method, with the range increasing to 113 to 1,064 m^2/day using the Cooper-Jacob analysis method. The upper transmissivity value of 1,064 m^2/day (Table 1) is likely erroneous due to erratic displacement data.
- A potentially less conductive feature was inferred near production bore PB02 (near Mine Creek), but there was no evidence of a hydraulic barrier being intersected in PB01 or PB03.

The analysis results are presented in Table 1.

Table 1: Test pumping results for production bores at Lamb Creek

Bore ID	Screen Length (m)	CRT Rate (L/s)	Total Drawdown (m)	Transmissivity (m^2/day)	Solution Method	Well Efficiency (%)	Associated Monitoring Bore (MB)	Distance between PB and MB
PB01	52	16	20.7	92 / 81	Radflow / Cooper-Jacob	32	MB4	2.9
PB02	64	29.8	14.2	256 / 113	Radflow / Cooper-Jacob	80	MB10	11.8
PB03	64	31.7	9	449 / (1,064*)	Radflow / (Cooper-Jacob)	65	MB6	8.1
PB04	--	--	--	--	--	--	MB7	8.1

*Considered erroneous due to erratic displacement data

3.2 Monitoring Bore Data Review

Water levels were recorded in nine monitoring bores across the Project area (Figure 1) during the test pumping investigation. Drawdown in the monitoring bores due to test pumping of PB01, PB02 and PB03 is shown in Figure 4 to Figure 6, respectively, for both the associated monitoring bores (noted in Table 1) and the more distant monitoring bores (displayed against the secondary y-axis).

Representative hydraulic parameters could not be estimated from either the associated monitoring bore data or the distant monitoring bore for the following reasons:

- The associated monitoring bores were very close to the production bores (between 2.9 m and 11.8 m apart) resulting in very high hydraulic conductivity estimates that appear to represent a localised hydraulic conductivity within the fracture zones targeted by the production bores.
- The drawdown response in the distant monitoring bores was evident but small (< ~0.16 m) and the resolution of the water level data was not adequate for the reliable estimation of hydraulic parameters.

Although monitoring bore response data could not be used for quantitative parameter estimates, it indicated hydraulic connectivity across the Project area, as follows:

- Localised hydraulic connection within the Lamb Creek orebody:
  - As indicated by the response in MB2 and MB3 to test pumping at PB01 (Figure 4)
  - Likely due to the enhanced permeability of the mineralised Brockman Iron Formation.
- Some degree of connectivity between the Lamb Creek orebody and Mine Creek along the targeted linear feature (Figure 3), as indicated by the response in MB5 and MB6 during test pumping of production bore PB01 (Figure 4).
- Hydraulic connection along linear features within Mine Creek, indicated by the response in MB5 to test pumping at PB03 (Figure 6), while there was no response in MB8 and a limited response in MB10, both of which are between PB03 and MB5. This highlights the discrete nature of the linear features.
- No hydraulic connection between PB04 and upgradient production bores PB01, PB02 and PB03:
  - As indicated by the lack of response in MB7 due to pumping at PB01 (Figure 4) and PB03 (Figure 6).
- No measurable water level response in MB8 to test pumping of any of the production bores further supporting the conceptual hydrogeological model of a fractured rock aquifer with groundwater flow largely controlled by the transmissivity and connectivity of faults and fractures.
- Distant monitoring bores responded to test pumping within 2 hours circa. Water levels did not fully recover between tests during the test pumping investigation, further supporting the transmissive but low-storage, fractured rock aquifer hydrogeological setting at the Project.

- During test pumping at PB02, a cyclical water level response was evident in distant monitoring bores (earth tide response) rather than any drawdown response, potentially due to limited fracture connectivity between PB02 and the more distant bores. This result supports the presence of a hydraulic barrier inferred at PB02 from the CRT analysis.

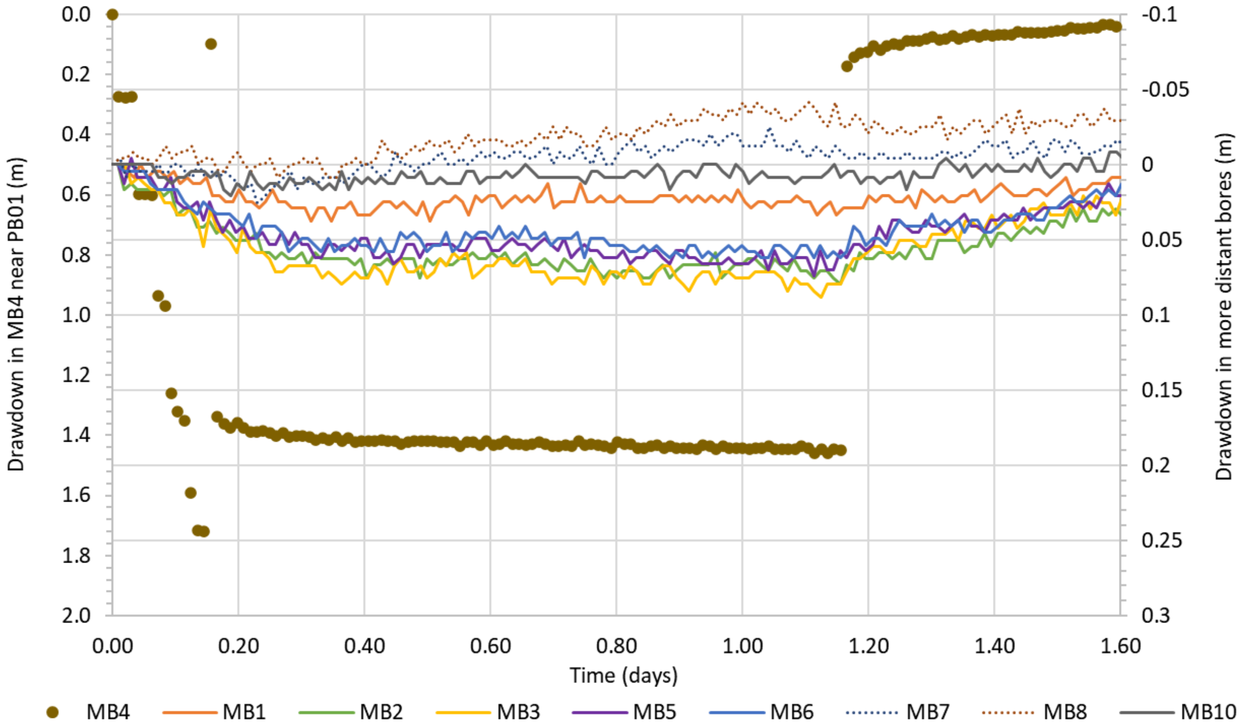

Figure 4: Drawdown in associated (dot symbol) and distant (line symbol) monitoring bores due to test pumping of PB01

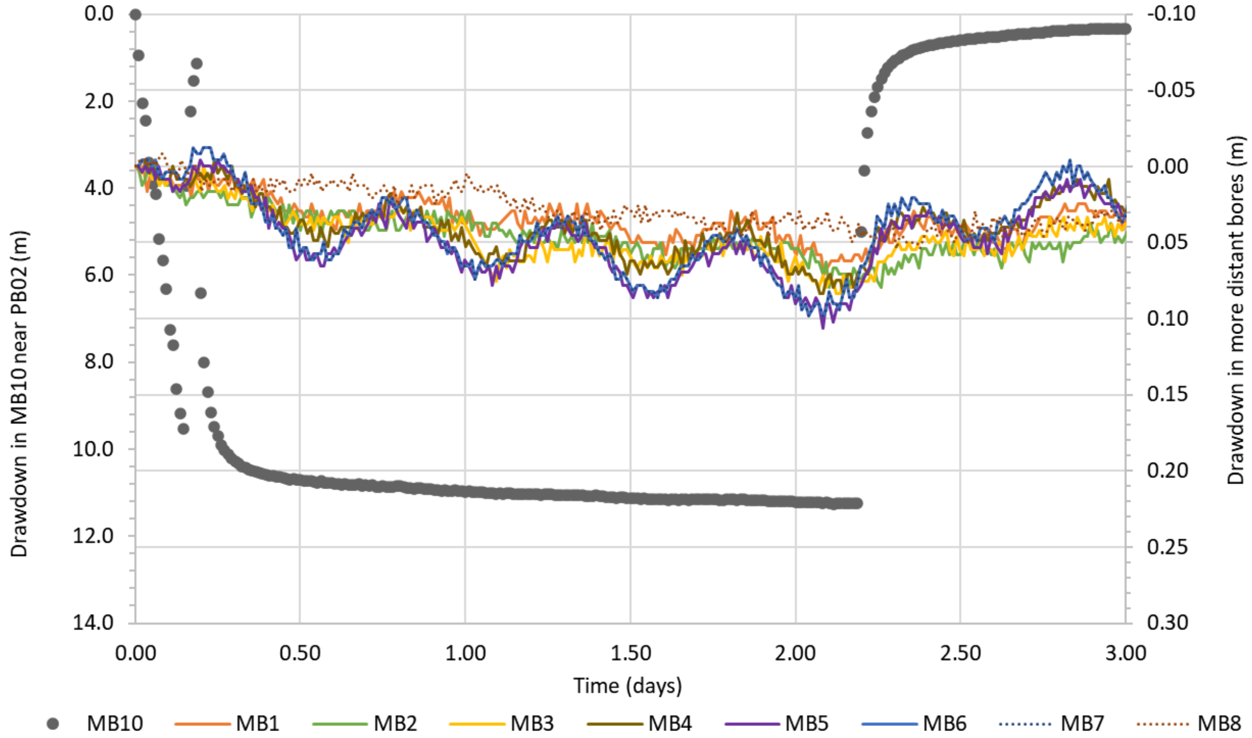

Figure 5: Drawdown in associated (dot symbol) and distant monitoring bores (line symbol) due to test pumping of PB02

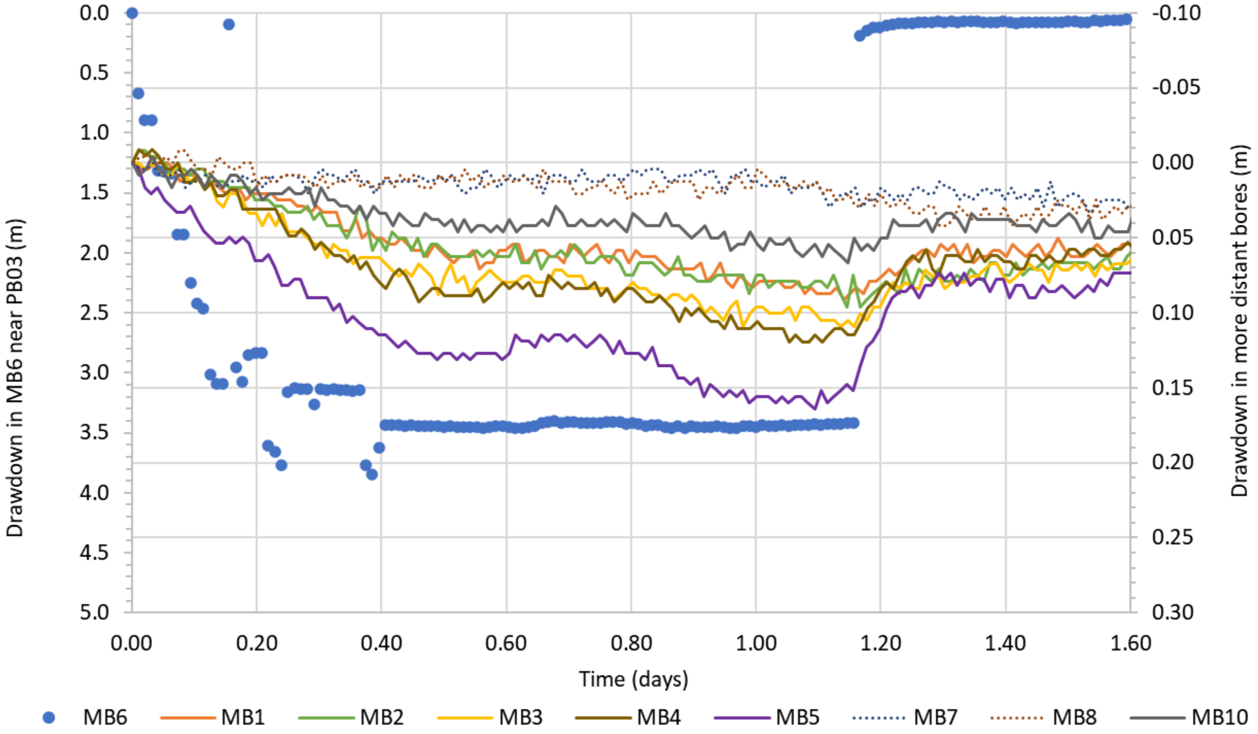

Figure 6: Drawdown in associated (dot symbol) and distant monitoring bores (line symbol) due to test pumping of PB03

3.3 Comparison of Aquifer Parameters Between the 2021 & 2022 Datasets

In 2021, PSM completed a H2 hydrogeological assessment for Lamb Creek, which included analytical modelling for a water supply and dewatering scenario using estimated aquifer parameters derived from a slug-testing program, also completed by PSM in 2021.

A comparison of the aquifer parameters derived from the 2022 test pumping investigation and the PSM 2021 slug testing is presented in Table 2, noting that the two most important hydrogeological units for assessment of dewatering and water supply are the *orebody* and *mine creek* units (respectively).

The results were comparable from both the slug and test pumping investigations.

Table 2: Comparison of 2021 and 2022 Aquifer Parameter Data

Hydrogeological unit	**Transmissivity 2021 Slug tests (m^2/day)**	**Transmissivity 2022 Test Pumping (m^2/day)**
Orebody	100 - 150	81 / 92
Mine Creek	350 - 700	113 – 449*
Watershed	30 – 70	-

* excluding erroneous data (see Section 3.1)

4 DEWATERING RATES AND STRATEGY

The mine water demand during construction and operation will primarily be met through abstraction from the orebody aquifer which will also facilitate passive dewatering of the pit. When there is insufficient yield from the orebody aquifer, the water supply will be supplemented by abstraction from production bores along Mine Creek. The yield from the existing production bore within the pit footprint (PB01) is not sufficient to meet the mine water demand so two additional in-pit production bores are planned to ensure the full construction and mine demand can initially be met through abstraction from the orebody aquifer.

4.1 Theoretical potential maximum dewatering rate

A theoretical potential maximum dewatering rate was estimated for the final pit floor elevation of 633 mAHD, assuming dewatering to a depth of 5 m below the final pit floor. The equations below were used for the dewatering rate estimate, based on the average transmissivity obtained from the test pumping of PB01 (near-pit bore), and the calculation is summarised in Table 3.

Theim-Dupuit inflow into a pit:

$$Q = \pi \cdot K \frac{(H^2 - h^2)}{\ln\left(\frac{R}{r}\right)}$$

Radial extent of dewatering drawdown at steady rate:

$$\mathrm{r}_0 = \sqrt{\frac{2.25\mathrm{Tt}}{\mathrm{S}_y}}$$

A low and high value for specific yield was used to obtain a range of dewatering rates (Table 3). The low specific yield (0.001) was based on the specific yield for a potential structural aquifer provided in the AQ2 assessment (AQ2, 2020) whereas a high specific yield of 0.01 was an assumed average accounting for the mineralised zone (>50%Fe) and waste rock zone (<50%Fe) within the pit and the more extensive structural aquifer. The average maximum dewatering rate is estimated to be about 33 L/s.

Table 3: Maximum dewatering rate estimate based on test pumping results

Parameter	**Pit floor elevation of 633 m AHD (deepest pit floor elevation)**
Hydraulic conductivity (m/day)	1.7
Saturated aquifer thickness, H (m)	49
Saturated thickness beneath dewatered pit floor	5
Radius of pit floor (m)	65
Specific yield, Sy	0.001 – 0.01
Radius of influence, r_o (m)	10,540 – 3,330
Q (m^3/day)	2,494
Q (L/s) – maximum dewatering rate	**29 - 37**

Note that the calculated dewatering rates are highly indicative as they are based on the assumption of an isotropic, homogeneous and continuous aquifer. Although transmissivities in fractured aquifers can be high, as at Lamb Creek, storage is often low and can be removed quickly. Only full-scale long-term pumping will be able to quantify the storage and clearly define long-term dewatering rates.

4.2 Estimated Pit Dewatering Volumes and Rates

Low and high pit dewatering volumes have been estimated based on the total volume of water that will be removed from the pit when there is:

- No inflow to the orebody aquifer (low volume scenario)
- A high constant rate of inflow into the orebody aquifer of 25 L/s (high volume scenario)

The volume of water within the pit shell has been estimated as the sum of:

i. The volume of water within the 50%Fe ore shell (i.e., highly mineralised ore), with an assumed specific yield of 0.1
ii. The remaining volume of water outside of the 50%+Fe ore shell but within the pit shell at a lower specific yield assumed to be 0.05.

The total volume of water stored inside the pit shell is estimated to be about 277 ML.

Under the low volume scenario (no inflow), abstraction of water to meet the 30 L/s mine water demand (or 2,592 m^3/day) would result in dewatering of the pit shell within ~3.5 months (Table 4); shown by the low volume curve in Figure 7.

Under the high volume scenario (inflows at 25 L/s), it is expected that abstraction for mine water demand at 30 L/s, with inflows, would still result is a dewatered pit ahead of mining, as shown in Figure 7.

Table 4: Estimated rate to dewater the pit shell (not including any inflow into the orebody aquifer or pit shell)

Parameter	**Value**
BWT volume within the pit shell and within the 50%Fe surface	2,055,800 m^3
Specific yield	0.1
Volume of pore water to be removed within the 50%Fe surface	205,580 m^3
BWT volume within the pit shell but outside of the 50%Fe surface	1,418,900 m^3
Specific yield	0.05
Volume of pore water to be removed within the pit shell but outside of the 50%Fe surface	70,950 m^3
TOTAL VOLUME of water within the pit shell	**276,530 m^3**
Mine water demand	30 L/s (2,592 m^3/day)
TOTAL DAYS to dewater the pit shell at the mine water demand rate	**107 days (~3.5 months)**

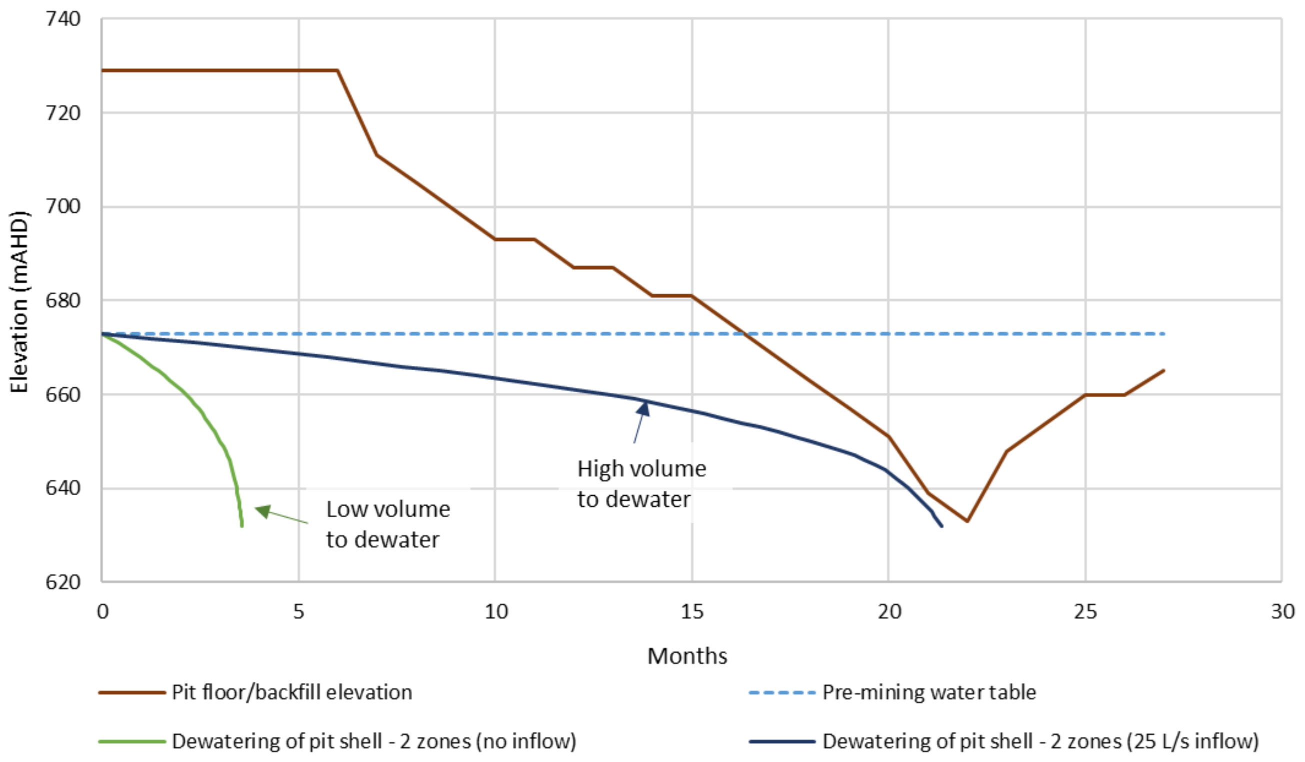

Figure 7: Estimated dewatering of the pit assuming no inflow and pit floor and backfill elevations during mining to the deepest part of the pit, assuming 6 months of water supply for construction

Based on this dewatering assessment, dewatering rates are expected to equal mine water demand and as such, excess water during the dewatering phase is not expected. As a contingency however, if there are periods during mining where dewatering volumes exceed mine water demand, the temporary excess water will be discharged to a larger site water storage facility that will be constructed as part of the mine infrastructure, if required.

4.3 Mine Water Balance – Deficit or Surplus

Existing and planned production bores in/near the pit will initially provide the water supply for mine construction and operation, so the initial mine water balance is simply:

Mine dewatering rate = Mine water demand

For the longer-term water balance, there is insufficient data to develop a quantitative (transient) water balance for Lamb Creek, largely due to the uncertainty associated with extrapolating 24 hr pump test data to long term mine dewatering. Nevertheless, the conceptual hydrogeological model for Lamb Creek indicates the mine is more likely to have a water deficit rather than a surplus because the volume of water within the pit shell (mineralised zone) will only provide ~3.5 months of mine water supply at the expected usage rate and inflows from the low storage fractured rock aquifer surrounding the pit shell are expected to be low.

Pumping data collected during the first few months of mine construction/operation will allow for the development of a longer-term water balance to identify the potential for a longer-term water deficit or temporary periods of water surplus. In the interim, high-level strategies are outlined below for the management of the mine water supply if there is a deficit or surplus.

Water Management Strategy for a Mine Water Deficit

If abstraction from in/near-pit production bores has largely dewatered the pit and/or these bores can no longer meet the mine water demand, additional water supply will be sourced from the two existing production bores to the west of the pit on Mine Creek (PB03 and PB02, in order of priority). Test pumping indicates these bores each have a peak yield of 20

L/s (Pennington Scott, 2022), so the combined sustained yield from these bores will be sufficient to meet the mine water demand for a period.

If the yield from PB03 and PB02 is found to be unsustainable over time, the following actions will be undertaken:

- Existing production bore PB04 to the north of the site will be developed and equipped to provide additional water supply. We note this bore is downgradient from PB02 and PB03, so may yield less than indicated by the airlift yield of 8.2 L/s measured during bore installation.
- An additional contingency production bore will be installed near monitoring bore MB9 to the north-east of the pit (Figure 3). During installation, MB9 had an airlift yield of ~8.5 L/s and this bore lies in a different catchment to production bores PB01 to PB04, indicating this is a suitable location for another production bore.

The additional water sources outlined above are considered sufficient to meet the mine water demand over the short LOM.

Water Management Strategy for a Mine Water Surplus

If dewatering rates exceed the mine water demand during below water table mining, there may be a temporary mine water surplus. As a contingency, if early pumping data indicates a large storage facility is required, the general mine layout includes a placeholder area that can accommodate a large water storage facility. The storage facility will be designed to store all temporary excess dewatering water from production bores, whilst minimising evaporative losses during periods of low water storage.

4.4 Water Supply and Dewatering Strategy

Due to the uncertainty associated with extrapolating results from a 24hr pumping test to longer term estimates of mine dewatering, an adaptive management approach will be undertaken to manage water supply and pit dewatering. This will involve telemetry monitoring of water levels and flow rates at all production and monitoring bores during the first few months of abstraction for construction water supply. The data will be reviewed prior to and during mining at regular intervals to further inform the dewatering strategy.

Based on the conceptual hydrogeological model, the water supply and dewatering strategy for the Project is outlined below:

- To enhance passive dewatering efforts, the construction and operational mine water demand (estimated to be about 30 L/s) will initially be sourced from the orebody aquifer via PB01 (16 L/s), and two new planned production bores at the southern end of the pit.
- If inflow into the orebody aquifer from the surrounding fractured rock aquifer is minimal:
    - Abstraction to meet the mine water demand will passively dewater the pit within the first 6 months of the Project commencing (Figure 7)
    - Additional water to meet the water demand, will be sourced from the Mine Creek production bores, PB03 and PB02, in order of priority.
    - Contingency water supply will be obtained from PB04 and from a new bore planned near MB9, if required.
- Groundwater abstraction for water supply is expected to practically dewater the pit ahead of mining. However, if inflow rates from the surrounding fractured rock aquifer are higher than expected, any temporary excess dewatering water will be stored on site in large water storage facilities that have been allowed for in the mine infrastructure.
- MinRes will be actively managing mine water supply and dewatering across the life of the Project through:
    - Targeted monitoring program over the early stages of mining to further understand the groundwater flow system
    - Integration of the monitoring results into the water supply and dewatering strategy over the first 12 to 18 months to actively manage passive dewatering of the pit and ensure water is efficiently used across the Project.

- The monitoring program should include the following:
    - Telemetered monitoring of flow rates from all active production bores (or regular recording of flow rates).
    - Telemetered monitoring of water level for all monitoring and production bores (or regular dipping and recording of water levels)
    - Monthly recording and review of actual dewatering rates to facilitate regular updates of projected dewatering rates.
    - Review of pumping rates and aquifer performance every 2-months after pumping has commenced.

5 CONCLUDING COMMENTS

Hydrogeological studies for the Lamb Creek project have shown the orebody aquifer is a porous and permeable (leaky) bathtub type aquifer, surrounded by a low conductivity, low storage, structural aquifer (unmineralized BIF/shale), with no hydraulic connection with the overlying tertiary detritals (Figure 2). Based on geological data and slug testing carried out in 2021, independent consultants concluded that water supply during pit dewatering alone will not meet the mine water demand for the LOM, and will therefore require the Mine Creek water source area for supplementary supply.

The results of the 2022 hydraulic test pumping program were comparable with the 2021 hydraulic slug testing program supporting the conclusions drawn by the independent consultants. Additional analyses presented in this memo have shown that the volume of water stored within the pit shell will only provide water supply for a short period of time, and abstraction to meet water supply will practically dewater the pit ahead of mining. In the event of a mine water deficit, additional water supply sources have been identified. However, if monitoring during the initial stages of mining indicates there will be some excess dewatering water, large surface water storage facilities have been included in the mine infrastructure layout as a contingency to store excess water. Based on all assessments, there will be no dewatering water discharged to Mine Creek.

6 REFERENCES

AQ2, July 2020, “Lamb Creek Iron Ore Project – Hydrogeological Scoping Study”, Memo, 28th July 2020

Pennington Scott, Nov 2022. “MRL – Hydraulic Bore Testing Completion Report – Lamb Creek Project.” Report: 2364 Rev0

PSM, May 2021a. “Lamb Creek Iron Ore Project – Hydrogeological Assessment.” Report: PSM4241-004R

PSM, May 2021b. “Mineral Resources Limited - Lamb Creek Groundwater Operating Strategy.” Report: PSM4241-006R

Appendix A

Pennington Scott, Nov 2022. “MRL – Hydraulic Bore Testing Completion Report – Lamb Creek Project.” Report: 2364 Rev0

Mineral Resources Limited

Hydraulic Bore Testing Completion Report

Lamb Creek Project

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Hydraulic Bore Testing Completion Report

Lamb Creek Project

2364 | Rev 0
November 4, 2022

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REVISION	**ISSUED**	**DESCRIPTION**
Rev 0	8 Nov 2022	Issued for Client review
Rev 1	10 Nov 2022	Final issued to client

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APPENDICES

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1. INTRODUCTION

Mineral Resources Limited (**MRL**) is seeking a supply of dust suppression water for the Lamb Creek Iron Ore Project in the Pilbara region of Western Australia. **Figure 1, Figure 2** and **Table 1** show the locations of four production water bores constructed by MRL, southeast of the Auski Roadhouse.

MRL engaged Pennington Scott (groundwater consultants) to undertake a hydraulic testing program to:

- Develop twenty (20) monitor bores by airlifting; and
- Pump test four (4) production bore to determine safe yields.

The contained document contains the results of the bore assessment, test pumping and water sampling, as well as the final recommendations for the bores along the Onslow Road.

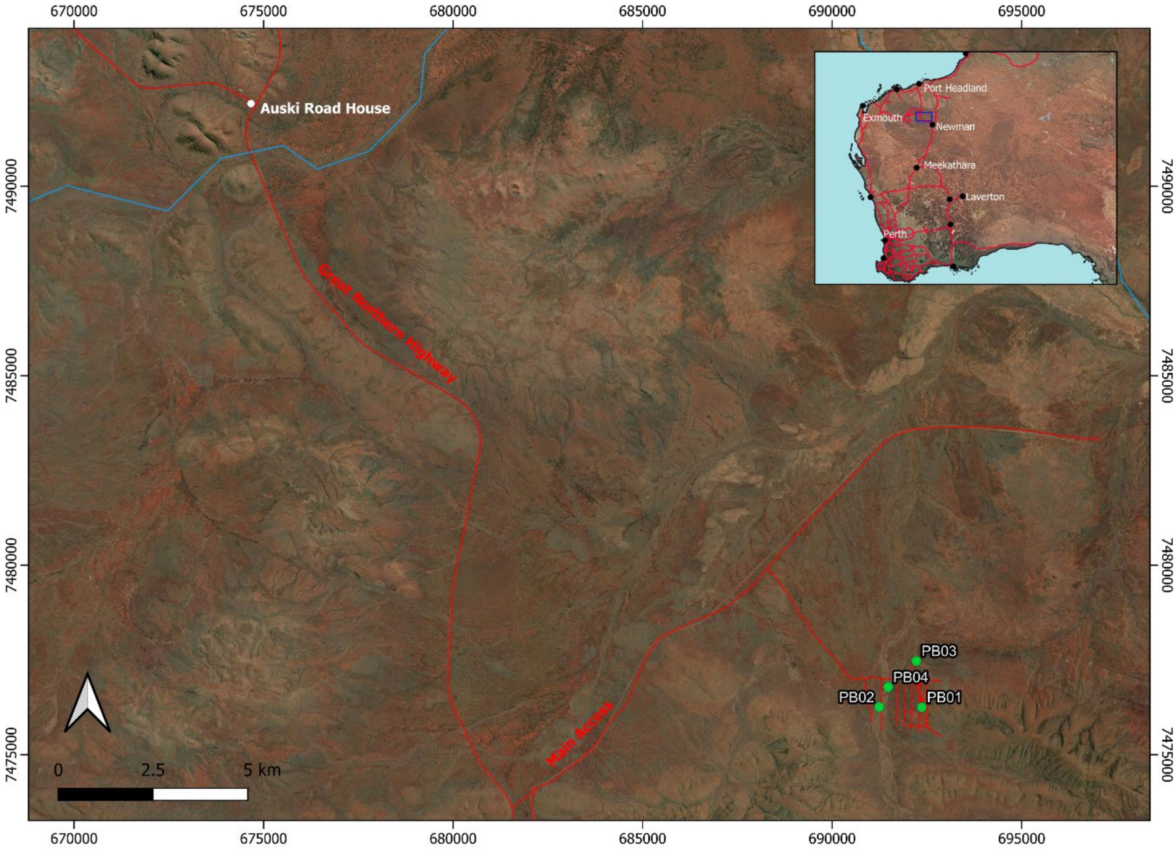

Figure 1 Regional locations of the Lamb Creek bores

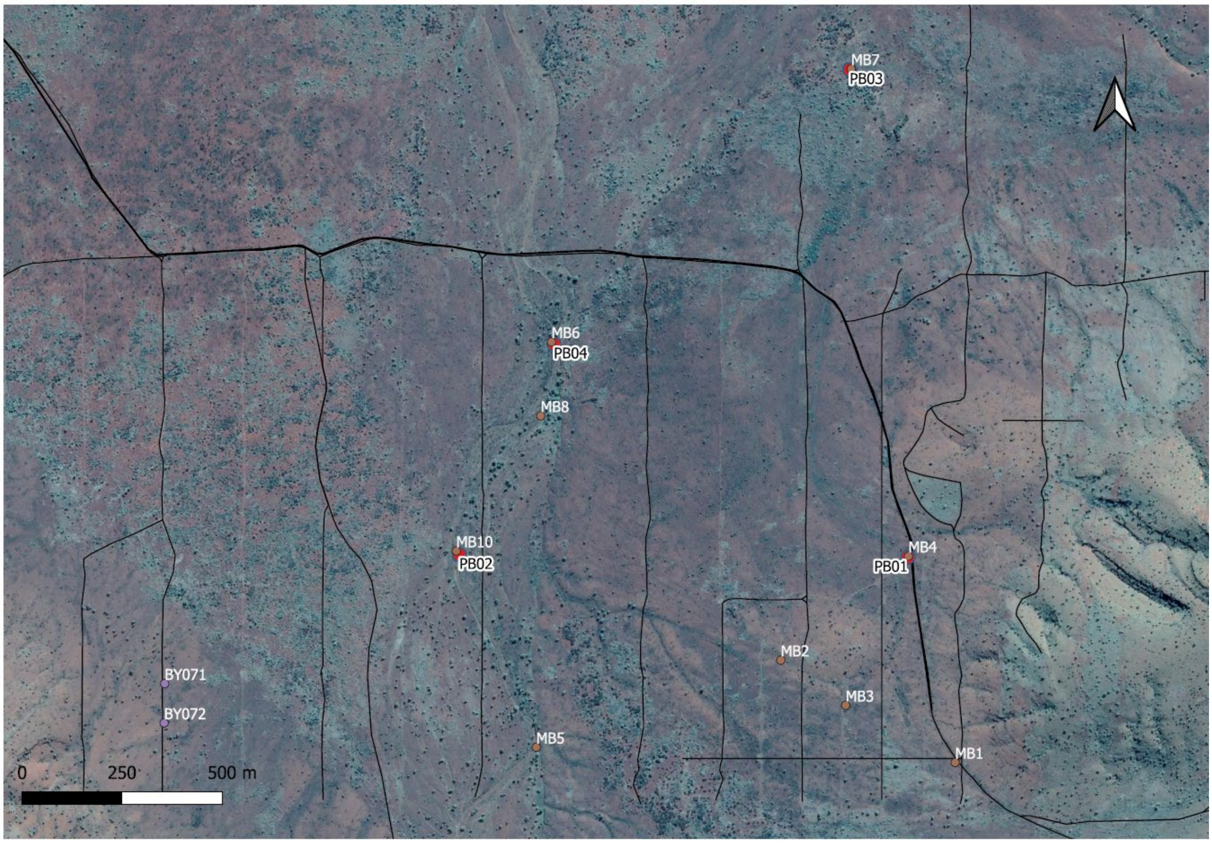

Figure 2 Detail of the Lamb Creek production and monitor bores (supplied by MRL)

Table 1 Lamb Creek Bores Details provided by MRL

Pump Test Number	Bore Type	Hole ID	Easting	Northing	Comment	Depth (mbgl)	Screen from (mbgl)	Screen to (mbgl)	SWL (mbgl)	Drilling Airlift Yield (L/s)	Development Airlift Yield (L/s)
1	**Production**	**PB01**	**692363.4886**	**7476255.282**	**10 " steel**	**98**	**46**	**98**	**43**	**9**	
1	Monitoring	MB01	692481.4059	7475736.186		84	70	76	56.2	0.8	0.2
1	Monitoring	MB02	692207.2312	7475883.702		120	77	83	47.77	2.5	
1	Monitoring	MB03	692039.935	7475990.927		111	72	78	47.5	1.8	
1	Monitoring	MB04	692364.0007	7476258.118		90	79	85	43.5		
1	Monitoring	MB08	691448.4374	7476606.234	Use existing MRL logger	96	69	93	31.55	4.5	0.8 - 1.0
2	**Production**	**PB02**	**691241.415**	**7476261.845**	**10" steel**	**100**	**36**	**100**	**32**	**11**	
2	Stygofauna	BYO71	690503.71	7475937.656	One Stygo only	72				Unknown	
2	Stygofauna	BYO72	690501.938	7475839.225	One Stygo only	66				Unknown	
2	Monitoring	MB02	692207.2312	7475883.702	Use existing MRL logger	120	77	83	47.77	2.5	
2	Monitoring	MB05	691435.8372	7475775.502		96	53.5	85.5	33.5	2.5	1.3
2	Monitoring	MB8	691448.4374	7476606.234		96	69	93	31.55	4.5	0.8 - 1.0
2	Monitoring	MB10	691234	7476271		90	75	87	32.23	12.3	1.7 - 2.2
3	**Production**	**PB03**	**692218.2482**	**7477475.151**	**10" steel**	**120**	**56**	**120**	**26**	**8.2 L/s**	
3	Monitoring	MB06	691472	7476794		96	82	94	27.8	7.8	
3	Monitoring	MB07	692223.2744	7477468.833		120	94	118	25.48	7.5	1
3	Monitoring	MB09	694477.753	7477610.094	Creek Line	96	84	96	47.46	8.6	2
3											
3											
3											
4	**Production**	**PB04**	**691478.0753**	**7476788.612**	**10" steel**	**105**	**56**	**105**	**28**	**11 L/s**	
4	Monitoring	MB02	692207.2312	7475883.702	Use existing MRL logger	120	77	83	47.77	2.5	
4	Monitoring	MB04	692364.0007	7476258.118	Use existing MRL logger	90	79	85	43.5		
4	Monitoring	MB06	691472	7476794		96	82	94	27.8	7.8	
4	Monitoring	MB07	692223.2744	7477468.833	Use existing MRL logger	120	94	118	25.48	7.5	1
4	Monitoring	MB8	691448.4374	7476606.234		96	69	93	31.55	4.5	0.8 - 1.0
4	Monitoring	MB10	691234	7476271		90	75	87	32.23	12.3	1.7 - 2.2

2. FIELD PROGRAM

On the 18th September 2022, Pennington Scott mobilised a 130 cfm air compressor, 75 KVA generator and 6” electrical submersible pumps to Auski Roadhouse to undertake a field program to clear twenty (20) monitor bores and test four (4) production water bores. The program had to be terminated on the 30th September 2022.

2.1 Bore Airlift development

Pennington Scott plumbed each hole to check whether they were open. Fishing tools were used as necessary to remove any root matter. A 130 CFM airline was then inserted to full depth in twenty (20) monitor bores and the hole purged with air to remove any residual drilling muds and fines.

2.2 Bore Test Pumping

Test pumping was completed on four (4) bores, and results are summarised in **Table 3.1**. For each pumping test, a step-test, constant rate test (**CRT**) and a recovery phase were undertaken.

The hydraulic testing program was conducted according to the following protocols:

- a 30 kW Lowara Z8125 04-L6W or 37 kW Lowara Z660 21-L6C 37kW electrical submersible pump was installed in each tested bore;
- Pennington Scott’s ‘SmartPump’ automated pumping test control system was used in each test which features water level and flow rate sensors, an actuated flow control valve, remote generator relays and a remote telemetry system;
- 5 x 40-minute step tests were performed at step rates in the range of 15 to 30 L/s;
- a sustainable pump rate was determined for the constant rate test based on step tests for each bore;
- where applicable, water levels in observation and production bores within a 200 m radius of the pumping bore were recorded throughout the CRT; and
- recovery measurements were completed for a minimum 2-hour period at the end of each constant rate test.

Appendix A provides bore logs of the four (4) production water bores at Lamb Creek. **Appendix B** summaries hydraulic bore tests according to the procedures laid out in **Section 2.3**

2.4 Step Test Results

Step tests are designed to assess the performance of the bore against different pumping rates. These are used to inform the choice of rate for the Constant Rate Test and can also be used to compute the 'Well Efficiency' – the proportion of drawdown that is caused by the bore (for example through poor screen placement or clogged screens).

Table 3-1 summarises the step test results with well efficiencies at different pump rates using the Hantush-Biershenk method (**Appendix B**). Both PB02 and PB03 can produce about 20 L/s at between 75 to 85% well efficiency. PB01 however struggles to produce more than 4 L/s at better than 66% well efficiency.

PB04 produced significant silty fines during step testing, which ultimately caused the pump motor to burn out the thrust bearings. Pennington Scott recommend that PB04 not be equipped.

Table 3-1 Summary of Step test data

Bore	Step Test Rates (L/s)	Well Efficiencies
PB01	3.8, 7.9, 12.0, 15.8., 18.5	66, 50, 40, 32, 28
PB02	9.8, 14.8, 19.7, 24.9, 29.8	94, 90, 86, 83, 80
PB03	10.1, 15.0, 19.7, 25.0, 30.0	84, 79, 74, 69, 65
PB04	Bore not developed	

2.5 Constant Rate Test Results

Reference to the CRT curves in **Appendix B** shows an initial high rate of drawdown in the first several minutes due to bore loss effects, usually followed by a period of straight-line logarithmic drawdown. Transmissivity values from each tested bore are presented in **Table 3-2** derived using the radial flow model method of Rushton (2004). Reference to **Table 3-2** shows that bore PB04 could not be reliably tested because the bore was undeveloped and pumping copious fines. The bore pumped dry within an hr at 6 L/s and destroyed the pump motor.

Nonetheless, analysis of the remaining three (3) bores suggests that transmissivities for the fractured aquifer at Lamb Creek range from 81 m^2/day to 450 m^2/day. Drawdown during the CRT was between 9 m and 20 m with pumping rates between 16 L/s and 32 L/s.

Table 3-2 Summary of CRT data & analytical results

Bore	Screen Length	Length	CRT Rate	Total Drawdown	Transmissivity (m^2/day)	
	(m)	(hrs)	L/s)	(m)	Cooper-Jacob	Radflow
PB01	52	24	16	20.7	81.3	92
PB02	64	48	29.8	14.2	113	256
PB03	64	24	31.7	9	1064	449
PB04	49	N/A	6	53	pumped dry	pumped dry

The Cooper Jacob analysis of PB02 apparently shows a barrier boundary at 5.9 m from the bore.

2.6 Water Quality testing

Water samples were collected from all bores at the end of pump testing and the samples handed to the MRL representative for analysis.

3. RECOMMENDED BORE YIELDS AND PUMP-SETTINGS

A safe bore yield is defined as the maximum rate that a bore can be pumped continuously for a specific design period without dewatering the bore. The **safe yield** of a particular bore is the lesser of the following two components:

- **pump yield** is the maximum rate achievable using the manufacturers recommended pump size for the given bore construction; and
- **aquifer yield** is the maximum rate that the aquifer can deliver water to the bore.

In fractured rock aquifers, it is difficult to assess the long-term aquifer safe yield due to the unknown extent and geometry of the fractures containing the water. Nevertheless **Appendix A** shows the forward modelled 6 month safe yield for all bores using the Eden Hazel method to determine the yield that achieves 80% of the available drawdown over a six-month pumping period. The results are summarised in **Table 4-1,** with the Specifications of the recommended installed pump, based upon the CRT pumping rates, presented in **Appendix B**.

The pump recommendations above are based on the following pump assumptions:

- All bores have 250 mm ID (10”) steel casing which can accommodate most conventional 6” electrical diameter submersible pumps;
- Peak yields are based a pumping duty cycle of 18 hrs/day;
- All bores will be fitted with a cooling shroud over the motor;
- All bores will be fitted with a low level cut-off switch fitted 2 m above the pump intake; and
- The pump will be set in each hole to ensure that the pump intake is no lower than 2 metres above the bottom of the hole and the base of the cooling shroud is no lower than 0.5 m above the bottom of the hole, which ever is the higher.

Table 4-1 Recommended bore sustainable yield

Bore Name	Installed peak yield (L/s)	6 month sustainable yield (L/s)	Pump intake setting (mbtoc)	Pump Submergence (m)	Suitable Lowara Pump	Power Requirement kW
PB01	12	12	90	47	ZN646/9-3	15KW
PB02	20	16	90	58	ZN660/10-3	18.5KW
PB03	20	16	90	62	ZN660/8-3	15KW
PB04	Do not equip					

4. REFERENCES

AUSTRALIAN AND NEW ZEALAND ENVIRONMENT AND CONSERVATION COUNCIL, 2000, Australian and New Zealand guidelines for fresh and marine water quality. Volume 1, The guidelines: Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand, Chapter 4, p4-1.1 – 4-4.19.

AUSTRALIAN AND NEW ZEALAND ENVIRONMENT AND CONSERVATION COUNCIL 2000. National Water Quality Management Strategy – Australian and New Zealand guidelines for fresh and marine water quality. Paper No.4

BARLOW, P.M., AND MOENCH, A.F., 1999, WTAQ—A computer program for calculating drawdowns and estimating hydraulic properties for confined and water-table aquifers: U.S. Geological Survey Water-Resources Investigations Report 99–4225, 74 p.

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NATIONAL UNIFORM DRILLERS LICENCING COMMITTEE 2021. The minimum construction requirements for water bores in Australia. Version 4

STANDARDS ASSOCIATION OF AUSTRALIA (1990) Australian Standard for test pumping of water wells. AS2368—1990 DR89112

RUSHTON K.R., (2004) Groundwater Hydrology – Conceptual and computational models. Pub. John Wiley and Sons ISBN 0-470-85004-3

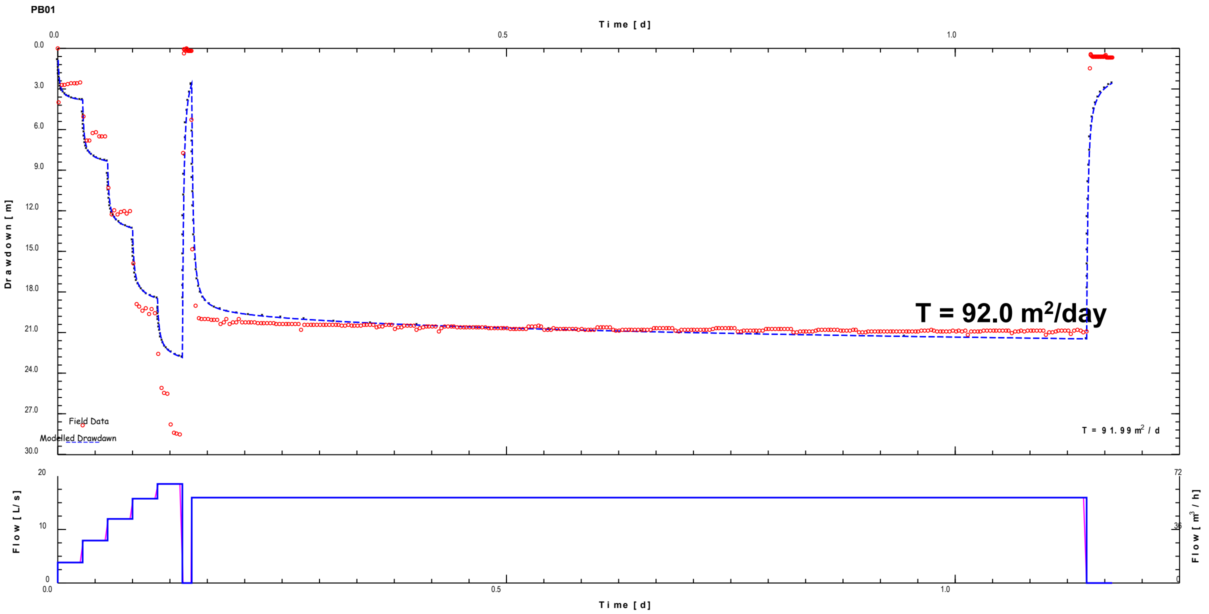
Appendix A

Test Pump Analyses

HYDRAULIC TEST ANALYSIS

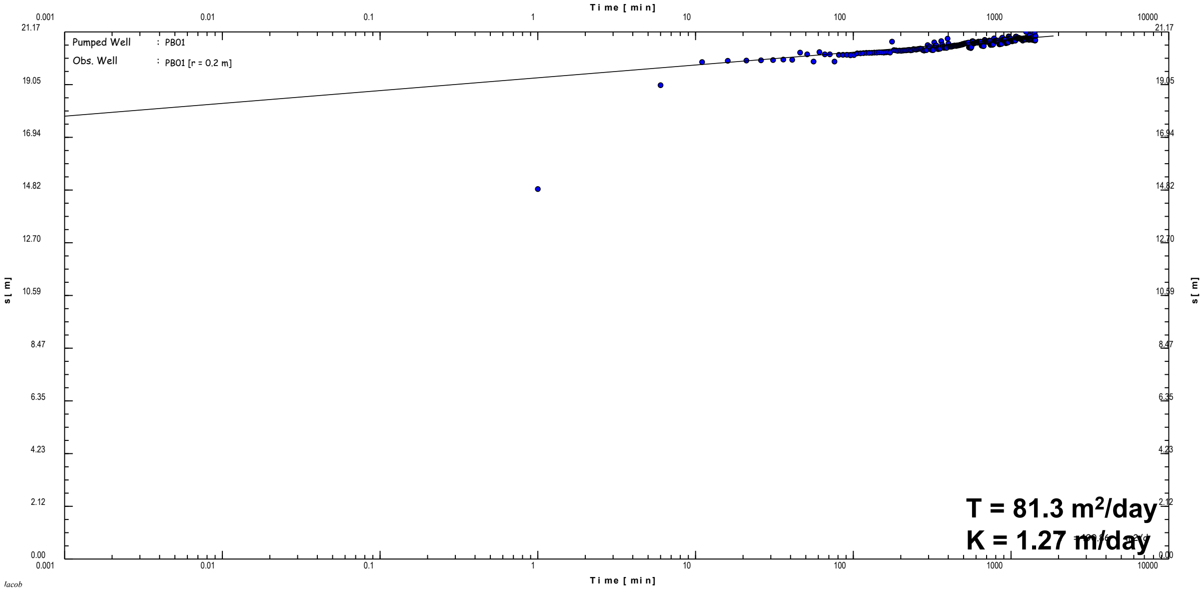
Project: 2364 Lamb Creek Water Bores

Bore: PB01



T = 92.0 m^2/day

a) Radflow Analysis



T = 81.3 m^2/day

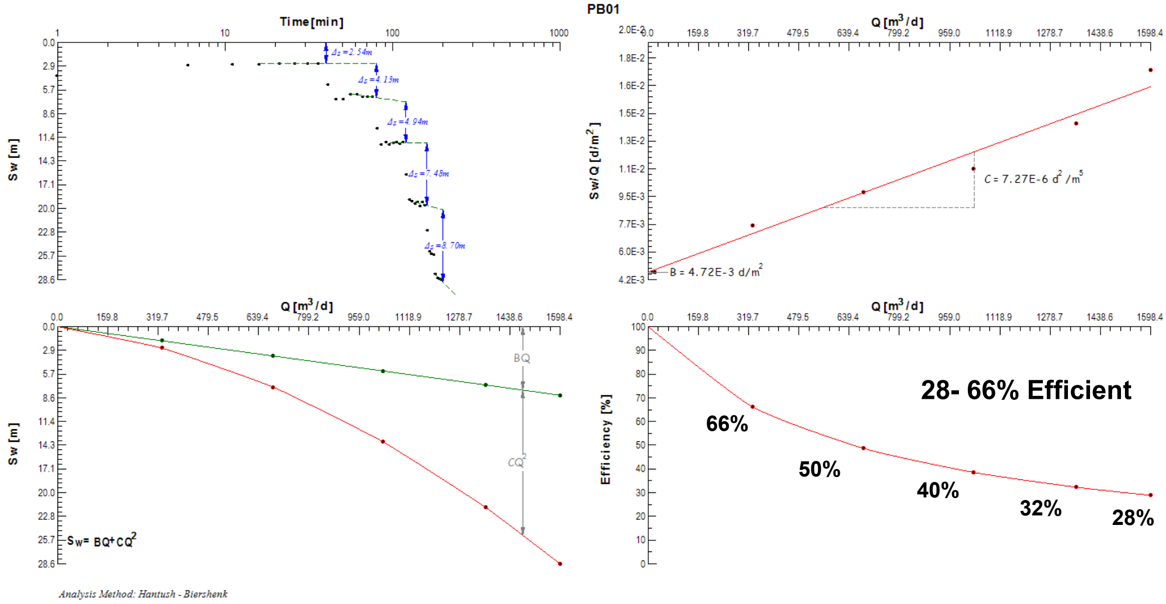
K = 1.27 m/day

b) Cooper Jacob Analysis

HYDRAULIC TEST ANALYSIS

Project: 2364 Lamb Creek Water Bores

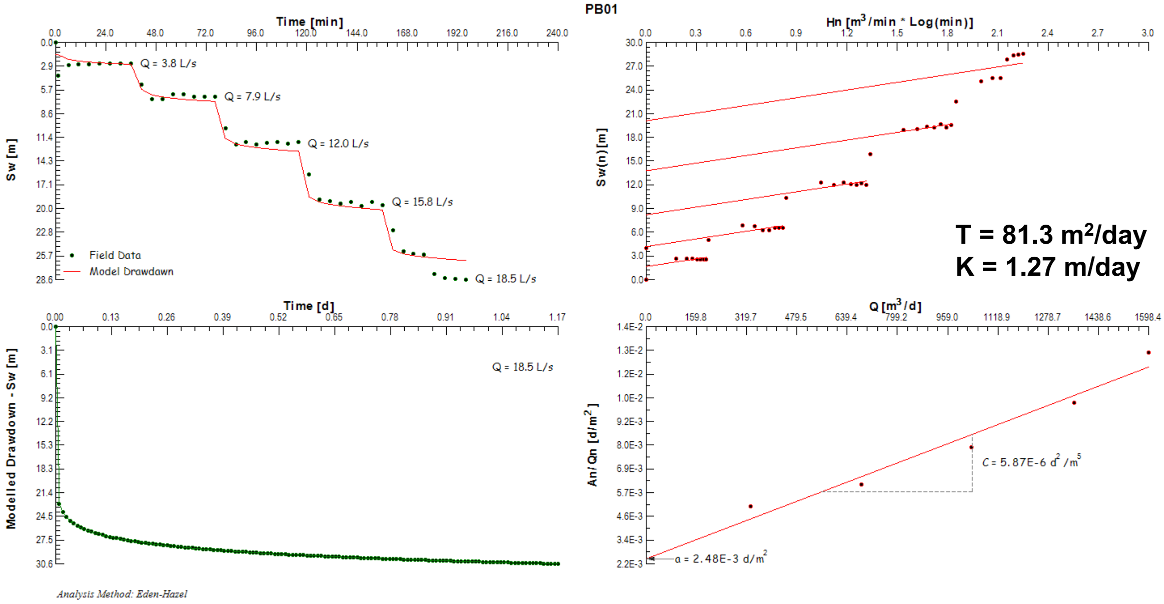
Bore: PB01



28- 66% Efficient

Analysis Method: Hantush - Biershenk

c) Hantush –Biershenk Analysis



T = 81.3 m^2/day
K = 1.27 m/day

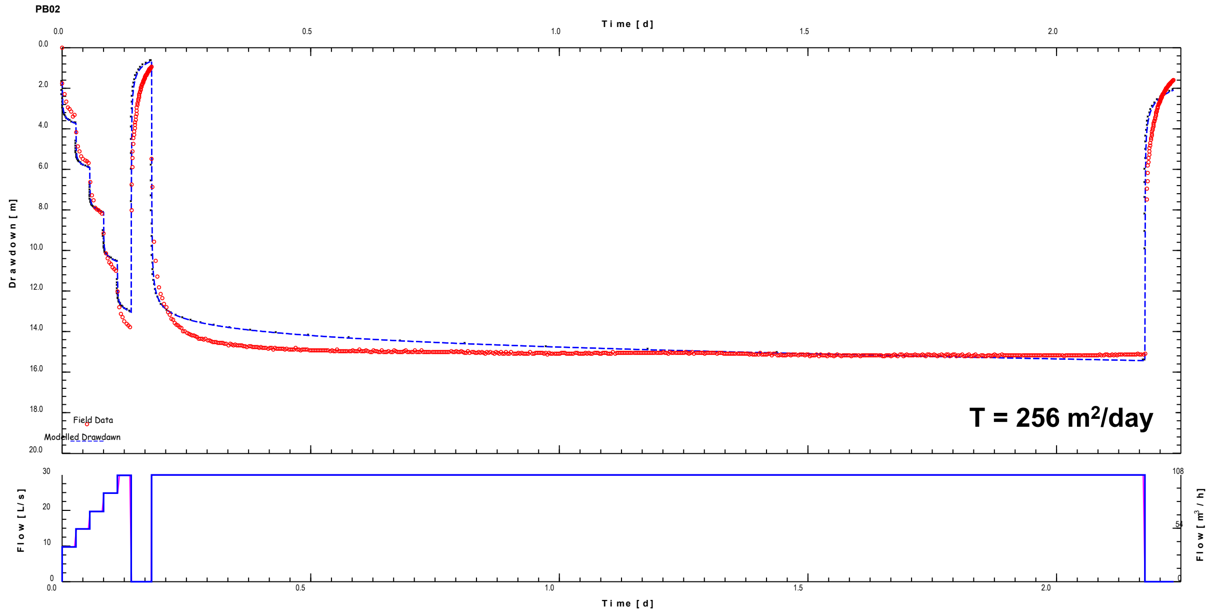
Analysis Method: Eden-Hazel

d) Eden Hazel Analysis

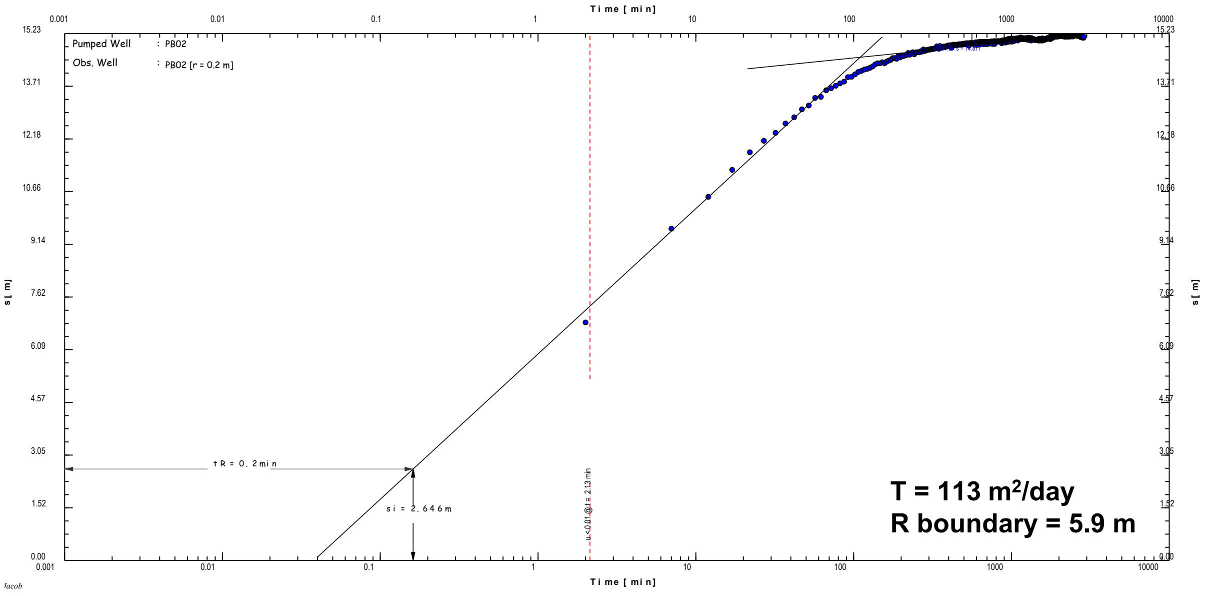
HYDRAULIC TEST ANALYSIS

Project: 2364 Lamb Creek Water Bores

Bore: PB02



a) Radflow Analysis

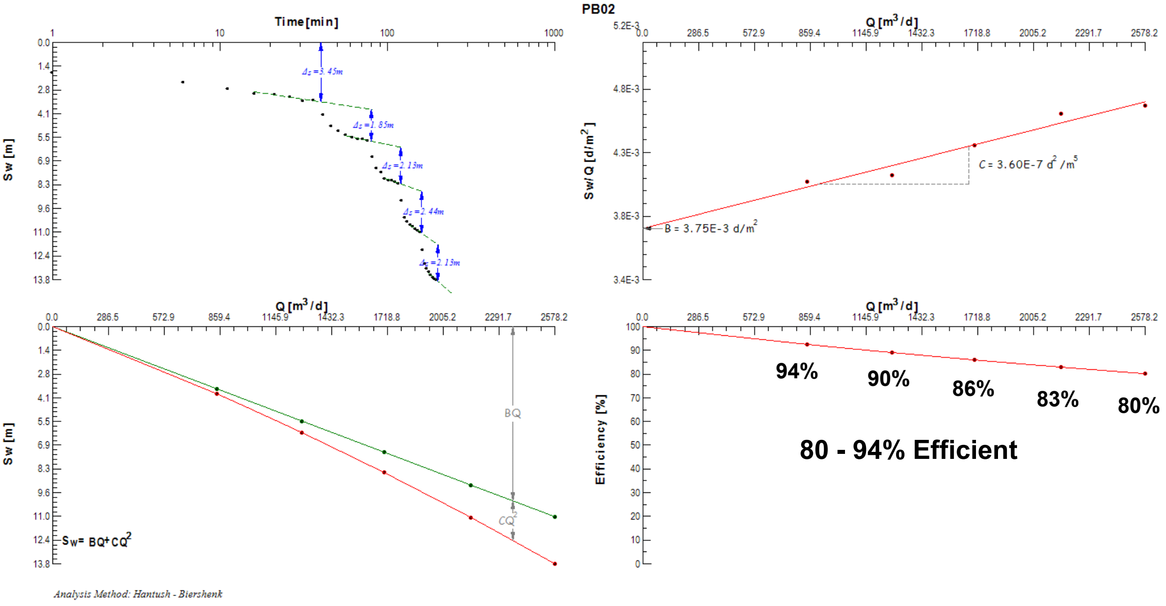


b) Cooper Jacob Analysis

HYDRAULIC TEST ANALYSIS

Project: 2364 Lamb Creek Water Bores

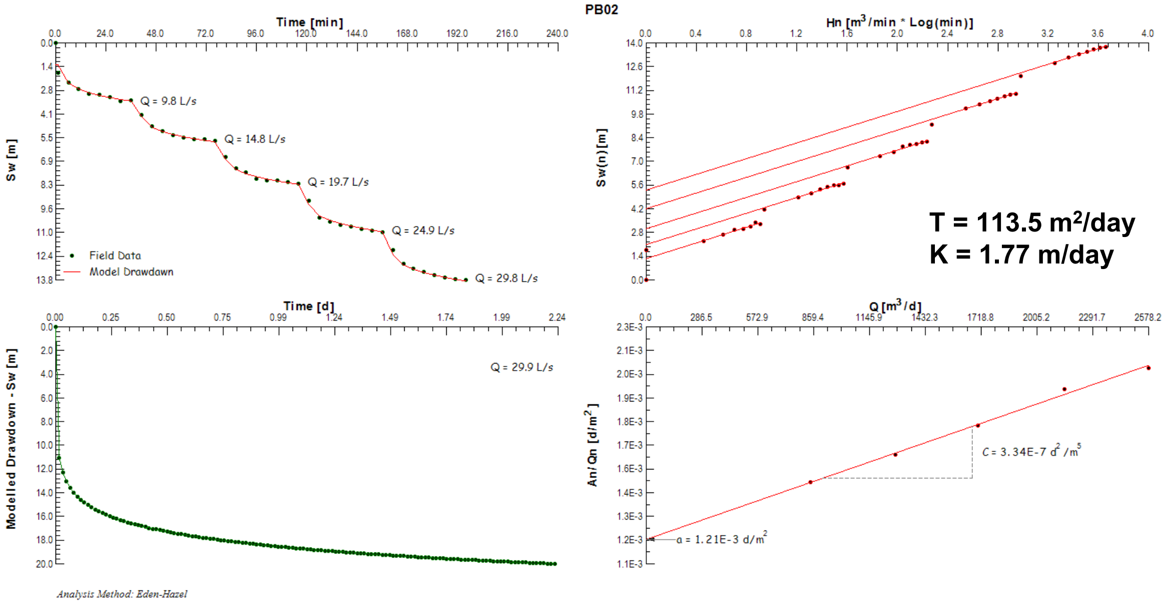
Bore: PB02



94% 90% 86% 83% 80%

80 - 94% Efficient

c) Hantush –Biershenk Analysis



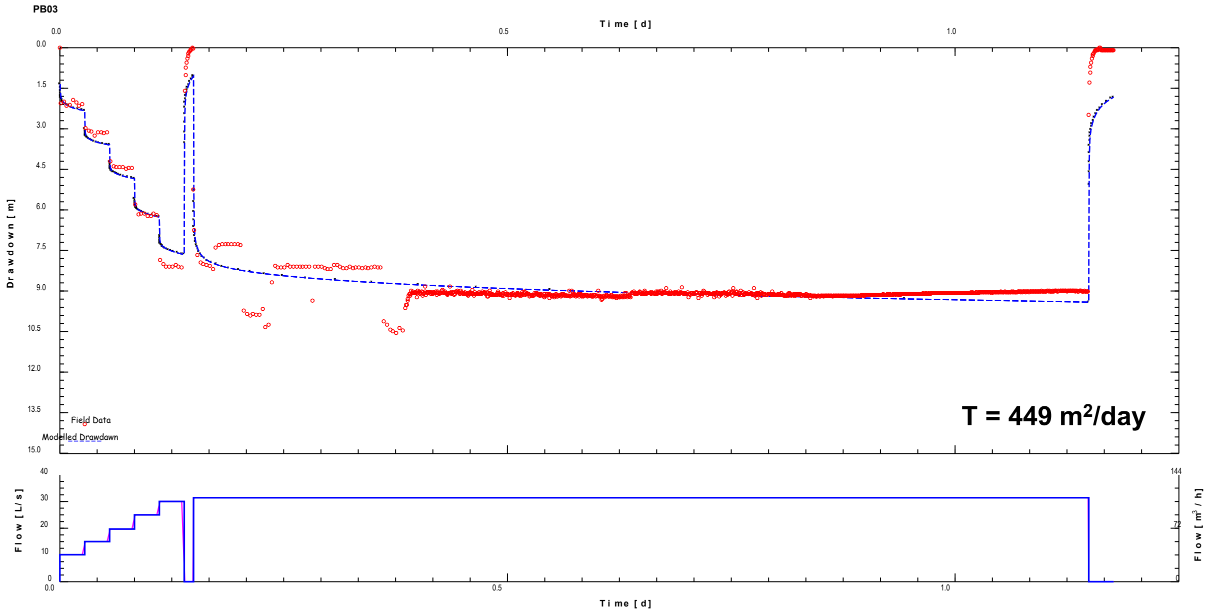
T = 113.5 m²/day
K = 1.77 m/day

d) Eden Hazel Analysis

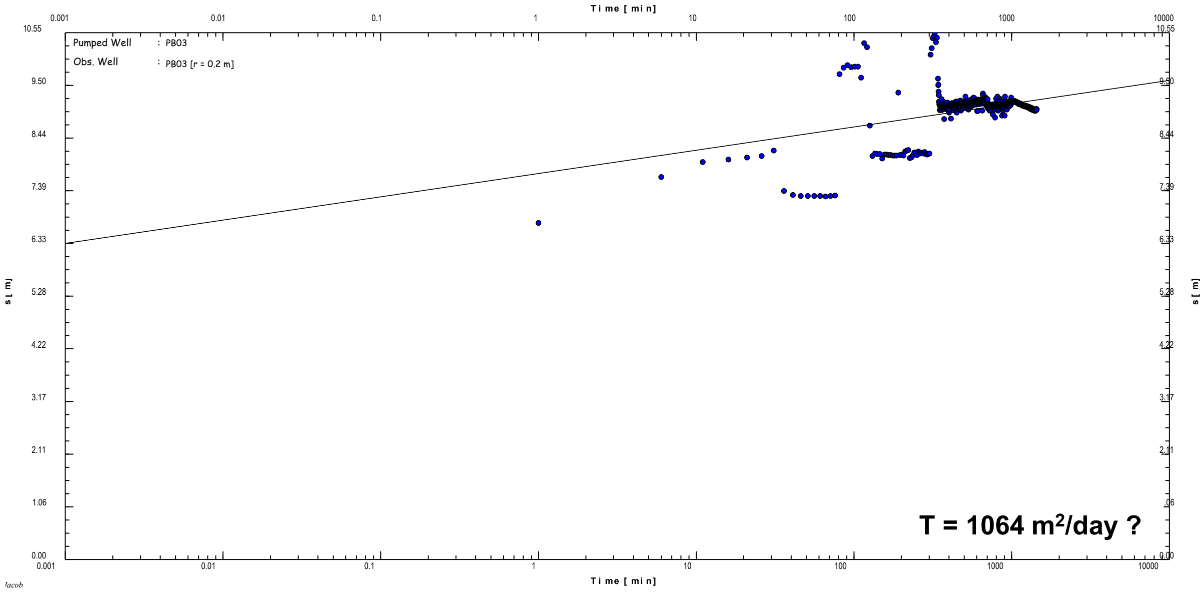
HYDRAULIC TEST ANALYSIS

Project: 2364 Lamb Creek Water Bores

Bore: PB03



a) Radflow Analysis

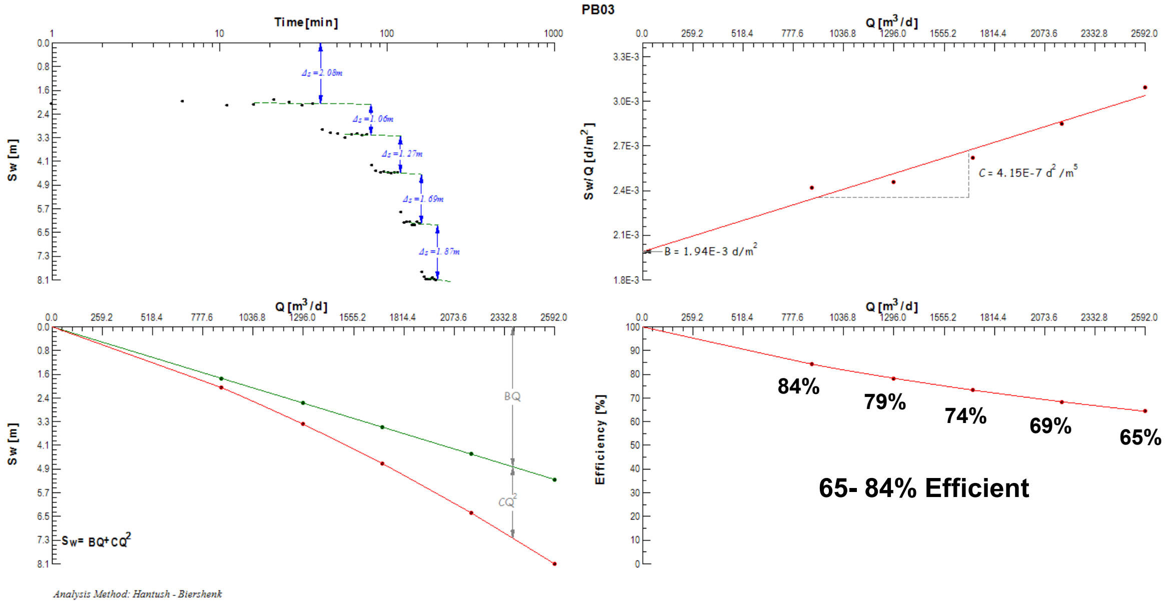


b) Cooper Jacob Analysis

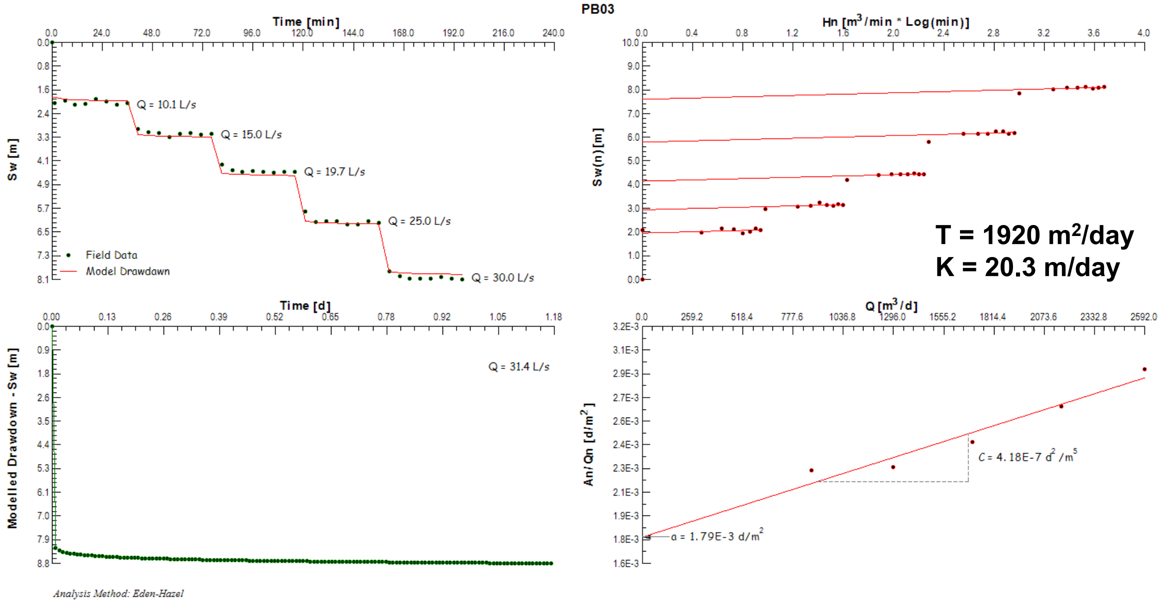
HYDRAULIC TEST ANALYSIS

Project: 2364 Lamb Creek Water Bores

Bore: PB03



c) Hantush –Biershenk Analysis



d) Eden Hazel Analysis

Appendix B

Specifications for recommended pumps

ZN660 08-L6W

Technical data

Company name
Contact
Phone number
e-mail address

Operating data

1	Pumpe type		Single head pump	Fluid		Water, pure
2	No. of pumps		1	Operating temperature t A	°C	4
3	Nominal flow	l/s	16	pH-value at t A		7
4	Nominal head	m	60	Density at t A	kg/dm³	1
5	Static head	m	0	Kin. viscosity at t A	mm²/s	1.569
6	Inlet pressure	bar	0.098	Vapor pressure at t A	bar	0.0083
7	Environmental temperature	°C	4	Solids		0
8	Available system NPSH	m	0	Altitude	m	0

Pump data

9	Design		Basins				
10	Execution		Standard version	Impeller Ø	Max.	mm	100
11	Operating speed	1/min	2847		designed	mm	8x 100 mm
12	Number of stages		8		Min.	mm	0
13	Suction nozzle		protected by strainer	Flow	Nominal	l/s	16.1 (16.1)
14	Discharge nozzle		Rp 3 / EN 10226		Max-	l/s	21.4
15	Max. casing pressure	bar			Min-	l/s	8.2
16	Max. working pressure	bar	11.8	Head	Nominal	m	60.5
17	Impeller type		Semi axial impeller		at Qmax	m	28
18	Head H(Q=0)	m	120		at Qmin	m	88.2
19	Total weight	kg	93.0	Shaft power		kW	12.49
20	Max. shaft power	kW	12.5	Power input		kW	15.41
21	NPSH 3%	m	3.3	Efficiency		%	76.08

Materials

22	Pump		Submersible motor	
23	Discharge head	Stainless steel, 1.4408, ASTM CF-8M (AISI 316)	Upper bracket	Cast iron, EN-JL1030, Class 25 B
24	Valve support	Stainless steel, 1.4408, ASTM CF-8M (AISI 316)	Spacer	Cast iron, EN-JL1030, Class 25 B
25	Valve	Stainless steel, 1.4404, AISI 316L	Cable	EPR
26	Elastomers	EPDM	Shaft end	AISI 431
27	Bolts and screws	Stainless steel, 1.4401, AISI 316	Elastomers	NBR
28	Shaft sleeve and bushing	Tungsten carbide	Motor sleeve	Stainless steel, 1.4306, AISI304L
29	Thrust bearing	PTFE+Graphite	Lower bracket	Cast iron, EN-JL1030, Class 25 B
30	Impeller	Stainless steel, 1.4404, AISI 316L	Thrust bearing bracket	Cast iron, EN-JL1030, Class 25 B
31	Diffuser	Stainless steel, 1.4404, AISI 316L		
32	Spacer	Duplex stainless steel, 1.4362, UNS S 32304		
33	Tie rod	Stainless steel, 1.4404, AISI 316L		
34	Cable guard	Stainless steel, 1.4404, AISI 316L		
35	Wear rings	Technopolymer PPO		
36	Strainer	Stainless steel, 1.4404, AISI 316L		
37	Shaft	Duplex stainless steel, 1.4462, UNS S 31803		
38	Coupling	Duplex stainless steel, 1.4362, UNS S 32304		
39	Lower support	Stainless steel, 1.4408, ASTM CF-8M (AISI 316)		
40				
41				

Motor data

Cable

42	Manufacturer	Lowara	Type	L6W150T405/C	Cable type		
43	Specific design	AISI 304 - 3ph water filled rewindable motors			Cable cross section	mmÃƒÆ’Ã¢â,¬Å¡Ãƒâ€šÃ,Â²	
44	Rated power	15 kW	Phases	3	Environmental temperature	°C	20
45	Corrected motor power	15 kW	No. starts / h	max. 20	cable length	m	
46	coolant speed	min. 0.3 m/s	Weight	66 kg			
47	Rated current	32.4 A	Electric voltage	400 V			
48	Reduced current	32.4 A	Starting mode	Directly			
49	Degree of protection	IP68	Nominal speed	2805 1/min			
50	motor connection		Installation				

Remarks

ZN660 08-L6W

Performance curve

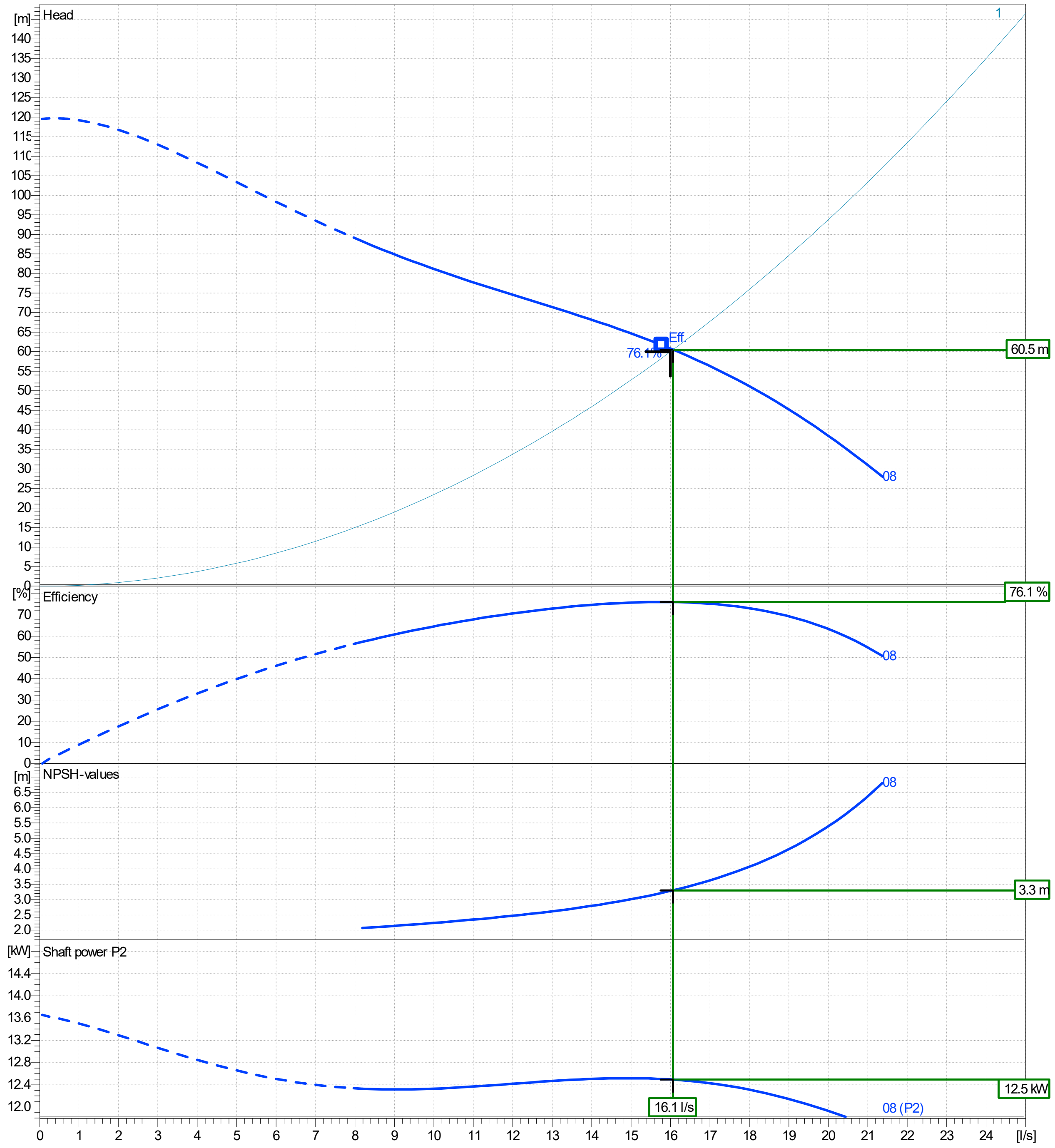
Company name
Contact
Phone number
e-mail address

	Ø	Pump capacity Operating range Min.	Max.	η Max.	Pump head H(Q=0)	η Max.	Shaft power P2 P2(Q=0)	Max.	η Max.
	mm	l/s	l/s	l/s	m	m	kW	kW	kW
actual	100	8.19	21.4	15.8	120	61.7		12.5	12.5
Min.	0	/	/	15.8	120	61.7		/	12.5
Max.	100	/	/	15.8	120	61.7		/	12.5

Frequency	Hz	50
Operating speed	1/min	2847
Nominal flow	l/s	16
Nominal head	m	60
Inlet pressure	bar	0.098
Static head	m	0

Power datas refered to: **hydr. Performance acceptance acc. To EN ISO 9906 Class Grade 3B**

Water, pure [100%] ; 4°C; 1kg/dm³; 1.57mm²/s



Project **Created by** **Last update**

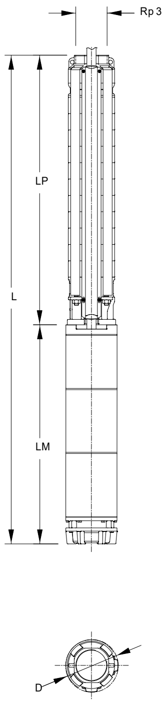
Block Artikel **Created on** 7/11/2022

Program version
65.0.1 - 27/09/2022 (Build 150)

Data version
20/10/2022 1:41 PM

User group(s)
Xylem:Australia - EXT,Products - Grindex

Pump with motor
Standard version
AISI 304 - 3ph water filled rewindable motors
L6W150T405/C



Dimensions	[mm]
L	2051
LM	833
LP	1218
ØD 1 Cable	142
ØD 2 Cable	144

Weight (+/- 5%)	[kg]
Total weight	**93**

Connections

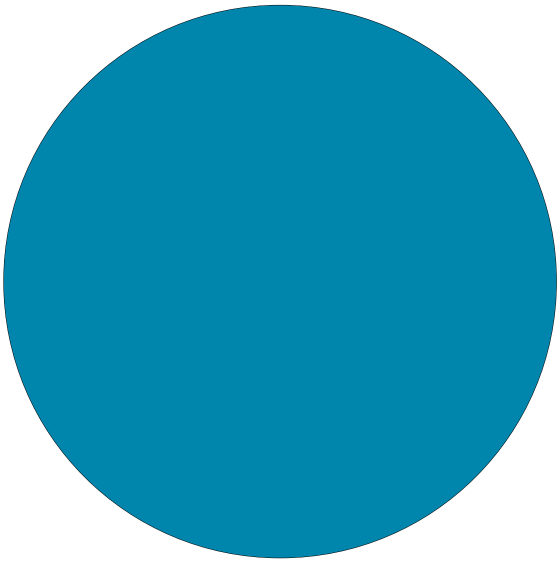
Suction nozzle	**Discharge nozzle**
protected by strainer	**Rp 3** **EN 10226**

Dimensions and weight without obligation

ZN660 08-L6W

Total lifetime	15	Inflation rate (rate of price increases)	2 %
Annual operating time	5600	Interest rate (for investment)	3 %
Energy cost per kWh	0.12 AUD		
Power input P1			

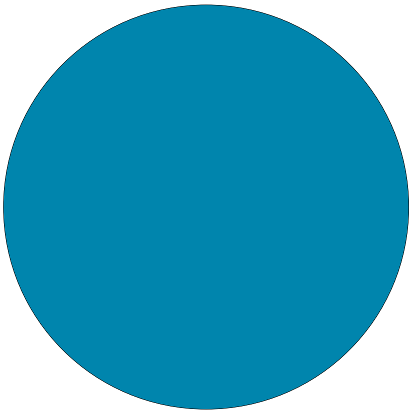
Total costs



100%	**142,057.77 AUD**	Energy
0%	**0.00 AUD**	Installation & commissioning
0%	**0.00 AUD**	Operating cost
0%	**0.00 AUD**	Maintenance & repair
0%	**0.00 AUD**	Downtime
0%	**0.00 AUD**	Environmental
0%	**0.00 AUD**	Decommissioning

142,057.77 AUD

First year costs



100%	**10,130.88 AUD**	Energy (1st year)
0%	**0.00 AUD**	Installation & commissioning (1st year)
0%	**0.00 AUD**	Operating cost (1st year)
0%	**0.00 AUD**	Maintenance & repair (1st year)
0%	**0.00 AUD**	Downtime (1st year)
0%	**0.00 AUD**	Environmental (1st year)
0%	**0.00 AUD**	Decommissioning (1st year)

10,130.88 AUD

Disclaimer: The calculations and the results are based on user input values and general assumptions and provide only estimated costs for the input data. Xylem inc can therefore not guarantee that the estimated savings will actually occur.

ZN660 10-L6W

Technical data

Company name
Contact
Phone number
e-mail address

Operating data

1	Pumpe type		Single head pump	Fluid		Water, pure
2	No. of pumps		1	Operating temperature t A	°C	4
3	Nominal flow	l/s	16	pH-value at t A		7
4	Nominal head	m	77	Density at t A	kg/dm³	1
5	Static head	m	0	Kin. viscosity at t A	mm²/s	1.569
6	Inlet pressure	bar	0.098	Vapor pressure at t A	bar	0.0083
7	Environmental temperature	°C	4	Solids		0
8	Available system NPSH	m	0	Altitude	m	0

Pump data

9	Design		Basins				
10	Execution		Standard version	Impeller Ø	Max.	mm	100
11	Operating speed	1/min	2870		designed	mm	10x 100 mm
12	Number of stages		10		Min.	mm	0
13	Suction nozzle		protected by strainer	Flow	Nominal	l/s	16.1 (16.1)
14	Discharge nozzle		Rp 3 / EN 10226		Max-	l/s	21.5
15	Max. casing pressure	bar			Min-	l/s	8.3
16	Max. working pressure	bar	15	Head	Nominal	m	77.5
17	Impeller type		Semi axial impeller		at Qmax	m	35.5
18	Head H(Q=0)	m	150		at Qmin	m	112
19	Total weight	kg	106.0	Shaft power		kW	15.97
20	Max. shaft power	kW	16	Power input		kW	19.22
21	NPSH 3%	m	3.3	Efficiency		%	76.21

Materials

22	Pump		Submersible motor	
23	Discharge head	Stainless steel, 1.4408, ASTM CF-8M (AISI 316)	Upper bracket	Cast iron, EN-JL1030, Class 25 B
24	Valve support	Stainless steel, 1.4408, ASTM CF-8M (AISI 316)	Spacer	Cast iron, EN-JL1030, Class 25 B
25	Valve	Stainless steel, 1.4404, AISI 316L	Cable	EPR
26	Elastomers	EPDM	Shaft end	AISI 431
27	Bolts and screws	Stainless steel, 1.4401, AISI 316	Elastomers	NBR
28	Shaft sleeve and bushing	Tungsten carbide	Motor sleeve	Stainless steel, 1.4306, AISI304L
29	Thrust bearing	PTFE+Graphite	Lower bracket	Cast iron, EN-JL1030, Class 25 B
30	Impeller	Stainless steel, 1.4404, AISI 316L	Thrust bearing bracket	Cast iron, EN-JL1030, Class 25 B
31	Diffuser	Stainless steel, 1.4404, AISI 316L		
32	Spacer	Duplex stainless steel, 1.4362, UNS S 32304		
33	Tie rod	Stainless steel, 1.4404, AISI 316L		
34	Cable guard	Stainless steel, 1.4404, AISI 316L		
35	Wear rings	Technopolymer PPO		
36	Strainer	Stainless steel, 1.4404, AISI 316L		
37	Shaft	Duplex stainless steel, 1.4462, UNS S 31803		
38	Coupling	Duplex stainless steel, 1.4362, UNS S 32304		
39	Lower support	Stainless steel, 1.4408, ASTM CF-8M (AISI 316)		
40				
41				

Motor data

Cable

42	Manufacturer	Lowara	Type	L6W185T405/C	Cable type		
43	Specific design	AISI 304 - 3ph water filled rewindable motors			Cable cross section	mmÃƒÆ’Ã¢â,¬Å¡Ãƒâ€šÃ,Â²	
44	Rated power	18.5 kW	Phases	3	Environmental temperature	°C	20
45	Corrected motor power	18.5 kW	No. starts / h	max. 20	cable length	m	
46	coolant speed	min. 0.3 m/s	Weight	74 kg			
47	Rated current	39.1 A	Electric voltage	400 V			
48	Reduced current	39.1 A	Starting mode	Directly			
49	Degree of protection	IP68	Nominal speed	2840 1/min			
50	motor connection		Installation				

Remarks

ZN660 10-L6W

Performance curve

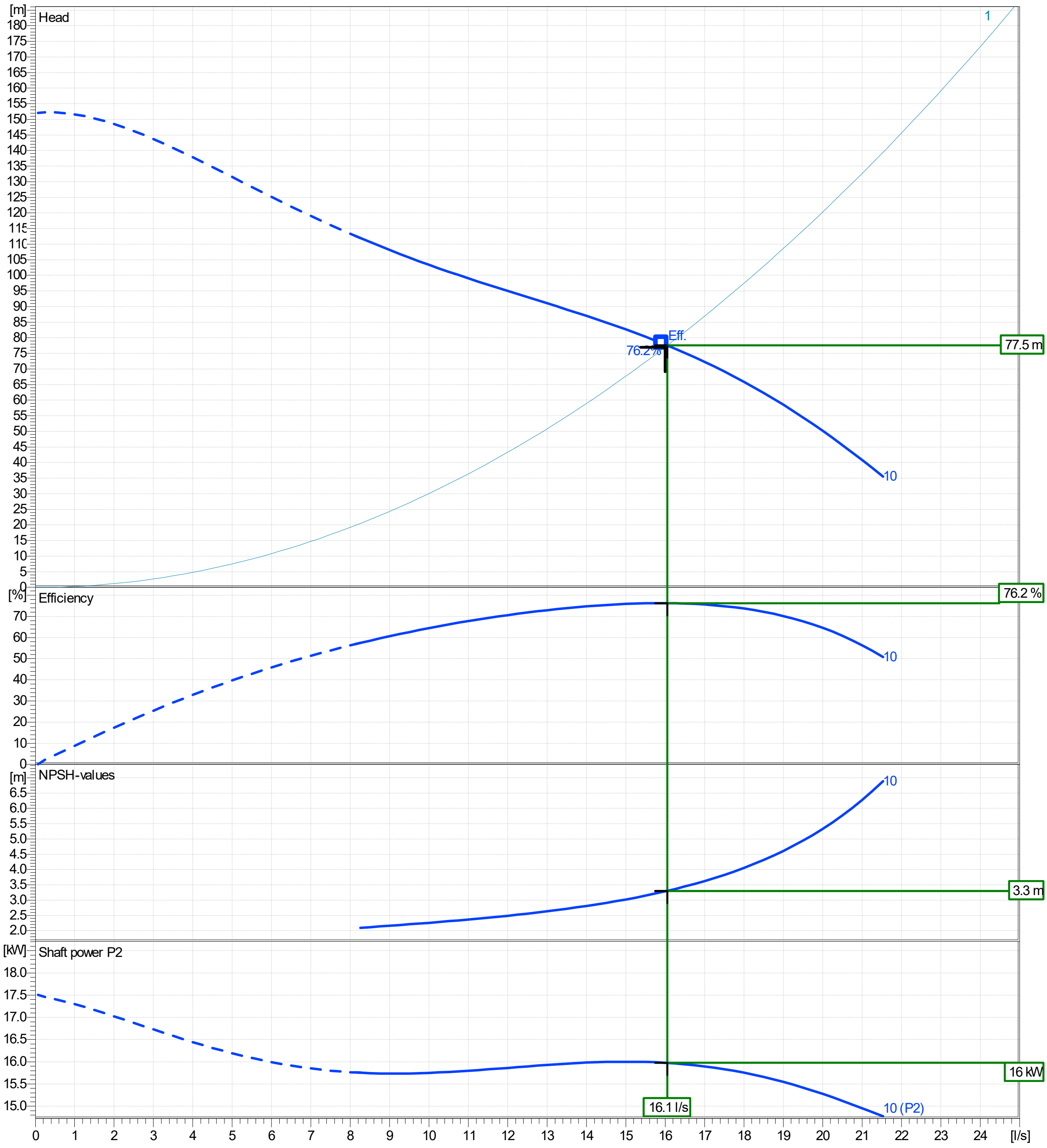
Company name
Contact
Phone number
e-mail address

	Ø	Pump capacity Operating range Min.	Max.	η Max.	Pump head H(Q=0)	η Max.	Shaft power P2 P2(Q=0)	Max.	η Max.
	mm	l/s	l/s	l/s	m	m	kW	kW	kW
actual	100	8.25	21.5	15.9	152	78.3		16	16
Min.	0	/	/	15.9	152	78.3		/	16
Max.	100	/	/	15.9	152	78.3		/	16

Frequency	Hz	50
Operating speed	1/min	2870
Nominal flow	l/s	16
Nominal head	m	77
Inlet pressure	bar	0.098
Static head	m	0

Power datas refered to: **hydr. Performance acceptance acc. To EN ISO 9906 Class** **Grade 3B**

Water, pure [100%] ; 4°C; 1kg/dm³; 1.57mm²/s



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Block	**Artikel**	**Created on**	7/11/2022	

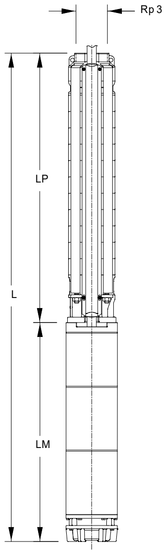
Program version
65.0.1 - 27/09/2022 (Build 150)
Data version
20/10/2022 1:41 PM
User group(s)
Xylem:Australia - EXT,Products - Grindex

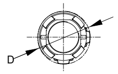
ZN660 10-L6W

Dimensions

Company name
Contact
Phone number
e-mail address

Pump with motor
Standard version
AISI 304 - 3ph water filled rewindable motors
L6W185T405/C





Dimensions	[mm]
L	2351
LM	903
LP	1448
ØD 1 Cable	142
ØD 2 Cable	144

Weight (+/- 5%)	[kg]
Total weight	**106**

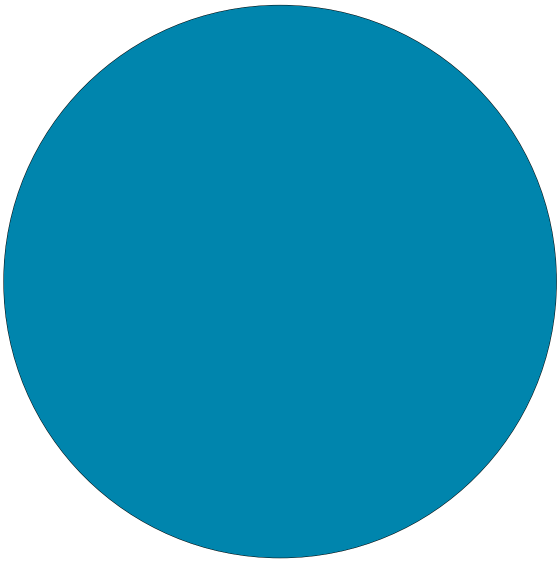
Connections	
Suction nozzle	**Discharge nozzle**
protected by strainer	**Rp 3** **EN 10226**

Dimensions and weight without obligation

ZN660 10-L6W

Total lifetime	15	Inflation rate (rate of price increases)	2 %
Annual operating time	5600	Interest rate (for investment)	3 %
Energy cost per kWh	0.12 AUD		
Power input P1			

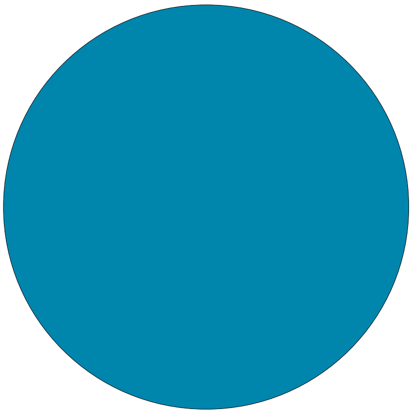
Total costs



100%	**177,475.26 AUD**	Energy
0%	**0.00 AUD**	Installation & commissioning
0%	**0.00 AUD**	Operating cost
0%	**0.00 AUD**	Maintenance & repair
0%	**0.00 AUD**	Downtime
0%	**0.00 AUD**	Environmental
0%	**0.00 AUD**	Decommissioning

177,475.26
AUD

First year costs



100%	**12,656.69 AUD**	Energy (1st year)
0%	**0.00 AUD**	Installation & commissioning (1st year)
0%	**0.00 AUD**	Operating cost (1st year)
0%	**0.00 AUD**	Maintenance & repair (1st year)
0%	**0.00 AUD**	Downtime (1st year)
0%	**0.00 AUD**	Environmental (1st year)
0%	**0.00 AUD**	Decommissioning (1st year)

12,656.69
AUD

Disclaimer: The calculations and the results are based on user input values and general assumptions and provide only estimated

ZN646 09-L6W

Technical data

Company name
Contact
Phone number
e-mail address

Operating data

1	Pumpe type		Single head pump	Fluid		Water, pure
2	No. of pumps		1	Operating temperature t A	°C	4
3	Nominal flow	l/s	12	pH-value at t A		7
4	Nominal head	m	74	Density at t A	kg/dm³	1
5	Static head	m	0	Kin. viscosity at t A	mm²/s	1.569
6	Inlet pressure	bar	0.098	Vapor pressure at t A	bar	0.0083
7	Environmental temperature	°C	4	Solids		0
8	Available system NPSH	m	0	Altitude	m	0

Pump data

9	Design		Basins				
10	Execution		Standard version	Impeller Ø	Max.	mm	99
11	Operating speed	1/min	2854		designed	mm	9x 99 mm
12	Number of stages		9		Min.	mm	0
13	Suction nozzle		protected by strainer	Flow	Nominal	l/s	12.1 (12.1)
14	Discharge nozzle		Rp 3 / EN 10226		Max-	l/s	16.4
15	Max. casing pressure	bar			Min-	l/s	6.6
16	Max. working pressure	bar	14.7	Head	Nominal	m	75.5
17	Impeller type		Semi axial impeller		at Qmax	m	43.8
18	Head H(Q=0)	m	150		at Qmin	m	106.8
19	Total weight	kg	96.0	Shaft power		kW	12.10
20	Max. shaft power	kW	12.2	Power input		kW	14.92
21	NPSH 3%	m	2.5	Efficiency		%	74.29

Materials

22	Pump		Submersible motor	
23	Discharge head	Stainless steel, 1.4408, ASTM CF-8M (AISI 316)	Upper bracket	Cast iron, EN-JL1030, Class 25 B
24	Valve support	Stainless steel, 1.4408, ASTM CF-8M (AISI 316)	Spacer	Cast iron, EN-JL1030, Class 25 B
25	Valve	Stainless steel, 1.4404, AISI 316L	Cable	EPR
26	Elastomers	EPDM	Shaft end	AISI 431
27	Bolts and screws	Stainless steel, 1.4401, AISI 316	Elastomers	NBR
28	Shaft sleeve and bushing	Tungsten carbide	Motor sleeve	Stainless steel, 1.4306, AISI304L
29	Thrust bearing	PTFE+Graphite	Lower bracket	Cast iron, EN-JL1030, Class 25 B
30	Impeller	Stainless steel, 1.4404, AISI 316L	Thrust bearing bracket	Cast iron, EN-JL1030, Class 25 B
31	Diffuser	Stainless steel, 1.4404, AISI 316L		
32	Spacer	Duplex stainless steel, 1.4362, UNS S 32304		
33	Tie rod	Stainless steel, 1.4404, AISI 316L		
34	Cable guard	Stainless steel, 1.4404, AISI 316L		
35	Wear rings	Technopolymer PPO		
36	Strainer	Stainless steel, 1.4404, AISI 316L		
37	Shaft	Duplex stainless steel, 1.4462, UNS S 31803		
38	Coupling	Duplex stainless steel, 1.4362, UNS S 32304		
39	Lower support	Stainless steel, 1.4408, ASTM CF-8M (AISI 316)		
40				
41				

Motor data

42	Manufacturer	Lowara	Type	L6W150T405/C
43	Specific design	AISI 304 - 3ph water filled rewindable motors		
44	Rated power	15 kW	Phases	3
45	Corrected motor power	15 kW	No. starts / h	max. 20
46	coolant speed	min. 0.3 m/s	Weight	66 kg
47	Rated current	32.4 A	Electric voltage	400 V
48	Reduced current	32.4 A	Starting mode	Directly
49	Degree of protection	IP68	Nominal speed	2805 1/min
50	motor connection		Installation	

Cable

Cable type		
Cable cross section	mmÃƒÆ’Ã¢â‚¬Å¡Ãƒâ€šÃ‚²	
Environmental temperature	°C	20
cable length	m	

Remarks

Project	**Created by**
Block Artikel	**Created on** 7/11/2022
Last update	

Program version
65.0.1 - 27/09/2022 (Build 150)

Data version
20/10/2022 1:41 PM

User group(s)
Xylem:Australia - EXT,Products - Grindex

ZN646 09-L6W

Performance curve

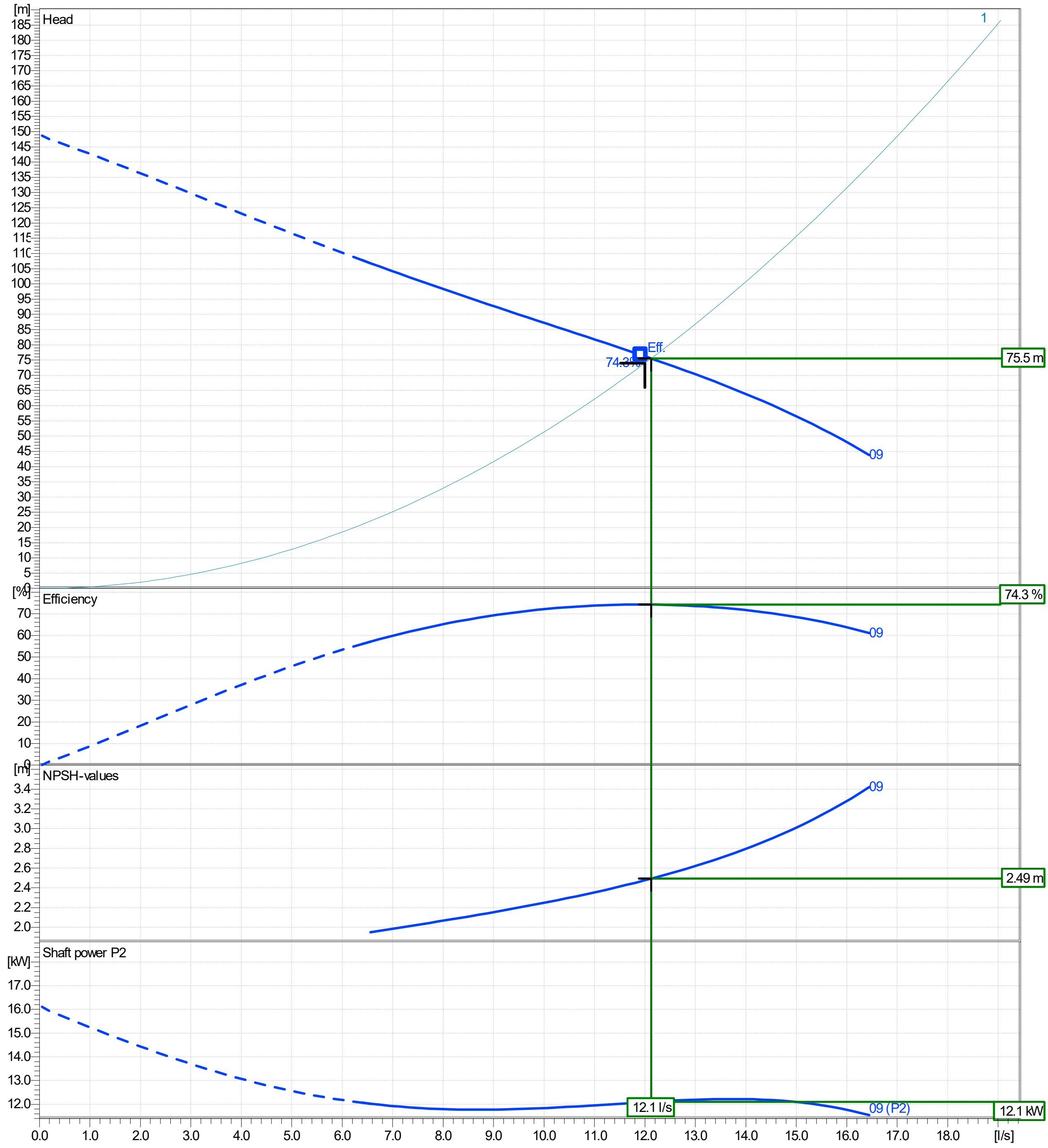
Company name
Contact
Phone number
e-mail address

	Ø	Pump capacity			Pump head		Shaft power P2			Frequency	Hz	50
		Operating range Min.	Max.	η Max.	H(Q=0)	η Max.	P2(Q=0)	Max.	η Max.	Operating speed	1/min	2854
	mm	l/s	l/s	l/s	m	m	kW	kW	kW	Nominal flow	l/s	12
actual	99	6.56	16.4	11.9	149	76.7		12.2	12.1	Nominal head	m	74
Min.	0	/	/	11.9	149	76.7		/	12.1	Inlet pressure	bar	0.098
Max.	99	/	/	11.9	149	76.7		/	12.1	Static head	m	0

Power datas refered to:

Water, pure [100%] ; 4°C; 1kg/dm³; 1.57mm²/s

hydr. Performance acceptance acc. To EN ISO 9906 Class **Grade 3B**



Project
Block **Artikel**

Created by
Created on **7/11/2022**

Last update

Program version
65.0.1 - 27/09/2022 (Build 150)

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20/10/2022 1:41 PM

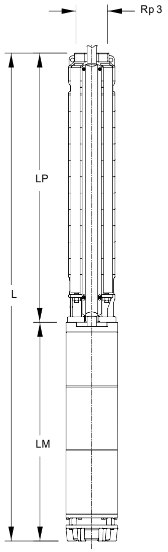
User group(s)
Xylem: Australia - EXT, Products - Grindex

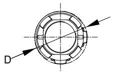
ZN646 09-L6W

Dimensions

Company name
Contact
Phone number
e-mail address

Pump with motor
Standard version
AISI 304 - 3ph water filled rewindable motors
L6W150T405/C





Dimensions	[mm]
L	2166
LM	833
LP	1333
ØD 1 Cable	142
ØD 2 Cable	144

Weight (+/- 5%)	[kg]
Total weight	**96**

Connections

Suction nozzle	Discharge nozzle
protected by strainer	**Rp 3** **EN 10226**

Dimensions and weight without obligation

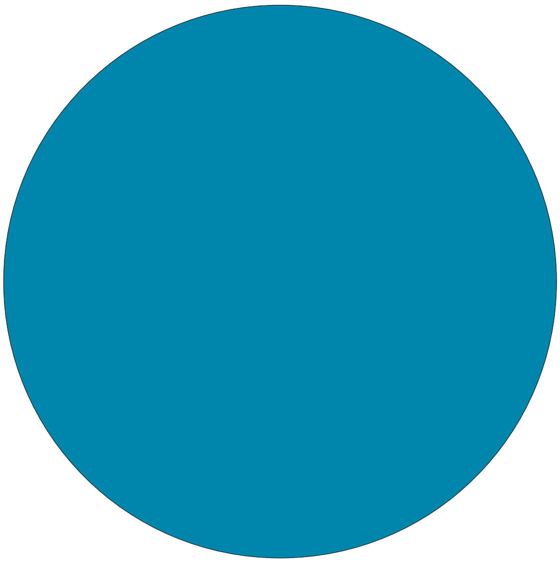
Project		**Created by**		**Last update**
Block	**Artikel**	**Created on**	**7/11/2022**	

Program version	Data version	User group(s)
65.0.1 - 27/09/2022 (Build 150)	20/10/2022 1:41 PM	Xylem: Australia - EXT, Products - Grindex

ZN646 09-L6W

Total lifetime	15	Inflation rate (rate of price increases)	2 %
Annual operating time	5600	Interest rate (for investment)	3 %
Energy cost per kWh	0.12 AUD		
Power input P1			

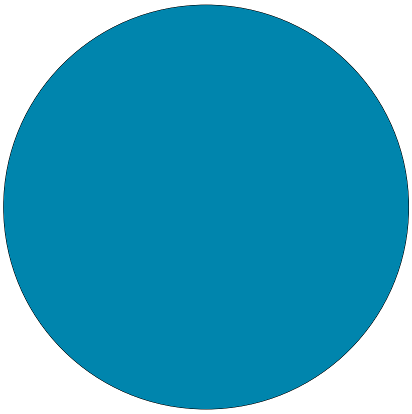
Total costs



100%	**135,002.55 AUD**	Energy
0%	**0.00 AUD**	Installation & commissioning
0%	**0.00 AUD**	Operating cost
0%	**0.00 AUD**	Maintenance & repair
0%	**0.00 AUD**	Downtime
0%	**0.00 AUD**	Environmental
0%	**0.00 AUD**	Decommissioning

135,002.55
AUD

First year costs



100%	**9,627.74 AUD**	Energy (1st year)
0%	**0.00 AUD**	Installation & commissioning (1st year)
0%	**0.00 AUD**	Operating cost (1st year)
0%	**0.00 AUD**	Maintenance & repair (1st year)
0%	**0.00 AUD**	Downtime (1st year)
0%	**0.00 AUD**	Environmental (1st year)
0%	**0.00 AUD**	Decommissioning (1st year)

9,627.74
AUD

Disclaimer: The calculations and the results are based on user input values and general assumptions and provide only estimated

Lamb Creek Iron Ore Project

Hydrogeological Assessment

PSM4241-004R 24 May 2021

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1. Introduction

Mineral Resources Limited (MRL) is intending to develop the Lamb Creek Iron Ore Project (the Project). Tenement M47/0019 covers the Project area in the upper reaches of the Marillana Creek, on the Mine Creek tributary. The Project setting is the upper reaches of the Marillana Creek catchment, approximately 90 km northwest of Newman, 14 km southwest of the BHP Yandi Mine, 31 km west of the RTIO Yandicoogina Mine, and 12 km north of BHP Area C Mine (Figure 1). Both the Yandi and Yandicoogina mines are also in the Marillana Creek catchment, on lower reaches. The Brockman Iron Formation orebody will be mined by open-pit methods for a period of twenty-six months, with mining below the water table planned during the last four months of operations. During operations there will be pit dewatering abstractions and a beneficial use water demand of about 30 L/sec (approximately 1 GL/annum) for construction, dust suppression and processing requirements. A secure water supply is required to meet this demand; under ideal circumstances this demand would be matched to the pit dewatering abstractions. Pit dewatering abstraction rates may, however, differ from the beneficial use water demands, alluding to the need of supplementary supply sources or alternatively surplus groundwater disposal.

This report presents a H2 hydrogeological assessment (DWER Operational Policy Number 5.12, 2009) for the proposed Lamb Creek Iron Ore Mine (the Project) in the Pilbara. The H2 level of assessment:

- Frames a basic hydrogeological assessment with the intention of informing a Mining Proposal, describing the potential pit dewatering for mining below the water table and beneficial use water supply requirements
- Is informed by groundwater exploration bores within the Project area, culminating in the measurements of groundwater yields and quality during drilling, construction of standpipe monitoring bores and slug tests to characterise point source hydraulics of local groundwater flow in weathered and fractured rocks
- Informs the requirement of Section 5C licence applications for the Project.

There are several registered heritage sites on Tenement M47/0019 and several potentially sensitive ecosystems in the Marillana Creek catchment. It is noteworthy that groundwater abstraction for dewatering of Channel Iron Deposits and discharge of surplus groundwater has occurred to support long-term mining operations at the Yandi and Yandicoogina mines.

1.1 Scope of Work

The hydrogeological assessment is informed by site investigations that involved groundwater exploration drilling and the construction of several monitoring bores. The scope of work for the site investigations included:

- Supervise drilling of pilot holes
- Support decisions for construction of monitoring bores
- Use of findings and facts to reconcile forward works program in context to water supply
- Record relevant hydrogeological data (for example airlift yield, groundwater strikes, loss circulation, cuttings wetness and so on)
- Geological logging of cuttings
- Perform in-situ hydraulic testing and analyse results
- Sample groundwater for laboratory analysis
- Redact bore completion reports/diagrams.

Outcomes form the groundwater exploration included a current snapshot of groundwater heads, groundwater quality and point-source hydraulics. Specific outputs from the site investigations and hydrogeological assessment included:

- A site water balance for dewatering, operational uses, discharge requirements, and groundwater recharge
- Groundwater quality from laboratory analysis
- Aquifer hydraulics for hydrogeological rock mass units in the pit and identified water supply sources
- Groundwater model and parameterisation as informed by the groundwater exploration
- Characterisation of transient pit dewatering rates, volumes, and drawdown footprint
- Closure landforms and pit-lake expressions.

2. Lamb Creek Mining Plans

Iron ore is hosted in the Brockman Iron Formation (Figure 2). Mineralisation occurs over a 1 km southwest to northeast strike length, width of 200 to 400 m wide and thickness from 30 to 60 m.

Mining plans for Lamb Creek have been developed at a concept level. The orebody will be mined by open-cut operations for a period of twenty-six months, with the single pit (shown on Figure 2) extending to depths of up to 95 m below the ground surface (640 m RL). The proposed mining schedule is shown in Table 1. Mining below the water table is first expected in Month 23, extending to a maximum of about 33 m below the water table by Month 26.

Following cessation of mining, the pit will be backfilled to above the water table.

Initial short-term water demand of approximately 0.5 L/sec (1.3 ML/month) is required for drilling and camp construction. During operations there will be a water demand of about 30 L/sec (1 GL/annum) for construction, dust suppression and processing requirements. A secure water supply is required to meet this supply demand.

Table 1 – Proposed Mining Schedule

Mining Period (Month)	Open Pit Mining Elevation (m RL)
1	730
2 – 5	720
6 – 9	710
10 – 14	700
15 – 19	690
20 – 22	680
23 – 24	670
25	660
26	640

3. Lamb Creek Setting

3.1 Climate

The Project area has an arid climate with hot summers and mild winters. Indicative monthly rainfall statistics are shown in Table 2 for the Bureau of Meteorology (BOM) weather stations that are nearby, including:

- Marillana Station: station 5009; 22.63° S 119.41° E, elevation: 430 m, approximate distance 60 km northeast from the Project area
- Newman Station: station 7151; 31.76° S 119.45° E, elevation: 400 m, 110 km southeast from the Project area
- Newman Aero Station: station 7176; 31.76° S 119.45° E, elevation: 400 m, 110 km southeast from the Project area.

The duration of operation for each BOM station is shown in Table 2.

Rainfall is widely variable by month and year. The long-term average annual rainfall in the region is in the range 310 to 330 mm. The highest rainfall occurs during episodic events in summer and autumn (January to March), generally associated with thunderstorms and tropical cyclones. The driest months are August to October.

Pan evaporation averages are shown for the Newman Aero station based on data between 1996 and 2013 (Table 2; RPS 2013). Evaporation greatly exceeds rainfall and is on average about 3,730 mm annually.

Table 2 – Climate Data Summary

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Rainfall (mm)													
Marillana (1936)	79.1	68.9	49.1	23.6	21.2	20.4	14	5.6	3.1	5.3	10.4	27.8	328.5
Newman (1965-2003)	51.4	80.1	38.6	25.3	23.2	25	12.6	10.5	4.1	3.9	9.7	27	311.4
Newman Aero (1971-)	69.2	70.2	41.7	21.3	18.4	15.9	14.4	6.4	3.6	5.9	12.4	35.3	314.7
Average Evaporation (mm)													
Newman Aero (1996-2013 data)	461	369	343	290	174	173	199	193	264	377	424	466	3733

3.2 Stream Flow

The Project is situated at elevations of about 700 to 1,010 m RL in the upper Marillana Creek catchment, with water-shedding northward to upper reaches of Marillana Creek. The Project is located about 600 m east of an un-named tributary of Marillana Creek, here referred as Mine Creek as in previous reports (AQ2 2020). Mine Creek drains northward to a confluence with Marillana Creek about 9 km north of the Project area. Marillana Creek flows into Weeli Wolli Creek about 60 km downstream of the Project, with ultimate discharge to the Fortescue Marsh. Lamb Creek is located 7 km to the east of the orebody and is also a tributary to Marillana Creek.

Creek flow is ephemeral, with relatively short duration flow following episodic rainfall events. Marillana Creek is gauged at Flat Rocks, about 24 km northeast of the Project area and with a source area of about 1,400 km^2. Flow on Marillana Creek occurs on average for 10 days a year (AQ2 2020b). Episodic stream flow events may overtop the Mine Creek low-flow channel and extend over the local floodplain.

3.3 Geology

The geology over the wider area is dominated by:

- Quaternary / Tertiary Transported valley-fill alluvium and unconsolidated detrital sediments – Recent, Quaternary and Tertiary
- Brockman Iron Formation (BIF) - Joffre, Mt Whaleback and Dales Gorge members
- Mount McRae Shale
- Weeli Wolli Formation.

The surface geology is shown in Figure 2. Fresh rock outcrops on the hill tops and upper slopes of the landscape and are dominated by BIF in the Project area. The surficial geology beneath valley floors and lower slopes consists of unconsolidated Quaternary and Tertiary sediments and or weathered and lateritic zones.

The Quaternary alluvium and colluvium (corresponding to Qa and Qw zones on Figure 2) comprise unconsolidated silt, sand, and gravel to sandy and clayey soil. These alluvium and colluvium beds may thicken towards Mine Creek.

Tertiary detrital of up to about 30 m thickness overly the bedrock beneath the Project area. These typically comprise immature detrital (unsorted, sub-angular to sub-rounded, coarse to medium BIF and chert fragments, within a partial red clay matrix) overlying more mature detrital (sorted, sub-angular to sub-rounded, coarse to medium BIF fragments with a red clay matrix). Weathering often occurs at the contact between Tertiary detrital and underlying basement and is represented as a vuggy hard-cap zone.

Within the proposed pit, BIF consists of three main members, with overall stratigraphy dipping to the north:

- Joffre Member
- Mt Whaleback Shale Member
- Dales Gorge Member (consisting of Dales Gorge Members 1, 2, 3 and 4).

Mineralisation occurs over a 1 km southwest to northeast strike length, width of 200 to 400 m and thickness from 30 to 60 m. The high-grade iron mineralisation is hosted mainly in the Dales Gorge Member, with a minor component in the Joffre Member and Mt McRae Shale.

The Project area is located on the southern section of the regional Yandicoogina Syncline, and lies on a broad, west-southwest trending anticlinal structure and associated syncline. Locally, the Joffre Member and Dales Gorge Member have minor cross-folding on northeast to southwest orientated axes.

Several north to south lineaments and potential faults are inferred beneath Mine Creek and immediate surrounds (Figure 2), influencing the creek alignment. Faults have potential to influence the hydrogeology with fractured rocks providing preferred flow paths and enabling deeper penetration of weathering.

3.4 Groundwater Dependent Ecosystems

Locally, tine Mine Creek is characterised by sparse riparian vegetation. Water table settings within the Project area are also comparatively deep (typically greater than 10 m), indicating unlikely groundwater dependency. To the north, near the Mine Creek and Marillana Creek confluence, it is expected that mapped calcretes reflect groundwater discharge zones, hence shallow water table environments. Calcretes with vuggy and karst textures may commonly host stygofauna and troglofaunal habitats.

Below the confluence with Marillana Creek, groundwater-fed springs, and seasonal pools at Flat Rocks, about 24 km downstream of the Project area, (Rio Tinto 2010) the shallow water table potentially supports riparian vegetation.

In the lower Marillana, Yandicoogina and Weeli Wolli creek systems, the unconfined alluvial aquifers recharged by creek floodwater support significant stands of riparian vegetation (Rio Tinto 2010). These riparian stands include Eucalyptus camaldulensis, E. victrix and M. argentea vegetation communities, which are somewhat dependent on water stored within the alluvial aquifer. This aquifer provides storage and through-flow base flow to support water sensitive vegetation species such as Melaleuca argentea.

In a regional context, potential groundwater dependent ecosystems (GDEs) include:

- Marillana Creek – riparian vegetation and seasonal pools in the Flat Rocks area, about 24 km downstream of the Project
- Weeli Wolli Creek – riparian vegetation and seasonal pools. Threatened Ecological Communities (for example at Weeli Wolli Spring), upstream of the confluence with Marillana Creek
- Fortescue Marsh, approximately 100 km downstream and northeast of the Project. It is the largest ephemeral wetland in the Pilbara and is a Threatened Ecological Community and draft proposed RAMSAR wetland.

Figure 3 shows the known groundwater dependent ecosystems. The Mine Creek and upper Marillana Creek also host priority flora and heritage sites. These are shown on Figure 4; the priority floras are not identified as groundwater dependent.

4. Lamb Creek Site Investigations

4.1 Introduction

The Lamb Creek groundwater exploration targeted interpreted fault and lineament intersections, both in the proposed pit setting and along the Mine Creek and tributaries. Groundwater exploration site investigations were conducted within the Project area between 10 December 2020 to 11 February 2021. Objectives of the groundwater exploration included to inform:

- Dewatering of the orebody
- Groundwater supply potentials beneath Mine Creek to the west and north of the orebody.

The groundwater exploration program included:

- Drilling of 13 holes
- Falling head hydraulic tests in the constructed monitoring bores
- Collection of representative groundwater samples from five of the monitoring bores
- Laboratory analysis of the groundwater samples.

4.2 Drilling and Monitoring Bore Construction

A total of 13 vertical holes were drilled in the vicinity of the orebody, and along Mine Creek. Drilling was by Egan Drilling using a combination of reverse-circulation (6 holes) and conventional rotary air-blast drilling techniques (7 holes). During the drilling:

- Cuttings were collected and logged at 1 m intervals
- Water strikes were logged based on observations
- Returns were measured using a timed-bucket method or v-notch weir to estimate the yields.

Of the 13 holes drilled:

- Eight long-term standpipes monitoring bores were installed (including standpipes being developed and concrete plinths installed)
- Two temporary standpipes were installed (these standpipes were not developed)
- BH2, BH4A and BH11 were left uncased.

Table 3 provides a summary of the drilling and monitoring bore constructions for the groundwater exploration holes. The locations of the standpipes are shown in Figure 5, and construction logs are shown in Appendix A.

Standpipes were constructed from 50 mm Class 18 PVC pipes, with an outer 150 mm (RC drilling) or 200 mm (conventional drilling) PVC collar installed at the surface. The slotted intervals (1 mm aperture, machine slotted PVC casing) targeted the BIF or shale formations. The annulus of each hole was gravel packed using 1.6 to 3.2 mm washed graded gravel. A bentonite seal was placed above the gravel pack to limit in-hole hydraulic connectivity with the overlying strata. Caving and collapse of the borehole sidewalls (for example in BH10) obstructed the bentonite seal, resulting in shallower emplacement. Above the bentonite, the annulus to approximately 2 to 3 m bgl was backfilled using gravel pack and topped with a bentonite cement seal to the ground surface.

The eight standpipe monitoring bores were completed with headworks, including a concrete surface plinth with a heavy-duty steel outer casing, and locking cap. Standpipe development by airlifting was completed between 29 January and 9 February 2021. Development of individual standpipes occurred up to 4 hours, until few fines were observed in the water column. Airlift yields during drilling and development are summarised in Table 3 and shown on the standpipe construction logs in Appendix A.

Airlift testing was also conducted in uncased geotechnical boreholes LC20RC038, LC20RC083 to measure yield potential. Results are summarised in Table 3 and described further in Appendix C.

Table 3 – Drilling and Standpipe Construction Summary

Hole ID	MB ID	Easting (m E)[1]	Northing (m N)[1]	Ground RL (m)[1]	Date Completed	Hole Depth (m)	Installation Depth (m)	Slotted Interval (m)	Screened Unit	Drilling Type	Depth to Water (m btoc)	Static Head (m RL)[3]	Airlift Developed	Max Drilling Airlift Yield (L/s)	Completion Airlift Yield (L/s)
BH1/TH14	MB2	692211	7475884	720.0	9/1/2021	120	83	77 - 83	Mineralised shale	RC	47.77	672.6	No	2.5	-
BH3/TH12	MB3	692049	7476001	715.2	10/1/2021	111	78	72 - 78	Mineralised shale	RC	47.5	668.5	Yes	1.8	
BH4B/TH16	MB4	692358	7476255	715.4	11/1/2021	90	85	79 - 85	BIF	RC	43.5	672.7	Yes	-	
BH5/TH19	MB1	692482	7475742	728.1	9/1/2021	84	76	70 - 76	Shale	RC	56.2	672.7	Yes	0.8	0.2
BH6/TH8	MB5	691434	7475780	704.8	15/1/2021	96	85.5	53.5 - 85.5	Shale	RC	33.50	672.1	Yes	2.5	1.3
BH10/TH4	MB10	691234	7476271	702.8	8/2/2021	90	87	75 - 87	BIF	RC	32.23	671.4	Yes	12.3	1.7 - 2.2
BH15/TH9	MB8	691445	7476609	700.7	29/1/2021	96	93	69 - 93	BIF	Conventional	31.55	670.0	Yes	4.5*	0.8 – 1.0
BH16/TH10	MB6	691472	7476794	699.7	24/1/2021	96	94	82 - 94	Mineralised shale	Conventional	27.80	672.2	No	7.8	-
BH19/TH15	MB7	692222	7477477	693.5	26/1/2021	120	118	94 - 118	BIF/Shale	Conventional	25.48	668.8	Yes	7.5	1
BH20/TH20	MB9	694477	7477617	714.4	6/2/2021	96	96	84 - 96	BIF/Chert	Conventional	47.46	667.8	Yes	8.6	2
BH2/TH18	-	692477	7476006	727.2	18/1/2021	96	-	-	-	Conventional	67[2]	-	-	1.8	-
BH7/TH11	-	691680	7476160	709.0	19/1/2021	96	-	-	-	Conventional	48[2]	-	-	4.8	-
BH11/TH5	-	691245	7476397	701.9	21/1/2021	96	-	-	-	Conventional	48[2]	-	-	6.4	-
LC20RC038[4]	-	692250	7475955	720	-	84	-	-	-	-	48.7	671.2	-	-	0.3 - 0.8
LC20RC083[4]	-	692450	7476105	722.3	-	72	-	-	-	-	49.5	672.8	-	-	-

[1] Approximate coordinates and elevations. Standpipes had not been surveyed at time of writing

[2] Water strike during drilling

[3] Based on assumed heights above ground for bore casings

[4] Geotechnical boreholes

4.3 Slug Tests

The slug test program was performed between 8th and 11th of February 2021. The falling head slug tests were performed on the completed standpipes (Table 4). This method involved adding a set volume of water (about 40 L) as quickly as practical to the standpipe, and recording the displacement in groundwater levels over time, using an electronic pressure transducer, until fully recovered.

The groundwater displacement curves fell into two main responses, and were analysed using AQTESOLV software with the following corresponding methods:

- Overdamped response: Hvorslev (1951) and Bouwer-Rice (1976) method
- Underdamped (oscillatory) response: Springer-Gelhar (1991) method.

The underdamped responses observed in the bores along Mine Creek (BH6 to BH16) are typically representative of high-transmissivity formations. The analysed hydraulic conductivities are summarised in Table 4, and analysis reports are presented in Appendix B. Slow adding of the water slugs and the relatively high transmissivity of the formation resulted in comparatively poor data in some tests. These tests are denoted 'Less reliable' in Table 4.

Table 4 – Slug Test Hydraulic Analysis

Hole ID	MB ID	Response Type	Comment	Interpreted Hydraulic Conductivity (m/day)	Slotted Interval Transmissivity (m^2/day)
Orebody and Surrounds					
BH1	MB2	Overdamped		1.1	7
BH3	MB3	Overdamped		1.7	10
BH4B	MB4	Overdamped		2.0	12
BH5	MB1	Overdamped		1.8	11
Mine Creek					
BH6	MB5	Underdamped	Less reliable	72	2,300
BH10	MB10	Underdamped	Less reliable	53	640
BH15	MB8	Underdamped		21	500
BH16	MB6	Underdamped	Less reliable	7	85
Watershed					
BH19	MB7	Overdamped	Less reliable	0.3	7
BH20	MB9	Overdamped	Less reliable	0.9	11

The interpreted hydraulic conductivity values included:

- A consistent dataset associated with the orebody and surrounds in the range 1.1 to 2.0 m/day, average about 1.7 m/day, with screen interval transmissivity 10 to 12 m^2/day
- A broader dataset associated with Mine Creek and interpreted underlying fault structures, with a range 7 to 72 m/day and average about 60 m/day, from oscillatory responses, and corresponding screen interval transmissivity 85 to 2,300 m^2/day. The Mine Creek groundwater exploration bores produced comparatively high airlift yields during drilling, being highest in MB6 and MB10 and these occurrences are broadly reflected in the interpreted hydraulics. This is not, however, a succinct and uniform correlation between yields and hydraulics. This reflects heterogeneity in the fractured rock and inconsistencies typical in representation provided by airlifts during drilling
- A consistent dataset from the 'Watershed', being structural targets in the wider Mine Creek catchment, in the range 0.3 to 0.9 m/day, average 0.6 m/day, with screen interval transmissivity about 10 m^2/day. Both 'Watershed' groundwater exploration bores produced comparatively high airlift yields during drilling.

4.4 Groundwater Heads

Groundwater heads (Table 3) were measured between December 2020 and February 2021 in:

- The constructed standpipes, measured after well completion and prior to slug tests
- LC20RC038 and LC20RC083 vertical geotechnical boreholes.

4.5 Groundwater Quality

Groundwater pH and Electrical Conductivity (EC) were measured (when there was sufficient airlift discharge) at 6 m intervals when drilling below the water table on the 13 groundwater exploration boreholes. Groundwater quality samples were also collected from the MB4, MB6, MB7, MB8 and MB10 standpipes to provide representative PFAS screening of the sampled groundwater.

The range of pH and EC measured in each borehole are summarised in Table 5, and shown on the respective bore log in Appendix A. Concentrations of PFAS analytes were below the limit of reporting. PFAS analyses and laboratory reports are presented in Appendix D.

Table 5 – Field Measured Groundwater Quality

Bore ID	MB ID	Field pH	Field EC (µS/cm)
BH1	MB2	7.2 - 8.1	373 - 580
BH2	-	7.7 – 8.0	317 – 385
BH3	MB3	8.3	748
BH4B	MB4	-	-
BH5	MB1	8.0	590
BH6	MB5	7.9 – 8.3	453 – 723
BH7	-	7.9 – 8.2	585 – 655
BH10	MB10	7.2 – 7.9	112 – 633
BH11	-	7.8 – 8.2	338 – 623
BH15	MB8	7.6 – 8.7	97 – 629
BH16	MB6	7.3 – 8.7	506 – 692
BH19	MB7	7.8 – 8.0[1] 8.25[2]	240 – 496[1] 535.5[2]
BH20	MB9	7.9[2]	661[2]

[1] Measured during drilling airlift unless otherwise denoted.

[2] Measured at end of well development

5. Conceptual Hydrogeology

5.1 Aquifer Systems

The principal aquifer system within the pit and Mine Creek Project area is formed by the BIF bedrocks. Predominant hydrogeological rock mass units include:

- Weathered bedrock
- Mineralised BIF (primarily Dales Gorge Member)
- Fresh, unfractured / unmineralized bedrock
- Fault zones in bedrocks.

The stratigraphic and structural attributes of the aquifer systems and described below.

5.1.1 Stratigraphic and Weathering Aspects

The Tertiary detrital throughout the orebody and Mine Creek settings occur above the water table. As such, the Tertiary detrital units do not locally form an aquifer. This aspect is expected to change further to the north at the confluence with Marillana Creek and within the outcropping calcretes on Marillana Creek.

Hydrogeological cross-sections showing the stratigraphy through the orebody (four cross-sections) and Mine Creek (two cross-sections) are shown on Figure 6 to Figure 12, inclusive. These are based on:

- Orebody geology and stratigraphy from the MRL geology model for the pit and surrounds
- Borehole logging during the groundwater exploration drilling (Section 4.2).

The cross-sections on Figure 7 to Figure 10, inclusive, show the following units below the water table in the pit and surrounds:

- Dales Gorge (1) Member to the south
- Dales Gorge (1 to 4) members to the north
- Whaleback Shale to the north.

The weathering profiles through the orebody (Figure 10) dip to the north and comprise:

- Highly weathered:
  - Thickness 20 to 50 m
  - Interpreted bottom elevations 690 m RL in the south to 650 m RL in the north.
- Moderately weathered profile with thickness of about 25 m and from about 670 to 630 m RL from south to north.

The dip of the BIF to the north influences the baseline water table transition from being in slightly weathered BIF in the south to highly weathered BIF in the north. Typically, weathered bedrock and mineralised BIF comprise the main aquifer units with enhanced hydraulic conductivity, transmissivity, and storage. Similarly, fresh and unmineralized BIF and shale form comparatively lower-transmissivity formations with limited groundwater storage. This includes the outcropping bedrock to the east of the orebody.

The baseline water table beneath Mine Creek is in the highly weathered profile. The stratigraphy is interpreted to have similar BIF and shale units as the orebody. Figure 11 shows an inferred continuation of the BIF (Dales Gorge Member and Whaleback Shale Member) along a north-south section of Mine Creek that corresponds to the orebody. Both detrital and weathering profiles dip and increase in thickness to the north (Figure 12). The Mine Creek setting features the following weathering profiles (Figure 12):

- Highly weathered, with base elevation of 680 to 650 m RL from south to north. Approximate thickness of 20 to 25 m
- Moderately weathered dipping from 665 to 580 m RL from south to north. Thicknesses increase from 15 m in the south to 65 m in the north.

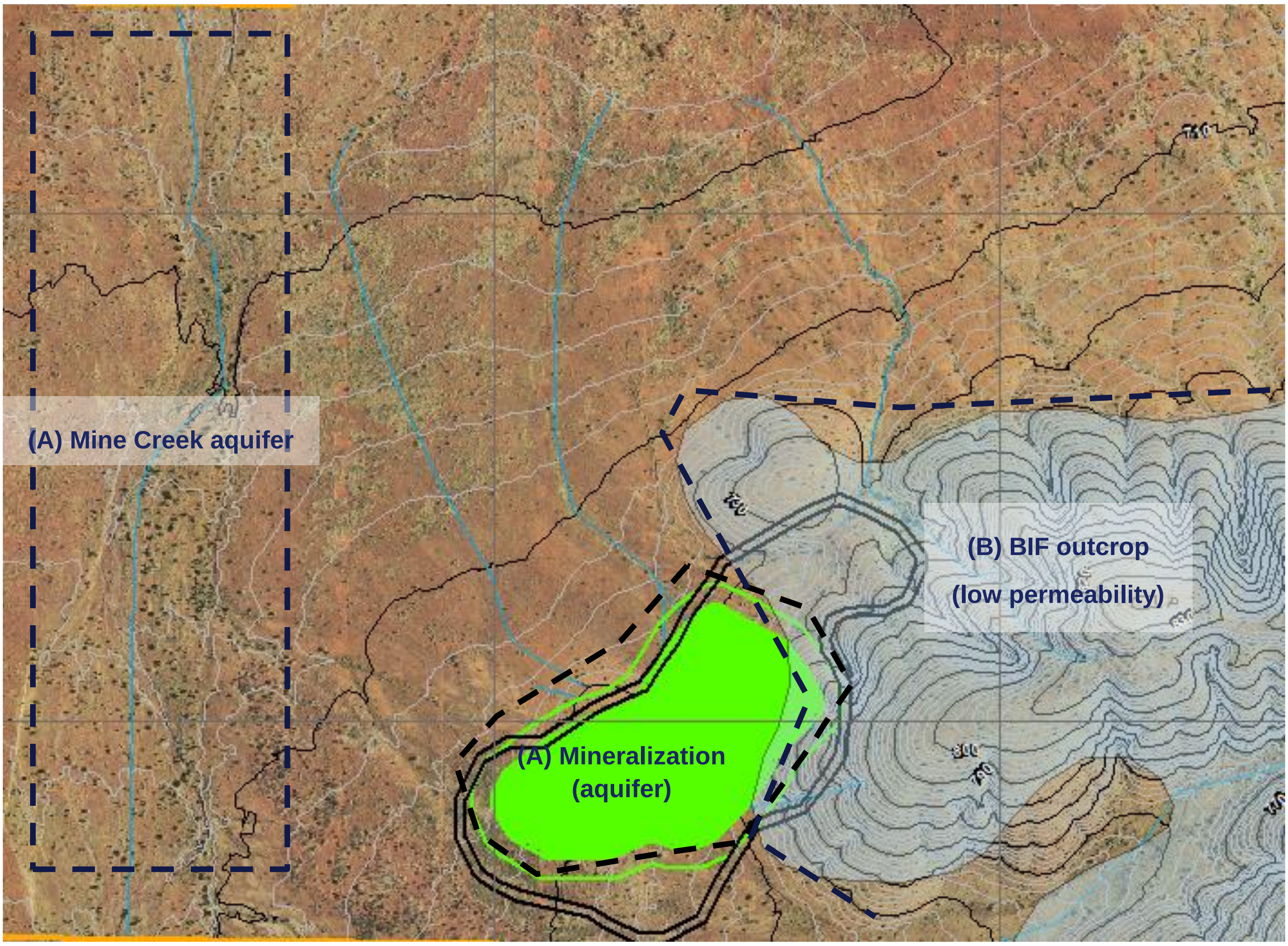
5.1.2 Fault Zones in Bedrocks

Faults and structural lineaments traverse the pit and Mine Creek settings on strikes to the north, northwest, east, and east-southeast. Contextually:

- Few interpreted faults or lineaments traverse the pit setting; however, the presence of iron ores commonly reflects preferential groundwater flow and weathering on shear zones
- Several interpreted faults and structural lineaments are aligned with Mine Creek, potentially influencing the creek alignment and linearity of the watercourse
- Faults potentially provide preferential connection pathways between the mineralised BIF and surrounds
- Faults beneath Mine Creek (associated with thicker weathering profiles) are inferred to be aligned with comparatively high transmissivity in the weathered bedrocks. This aspect was reflected higher airlift yields during groundwater exploration along Mine Creek.

Conceptually, the fractured rock aquifers are preferentially developed on the faults and structural lineaments. In settings where these structures are diminished the aquifer system may be in part at least bound in horizontal extents, including:

- On the perimeter of iron ore mineralization, with secondary porosity fracture features being enhanced in the mineralization zone and comparatively massive, low-transmissivity bedrocks prevailing in adjoining areas (refer to Inset 1)
- Where fresh BIF bedrocks outcrop or form shallow sub-crops
- Outside a structure corridor aligned between faults beneath Mine Creek (Inset 1).



Inset 1: Potential Aquifer System Bounds

5.2 Baseline Groundwater Heads

Measured and interpreted heads are shown in Table 3 and on the stratigraphy sections in Figure 7 to Figure 12, inclusive. These data indicate depths to standing water in the range 25 to 56 m, Groundwater head data from December 2020 to February 2021 are also shown in plan view on Figure 13, and range between 667 m RL in the north to 674 m RL at the orebody.

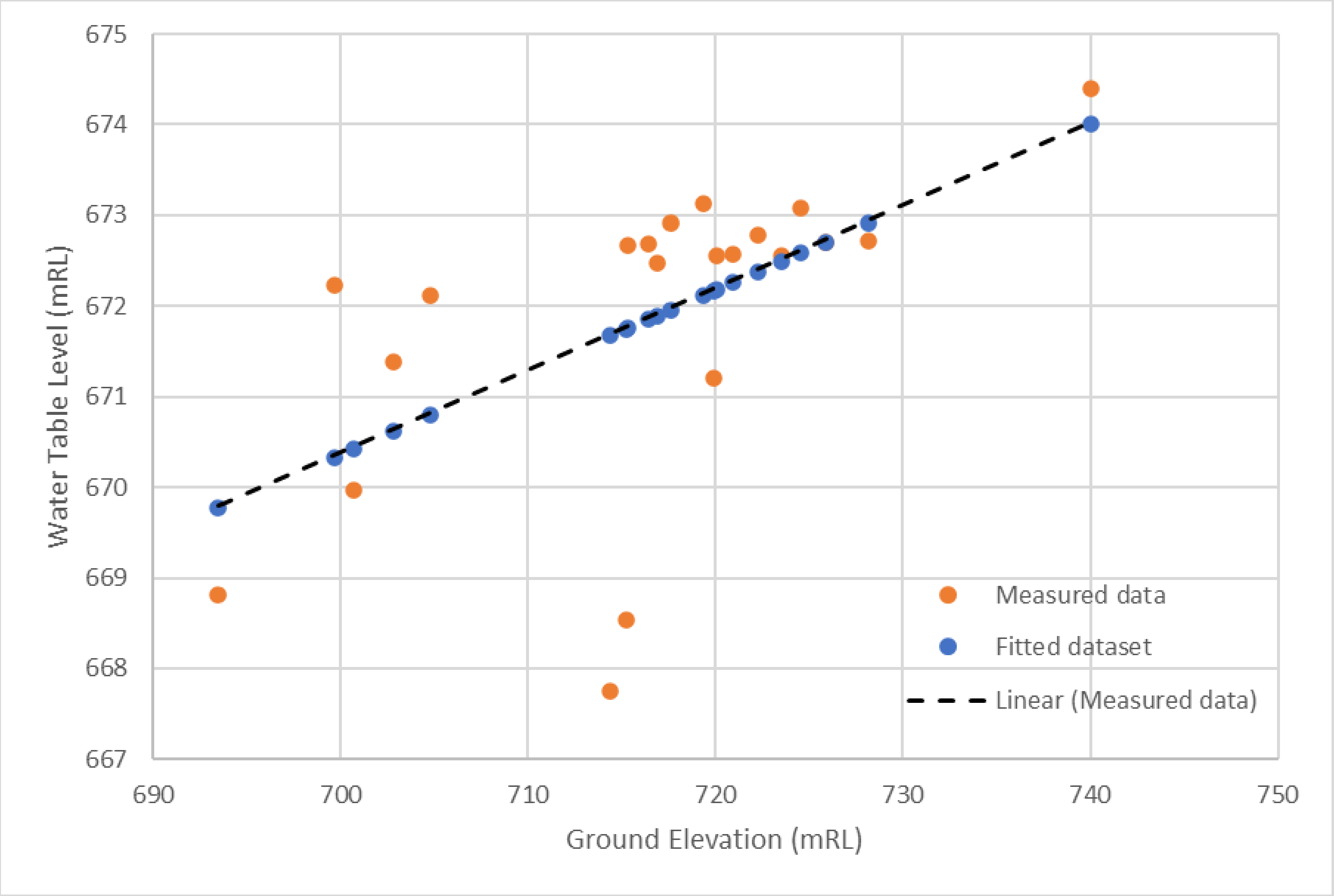
The reported groundwater heads are approximate as standpipe collar elevations had not been surveyed at time of writing. Further, data to inform transient hydrographs were not available, hence:

- The measured groundwater heads represent a snapshot at the time of measurement
- The influences of episodic rainfall recharge on groundwater heads, and subsequent decay, could not be determined.

A semi-quantitative topography to groundwater head relationship was used to infer the water table heads contours across the Project area. The measured groundwater heads were fitted to a linear relationship between measured heads and ground surface elevations (Inset 2), and contours inferred from the fitted heads. Interpreted groundwater head contours are shown on Figure 13. Locally the flow is from the BIF ridge to the west and northwest to Mine Creek. Regionally, the overall flow direction is to the north and Marillana Creek (Golder 2015).

The interpreted head contours were inferred to steepen (hence steeper hydraulics gradients – 0.01 m/m) beneath the BIF ridge (that is outcropping bedrock) immediately east of the proposed pit as a reflection of the data and expected low transmissivity of the fresh bedrocks. Elsewhere beneath the foot-slopes and valley, the interpreted hydraulic gradients are comparatively flat in the range 0.001 to 0.004 m/m.

The comparatively flat and uniform hydraulic gradients between the mineralized zones in the proposed pit and beneath Mine Creek provide indications of an open aquifer system.



Inset 2: Measured and Fitted Baseline Heads

5.3 Hydraulics

Given the groundwater exploration was focussed on mineralisation, fault, and lineament interception, the interpreted hydraulics reflect these aquifer system zones. Based on the slug tests (Section 4.3, Table 4), the interpreted screen interval hydraulic conductivity values were broadly:

- Orebody: 1 to 2 m/day
- Mine Creek: 5 to 20 m/day (though noted to locally higher in areas)
- Watershed: 0.5 to 1 m/day.

The common heterogeneous nature of fractured rock aquifers potentially belies the consistency of the hydraulics test results. Similarly, the airlifts measured during drilling reflect variability, albeit it that these measures tend to be influenced by submergence and other down-hole factors. Conceptually, fractures and defects in the fresh bedrock are expected to close with increased depth, resulting in decreased hydraulic conductivity and transmissivity with increased depth. Therefore, cumulatively these factors were interpreted to resolve that the slug test hydraulics were conservatively high. This aspect was applied in consideration of aquifer system transmissivity. The aquifer thickness was assumed to extend about 70 m from the interpreted water table elevations to low-transmissivity fresh bedrocks in both orebody and Mine Creek settings. This gives rise to interpreted transmissivity ranges as follows:

- Orebody: 100 to 150 m^2/day
- Mine Creek: 350 to 700 m^2/day
- Watershed: 30 to 70 m^2/day.

These inferred extents of these inferred transmissivity zones are shown on Figure 7 to Figure 12, inclusive. Note that Figure 7 to Figure 10 also show the saturated thickness within the proposed pit (water table elevation to base of pit) is only 30 to 35 m, hence not fully penetrating the aquifer profile and of lower effective transmissivity.

5.4 Groundwater Quality

Collected groundwater quality measurements indicate the local groundwater is characterised as:

- Neutral to slightly alkaline pH in the range 7.2 to 8.7
- Fresh (EC between 98 to 723 µS/cm)
- PFAS concentrations below LoR detection limits.

Groundwater quality from nearby mining operations is dominated by a calcium / magnesium and bicarbonate type (AQ2 2020).

5.5 Groundwater Dependent Ecosystems

Measured Groundwater heads are about 44 to 60 m bgl across the orebody and 25 to 35 m bgl beneath Mine Creek. The measured heads reflect comparatively deep settings of the water table, deeper than the 10 m to 12 bgl criteria usually considered for vegetation dependency (BHP 2015). Hence the Project area and surrounds are not expected to support terrestrial groundwater dependent ecosystems.

The local waterways, including Mine Creek, are ephemeral, and are characterised as a losing system. Surface water is largely dissipated by evapotranspiration and infiltration.

5.6 Conceptual Hydrogeology Model

The local conceptual hydrogeological model includes:

- The Project area in the headwaters of a tributary to Marillana Creek, forms a groundwater recharge zone; the groundwater is fresh. Recharge rates is expected to be comparatively low and episodic. For example, recharge rates of up to 10 mm/year has been estimated for alluvium and calcrete in the Marillana catchment (Golder 2015)
- Interpreted water table elevations and measured hydraulic gradients are relatively consistent and flat away from BIF escarpments and likely characterised by vertical downward fluxes, reflective of recharge conditions
- Groundwater heads increase and hydraulic gradients steepen beneath the BIF escarpment (that is outcropping BIF bedrocks), reflective of the expected decreasing transmissivity in fresh bedrocks
- Low rates of diffuse recharge are expected to the regional groundwater system. Groundwater recharge may be focussed on areas of increased water availability - mostly along the major watercourses and areas inundated during rainfall-runoff events
- The Tertiary detrital profile is dry within the Project area. It is possible a surficial, perched aquifer unit may form beneath Mine Creek after stream flow events. This is dependent on the infiltration properties of the alluvium, detrital, and rocky clay unit, and vertical flux potentials of the rocky clay unit
- The interpreted wate table occurs at depths in the range 44 to 60 m bgl across the orebody and 25 to 35 m bgl beneath Mine Creek

- Weathered BIF comprises the main aquifer unit, with enhanced hydraulics and storage characteristics on shear zones (the orebody) faults and structural lineaments
- The aquifer is preferentially developed beneath the Mine Creek valley settings and is likely bound in both horizontal and vertical extents by fresh massive BIF bedrocks. This conceptualisation is shown for the Mine Creek catchment on Figure 14 whereby the BIF and Weeli Wolli Formation outcrops are referred as low-transmissivity and the valley-floor settings provide preferential flow in weathered and faulted profiles. The lateral bounding aspects are supported by the interpreted water table elevations which show comparatively flat hydraulics gradients in the range 0.001 to 0.004 m/m beneath foot slopes and Mine Creek valley and steepening beneath the BIF escarpment immediately east of the proposed pit. In vertical context, the aquifer is bounded by low-transmissivity fresh BIF bedrocks
- Groundwater inflows during pit dewatering may be limited by low-transmissivity lateral and vertical discharge boundaries
- The hydraulic connectivity of the faults in the Project area are not characterised. The slug test hydraulics on the interpreted fault intersections along which Mine Creek infer increased aquifer transmissivity beneath the watercourse
- Interpreted transmissivity ranges as follows:
  - Orebody: 100 to 150 m^2/day, assuming 70 m aquifer thickness but potentially less given partial penetration of the aquifer by the pit and 30 to 35 m saturated profile to be mined
  - Mine Creek: 350 to 700 m^2/day
  - Watershed: 30 to 70 m^2/day.
- The natural baseline groundwater quality is fresh, circum-neutral to slightly alkaline and a calcium/ magnesium/bicarbonate type.

6. Pit Dewatering Assessments

Mining below the water table is planned during Month 23 to Month 26. A constant water supply demand of 30 L/sec is required over the entire 26-month duration of mining. Hence the pit dewatering would need to commence at the inception of mining for these abstractions to meet or contribute to the supply demands. Advancement of the pit dewatering ahead of mining is beneficial to achieving dry mining conditions and optimises the site water balance by synchronising (where practical) the pit dewatering rate with the supply demand. The advance dewatering, however, relies on production bores in a setting where the groundwater exploration has demonstrated comparatively low yields. Further, a balance between pit dewatering rates and supply demand may not be sustained dependent on cumulative yields of the pit dewatering production bores and reductions in yields as the transmissivity of the local aquifer is reduced by dewatering.

Based on the groundwater exploration program findings the Mine Creek valley setting forms a heterogeneous aquifer wherein the transmissivity is variable over an order of magnitude, dependent on saturated thickness and nature of faults, shear zines and bedding defects in the weathered rock mass. The setting of the proposed pit, immediate proximity of low-transmissivity BIF outcrops, observed comparatively low yields and 26-month dewatering timetable cumulatively provide likely drivers that the pit dewatering will at times be in deficit of the water supply demands. To explore this eventuality three scenarios for advance dewatering of the proposed pit were developed:

- Base-case scenario: pit dewatering is equal to supply demand
- Upper-bound scenario: pit dewatering is greater than supply demand (that is 30 L/sec)
- Lower-bound scenario: pit dewatering is less than supply demand.

Each scenario considered a constant dewatering rate from the pit over the duration of mining. The Lower-bound scenario is considered the most likely. This aspect was reinforced by:

- The comparatively ow groundwater exploration yields form the proposed pit setting
- Dupuit-Forchheimer empirical assessments of the pit dewatering by sump-pumping which indicated yields up to about 6 L/sec (500 kL/day) being sustained for four months, with lower yields likely dependent on effective aquifer transmissivity in the pit setting.

6.1 Assessment Method

6.1.1 Transmissivity Model

Dewatering calculations for the proposed pit used a transmissivity-based model. A software program (DMB8 – derived from Walton 1979) was used to estimate the groundwater drawdown based on application of radial flow in an unconfined aquifer for a period of pumping or injection. The equations assume horizontal flow in a homogenous porous media.

Dewatering in the pit was represented through five production bores (dewatering wells).

Interference effects from discharge boundaries (for example low-transmissivity BIF bedrocks) or recharge boundaries (for example infiltration from creeks) to the aquifer are represented using image wells.

6.1.2 Key Assumptions and Model Limitations

Key assumptions and limitations of the analytical approach are discussed here:

- The lateral and vertical hydraulic extents of the orebody aquifer and its connectivity to faults are not characterised and defined. This is reflected in coarse parameterisation reflecting broad-scale representation of the aquifer system
- The base of the aquifer was assumed to be bounded by low-transmissivity bedrocks of fresh BIF
- No interpreted faults are explicitly represented in the model
- The range of simulated dewatering rates and drawdown extents are considered indicative given influences from assumptions and model representation
- Rainfall recharge was not considered in the simulated water budgets.

6.1.3 Model Confidence Level Classification

The analytical predictive approach described is viewed with a Class 1 ranking based on classification templates provided in the Australian Groundwater Modelling Guidelines (Barnett et al 2012). This classification fits the prescribed “specific use” in the guidelines and acknowledges that the predictive outcomes are influenced by assumptions. From a practical perspective, however, a Class 1 ranking predominantly reflects:

- Broad-scale layer form and hydraulic parameterisation
- Uncertainty commonly associated with fractured rock aquifer heterogeneity together with lateral and vertical extents and role of faults in enhancing transmissivity and connectivity
- The broad-scale representation of the fractured rock as porous media, with consistent hydraulic characteristics on a sub-catchment scale
- Recognition that there may be discrete preferred groundwater flow paths on structure, but that the influence of these on groundwater flow are not characterised.

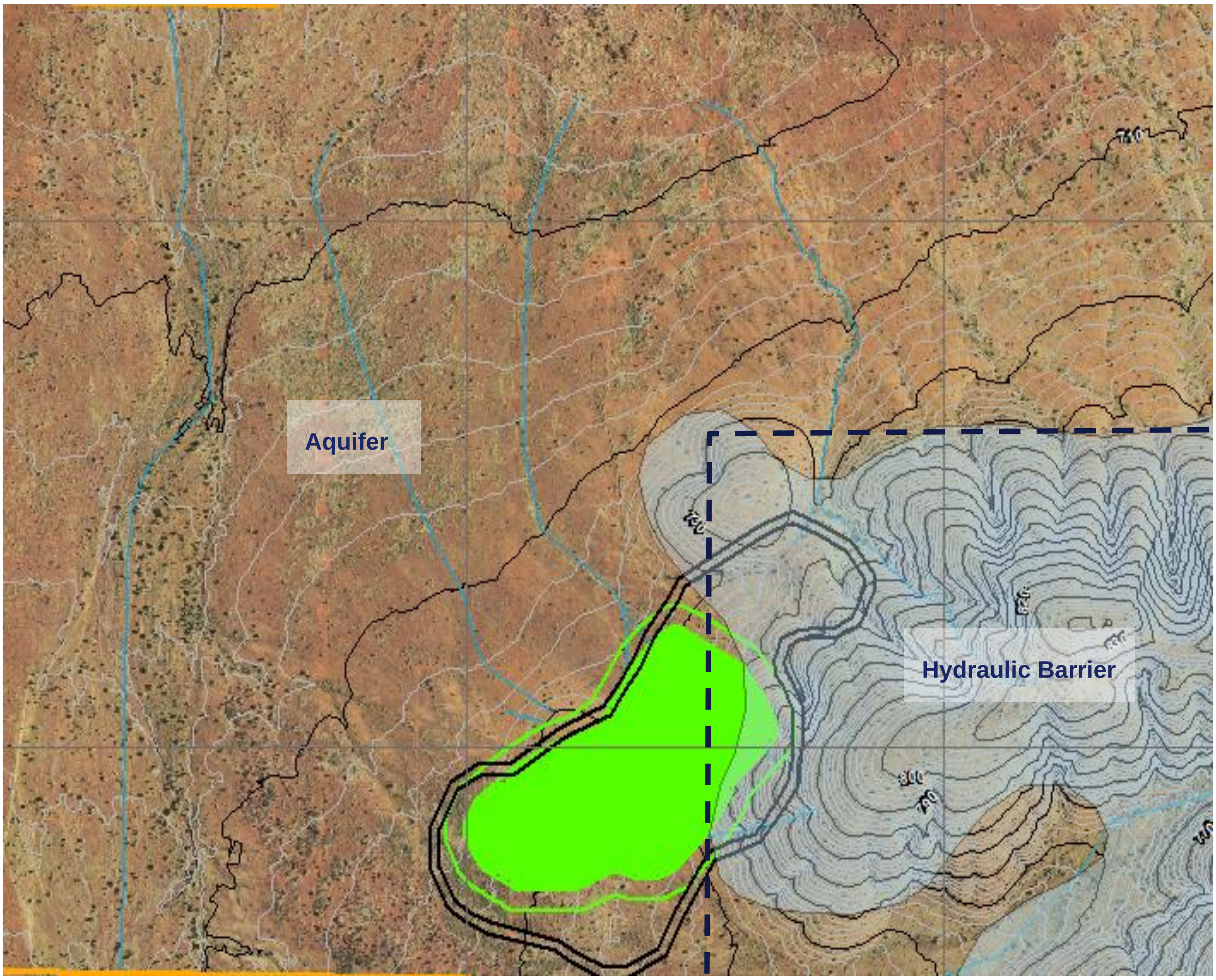
6.2 Conceptualisation

The model conceptualisation (Inset 3) is based on Conceptualisation B described in Section 5.1, Inset 1 and shown on Figure 14. This conceptualisation represents the orebody and Mine Creek aquifer zones in hydraulic connection and bounded by low-transmissivity fresh BIF bedrocks.

A water table elevation of 673 m RL was assumed for the calculations. The orebody and weathered BIF beneath the Mine Creek valley are represented as a laterally unbounded aquifer. The outcrops of BIF bedrock on the escarpment to the east of the proposed pit were assumed to have low transmissivity and act as a groundwater flow barrier. Low-transmissivity fresh bedrocks at depth are recognised through the selected model transmissivity parameterisation. The aquifer was assumed to extend 40 m below the final pit depth (based on the approximate production bore depth)

The approach represents the aquifer with a transmissivity and storage that is uniform for the model domain, encompassing the relatively high transmissivity beneath the Mine Creek and mineralisation zones to the lower transmissivity watershed zones away from the mineralisation. An initial transmissivity of 150 m^2/day was used in the calculations then adjusted for each scenario to test sensitivity. To compensate for the saturated thickness of aquifer decreasing during dewatering, half of the value of transmissivity was adopted in the calculations.

The fault zones beneath the Mine Creek are not explicitly represented as a higher-transmissivity domain. A specific yield of 0.01 (dimensionless) was used to represent the storage in fractured rock aquifer. This specific yield parameterisation is more representative of fractures in fresh bedrocks and semi-confined conditions, and hence may under-estimate the storage characteristics of weathered bedrocks where the weathering increases the primary porosity. This parameterisation in weathered bedrocks provides a conservative approach that minimises the simulated volumes of groundwater in storage. Further, the rate of spread of drawdown is proportional to the storage: transmissivity quotient, hence over-estimated.



Inset 3: **Conceptualisation Used in Dewatering Calculations**

6.3 Predictive Model Scenarios

Three Base-case, Upper-bound and Lower-bound scenarios were considered to estimate a possible range in pit dewatering, independent supply, and drawdown extents. The Lower-bound and Base-case simulations are seen as most likely and possible, respectively, and the Upper-bound scenario less likely.

For the Base-case scenario:

- The simulated pit dewatering rate was equal to the water supply demand
- The transmissivity required to achieve this scenario was 70 m^2/day, hence less than the interpreted transmissivity determined form the slug tests, but dependent on local discharge boundary conditions associated with the orebody and reduced effective transmissivity of the orebody because of local drawdown.

In the Upper-bound scenario:

- The orebody was simulated with an upper-bund effective transmissivity of 150 m^2/day
- The predicted dewatering rate under these circumstances 58 L/sec

- This scenario produced a surplus of 28 L/sec
- The groundwater mounding due to the discharge to Mine Creek was estimated by assuming the surplus locally infiltrated to the water table – akin to reinjection.

For the Lower-bound scenario:

- An initial simulation was conducted to estimate the pit dewatering rate assuming the aquifer was bounded to an area about twice the size of the mineralisation with a transmissivity of 150 m^2/day (like Conceptualisation A on Inset 1, Section 5.1.2). The predicted pit dewatering rate under these circumstances was 17 L/sec
- The make-up water supply of 13 L/sec was simulated based on two production bores at Mine Creek (Also shown as part of Conceptualisation A on Inset 1, Section 5.1.2). As with the pit dewatering, the production bores at Mine Creek were simulated with a constant pumping rate during the 26-month mining operations
- To estimate the drawdown extent, the dewatering rates were fixed, and the transmissivity adjusted to achieve the required drawdown of 33 m at the pit by Month 25.

Note that the Lower-bound scenario is driven by a bounded aquifer, not comparatively low transmissivity. Hence this scenario retains a conservatively high approach to pit dewatering estimates.

6.4 Summary of Predicted Pit Dewatering and Water Supply

The simulated transmissivities, dewatering rates and supply metrics for the Base-case, Upper-bound and Lower-bound scenarios are summarised in Table 6.

Table 6 – Predictive Scenarios and Dewatering Rates

Scenario	Transmissivity (m^2/day)	Pit Dewatering Rate (L/sec)	Creek Supply Rate (L/sec)
Base-case: Pit dewatering = supply demand	70	30	-
Upper Bound: Pit dewatering > supply demand	150	58	-28 (discharge)
Lower Bound: Pit dewatering < supply demand	150 Bounded	17	13

As discussed in Section 6.0 and Section 6.3, the Lower-bound scenario is considered the most likely and provides a conservatively high estimates of pit dewatering. Alternative Dupuit-Forchheimer assessments of the assessments of pit dewatering indicated yields up to about 6 L/sec being sustained for four months. These assessments provide indications that pit dewatering by sump-pumping may be a pragmatic option given demonstrated comparatively low groundwater exploration yields in the pit setting.

6.5 Summary of Predicted Drawdowns

The approximate drawdown extents at the end of mining are shown in Figure 15, Figure 16, and Figure 17 for the Base-case, Upper-bound, and Lower-bound scenarios, respectively. The predicted drawdown distribution was intended to reflect reasonable worst-case attributes as a function of simulated transmissivity, discharge boundary conditions and storage characteristics. Figures show drawdown propagation beneath the Mine Creek valley and bounded by low-transmissivity BIF and Weeli Wolli Formation outcrops. The predicted drawdown amplitudes and extends were viewed as broadly indicative in context to the interpreted heterogeneity in aquifer transmissivity and recognition that the lowering of transmissivity because of dewatering would curtail the propagation.

Drawdown extents are greatest for the Upper-bound scenario (up to about 6.3 km for the 1 m drawdown extent), though are limited to the northwest on Mine Creek by the surplus water discharge. The 1 m drawdown extent is up to approximately 4.4 and 5.4 km from the pit for the Base-case and Lower-bound scenarios, respectively.

The Lower-bound scenario appears to describe the most reasonable and practical outcome, with the Base-case and Upper-bound scenarios less likely. The Lower-bound scenario realises shortfalls in supply from the pit dewatering and responds with make-up supply sourced from the Mine Creek setting. Figure 18 rationalises this outcome and shows preferential locations domains for the pit dewatering and water supply production bores. For the pit dewatering the preferred production bore locations occur on the northwest pit perimeter, taking advantage of the stratigraphy dipping to the north for enhancement of submergence and propagation of drawdown up-dip within the orebody. The water supply source area is focused on the high-yield and high transmissivity yield locations identified by the groundwater exploration program.

6.6 Groundwater Quality Expectations

Fresh and circum-neutral groundwater quality is expected from the pit dewatering and supply sources.

Risks related to groundwater quality are considered negligible.

6.7 Potential Groundwater Impacts on GDE

The depth of the water table in the range from 25 to 60 m discounts the local presence of GDEs within the project area and immediate surrounds.

The following perspectives on potential impacts on GDEs were derived from the pit dewatering predictive scenarios:

- Drawdown of more than 1 m amplitude is not expected to propagate onto calcretes near the confluence of Mine and Marillana creeks
- In the Upper-bound Scenario, surplus discharges to the Mine Creek would temporarily increase the water availability, potentially with consistent surface water expressions at and directly downstream of the discharge points:
  - The increased water availability would potentially support riparian woodlands, with potential temporary outcomes being enhanced recruitment, increased abundance and increase in vegetation densities and foliage cover
  - Reinjection would tend to limit the increased availability of surface water.

Note that the Upper-bound scenario is considered the most unlikely, such that there is not an expectation of groundwater surplus.

7. Post-Closure Change

It is unclear in the absence of local monitoring hydrographs where the measured heads occur in the episodic saw-tooth recharge and decay cycles common in Pilbara hydrographs. Episodic recharge events typically occur over summer months due to cyclone and thunderstorm events. The scale of these events dictates the amplitude of the highest water table elevation. Further, the range between the peak and troughs in observed heads is known to range up to 5 m.

Post-closure, the pit would be backfilled to above the interpreted pre-mining water table elevations. Under these circumstances, the water table is expected to fully recover – with no residual drawdown. The time for recovery will reflect the rates of groundwater through-flow and recharge; the pit acting as a local surface water sink and infiltration source may promote increased recharge and hence recovery. Over time, these attributes may potentially create a locally mounded water table beneath the pit.

The occurrence of high rainfall and high stream flow events after cessation of mining and backfill of the pit is expected to influence the recovery times tables - with longer timetables in the absence of such events. Notwithstanding, most of the water table recovery will occur within three years of the cessation of abstraction for pit dewatering or supply. Thereafter, rates of recovery will slow, with recharge required to replace the abstracted storage volumes. Indicatively, full recharge may take five to 10 years under comparatively dry conditions.

8. Groundwater Risk Ranking

A summary of identified risks and risk ranking is provided in Table 7. Comments are provided to rationalise the risk ranking and provide a high-level Water Management Plan.

Table 7 – Identified Risk Rating

Hazards	Assessed Risk	Comments
Groundwater abstraction for pit dewatering	Low	The water table is comparatively deep in the range 44 to 60 m. The pit dewatering is expected to be reasonably and practically manageable using low-yield production bores or sump-pumping. The commencement of the pit dewatering at the inception of mining will provide a significant lead-time ahead of mining below the baseline water table elevation. The matching of pit dewatering to water supply demands may promote accelerated dewatering rates. Measurements of cumulative abstraction rates and volumes and drawdown amplitudes and rates will enable assessments of dewatering progress against mine plans and water supply demands. Adjustments can be made and managed through these measurements.
Dedicated groundwater abstraction for supply	Low	The water table is at depths of 25 to 35 m. Structures are interpreted to contribute to higher local transmissivity and enhanced production bore yields in the vicinity of Mine Creek. Dedicated abstraction for supply will be tailored to and synchronized based on transient deficits from the pit dewatering abstractions. The commencement of the pit dewatering at the inception of mining will initially limit dedicated abstraction for supply. This is expected to change over time as the it is dewatered. Measurements of cumulative pit dewatering abstraction rates and volumes will enable assessments of transient supply deficits. Adjustments to the dedicated supply can be made and managed through these measurements.
Drawdown of the water table	Low	Local drawdown of the water table beneath the pit, Mine Creek and surrounds will occur. Measurements of drawdown beneath the proposed pit will guide the management of the dewatering program for compatibility to the mining plans. Measurements of drawdown in the vicinity of Mine Creek will guide aquifer performance and possible decay of local supply potentials because of cumulative drawdown and local dewatering. Local depths of about 25 to 60 m to the water table limit the presence of potential groundwater dependent ecosystems and diminish potential risks linked to drawdown.
Pore pressures	Low	The measured hydraulics indicate gravity drainage of the transported and weathered bedrock profiles. saprolite and saprock. Pore pressures may temporarily increase after episodic high rainfall events.
Groundwater quality	Low	Local groundwater is low salinity and circum-neutral. No quality impacts are expected.
Change to groundwater dependant ecosystem	Low	No groundwater dependency has been identified.
Closure Landform	Low	Pit to be backfilled to elevations above the baseline water table. This will enable full recovery of groundwater heads. Th residual mined void would form a local surface water sink and this may provide localised enhancement of recharge to the water table. The absence of residual drawdown from the pit reflects that the water supply source should also fully recover.

9. Recommendations

This H2 hydrogeological assessment has been prepared to inform a Mining Proposal and Section 5C licence application for the Project.

The following recommendations result from this study:

9.1 Pit Dewatering and Water Supply Strategy

The pit dewatering is not expected to meet the supply demands for the duration of the Project. Due to the comparatively low yields and commensurate interpreted transmissivity in the pit setting there is residual uncertainty in the pit dewatering rates and ability to achieve an effective and efficient dewatering program using pit-perimeter production bores alone. This uncertainty provides drivers to include sump-pumping in the pit dewatering strategy and to develop an independent water supply source on Mine Creek. The dewatering and supply strategy is expected to need flexibility to offset this uncertainty.

At a conceptual level, the dewatering and supply strategy will preferentially involve either:

- Production bores with specific pit dewatering and water supply objectives, including:
  - Installation of production bores on the pit perimeter and nearby monitoring bores early in the mining schedule
  - Commence dewatering early in the mining schedule and conduct regular monitoring of rates of dewatering progress and cumulative yield trends from the orebody aquifer. Ongoing monitoring of residual saturation and comparison of dewatering yield will inform potential future supply capabilities
  - Installation of water supply production bores on Mine Creek. These production bores would make-up shortfalls from the pit dewatering and balance supply
- Sump-pumping for the pit dewatering and dedicated water supply production bores, including:
  - Establishment of a dedicated water supply borefield on Mine Creek, with this meeting supply demands from Month 1 to Month 23
  - Use of sump-pumping once the pit is excavated to the water table from Month 23
  - Supplement the water supply demands from the pit dewatering abstractions during Month 23 to Month 26, with commensurate reductions in abstraction from the water supply source.

Either strategy would offer security of supply and the need to balance supply demands with abstraction from a dedicated supply source and make-up from the pit dewatering. Under the circumstances identified from the groundwater exploration the pit dewatering by sump-pumping represents a pragmatic approach. The pragmatism needs to be weighed against the benefits which would be provided by advance dewatering.

9.2 Characterise Hydraulic Extents and Connectivity

The completed groundwater exploration has delivered point-source aquifer attributes and associated uncertainty in aquifer characteristics. The drilling and test-pumping of pit dewatering and water supply production bores would enable improved characterisation of the aquifer hydraulics, extents of the aquifer and hydraulic connectivity to faults thereby limiting residual uncertainty in the aquifer characteristics. The objective of further groundwater exploration would be to improve the confidence in the design of the pit dewatering and water supply, including:

- Transient pit dewatering rates and volumes
- Preferred approach to pit dewatering – sump pumping versus advance dewatering using production bores or a hybrid approach
- Water supply metrics
- Design of associated infrastructure
- Circumstances where there is more groundwater abstracted than required for demand.

These investigations would preferentially be focussed on the domains shown on Figure 18 and involve:

- Real-time monitoring of the groundwater heads in selected monitoring bores in the orebody and on Mine Creek. The monitoring will characterise head trends and support estimating the rainfall recharge contribution to the pit dewatering and supply water balances

- Drilling and construction of production bores on the proposed pit perimeter. The prior groundwater exploration did not define specific targets; hence site selection can be enhanced by application of the geology and resource model and structure interpretations to identify comparatively deep ore and weathering zones
- Drilling and construction of production bores on the Mine Creek targets identified by the prior groundwater exploration
- Completion of pumping tests in selected production bores
- Collection of groundwater samples from the drilling program and pumping tests, and analyses for major ions and physicochemical attributes
- Application of the findings from the drilling and pumping tests to consolidate the pit dewatering and water supply designs and specifications.
- Rationalise the likelihood of excess water and potential needs of discharge to Mine Creek resulting in the requirement for an impact assessment under the Environmental Factors Guideline Inland Waters (EPA 2018).

Yours Sincerely

MING WU **SENIOR HYDROGEOLOGIST**	**IAN BRUNNER** **PRINCIPAL**

References

1. AQ2, 2020 Lamb Creek Iron Ore Project – Hydrogeological Scoping Study, Report prepared for MRL, Reference no. 326B-005a
2. AQ2, 2020b Lamb Creek Iron Ore Project – Surface Water Management Plan, Report prepared for MRL, Reference no. 326B-004a
3. BHP 2015, SEA Hydrology: Ecohydrological Change Assessment.
4. Golder 2015, Ecohydrological Conceptualisation of the Marillana Creek Region, Report prepared for BHP, Reference no. 137646040-002-R-Rev4
5. Rio Tinto 2010, Marillana Creek Regional Flow Balance and Catchment Hydrology.
6. RPS 2015, Ecohydrogeological Conceptualisation of the Central Pilbara Region, Report prepared for BHP, Reference no. 1549B/600/275f

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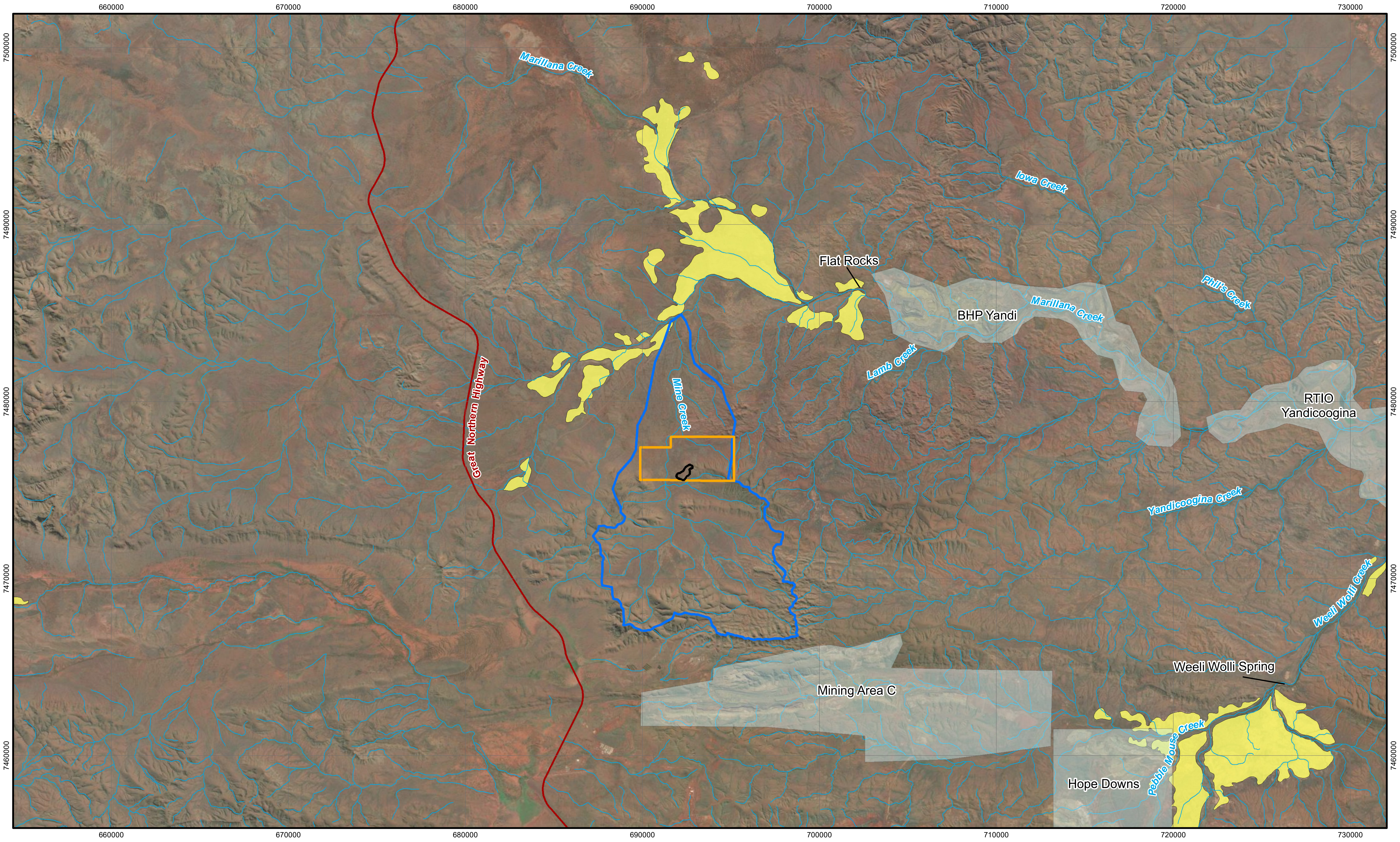

Legend

— Pit Outline	▭ Mines in Region
🟧 Tenure Boundary	— Major Road
🟦 Catchment Area for Mine Creek	
— Drainage - Creeks	
🟨 Calcrete - Groundwater Discharge Zones and Shallow Water Table	

N

Scale 1:200,000

0 2 4 6 8 10 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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PROJECT SETTING

PSM4241-004R | Figure 1

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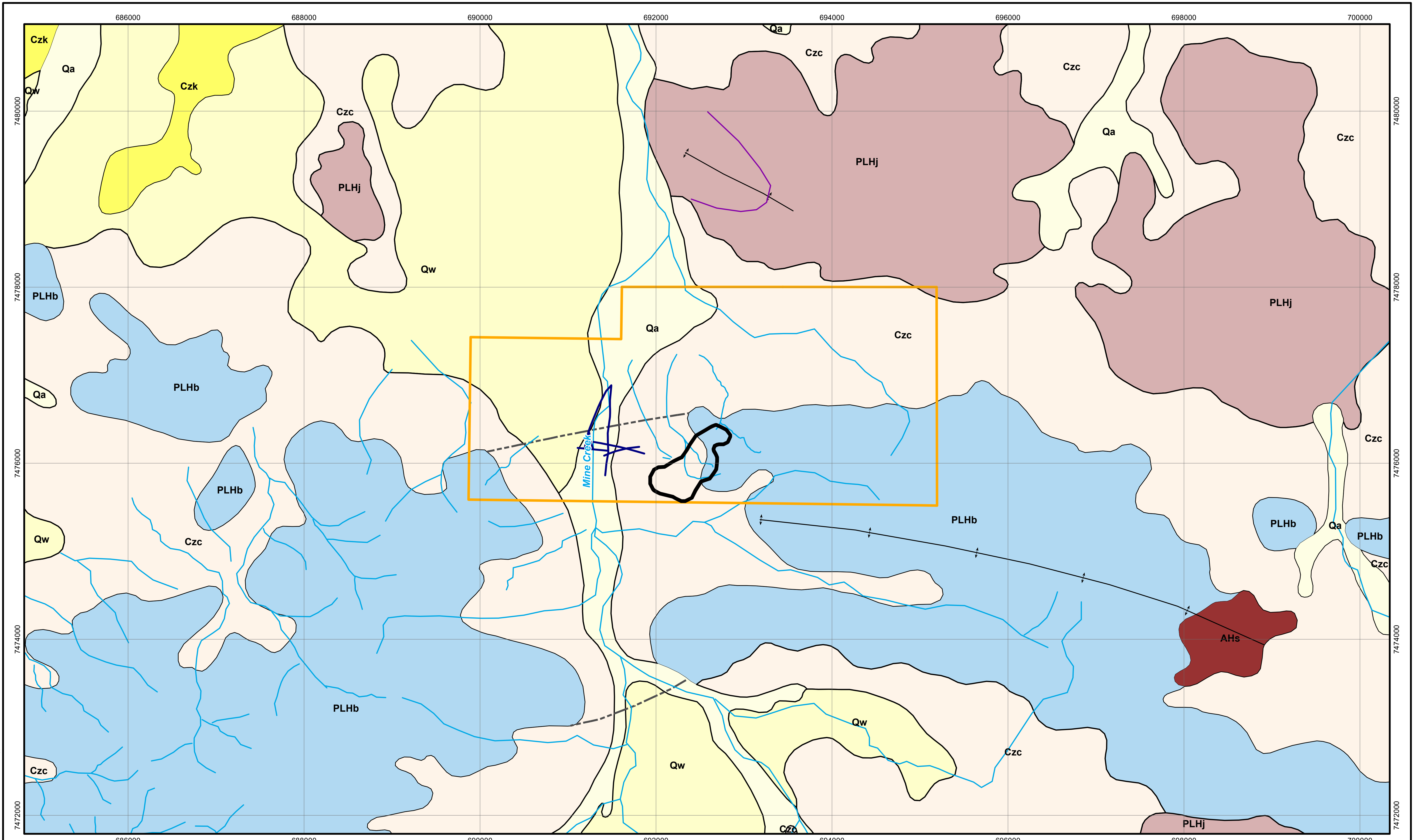

Legend

250k WA Geology

- Qa (Alluvium)
- Qw (Alluvium and Colluvium)
- Czc (Colluvium)
- Czk (Calcrete)
- PLHj (Weeli Wooli Formation)
- PLHb (Brockman Iron Formation)
- AHs (Mt McRae Shale)
- Bedding
- Major fold, showing trend and plunge direction
- Potential Continuation of BIF Zone
- Pit Outline
- M47/0019
- Drainage - Creeks
- Interpreted Structures Beneath Mine Creek

N

Scale 1:40,000

0 0.5 1 1.5 2 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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LOCAL OUTCROP GEOLOGY

PSM4241-004R Figure 2

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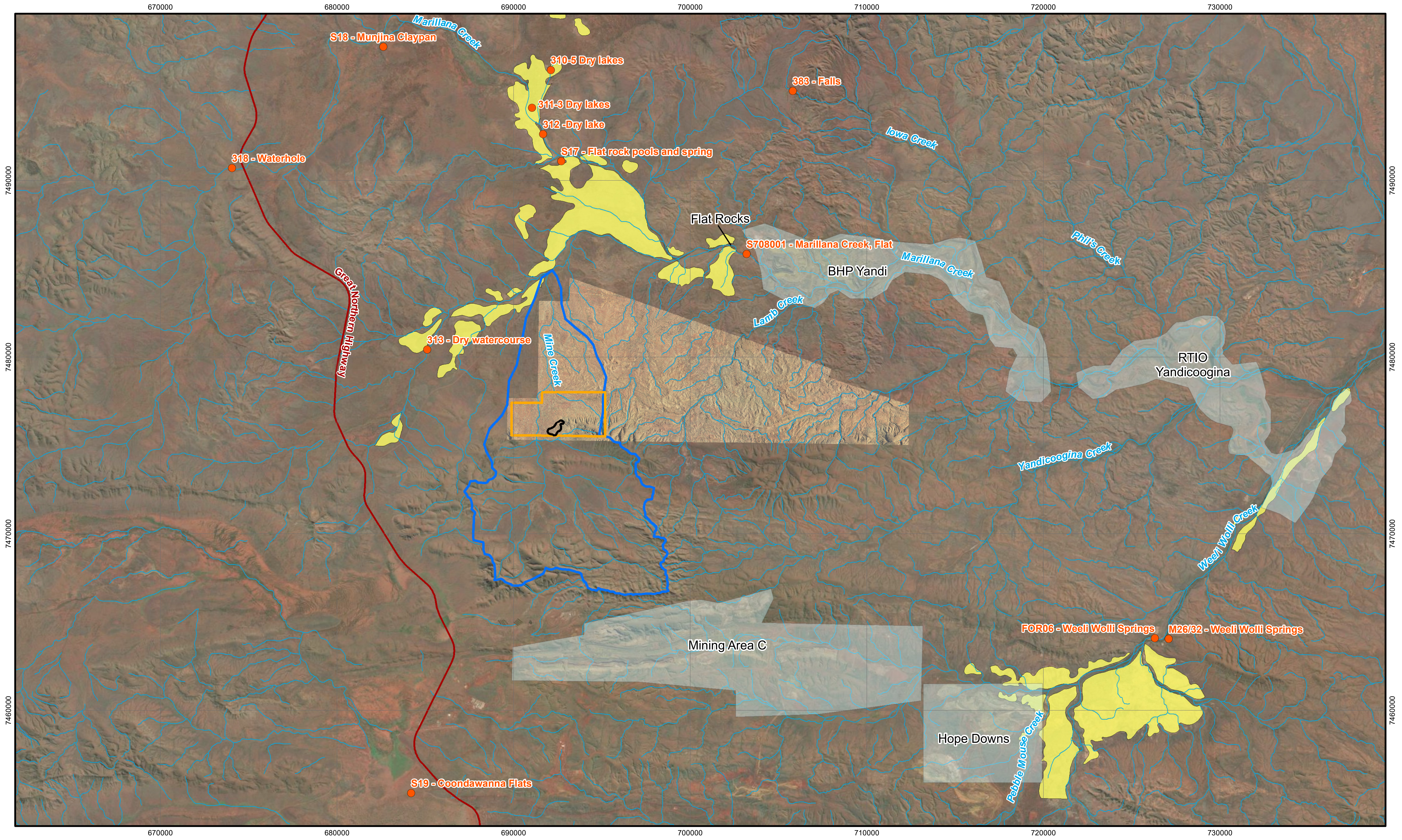

Legend

— Pit Outline	— Major Road
▭ Tenure Boundary	**Potential Groundwater Dependent Ecosystems**
▭ Catchment Area for Mine	● Specific Locations (Reference)
— Drainage - Creeks	🟨 Calcrete - Groundwater Discharge Zones and Shallow Water Table
▭ Mines in Region	

N

Scale 1:200,000

0 2 4 6 8 10 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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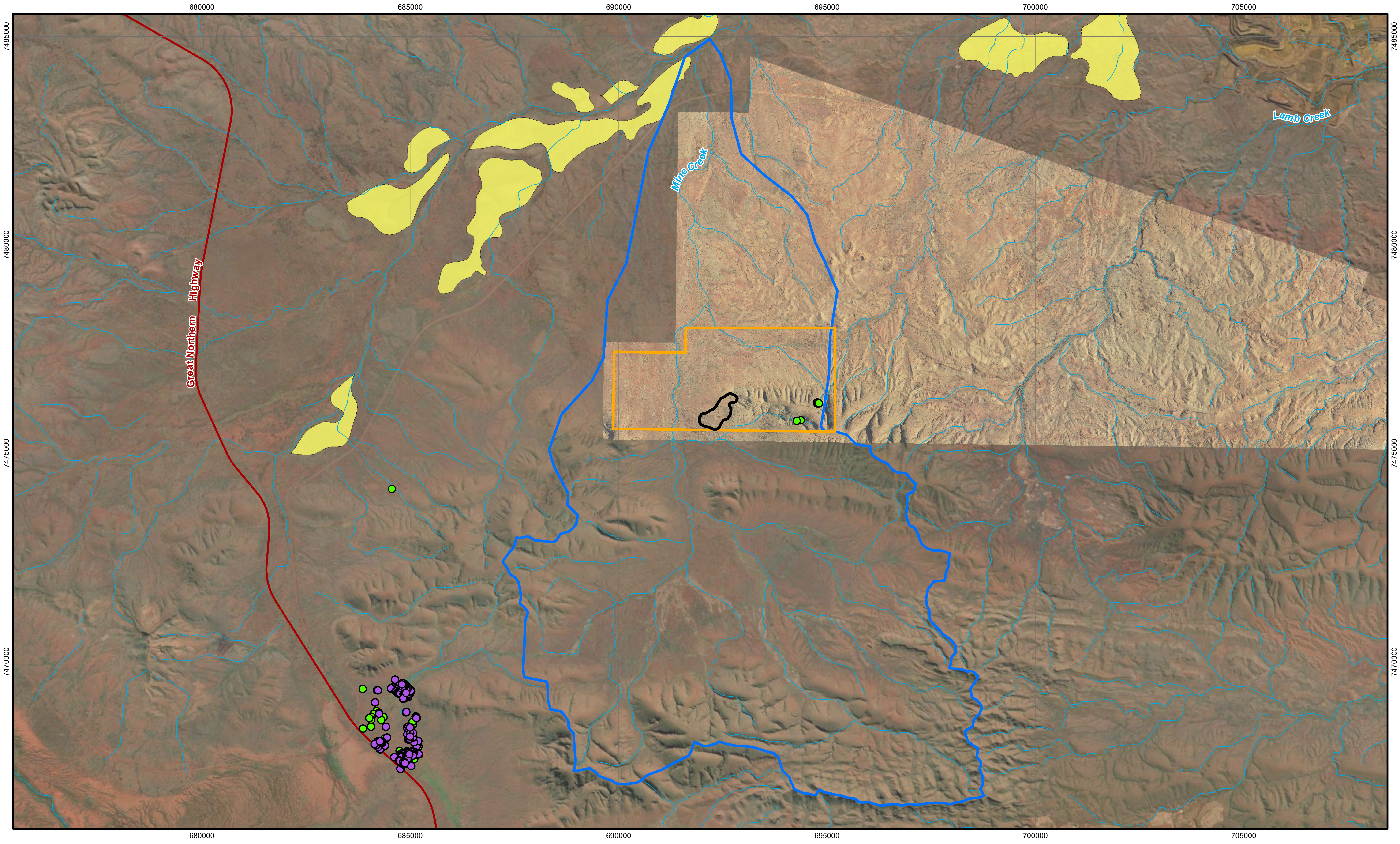
POTENTIAL GROUNDWATER
DEPENDENT ECOSYSTEMS

PSM4241-004R

Figure 3

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 3 Potential Groundwater Dependent Ecosystems.mxd



Legend

— Pit Outline

🟧 Tenure Boundary

🟦 Catchment Area for Mine

— Drainage - Creeks

🟨 Calcrete - Groundwater Discharge Zones and Shallow Water Table

— Major Road

Lamb Creek 2020 Priority Flora

● P2

● P3

N

Scale 1:85,000

0 1 2 3 4 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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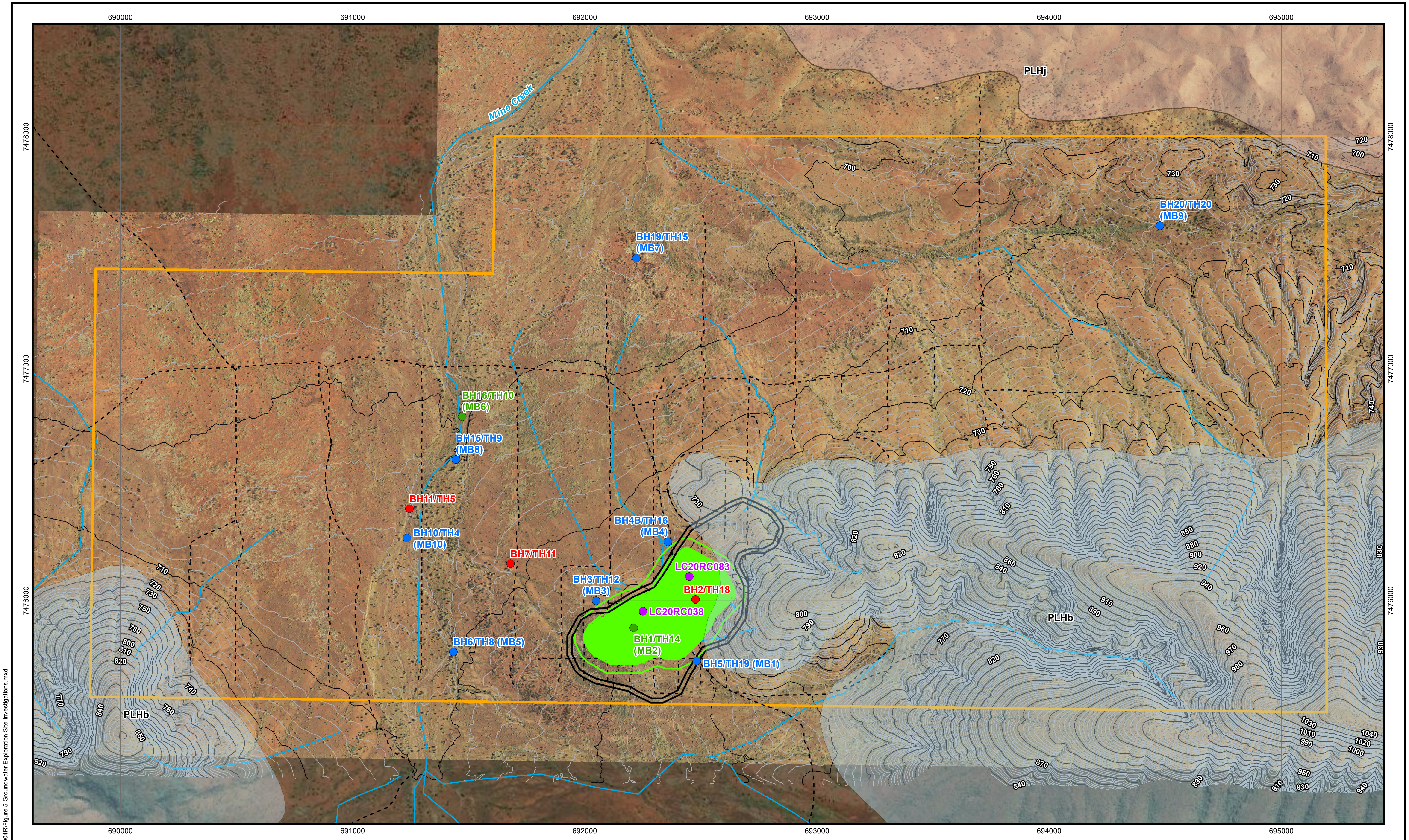
PRIORITY FLORA LOCATIONS

PSM4241-004R

Figure 4

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 4 Priority Flora Locations.mxd



Legend

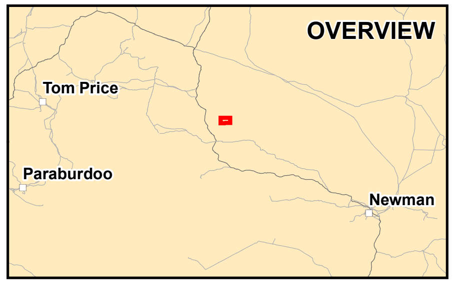
Boreholes

- ● Exploratory Drilling
- ● Short-Term Standpipe (Installed Only)
- ● Long-Term Standpipe (Installed and Developed)
- ● Geotechnical Boreholes (Airlift)

- — Pit Outline
- — Mineralisation (At Depth)
- - - Tracks
- ▭ M47/0019
- — Drainage - Creeks
- — Topography

250k WA Geology

- ▨ PLHj (Weeli Wooli Formation)
- ▨ PLHb (Brockman Iron Formation)



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Scale 1:15,000

0 0.2 0.4 0.6 0.8 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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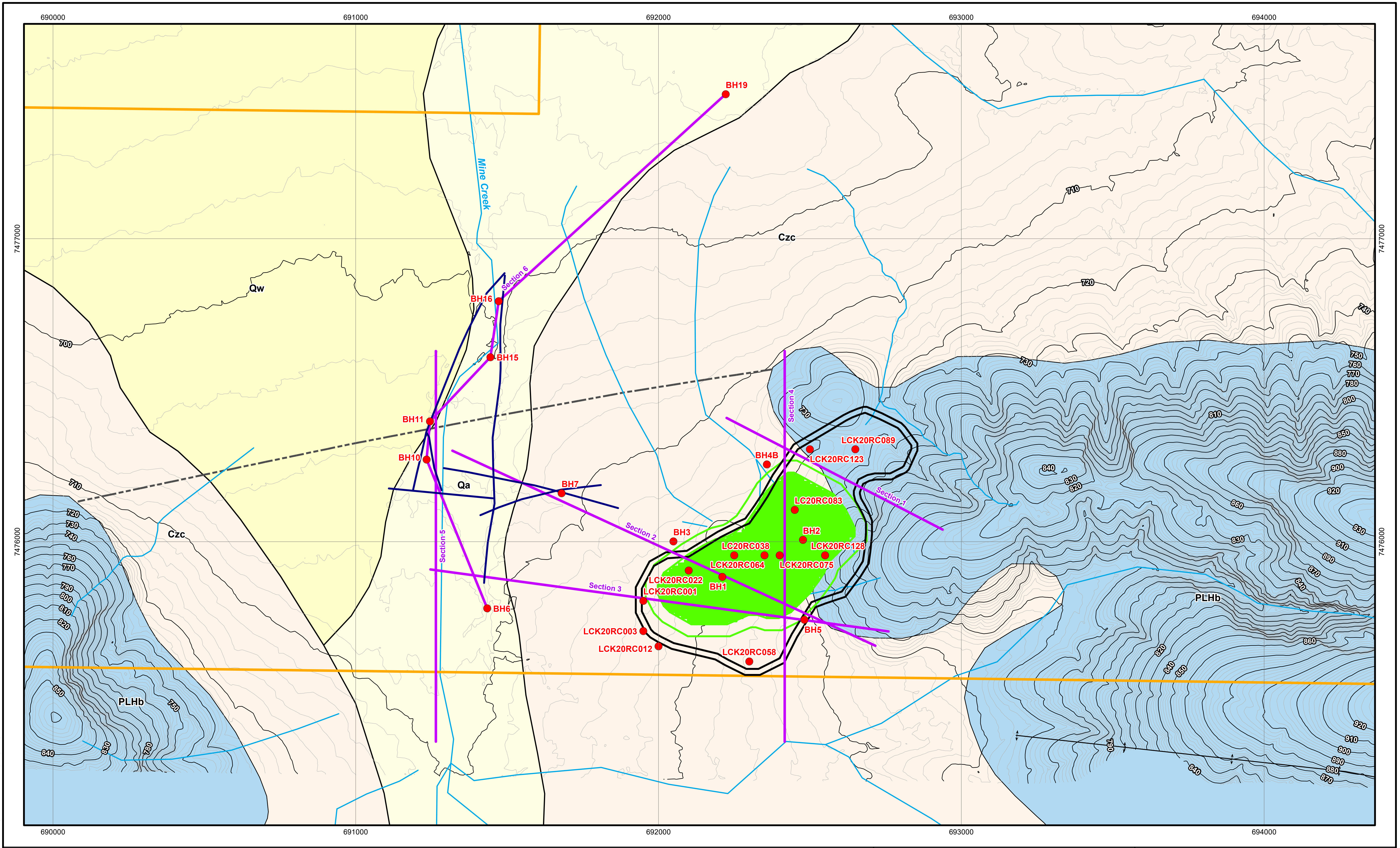
GROUNDWATER EXPLORATION
SITE INVESTIGATIONS

PSM4241-004R

Figure 5

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 5 Groundwater Exploration Site Investigations.mxd



Legend

● Boreholes

— Cross-Section Locations

— Pit Outline

— Mineralisation (At Depth)

▭ Tenure Boundary

— Drainage - Creeks

250k WA Geology

▭ Qa (Alluvium)

▭ Qw (Alluvium and Colluvium)

▭ Czc (Colluvium)

▭ PLHb (Brockman Iron Formation)

↕ Major fold, showing trend and plunge direction

- - Potential Continuation of BIF Zone

— Topography

— Interpreted Structures Beneath Mine Creek

N

Scale 1:11,500

0 0.1 0.2 0.3 0.4 0.5 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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LOCATION OF HYDROGEOLOGICAL
CROSS-SECTIONS

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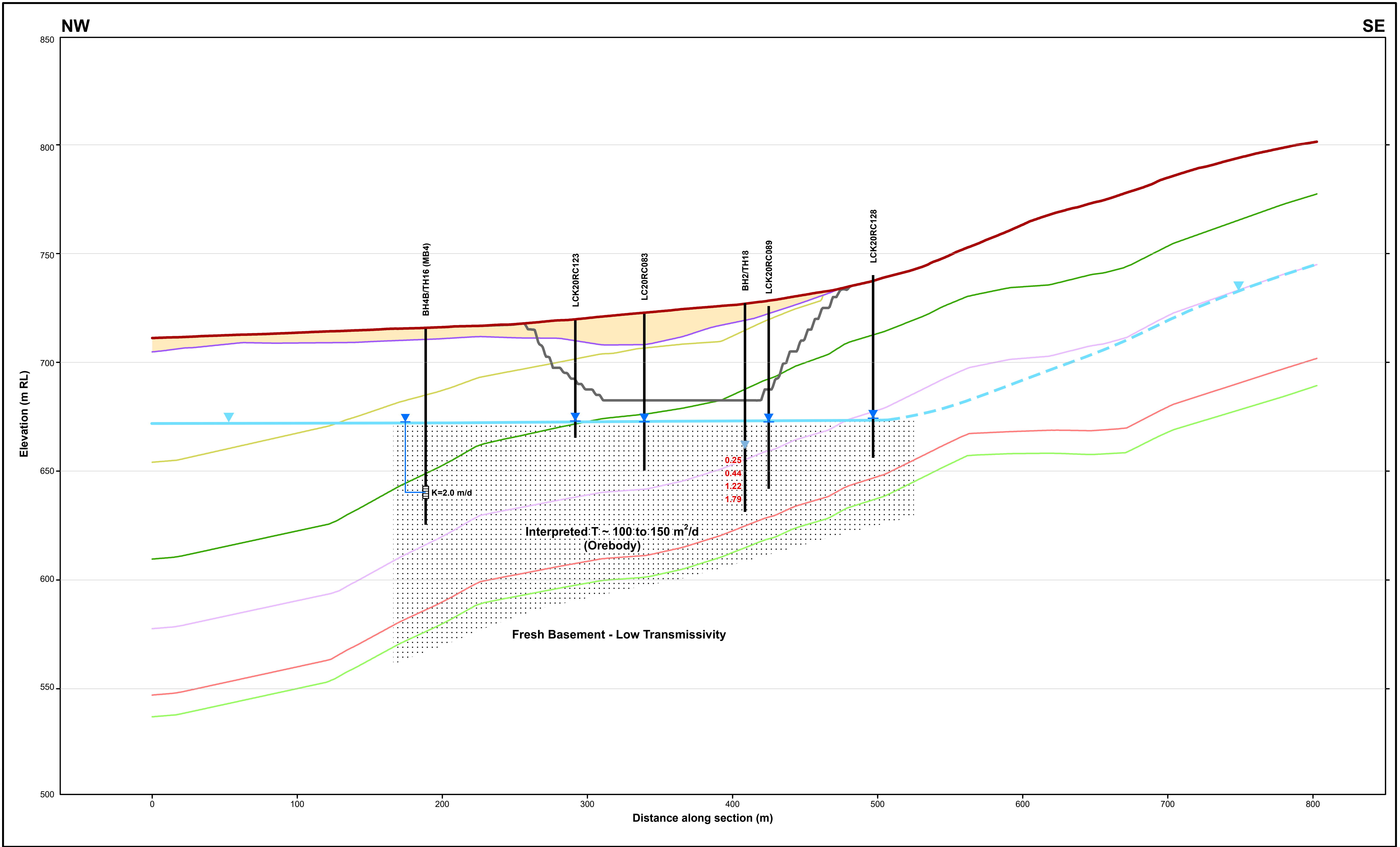
Figure 6

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 6 Location of Hydrogeological Cross-Sections.mxd



Legend

- — Ground
- — Pit
- — Detrital Footwall
- — Whaleback Shale Footwall
- — Dales Gorge 4 Footwall
- — Dales Gorge 3 Footwall
- — Dales Gorge 2 Footwall
- — Dales Gorge 1 Footwall
- ▨ Detrital
- — Borehole Trace
- ▥ Borehole Screen
- ▼ Measured Groundwater Head (January and February 2021)
- ▼ Drilling Water Strike
- 0.25 Drilling Airlift Yield (L/sec)
- ▼ Interpreted Baseline Water Table
- ⁚⁚ Interpreted Transmissivity Zone

0 25 50 100 150 m

Horizontal Scale
Vertical Exaggeration 1.5 x

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HYDROGEOLOGICAL
CROSS-SECTION 1 -
PIT SETTING

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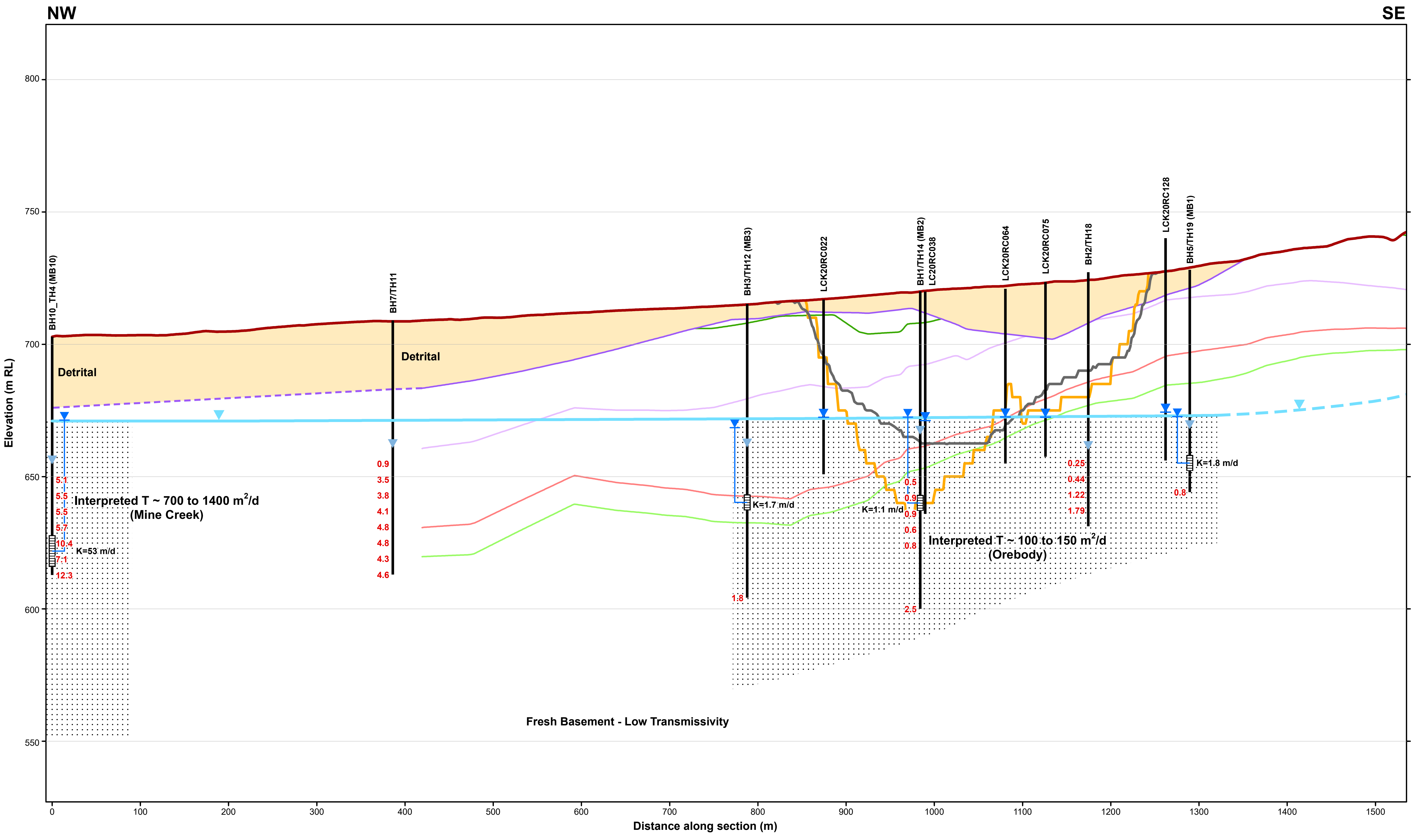
Figure 7

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 7 Hydrogeological Cross-Section 1 - Pit Setting.mxd



Legend

- Ground
- Pit
- Mineralisation
- Detrital Footwall
- Dales Gorge 4 Footwall
- Dales Gorge 3 Footwall
- Dales Gorge 2 Footwall
- Dales Gorge 1 Footwall
- Detrital
- Borehole Trace
- Borehole Screen
- ▼ Measured Groundwater Head (January and February 2021)
- ▼ Drilling Water Strike
- 0.25 Drilling Airlift Yield (L/sec)
- ▼ Interpreted Baseline Water Table
- ⁝ Interpreted Transmissivity Zone

0 50 100 200 m
Horizontal Scale
Vertical Exaggeration 3 x

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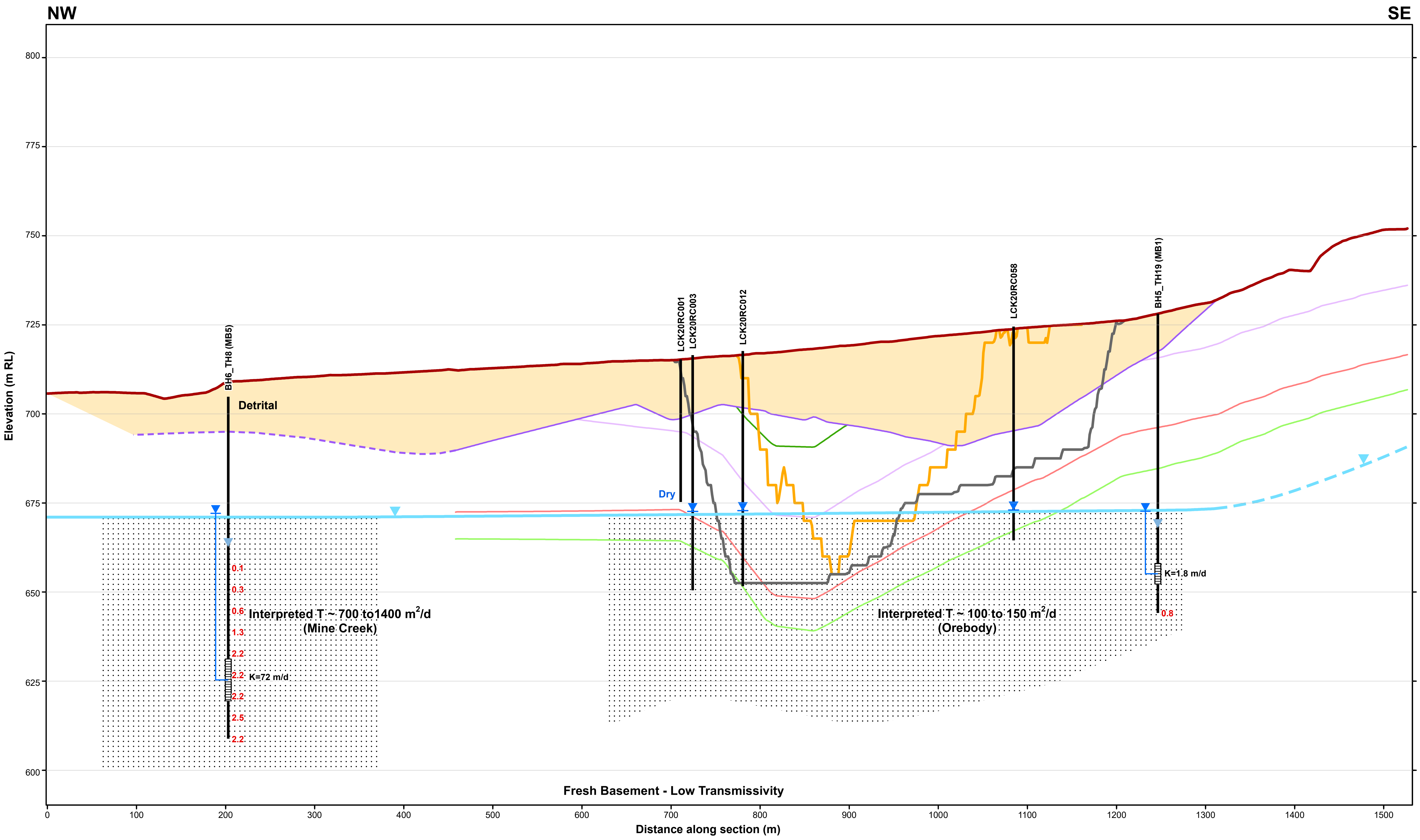
HYDROGEOLOGICAL
CROSS-SECTION 2 -
PIT SETTING

PSM4241-004R
Figure 8

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 8 Hydrogeological Cross-Section 2 - Pit Setting.mxd



Legend

- Ground
- Pit
- Mineralisation
- Detrital Footwall
- Dales Gorge 4 Footwall
- Dales Gorge 3 Footwall
- Dales Gorge 2 Footwall
- Dales Gorge 1 Footwall
- Detrital
- Borehole Trace
- Borehole Screen
- ▼ Measured Groundwater Head (January and February 2021)
- ▼ Drilling Water Strike
- 0.25 Drilling Airlift Yield (L/sec)
- ▼ Interpreted Baseline Water Table
- ⁘ Interpreted Transmissivity Zone

0 50 100 200 m

Horizontal Scale
Vertical Exaggeration 4 x

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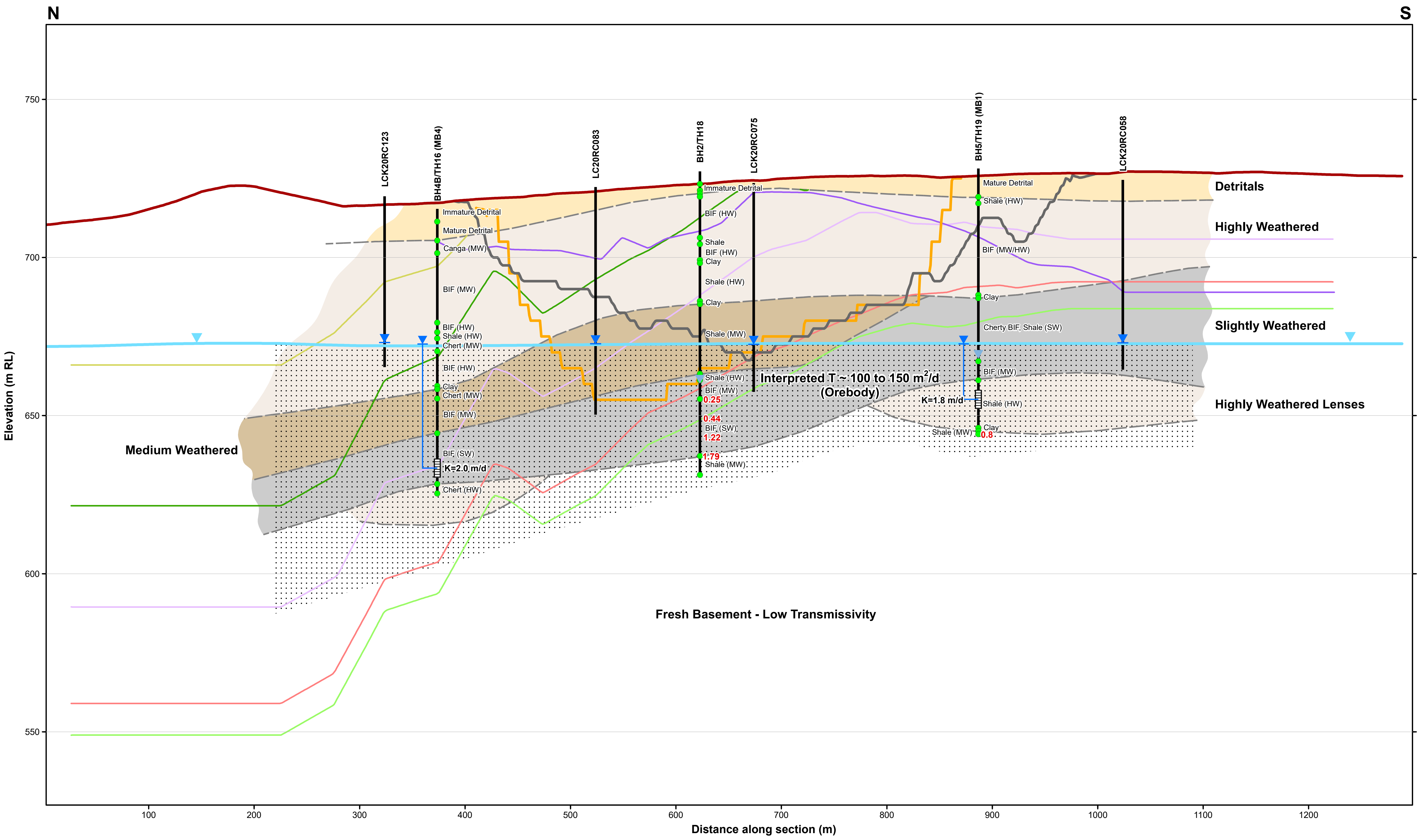
HYDROGEOLOGICAL
CROSS-SECTION 3 -
PIT SETTING

PSM4241-004R

Figure 9

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 9 Hydrogeological Cross-Section 3 - Pit Setting.mxd



Legend

- Ground
- Pit
- Mineralisation
- Detrital Footwall
- Whaleback Shale Footwall
- Dales Gorge 4 Footwall
- Dales Gorge 3 Footwall
- Dales Gorge 2 Footwall
- Dales Gorge 1 Footwall
- ● Stratigraphy
- Detrital
- Highly Weathered
- Medium Weathered
- Slightly Weathered
- Borehole Trace
- Borehole Screen
- ▼ Measured Groundwater Head (January and February 2021)
- ▼ Drilling Water Strike
- 0.25 Drilling Airlift Yield
- Interpreted Baseline Water Table
- ∴ Interpreted Transmissivity Zone

0 50 100 200 m

Horizontal Scale
Vertical Exaggeration 3 x

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HYDROGEOLOGICAL
CROSS-SECTION 4 -
PIT SETTING

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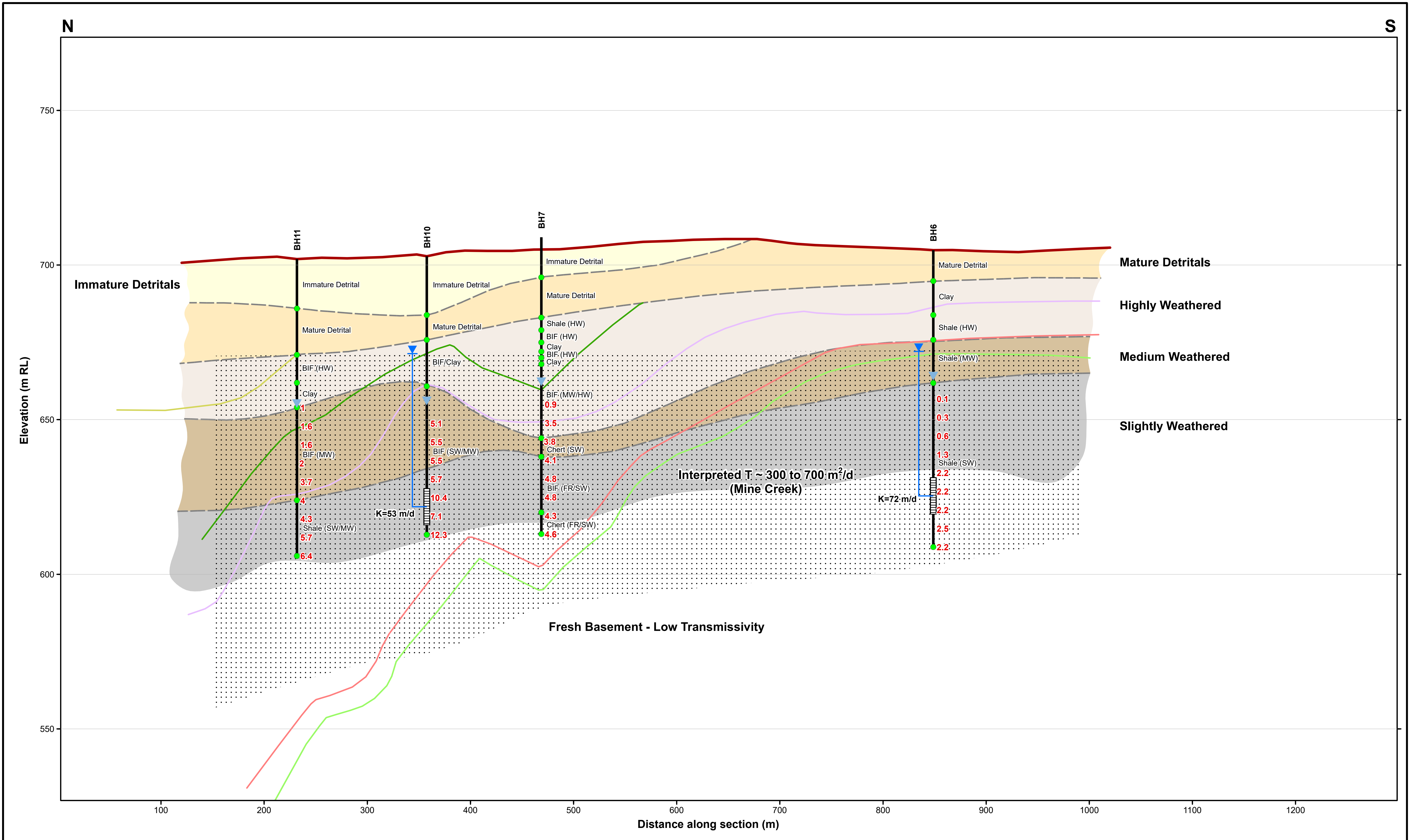
D:\PSM_Projects\PSM4241103_Figures\PSM4241-004R\Figure 10 Hydrogeological Cross-Section 4 - Pit Setting.mxd



Legend

Ground	● Stratigraphy	Borehole Trace
Whaleback Shale	Immature Detrital	Borehole Screen
Dales Gorge 4	Mature Detrital	▼ Measured Groundwater Head (January and February 2021)
Dales Gorge 3	Highly Weathered	▼ Drilling Water Strike
Dales Gorge 2	Medium Weathered	0.25 Drilling Airlift Yield (L/sec)
Dales Gorge 1	Slightly Weathered	Interpreted Transmissivity Zone

0 50 100 200 m
Horizontal Scale
Vertical Exaggeration 3 x

PSM

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HYDROGEOLOGICAL
CROSS-SECTION 5 -
MINE CREEK SETTING

PSM4241-004R
Figure 11

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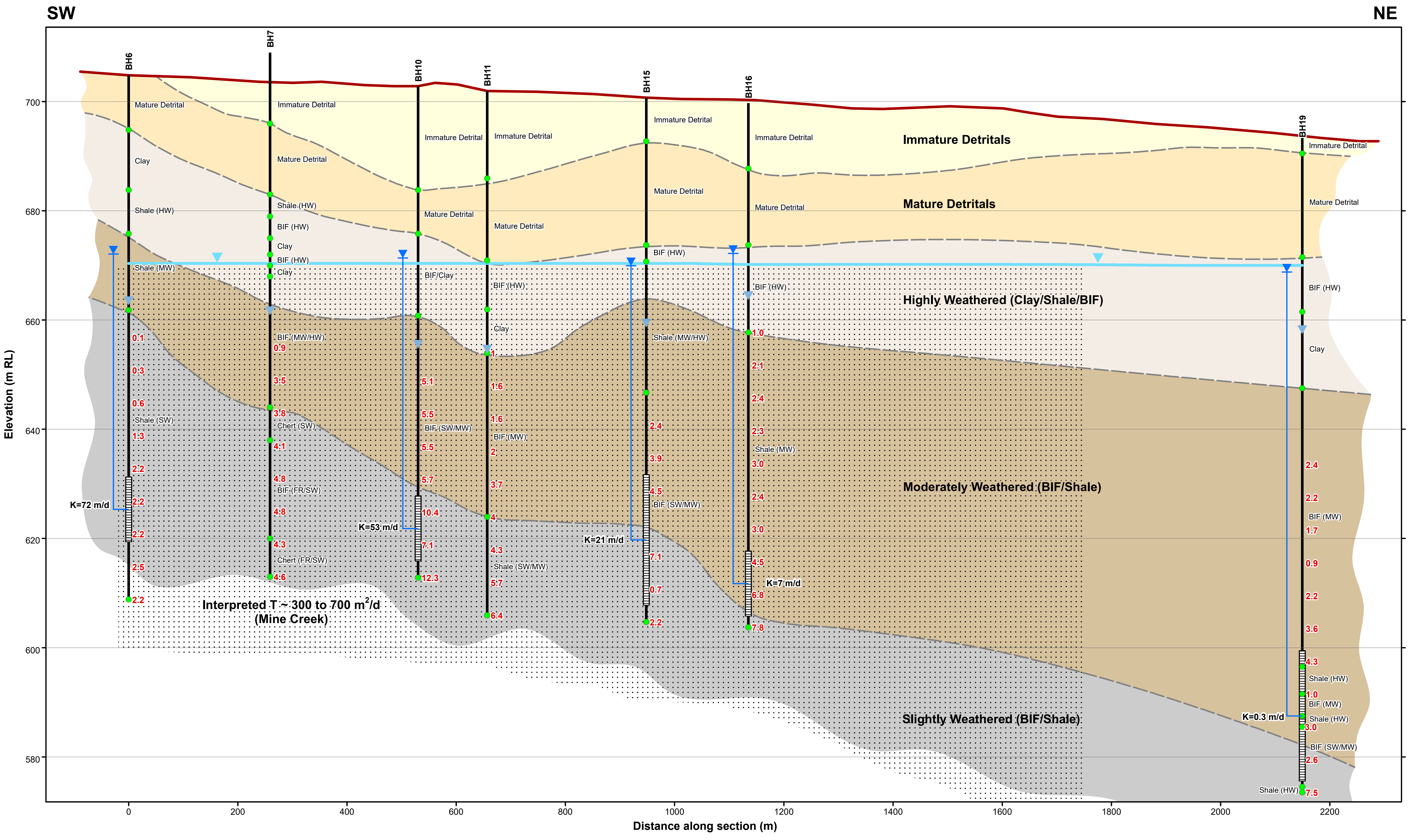

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 12 Hydrogeological Cross-Section 6 - Mine Creek Setting.mxd

Legend

― Ground
● Stratigraphy
🟨 Immature Detrital
🟧 Mature Detrital
⬜ Highly Weathered
🟫 Medium Weathered
⬛ Slightly Weathered
― Borehole
▥ Borehole Screen
▼ Measured Groundwater Head (January and February 2021)
▼ Drilling Water Strike
0.25 Drilling Airlift Yield (L/sec)
▼ Interpreted Baseline Water Table
⁙ Interpreted Transmissivity Zone

0 50 100 200 300 400 m
Horizontal Scale
Vertical Exaggeration 10x

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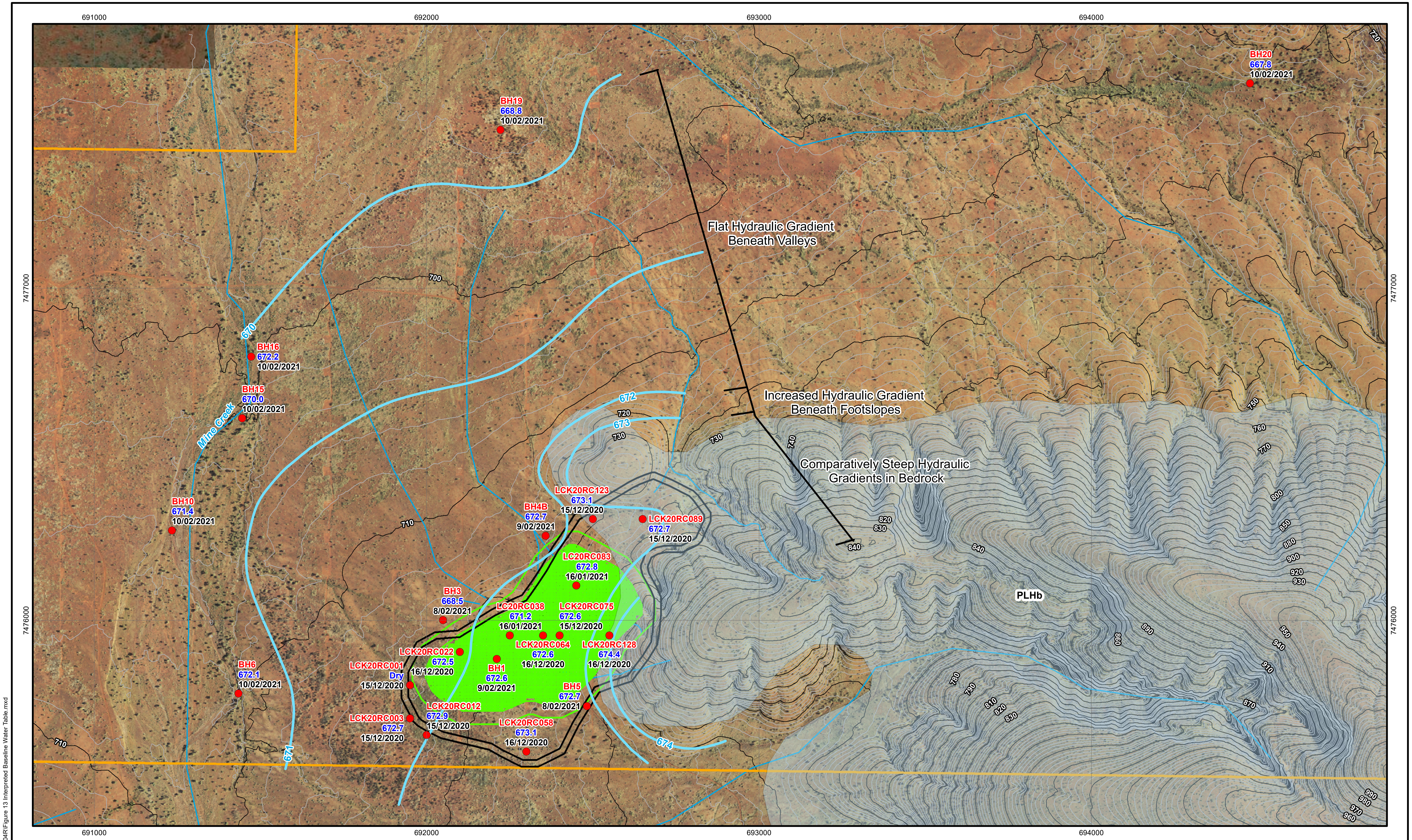
Hydrogeology Assessment

HYDROGEOLOGICAL
CROSS-SECTION 6 -
MINE CREEK SETTING

PSM4241-004R
Figure 12



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

Legend

- ● Boreholes
- 670 Measured Groundwater Heads (m RL)
- 9/02/2021 Date of Groundwater Heads Measurement
- Interpreted Water Table Contours (Early 2021)
- Pit Outline
- Mineralisation (At Depth)
- ☐ M47/0019
- Drainage - Creeks
- Topography

250k WA Geology

- ▨ PLHb (Brockman Iron Formation)

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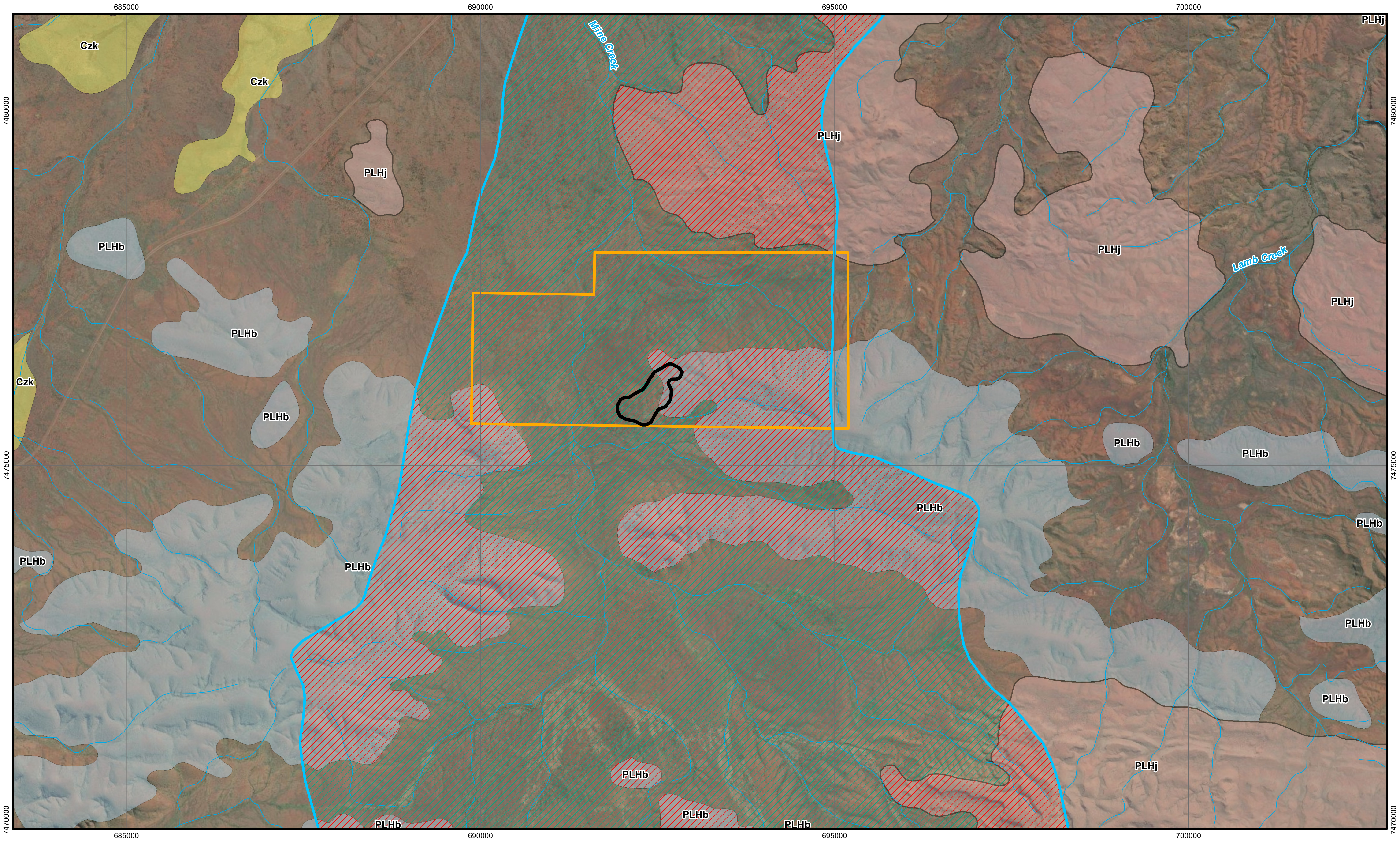
INTERPRETED
BASELINE WATER TABLE

PSM	Created By: MB	Revision: A	
	Date: 28 Apr 2021	Paper Size: A3	PSM4241-004R	Figure 13

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 13 Interpreted Baseline Water Table.mxd



Legend

— Pit Outline

🟧 M47/0019

— Drainage - Creeks

250k WA Geology

🟨 Czk (Calcrete)

▨ PLHj (Weeli Wooli Formation)

🟦 PLHb (Brockman Iron Formation)

— Mine Creek Catchment

▨ Low-Transmissivity Bedrocks - Discharge Boundaries

▨ Preferential Flow in Weathered and Valley-Fill Profiles

N

Scale 1:50,000

0 0.5 1 1.5 2 2.5 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

P S M

Created By: MB	Revision: A
Date: 05 May 2021	Paper Size: A3

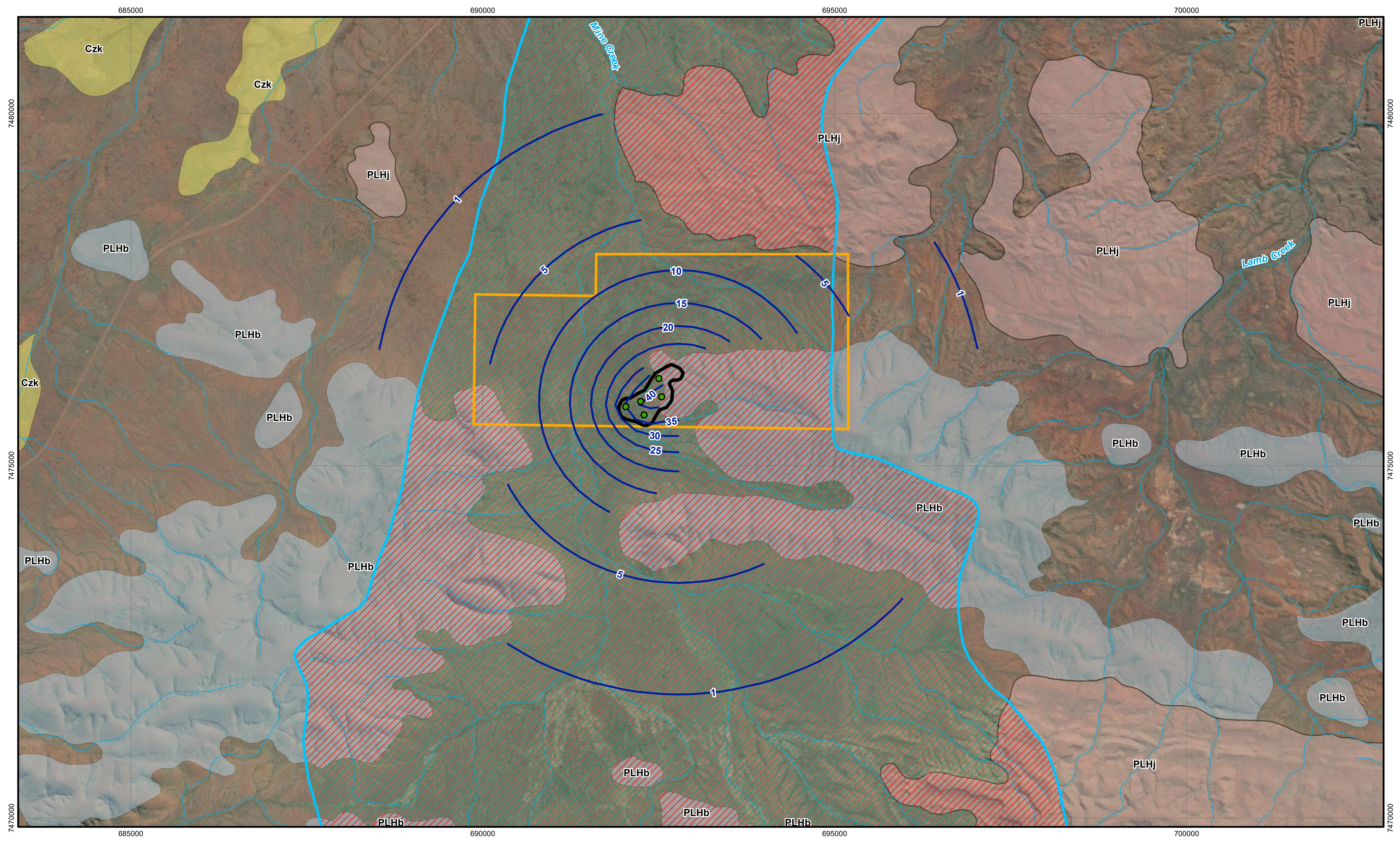
Mineral Resources Ltd
Lamb Creek Iron Ore Project
Hydrogeology Assessment

CONCEPTUAL AQUIFER SYSTEM

PSM4241-004R

Figure 14

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 14 Conceptual Aquifer System.mxd



Legend

— Pit Outline

▭ M47/0019

— Drainage - Creeks

— Predicted Drawdown (m) Contours

Model Bore Type

● Dewatering

250k WA Geology

🟨 Czk (Calcrete)

▨ PLHj (Weeli Wooli Formation)

▨ PLHb (Brockman Iron Formation)

— Mine Creek Catchment

▨ Low-Transmissivity Bedrocks - Discharge Boundaries

▨ Preferential Flow in Weathered and Valley-Fill Profiles

N

Scale 1:50,000

0 0.5 1 1.5 2 2.5 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

PSM

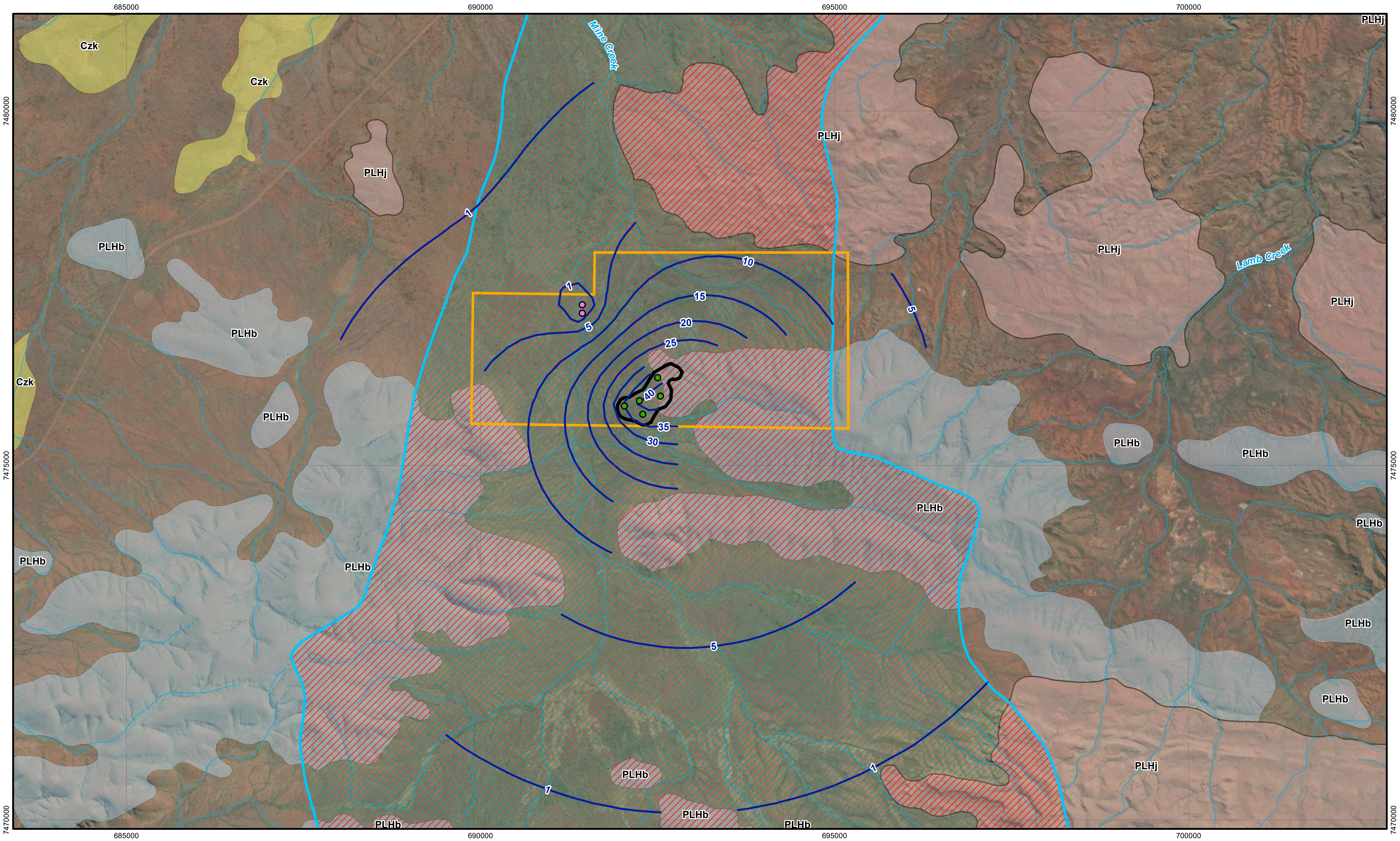
Created By: MB	Revision: A
Date: 05 May 2021	Paper Size: A3

Mineral Resources Ltd
Lamb Creek Iron Ore Project
Hydrogeology Assessment

BASE SCENARIO
PIT DEWATERING EQUIVALENT TO
SUPPLY DEMAND

PSM4241-004R Figure 15

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 15 Base scenario Pit Dewatering Equivalent to Supply Demand.mxd



Legend

Pit Outline

M47/0019

Drainage - Creeks

Predicted Drawdown (m) Contours

Model Bore Type

● Dewatering

● Injection

250k WA Geology

Czk (Calcrete)

PLHj (Weeli Wooli Formation)

PLHb (Brockman Iron Formation)

Mine Creek Catchment

▨ Low-Transmissivity Bedrocks - Discharge Boundaries

▨ Preferential Flow in Weathered and Valley-Fill Profiles

N

Scale 1:50,000

0 0.5 1 1.5 2 2.5 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

PSM

Created By: MB

Revision: A

Date: 05 May 2021

Paper Size: A3

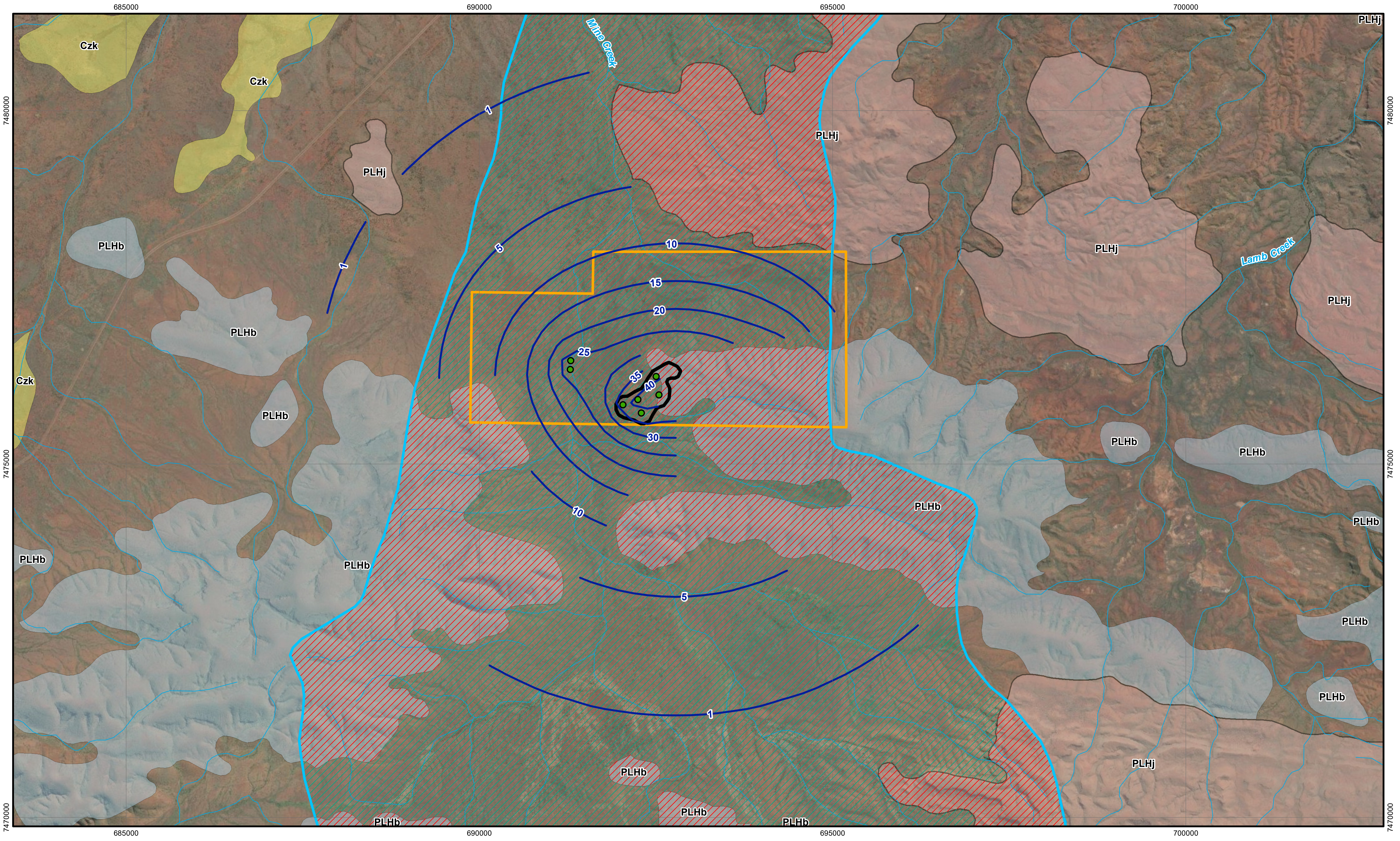
Mineral Resources Ltd
Lamb Creek Iron Ore Project
Hydrogeology Assessment

UPPER BOUND SCENARIO
PIT DEWATERING GREATER THAN
SUPPLY DEMAND

PSM4241-004R

Figure 16

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 16 Upper bound scenario Pit Dewatering Greater than Supply Demand.mxd



Legend

- Pit Outline
- M47/0019
- Drainage - Creeks
- Predicted Drawdown (m) Contours

Model Bore Type

- ● Dewatering

250k WA Geology

- Czk (Calcrete)
- PLHj (Weeli Wooli Formation)
- PLHb (Brockman Iron Formation)

- Mine Creek Catchment
- Low-Transmissivity Bedrocks - Discharge Boundaries
- Preferential Flow in Weathered and Valley-Fill Profiles

N

Scale 1:50,000

0 0.5 1 1.5 2 2.5 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

PSM

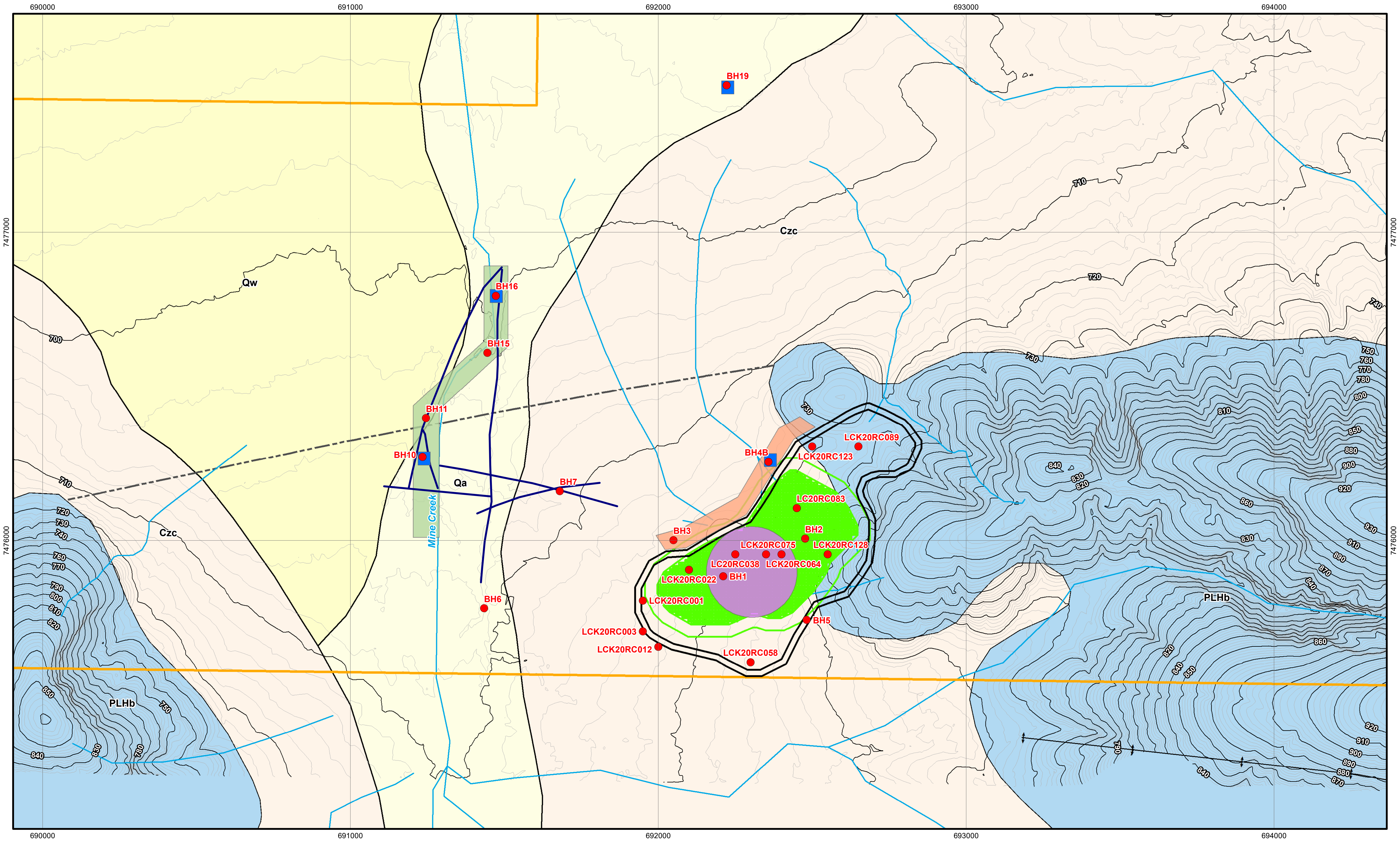
Created By: MB	Revision: A
Date: 05 May 2021	Paper Size: A3

Mineral Resources Ltd
Lamb Creek Iron Ore Project
Hydrogeology Assessment

LOWER BOUND SCENARIO
PIT DEWATERING LESS THAN
SUPPLY DEMAND

PSM4241-004R | Figure 17

D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 17 Lower bound scenario Pit Dewatering Less than Supply Demand.mxd



D:\PSM_Projects\PSM4241\03_Figures\PSM4241-004R\Figure 18 Preferred Groundwater Source Areas.mxd

Legend

- ● Boreholes
- 🟦 Proposed Pumping Bores
- Pit Outline
- Mineralisation (At Depth)
- Tenure Boundary
- Drainage - Creeks

250k WA Geology

- Qa (Alluvium)
- Qw (Alluvium and Colluvium)
- Czc (Colluvium)
- PLHb (Brockman Iron Formation)

- Major fold, showing trend and plunge direction
- Potential Continuation of BIF Zone
- Topography
- Interpreted Structures Beneath Mine Creek

- Ore Below the Water Table
- ☒ Conceptual Pit Dewatering Production Bore Locations and Targets
- ☒ Conceptual Water Supply Production Bore Locations and Targets

N

Scale 1:11,500

0 0.1 0.2 0.3 0.4 0.5 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

PSM

Created By: MB
Revision: A
Date: 05 May 2021
Paper Size: A3

Mineral Resources Ltd
Lamb Creek Iron Ore Project
Hydrogeology Assessment

PREFERRED GROUNDWATER
SOURCE AREAS

PSM4241-004R
Figure 18

Appendix A
Bore Logs

Borehole ID

BH1/TH14 (MB2)

Sheet 1 of 3

Monitoring Bore

Job No: PSM4241
Client: MRL
Project: Lamb Creek Hydrogeology Inv.
Drilling subcontractor: Egan Drilling
Date hole commenced: 13/12/20
Date hole complete: 14/12/20

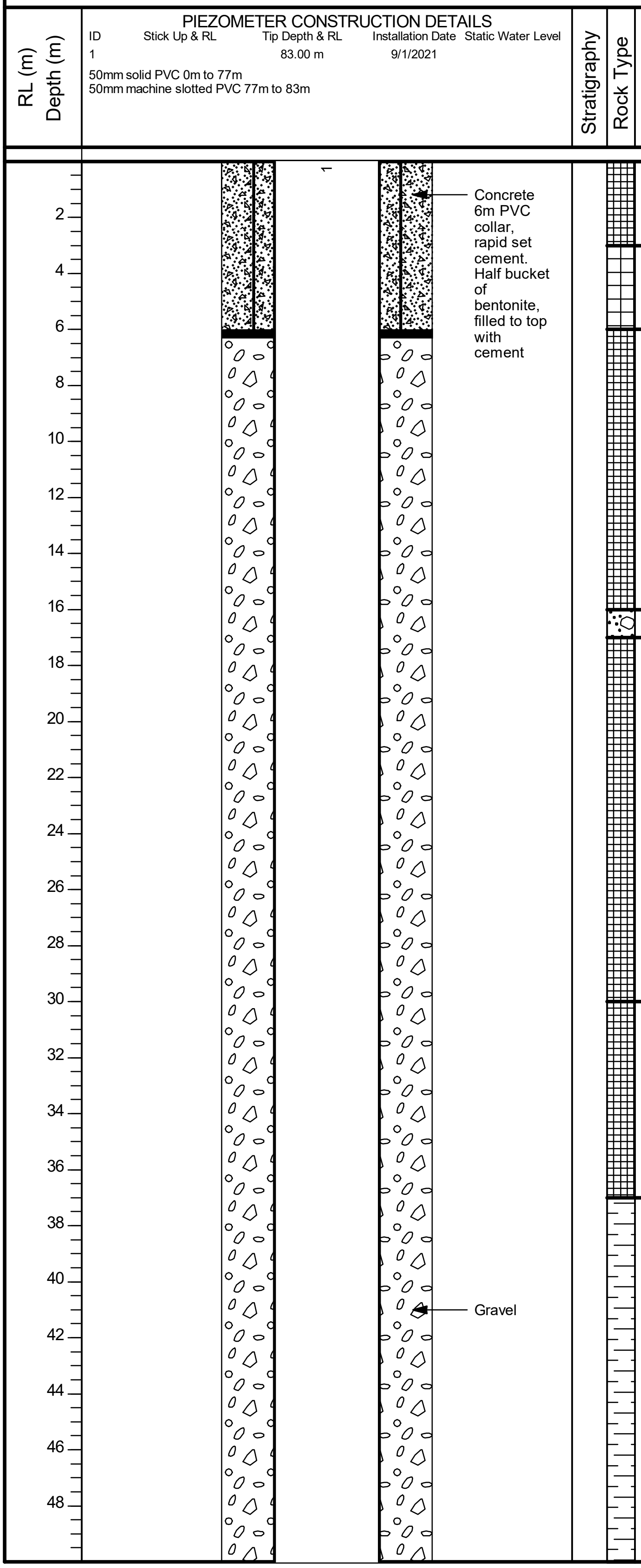
Drill information: AustEX-X400
Hole diameter: 143 mm
Datum: GDA94 Zone 50
Borehole location: In the orebody
Inclination/Azimuth: -90° /
Surface R.L.:

Drilling Method: RC
Hole Depth: 120 m
Easting: 692211
Northing: 7475884
Logged by: Yang Wang

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		83.00 m	9/1/2021	

50mm solid PVC 0m to 77m
50mm machine slotted PVC 77m to 83m



Material Description
(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

Discharge (l/s) 1 2 3 4
Electrical Conductivity (mS/cm) 150 300 450 600
pH 2 4 6 8

MINERALISED BIF: Brown red, BIF clasts with mm scale laminae and some mineralised BIF (goethite) with minor chert, non-magnetic.

BANDED IRON FORMATION: Black brown, highly weathered BIF with clay and minor mineralised shale (goethite), 1- 3mm magnetic nodules, magnetic.

MINERALISED BIF: Brown purple, highly weathered mineralised BIF (goethite and hematite), mineralised shale (goethite), minor shale and BIF. Some 1-3mm magnetic nodules, non-magnetic.

MATURE DETRITAL: Sub-rounded to rounded hematite nodules, magnetic.

MINERALISED BIF: Purple black, highly weathered mineralised BIF (hematite) and unmineralised shale, non-magnetic.

MINERALISED BIF: Yellow black, highly weathered BIF (goethite and hematite) and mineralised shale (goethite), non-magnetic.

CLAY: Grey yellow, clay with minor BIF and shale clasts, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH1/TH14 (MB2)

Sheet 2 of 3

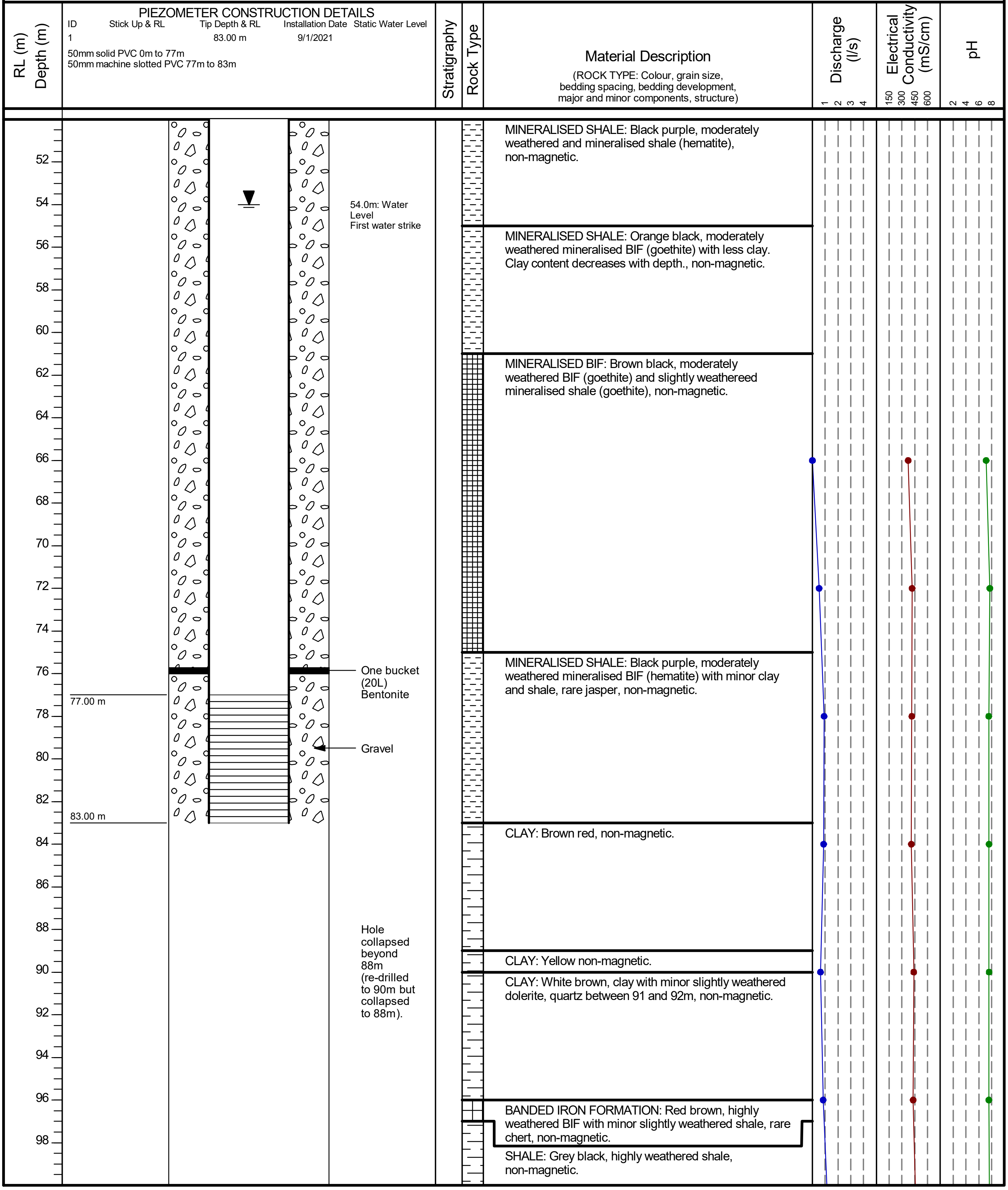
Monitoring Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	143 mm	Drilling Method:	RC
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	120 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In the orebody	Easting:	692211
Date hole commenced:	13/12/20	Inclination/Azimuth:	-90° /	Northing:	7475884
Date hole complete:	14/12/20	Surface R.L.:		Logged by:	Yang Wang

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		83.00 m	9/1/2021	

50mm solid PVC 0m to 77m
50mm machine slotted PVC 77m to 83m



MINERALISED SHALE: Black purple, moderately weathered and mineralised shale (hematite), non-magnetic.

MINERALISED SHALE: Orange black, moderately weathered mineralised BIF (goethite) with less clay. Clay content decreases with depth., non-magnetic.

MINERALISED BIF: Brown black, moderately weathered BIF (goethite) and slightly weathereed mineralised shale (goethite), non-magnetic.

MINERALISED SHALE: Black purple, moderately weathered mineralised BIF (hematite) with minor clay and shale, rare jasper, non-magnetic.

CLAY: Brown red, non-magnetic.

CLAY: Yellow non-magnetic.

CLAY: White brown, clay with minor slightly weathered dolerite, quartz between 91 and 92m, non-magnetic.

BANDED IRON FORMATION: Red brown, highly weathered BIF with minor slightly weathered shale, rare chert, non-magnetic.

SHALE: Grey black, highly weathered shale, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH1/TH14 (MB2)

Sheet 3 of 3

Monitoring Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	143 mm	Drilling Method:	RC
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	120 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In the orebody	Easting:	692211
Date hole commenced:	13/12/20	Inclination/Azimuth:	-90° /	Northing:	7475884
Date hole complete:	14/12/20	Surface R.L.:		Logged by:	Yang Wang

RL (m) Depth (m)

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		83.00 m	9/1/2021	

50mm solid PVC 0m to 77m
50mm machine slotted PVC 77m to 83m

Stratigraphy | Rock Type

Material Description
(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

CLAY: Black non-magnetic.

NO RECOVERY: Only black water but no sample chips were recovered

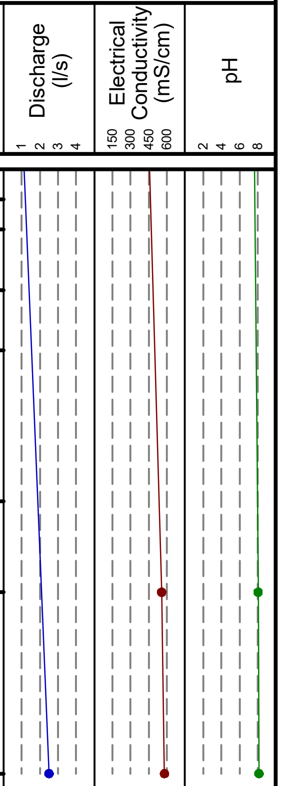
SHALE: Black fresh shale

SHALE: Black fresh shale with quartz, quartz content increases with depth, non-magnetic.

NO RECOVERY: Only black water but no sample chips were recovered

SHALE: Black fresh shale, non-magnetic.

EOH:
120m



102
104
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146
148

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

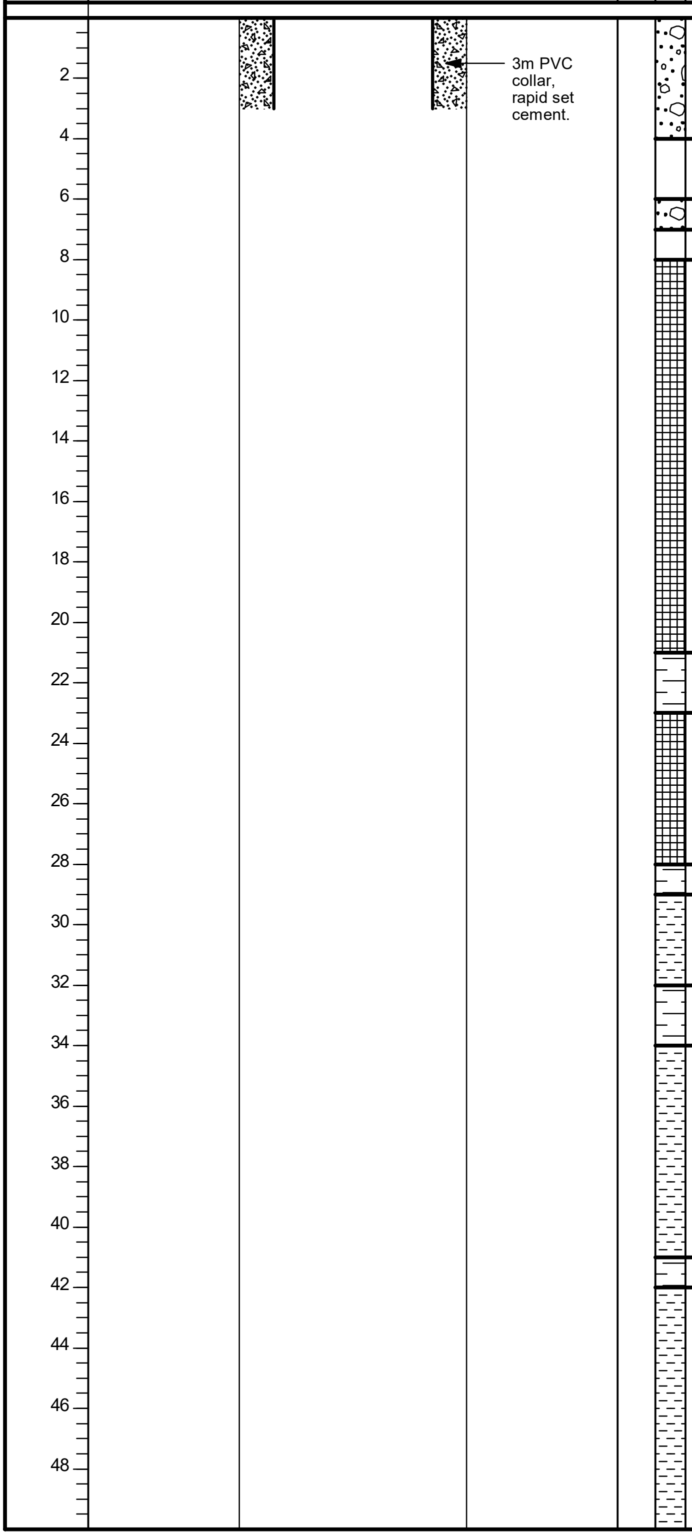
BH2/TH18

Sheet 1 of 2

Exploration Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	96 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In the orebody	Easting:	692477
Date hole commenced:	17/01/21	Inclination/Azimuth:	-90° /	Northing:	7476006
Date hole complete:	18/01/21	Surface R.L.:		Logged by:	Yang Wang

RL (m) Depth (m)	PIEZOMETER CONSTRUCTION DETAILS	Stratigraphy	Rock Type	Material Description (ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)	Discharge (l/s) 1 2 3 4	Electrical Conductivity (mS/cm) 150 300 450 600	pH 2 4 6 8



IMMATURE DETRITAL: Red fine-grained colluvium, red ferruginous coating on clasts and minor 1-5 mm magnetic angular clasts. Poor recovery 1-4m, non-magnetic.

NO RECOVERY

IMMATURE DETRITAL: Yellow black, minor amount of highly weathered angular detritals were recovered, non-magnetic.

NO RECOVERY

MINERALISED BIF: Brown black, highly weathered mineralised BIF and shale (goethite and hematite) and 1-5mm magnetic clasts throughout, magnetic.

SHALE: White pink, bleached non-magnetic clasts with clay matrix, non-magnetic.

MINERALISED BIF: Brown black, highly weathered mineralised BIF and shale chips (majority goethite), non-magnetic.

CLAY: Yellow pink, well-sorted sub-rounded to angular clasts with clay matrix, non-magnetic.

MINERALISED SHALE: Grey black, highly weathered mineralised shale chips (hematite) and BIF (goethite), non-magnetic.

SHALE: Purple red, highly weathered, non-magnetic.

MINERALISED SHALE: Brown black, Highly weathered and magnetic mineralised shale (hematite), minor jasper, 1-5mm magnetic clasts throughout, magnetic.

CLAY: Yellow brown, bleached, highly weathered, non-magnetic.

MINERALISED SHALE: Grey black, moderately weathered hematitic shale with minor yellow coated clasts, rare magnetic angular clasts above 56m, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

PSM

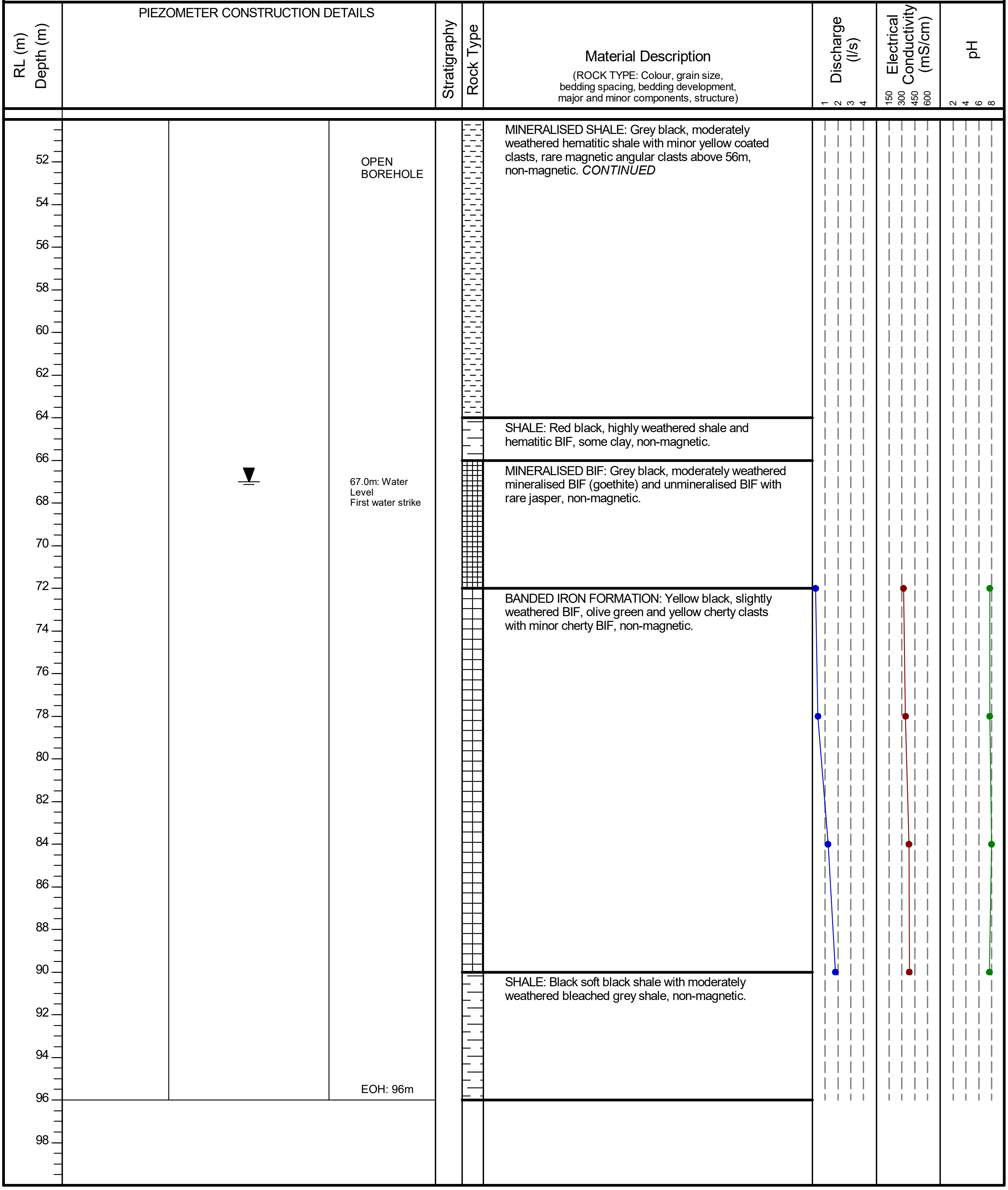
Borehole ID

BH2/TH18

Sheet 2 of 2

Exploration Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	96 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In the orebody	Easting:	692477
Date hole commenced:	17/01/21	Inclination/Azimuth:	-90° /	Northing:	7476006
Date hole complete:	18/01/21	Surface R.L.:		Logged by:	Yang Wang



MINERALISED SHALE: Grey black, moderately weathered hematitic shale with minor yellow coated clasts, rare magnetic angular clasts above 56m, non-magnetic. *CONTINUED*

SHALE: Red black, highly weathered shale and hematitic BIF, some clay, non-magnetic.

MINERALISED BIF: Grey black, moderately weathered mineralised BIF (goethite) and unmineralised BIF with rare jasper, non-magnetic.

BANDED IRON FORMATION: Yellow black, slightly weathered BIF, olive green and yellow cherty clasts with minor cherty BIF, non-magnetic.

SHALE: Black soft black shale with moderately weathered bleached grey shale, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Monitoring Bore

Borehole ID

BH3/TH12 (MB3)

Sheet 1 of 3

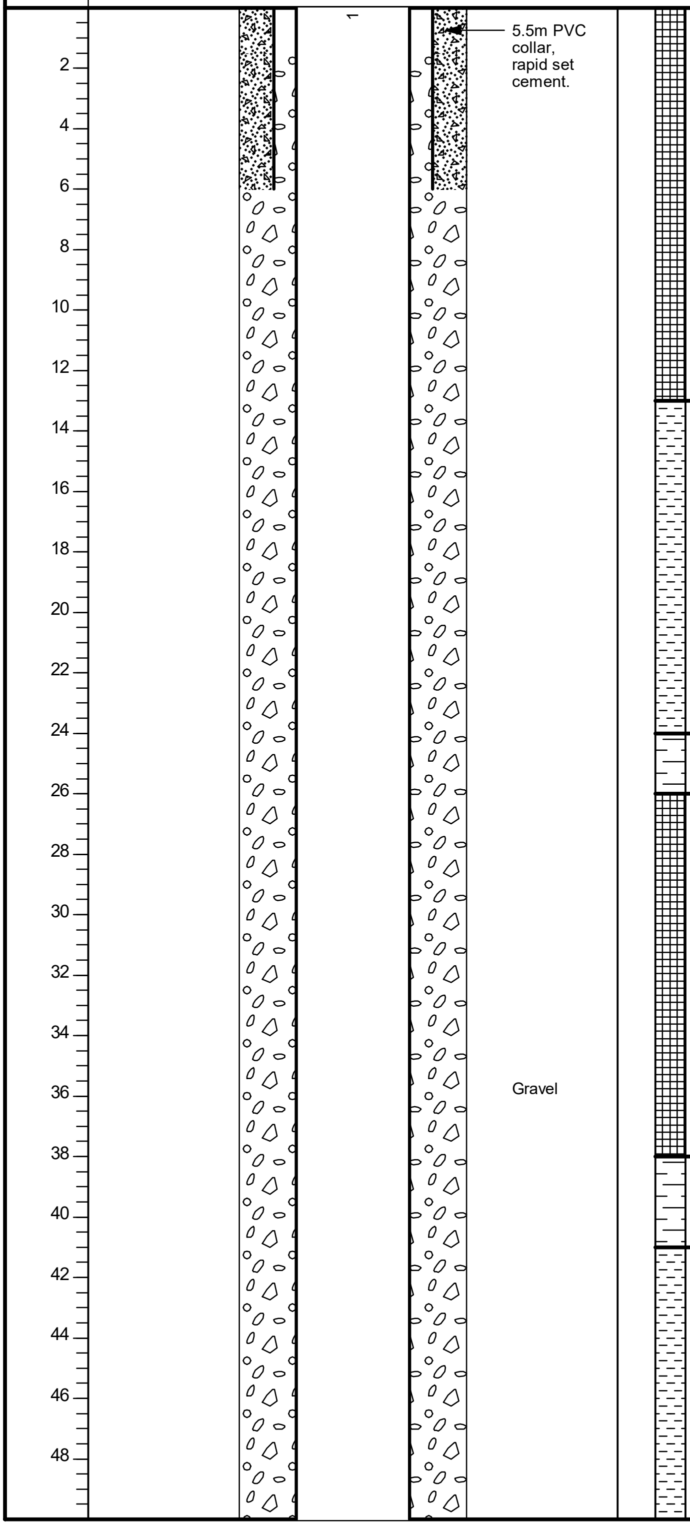
Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	143 mm	Drilling Method:	RC
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	111 m
Drilling subcontractor:	Egan Drilling	Borehole location:	Ex-orebody	Easting:	692049
Date hole commenced:	12/12/20	Inclination/Azimuth:	-90° /	Northing:	7476001
Date hole complete:	13/12/20	Surface R.L.:		Logged by:	Yang Wang

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		78.00 m	10/1/2021	

50mm solid PVC 0m to 72m
50mm machine slotted PVC 72m to 78m
Well development completed

RL (m) | Depth (m) | Stratigraphy | Rock Type | Material Description (ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure) | Discharge (l/s) 1 2 3 4 | Electrical Conductivity (mS/cm) 150 300 450 600 | pH 2 4 6 8



MINERALISED BIF: Red black, highly weathered, magnetic mineralised BIF (goethite) and moderately weathered mineralised shale (hematite). Minor BIF, magnetic.

MINERALISED SHALE: Purple black, moderately weathered mineralised shale and BIF (hematite and goethite). Minor BIF and chert, non-magnetic.

CLAY: Pink white, bleached, highly weathered, non-magnetic.

MINERALISED BIF: Black brown, highly weathered mineralised BIF and shale (hematite). Minor clay, chert and jasper, non-magnetic.

CLAY: Purple red, clay with highly weathered BIF and minor shale, non-magnetic.

MINERALISED SHALE: Grey black, slightly weathered mineralised shale (hematite) with minor BIF (mm-laminae) and shale. Clay between 53-54m and rare chert clasts. Fractured ground at 71m, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH3/TH12 (MB3)

Sheet 2 of 3

Monitoring Bore

Job No: PSM4241
Client: MRL
Project: Lamb Creek Hydrogeology Inv.
Drilling subcontractor: Egan Drilling
Date hole commenced: 12/12/20
Date hole complete: 13/12/20

Drill information: AustEX-X400
Hole diameter: 143 mm
Datum: GDA94 Zone 50
Borehole location: Ex-orebody
Inclination/Azimuth: -90° /
Surface R.L.:

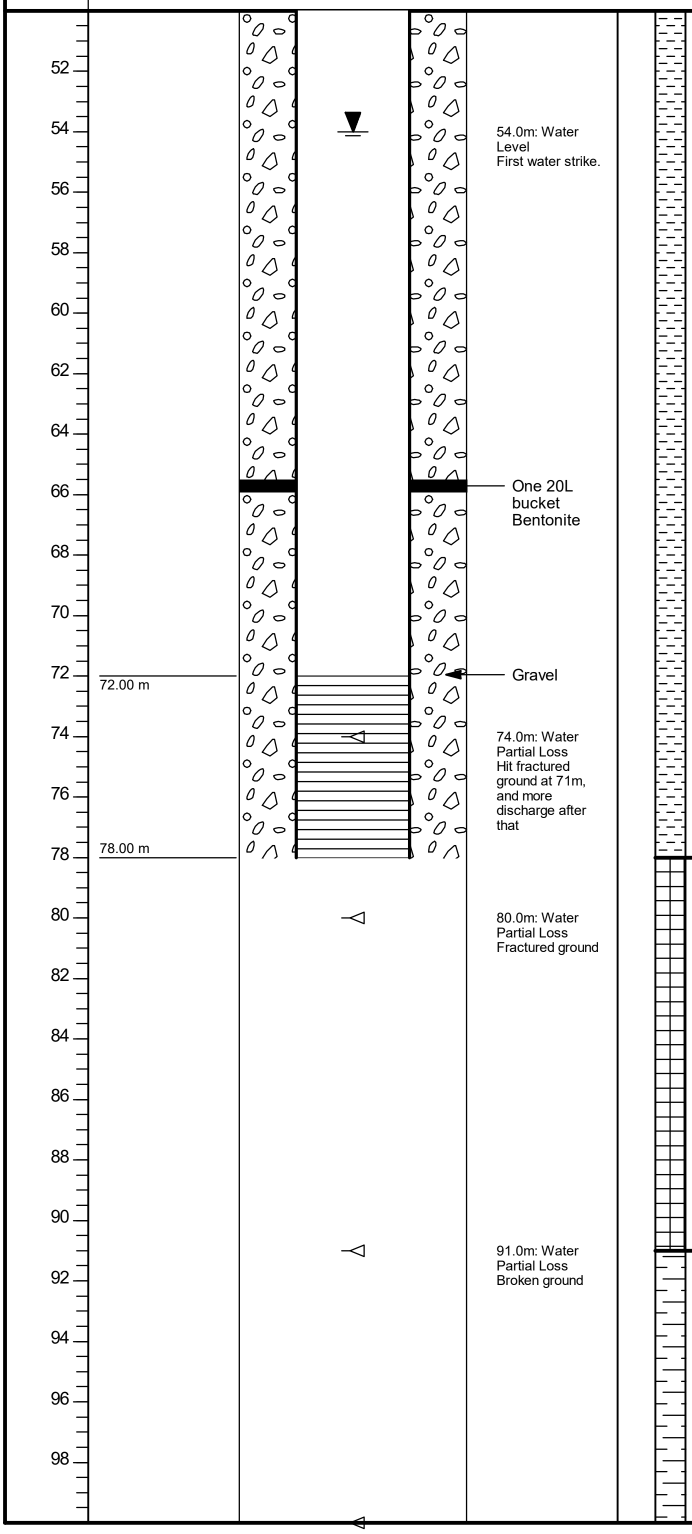
Drilling Method: RC
Hole Depth: 111 m
Easting: 692049
Northing: 7476001
Logged by: Yang Wang

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		78.00 m	10/1/2021	

50mm solid PVC 0m to 72m
50mm machine slotted PVC 72m to 78m
Well development completed

RL (m) Depth (m)	Stratigraphy	Rock Type	Material Description (ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)	Discharge (l/s) 1 2 3 4	Electrical Conductivity (mS/cm) 150 300 450 600	pH 2 4 6 8



MINERALISED SHALE: Grey black, slightly weathered mineralised shale (hematite) with minor BIF (mm-laminae) and shale. Clay between 53-54m and rare chert clasts. Fractured ground at 71m, non-magnetic. *CONTINUED*

BANDED IRON FORMATION: Grey black, moderately weathered BIF (mm-laminae) with shale and chert. Some magnetic clasts. Fractured ground at 80m, non-magnetic.

SHALE: White grey, slightly weathered shale and cherty BIF. Jasper content decreases with depth. Broken ground at 91-92m and 0.5m cavity at 100m, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH3/TH12 (MB3)

Sheet 3 of 3

Monitoring Bore

Job No: PSM4241
Client: MRL
Project: Lamb Creek Hydrogeology Inv.
Drilling subcontractor: Egan Drilling
Date hole commenced: 12/12/20
Date hole complete: 13/12/20

Drill information: AustEX-X400
Hole diameter: 143 mm
Datum: GDA94 Zone 50
Borehole location: Ex-orebody
Inclination/Azimuth: -90° /
Surface R.L.:

Drilling Method: RC
Hole Depth: 111 m
Easting: 692049
Northing: 7476001
Logged by: Yang Wang

RL (m) Depth (m)

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		78.00 m	10/1/2021	

50mm solid PVC 0m to 72m
50mm machine slotted PVC 72m to 78m
Well development completed

Stratigraphy

Rock Type

Material Description
(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

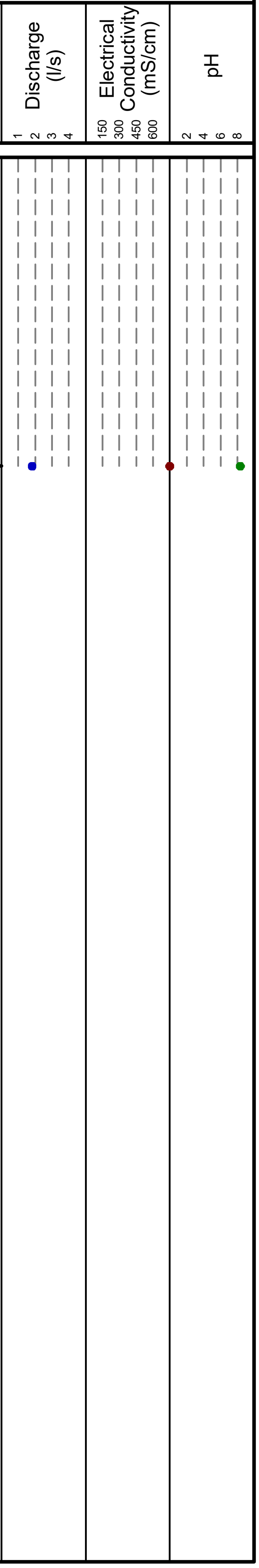
102 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142 144 146 148

100.0m: Water Partial Loss Cavity

106.0m: Final airlift yield recorded after 15 minutes of airlifting

EOH: 111m

SHALE: White grey, slightly weathered shale and cherty BIF. Jasper content decreases with depth. Broken ground at 91-92m and 0.5m cavity at 100m, non-magnetic. *CONTINUED*



Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH4B/TH16 (MB4)

Sheet 1 of 2

Monitoring Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	143 mm	Drilling Method:	RC
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	90 m
Drilling subcontractor:	Egan Drilling	Borehole location:	Ex-orebody	Easting:	692358
Date hole commenced:	10/01/21	Inclination/Azimuth:	-90° /	Northing:	7476255
Date hole complete:	11/01/21	Surface R.L.:		Logged by:	Yang Wang

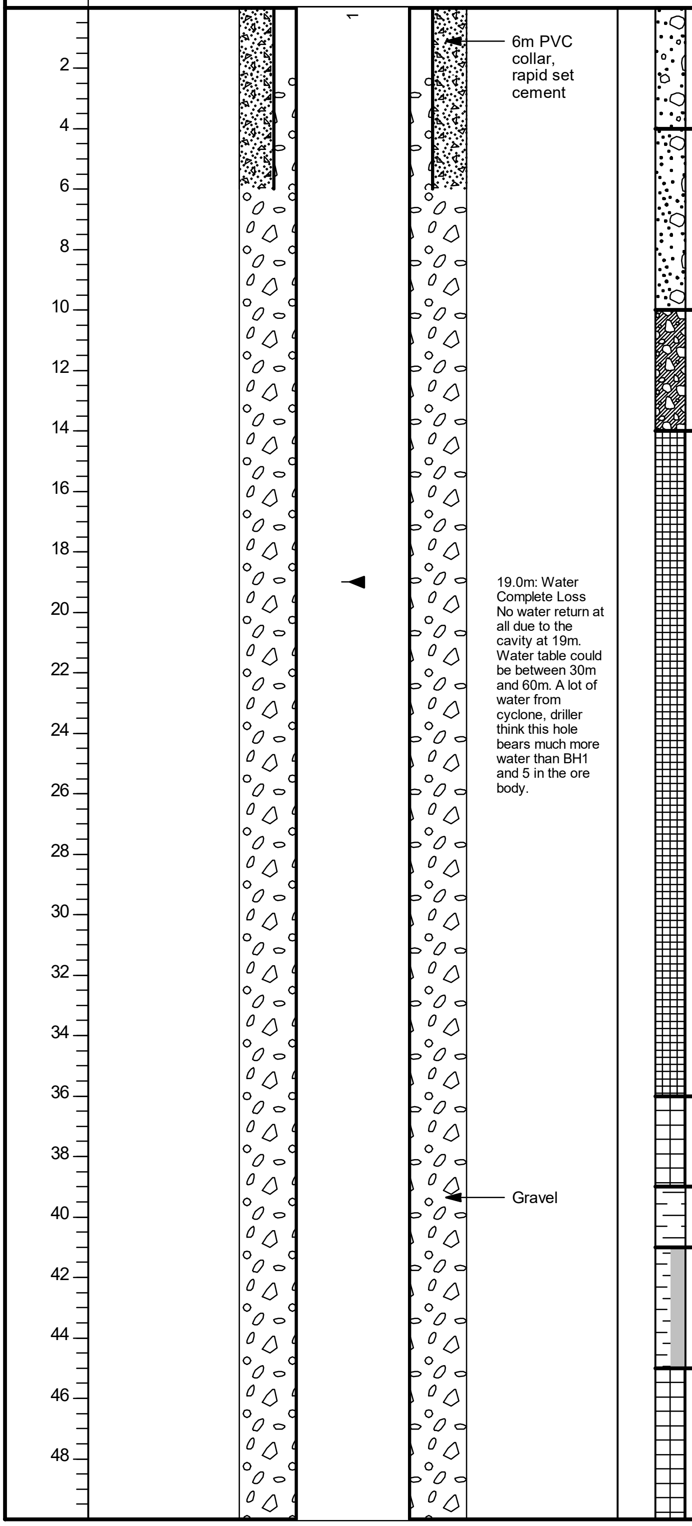
RL (m) Depth (m)

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		85.00 m	11/1/2021	

50mm solid PVC 0m to 79m
50mm machine slotted PVC 79m to 85m
Borehole collapse at 86m
Well development completed

Stratigraphy | Rock Type | Material Description (ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure) | Discharge (l/s) | Electrical Conductivity (mS/cm) | pH



6m PVC collar, rapid set cement

19.0m: Water Complete Loss No water return at all due to the cavity at 19m. Water table could be between 30m and 60m. A lot of water from cyclone, driller think this hole bears much more water than BH1 and 5 in the ore body.

Gravel

IMMATURE DETRITAL: Black brown, fine sandy colluvium, sub-angular to sub-rounded BIF and shale clasts, 1-5mm magnetic clasts and nodules throughout, magnetic.

MATURE DETRITAL: red, strongly magnetic medium to coarse grained, well-sorted, sub-rounded to rounded pisolites with red ferruginous coating., magnetic.

CANGA: Yellow black, moderately weathered cemnented canga with goethtite clasts, non-magnetic.

MINERALISED BIF: Grey black, moderately weathered geothetic and hematitic BIF, highly weathered hematitic shale, minor BIF. Cavity at 19m, non-magnetic.

BANDED IRON FORMATION: Yellow red, highly weathered BIF and cherty BIF with some white calcrete at 37m, non-magnetic.

SHALE: Red black, highly weathered shale and BIF. Minor hematitic shale, non-magnetic.

CHERT: White yellow, moderately weathered chert and minor quartz. Quartz content decreases with depth, non-magnetic.

BANDED IRON FORMATION: Red black, highly weathered BIF and cherty BIF with minor shale and chert clasts. Very minor hematitic BIF and shale., non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

PSM

Borehole ID

BH4B/TH16 (MB4)

Sheet 2 of 2

Monitoring Bore

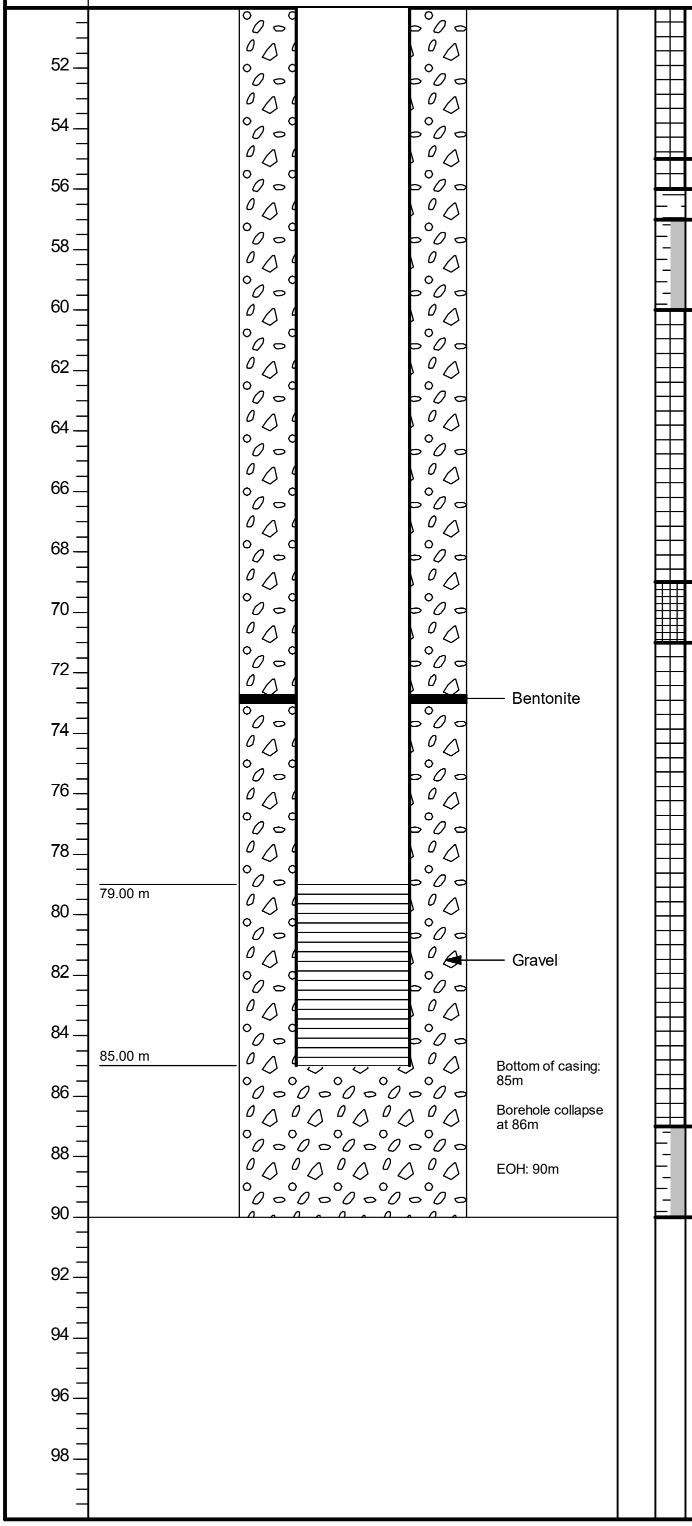
Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	143 mm	Drilling Method:	RC
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	90 m
Drilling subcontractor:	Egan Drilling	Borehole location:	Ex-orebody	Easting:	692358
Date hole commenced:	10/01/21	Inclination/Azimuth:	-90° /	Northing:	7476255
Date hole complete:	11/01/21	Surface R.L.:		Logged by:	Yang Wang

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		85.00 m	11/1/2021	

50mm solid PVC 0m to 79m
50mm machine slotted PVC 79m to 85m
Borehole collapse at 86m
Well development completed

RL (m) | Depth (m) | Stratigraphy | Rock Type | Material Description (ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure) | Discharge (l/s) | Electrical Conductivity (mS/cm) | pH



BANDED IRON FORMATION: Red black, highly weathered BIF and cherty BIF with minor shale and chert clasts. Very minor hematitic BIF and shale., non-magnetic. *CONTINUED*

BANDED IRON FORMATION: green, cherty BIF, non-magnetic.

CLAY: Yellow black, mixed clay with shale clasts, non-magnetic.

CHERT: Yellow brown, moderately weathered chert with rare quartz, non-magnetic.

BANDED IRON FORMATION: Purple black, moderately weathered BIF. Greenish cherty BIF and chert clasts between 64m and 65m, non-magnetic.

MINERALISED BIF: Purple black, moderately weathered hematitic BIF and shale, minor unmineralised BIF, non-magnetic.

BANDED IRON FORMATION: Grey black, moderately to slightly weathered BIF and chert. Greenish chert becomes yellow with depth. Chert content decreases with depth, non-magnetic.

CHERT: White red, highly weathered chert, bleached shale, and quartz, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH5/TH19 (MB1)

Sheet 1 of 2

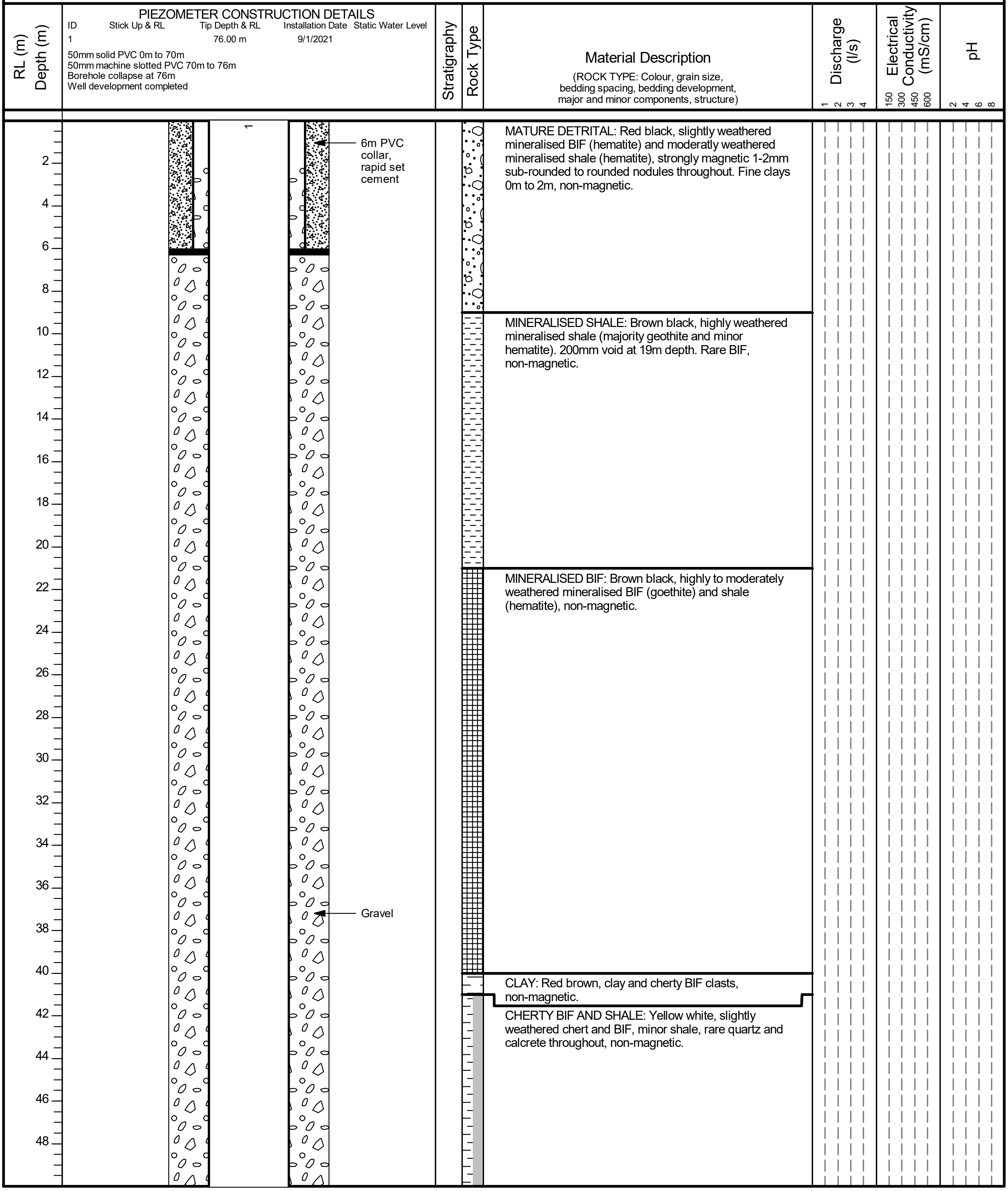
Monitoring Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	143 mm	Drilling Method:	RC
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	84 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In a creek/river bed	Easting:	692482
Date hole commenced:	08/01/21	Inclination/Azimuth:	-90° /	Northing:	7475742
Date hole complete:	08/01/21	Surface R.L.:		Logged by:	Yang Wang

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		76.00 m	9/1/2021	

50mm solid PVC 0m to 70m
50mm machine slotted PVC 70m to 76m
Borehole collapse at 76m
Well development completed



Material Description
(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

MATURE DETRITAL: Red black, slightly weathered mineralised BIF (hematite) and moderatly weathered mineralised shale (hematite), strongly magnetic 1-2mm sub-rounded to rounded nodules throughout. Fine clays 0m to 2m, non-magnetic.

MINERALISED SHALE: Brown black, highly weathered mineralised shale (majority geothite and minor hematite). 200mm void at 19m depth. Rare BIF, non-magnetic.

MINERALISED BIF: Brown black, highly to moderately weathered mineralised BIF (goethite) and shale (hematite), non-magnetic.

CLAY: Red brown, clay and cherty BIF clasts, non-magnetic.

CHERTY BIF AND SHALE: Yellow white, slightly weathered chert and BIF, minor shale, rare quartz and calcrete throughout, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Monitoring Bore

Borehole ID

BH5/TH19 (MB1)

Sheet 2 of 2

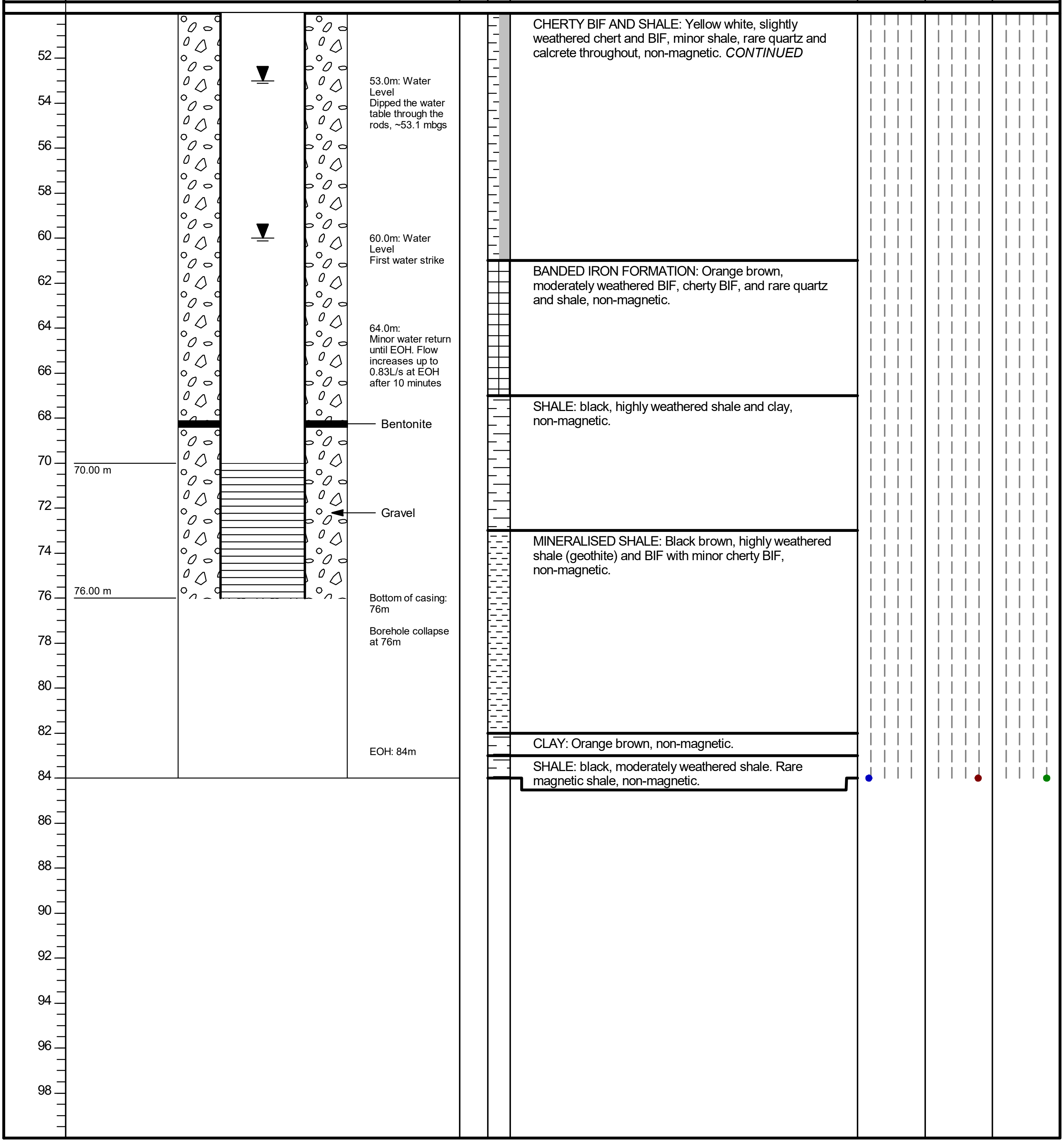
Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	143 mm	Drilling Method:	RC
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	84 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In a creek/river bed	Easting:	692482
Date hole commenced:	08/01/21	Inclination/Azimuth:	-90° /	Northing:	7475742
Date hole complete:	08/01/21	Surface R.L.:		Logged by:	Yang Wang

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		76.00 m	9/1/2021	

50mm solid PVC 0m to 70m
50mm machine slotted PVC 70m to 76m
Borehole collapse at 76m
Well development completed

RL (m) | Depth (m) | Stratigraphy | Rock Type | Material Description (ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure) | Discharge (l/s) | Electrical Conductivity (mS/cm) | pH



53.0m: Water Level
Dipped the water table through the rods, ~53.1 mbgs

60.0m: Water Level
First water strike

64.0m:
Minor water return until EOH. Flow increases up to 0.83L/s at EOH after 10 minutes

Bottom of casing: 76m

Borehole collapse at 76m

EOH: 84m

CHERTY BIF AND SHALE: Yellow white, slightly weathered chert and BIF, minor shale, rare quartz and calcrete throughout, non-magnetic. *CONTINUED*

BANDED IRON FORMATION: Orange brown, moderately weathered BIF, cherty BIF, and rare quartz and shale, non-magnetic.

SHALE: black, highly weathered shale and clay, non-magnetic.

MINERALISED SHALE: Black brown, highly weathered shale (geothite) and BIF with minor cherty BIF, non-magnetic.

CLAY: Orange brown, non-magnetic.

SHALE: black, moderately weathered shale. Rare magnetic shale, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH6/TH8 (MB5)

Sheet 1 of 2

Monitoring Bore

Job No: PSM4241
Client: MRL
Project: Lamb Creek Hydrogeology Inv.
Drilling subcontractor: Egan Drilling
Date hole commenced: 12/01/21
Date hole complete: 13/01/21

Drill information: AustEX-X400
Hole diameter: 143 mm
Datum: GDA94 Zone 50
Borehole location: In a creek
Inclination/Azimuth: -90° /
Surface R.L.:

Drilling Method: RC
Hole Depth: 96 m
Easting: 691434
Northing: 7475780
Logged by: Yang Wang

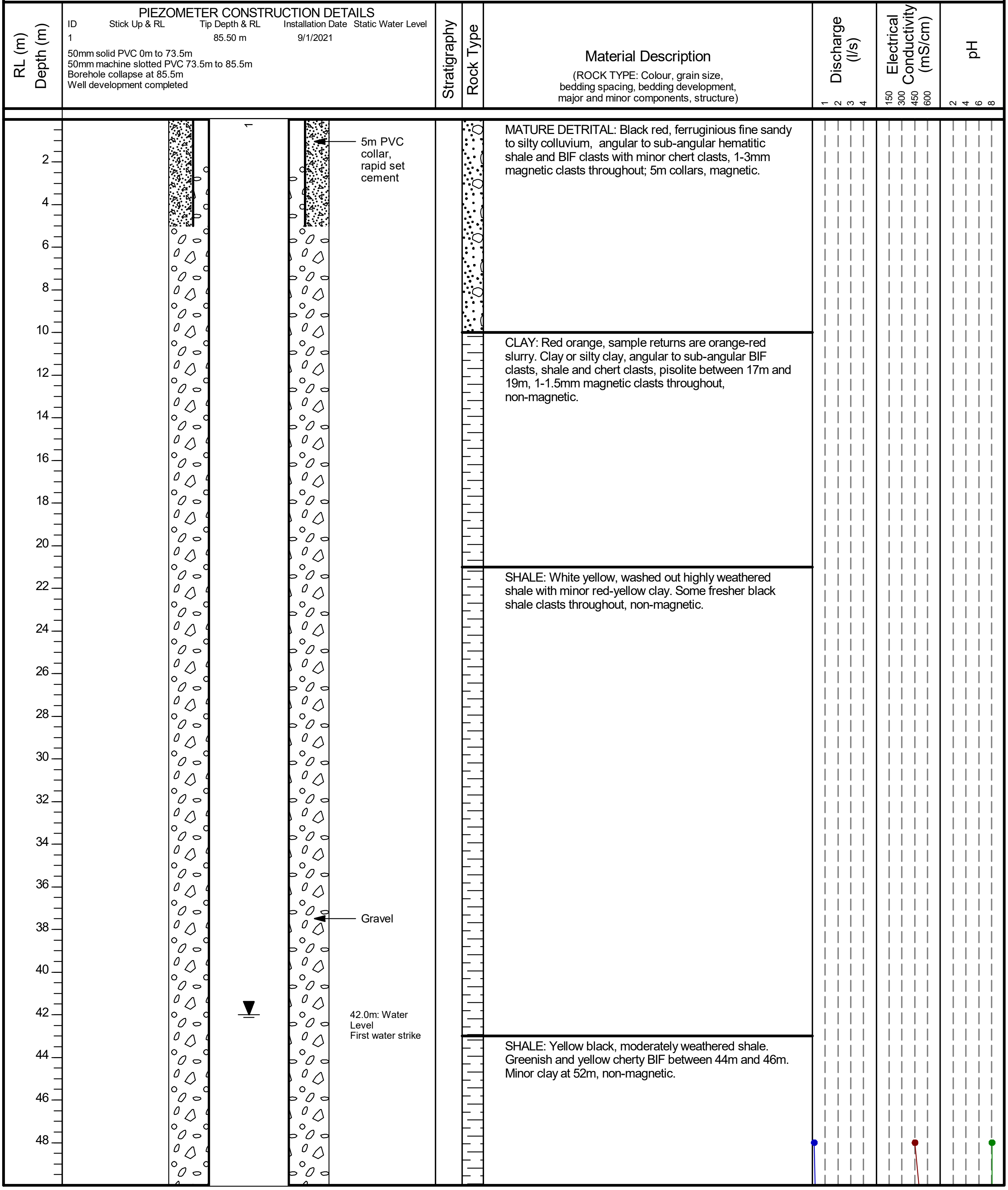
PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		85.50 m	9/1/2021	

50mm solid PVC 0m to 73.5m
50mm machine slotted PVC 73.5m to 85.5m
Borehole collapse at 85.5m
Well development completed

Material Description

(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)



MATURE DETRITAL: Black red, ferruginious fine sandy to silty colluvium, angular to sub-angular hematitic shale and BIF clasts with minor chert clasts, 1-3mm magnetic clasts throughout; 5m collars, magnetic.

CLAY: Red orange, sample returns are orange-red slurry. Clay or silty clay, angular to sub-angular BIF clasts, shale and chert clasts, pisolite between 17m and 19m, 1-1.5mm magnetic clasts throughout, non-magnetic.

SHALE: White yellow, washed out highly weathered shale with minor red-yellow clay. Some fresher black shale clasts throughout, non-magnetic.

SHALE: Yellow black, moderately weathered shale. Greenish and yellow cherty BIF between 44m and 46m. Minor clay at 52m, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH6/TH8 (MB5)

Sheet 2 of 2

Monitoring Bore

Job No: PSM4241
Client: MRL
Project: Lamb Creek Hydrogeology Inv.
Drilling subcontractor: Egan Drilling
Date hole commenced: 12/01/21
Date hole complete: 13/01/21

Drill information: AustEX-X400
Hole diameter: 143 mm
Datum: GDA94 Zone 50
Borehole location: In a creek
Inclination/Azimuth: -90° /
Surface R.L.:

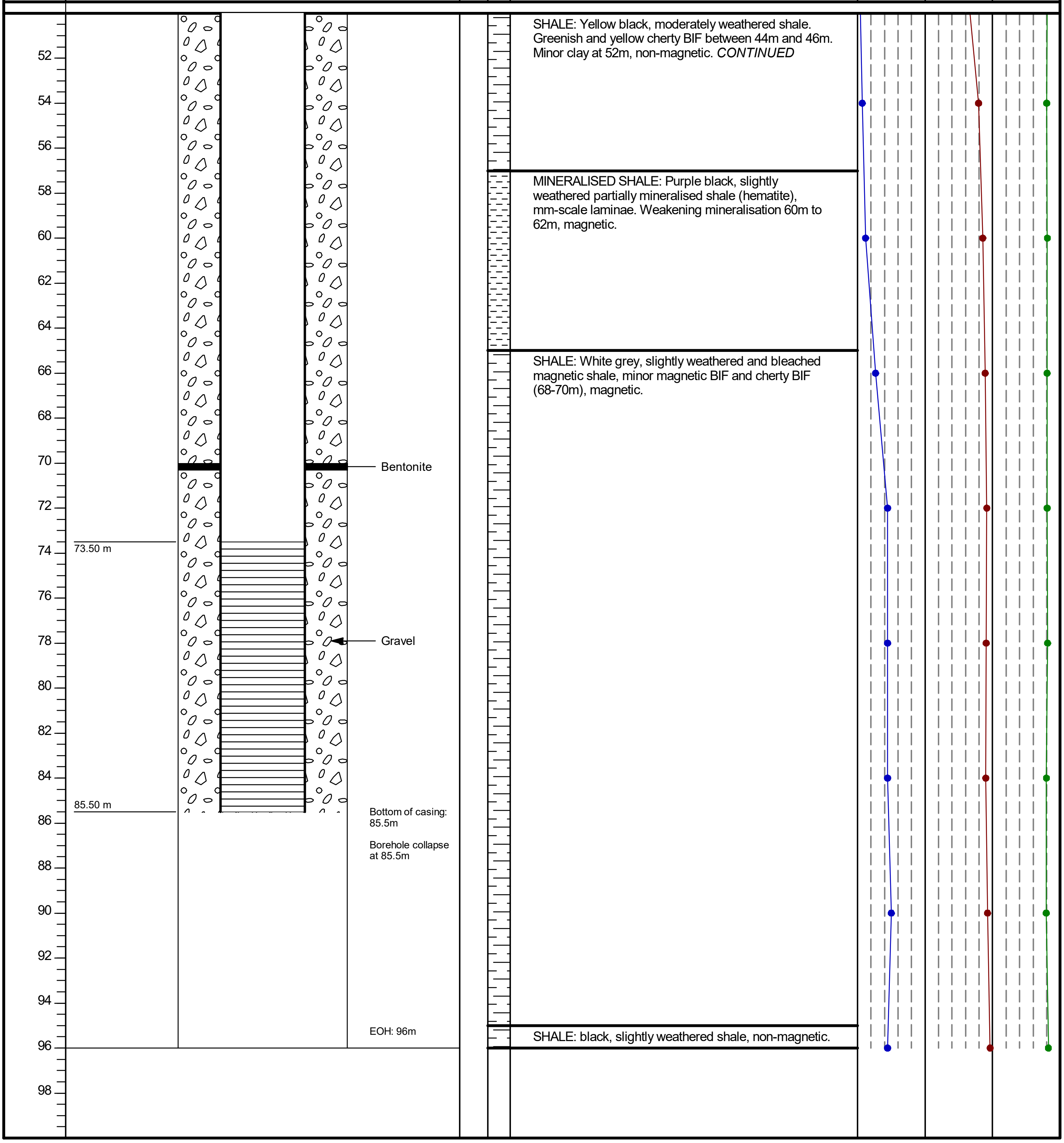
Drilling Method: RC
Hole Depth: 96 m
Easting: 691434
Northing: 7475780
Logged by: Yang Wang

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		85.50 m	9/1/2021	

50mm solid PVC 0m to 73.5m
50mm machine slotted PVC 73.5m to 85.5m
Borehole collapse at 85.5m
Well development completed

RL (m) | Depth (m) | Stratigraphy | Rock Type | Material Description (ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure) | Discharge (l/s) | Electrical Conductivity (mS/cm) | pH



SHALE: Yellow black, moderately weathered shale. Greenish and yellow cherty BIF between 44m and 46m. Minor clay at 52m, non-magnetic. *CONTINUED*

MINERALISED SHALE: Purple black, slightly weathered partially mineralised shale (hematite), mm-scale laminae. Weakening mineralisation 60m to 62m, magnetic.

SHALE: White grey, slightly weathered and bleached magnetic shale, minor magnetic BIF and cherty BIF (68-70m), magnetic.

SHALE: black, slightly weathered shale, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH7/TH11

Sheet 1 of 2

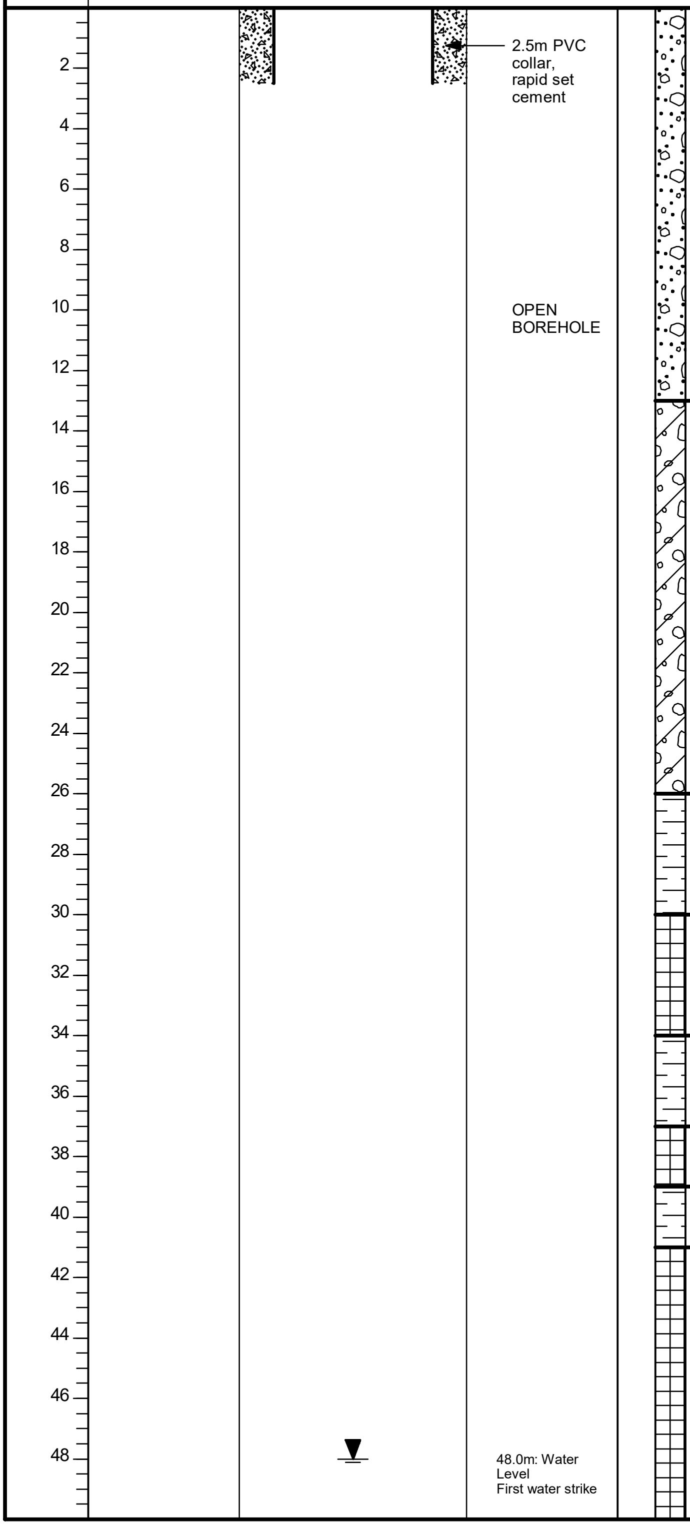
Exploration Bore

Job No: PSM4241
Client: MRL
Project: Lamb Creek Hydrogeology Inv.
Drilling subcontractor: Egan Drilling
Date hole commenced: 19/01/21
Date hole complete: 19/01/21

Drill information: AustEX-X400
Hole diameter: 203 mm
Datum: GDA94 Zone 50
Borehole location: Beside a creek
Inclination/Azimuth: -90° /
Surface R.L.:

Drilling Method: RAB
Hole Depth: 96 m
Easting: 691680
Northing: 7476160
Logged by: Yang Wang

RL (m) Depth (m) | PIEZOMETER CONSTRUCTION DETAILS | Stratigraphy | Rock Type | Material Description (ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure) | Discharge (l/s) 1 2 3 4 | Electrical Conductivity (mS/cm) 150 300 450 600 | pH 2 4 6 8



IMMATURE DETRITAL: Red Brown silty to coarse sandy transported covers, sub-rounded to angular BIF and chert clasts, red ferruginous coating, 1-10 mm magnetic clasts throughout, magnetic.

MATURE DETRITAL: Brown Red clayey to silty transported covers, 1-5mm sub-rounded to rounded, well-sorted magnetic pisolites, magnetic.

SHALE: Yellow White highly weathered shale and BIF clasts with yellow clay matrix, rare 1-3 mm strongly magnetic clasts, non-magnetic.

BANDED IRON FORMATION: Black Red highly weathered BIF clasts with silty/sandy clay matrix, non-magnetic.

CLAY: White Yellow non-magnetic.

BANDED IRON FORMATION: Black Brown highly weathered BIF clasts, non-magnetic.

CLAY: White non-magnetic.

BANDED IRON FORMATION: Red Black moderately to highly weathered BIF with mm-scale laminae. Some bleached yellow cherty BIF between 56m and 62m, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

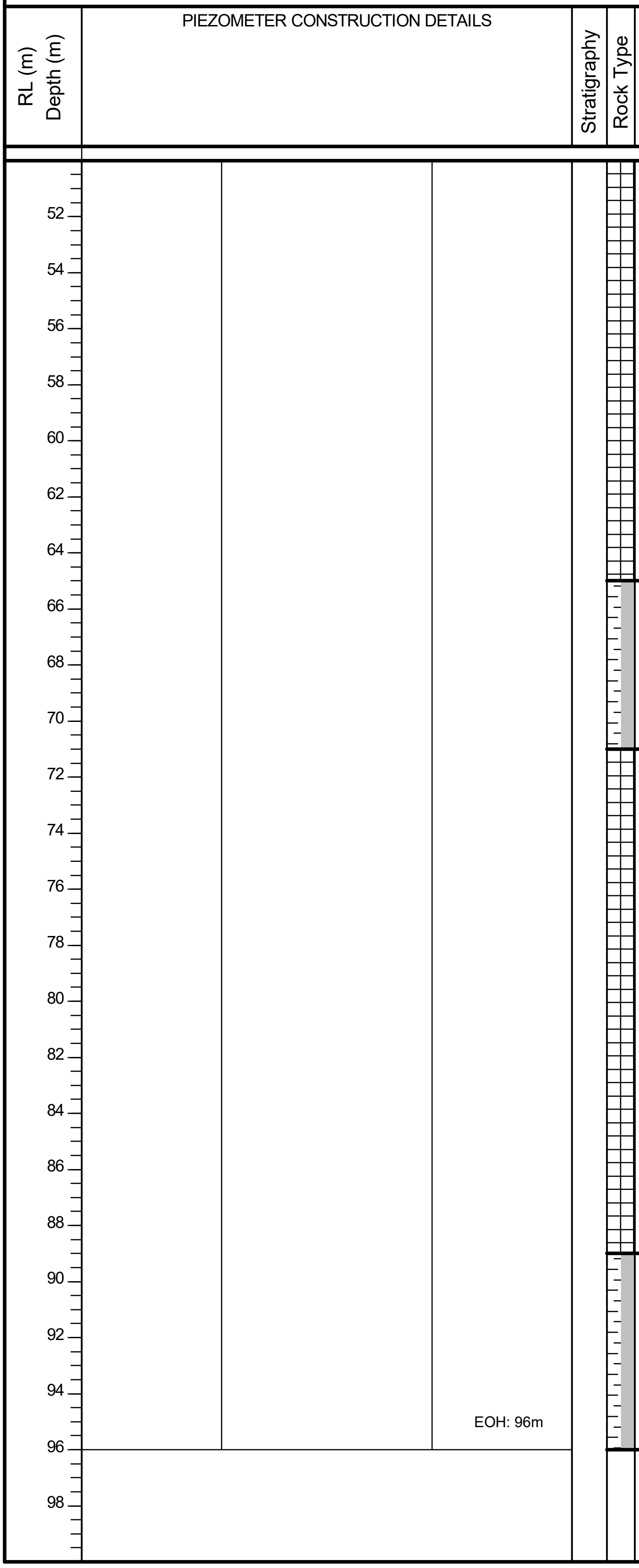
Borehole ID

BH7/TH11

Sheet 2 of 2

Exploration Bore

Job No:	PSM4241	Drill information:	AustEX-X400	Drilling Method:	RAB
Client:	MRL	Hole diameter:	203 mm	Hole Depth:	96 m
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Easting:	691680
Drilling subcontractor:	Egan Drilling	Borehole location:	Beside a creek	Northing:	7476160
Date hole commenced:	19/01/21	Inclination/Azimuth:	-90° /	Logged by:	Yang Wang
Date hole complete:	19/01/21	Surface R.L.:			



Material Description

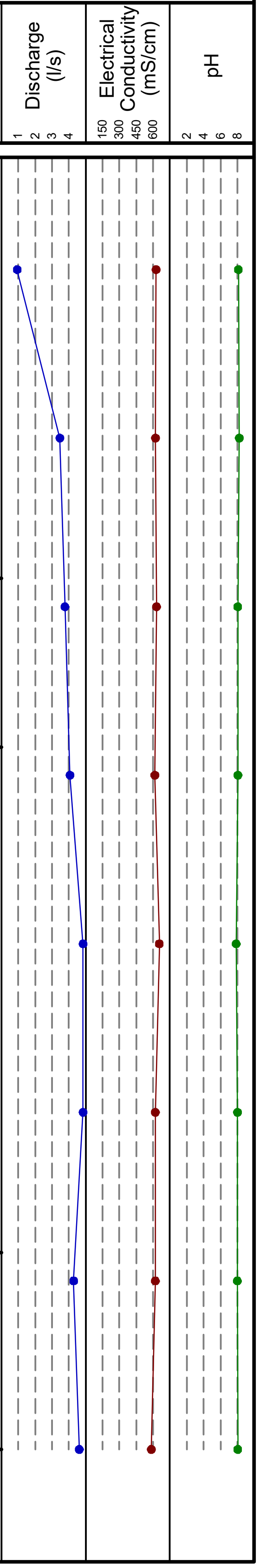
(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

BANDED IRON FORMATION: Red Black moderately to highly weathered BIF with mm-scale laminae. Some bleached yellow cherty BIF between 56m and 62m, non-magnetic. *CONTINUED*

CHERT: Grey White slightly weathered bleached white-green BIF and chert.Strongly magnetic black-red BIF clasts 69m to 71m, magnetic.

BANDED IRON FORMATION: Green Grey fresh to slighly weathered cherty BIF (mm-scale laminae) with minor green-black chert, some strongly magnetic 1-10 mm clasts throughout, rare black shale, non-magnetic.

CHERT: Green Yellow slightly weathered chert with fresh cherty BIF, non-magnetic.



Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH10/TH4 (MB10)

Sheet 1 of 2

Monitoring Bore

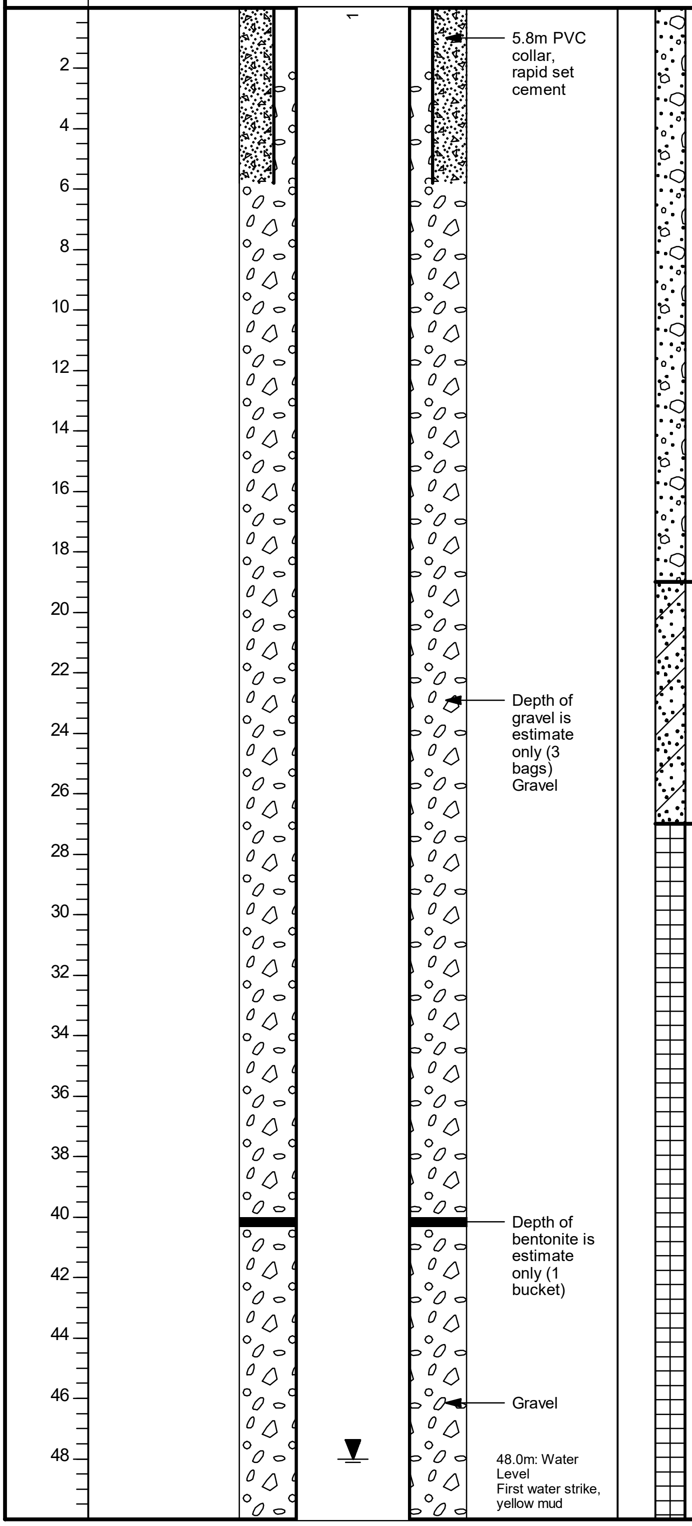
Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	90 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In a creek/river bed	Easting:	691234
Date hole commenced:	07/02/21	Inclination/Azimuth:	-90° /	Northing:	7476271
Date hole complete:	08/02/21	Surface R.L.:		Logged by:	Ming Wu

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		87.00 m	8/2/2021	

50mm solid PVC 0m to 75m
50mm machine slotted PVC 75m to 87m
Well development completed

RL (m) | Depth (m) | Stratigraphy | Rock Type | Material Description (ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure) | Discharge (l/s) 8 11 14 17 | Electrical Conductivity (mS/cm) 150 300 450 600 | pH 2 4 6 8



IMMATURE DETRITAL: Brown red, clayey to sandy transported covers, sub-angular to angular, poorly graded BIF and chert clasts, red weathered ferruginous coating, and 1-20 mm magnetic clasts throughout, magnetic.

MATURE DETRITAL: Brown red, clayey to silty transported cover, 1-5mm sub-rounded to rounded, well-sorted magnetic pisolites, ferruginous coating. Minor 10-20mm clasts, magnetic.

BANDED IRON FORMATION: Brown yellow, clay with highly weathered chert clasts (5-20mm) and BIF clasts (mm-scale laminae). Broken ground between 24-36m, and cavities 48-60m noted by drillers, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH10/TH4 (MB10)

Sheet 2 of 2

Monitoring Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	90 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In a creek/river bed	Easting:	691234
Date hole commenced:	07/02/21	Inclination/Azimuth:	-90° /	Northing:	7476271
Date hole complete:	08/02/21	Surface R.L.:		Logged by:	Ming Wu

RL (m) Depth (m)

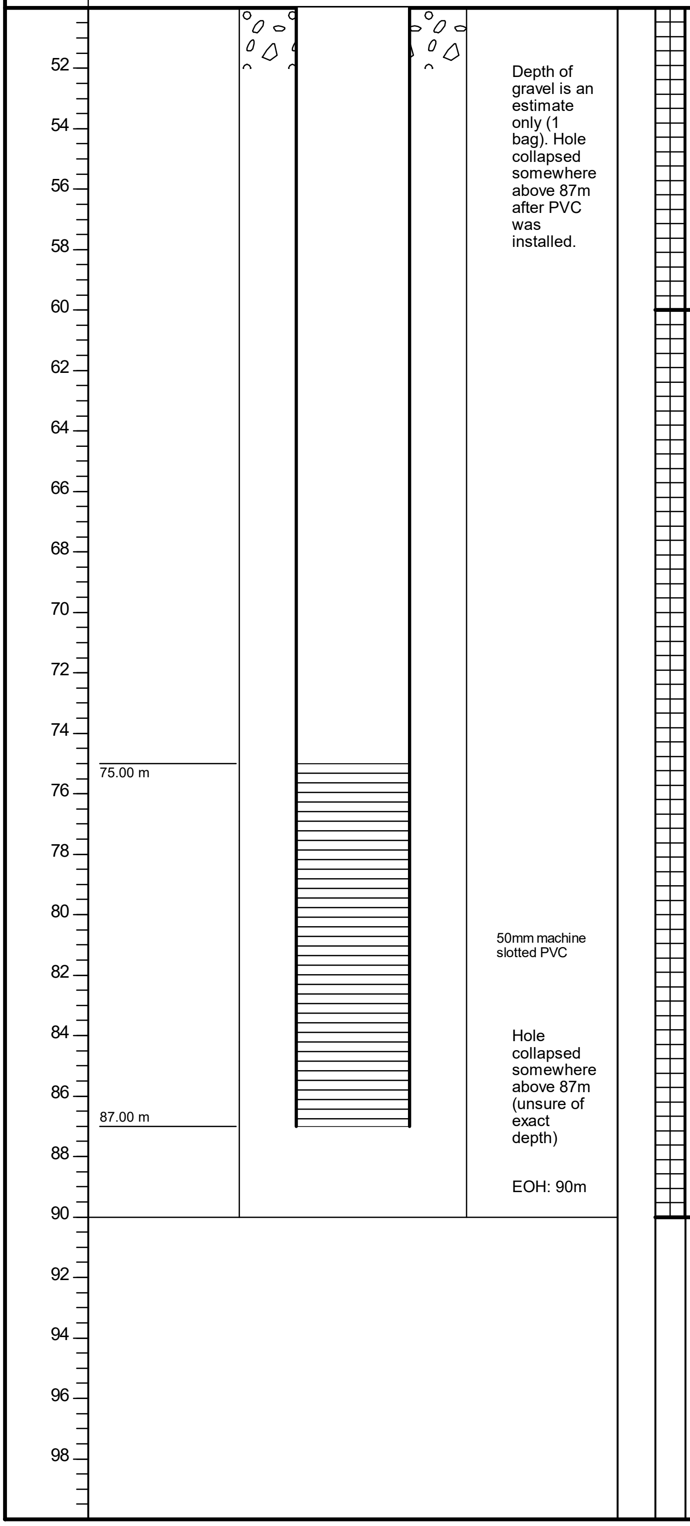
PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		87.00 m	8/2/2021	

50mm solid PVC 0m to 75m
50mm machine slotted PVC 75m to 87m
Well development completed

Stratigraphy

Rock Type



Depth of gravel is an estimate only (1 bag). Hole collapsed somewhere above 87m after PVC was installed.

50mm machine slotted PVC

Hole collapsed somewhere above 87m (unsure of exact depth)

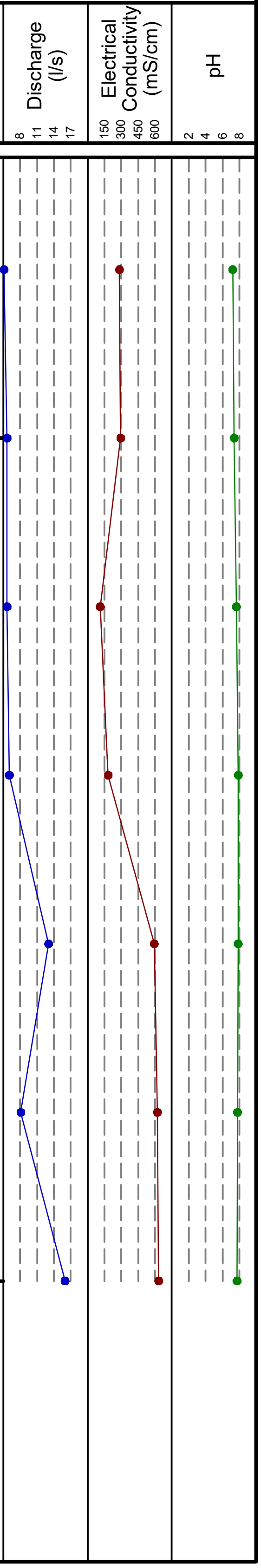
EOH: 90m

Material Description

(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

BANDED IRON FORMATION: Brown yellow, clay with highly weathered chert clasts (5-20mm) and BIF clasts (mm-scale laminae). Broken ground between 24-36m, and cavities 48-60m noted by drillers, non-magnetic. *CONTINUED*

BANDED IRON FORMATION: Grey red, moderately to slightly weathered BIF (mm-scale laminae, hematite & goethite, leached) and chert clasts. Minor slightly weathered shale clasts. Rare white calcrete. Rock noted as fractured between 60m and 78m by driller, magnetic.



Refer to Explanation Sheets Attached for Classification Systems

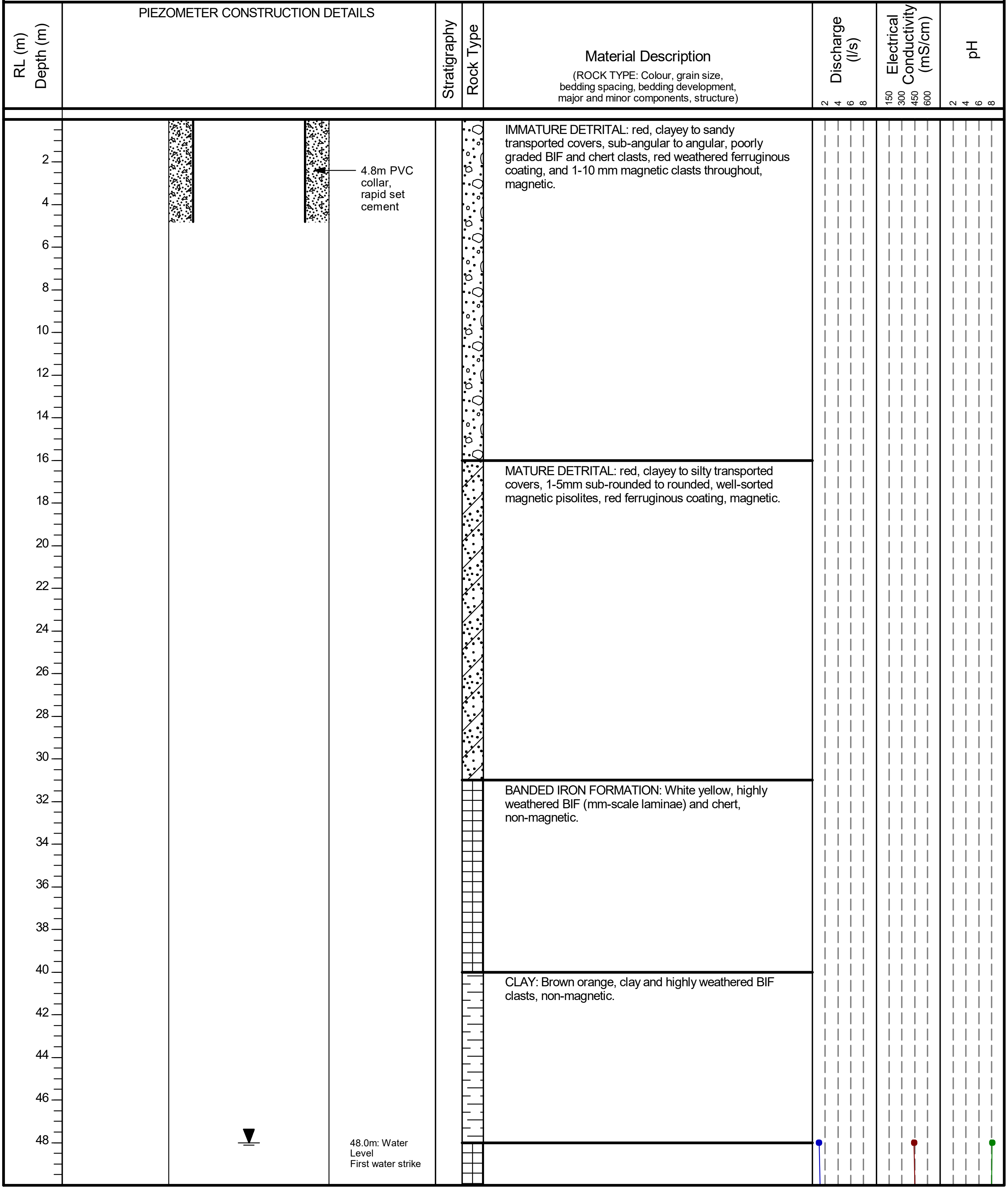
Exploration Bore

Borehole ID

BH11/TH5

Sheet 1 of 2

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	96 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In a creek/river bed	Easting:	691245
Date hole commenced:	20/01/21	Inclination/Azimuth:	-90° /	Northing:	7476397
Date hole complete:	21/01/21	Surface R.L.:		Logged by:	Yang Wang



4.8m PVC collar, rapid set cement

IMMATURE DETRITAL: red, clayey to sandy transported covers, sub-angular to angular, poorly graded BIF and chert clasts, red weathered ferruginous coating, and 1-10 mm magnetic clasts throughout, magnetic.

MATURE DETRITAL: red, clayey to silty transported covers, 1-5mm sub-rounded to rounded, well-sorted magnetic pisolites, red ferruginous coating, magnetic.

BANDED IRON FORMATION: White yellow, highly weathered BIF (mm-scale laminae) and chert, non-magnetic.

CLAY: Brown orange, clay and highly weathered BIF clasts, non-magnetic.

48.0m: Water Level
First water strike

Refer to Explanation Sheets Attached for Classification Systems

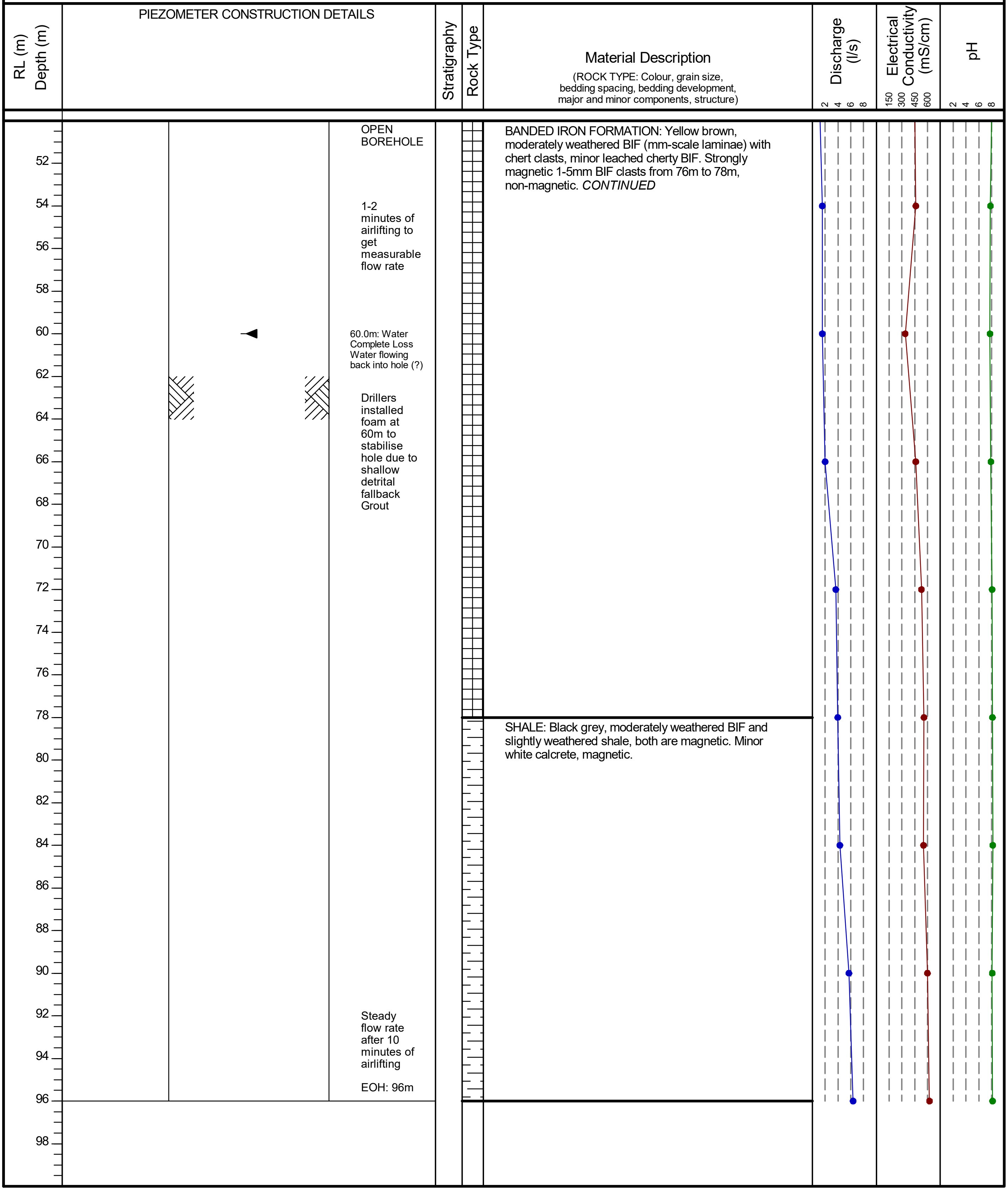
Borehole ID

BH11/TH5

Sheet 2 of 2

Exploration Bore

Job No:	PSM4241	Drill information:	AustEX-X400	Drilling Method:	RAB
Client:	MRL	Hole diameter:	203 mm	Hole Depth:	96 m
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Easting:	691245
Drilling subcontractor:	Egan Drilling	Borehole location:	In a creek/river bed	Northing:	7476397
Date hole commenced:	20/01/21	Inclination/Azimuth:	-90° /	Logged by:	Yang Wang
Date hole complete:	21/01/21	Surface R.L.:			



OPEN BOREHOLE

1-2 minutes of airlifting to get measurable flow rate

60.0m: Water Complete Loss Water flowing back into hole (?)

Drillers installed foam at 60m to stabilise hole due to shallow detrital fallback Grout

Steady flow rate after 10 minutes of airlifting

EOH: 96m

BANDED IRON FORMATION: Yellow brown, moderately weathered BIF (mm-scale laminae) with chert clasts, minor leached cherty BIF. Strongly magnetic 1-5mm BIF clasts from 76m to 78m, non-magnetic. *CONTINUED*

SHALE: Black grey, moderately weathered BIF and slightly weathered shale, both are magnetic. Minor white calcrete, magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH15/TH9 (MB8)

Sheet 1 of 2

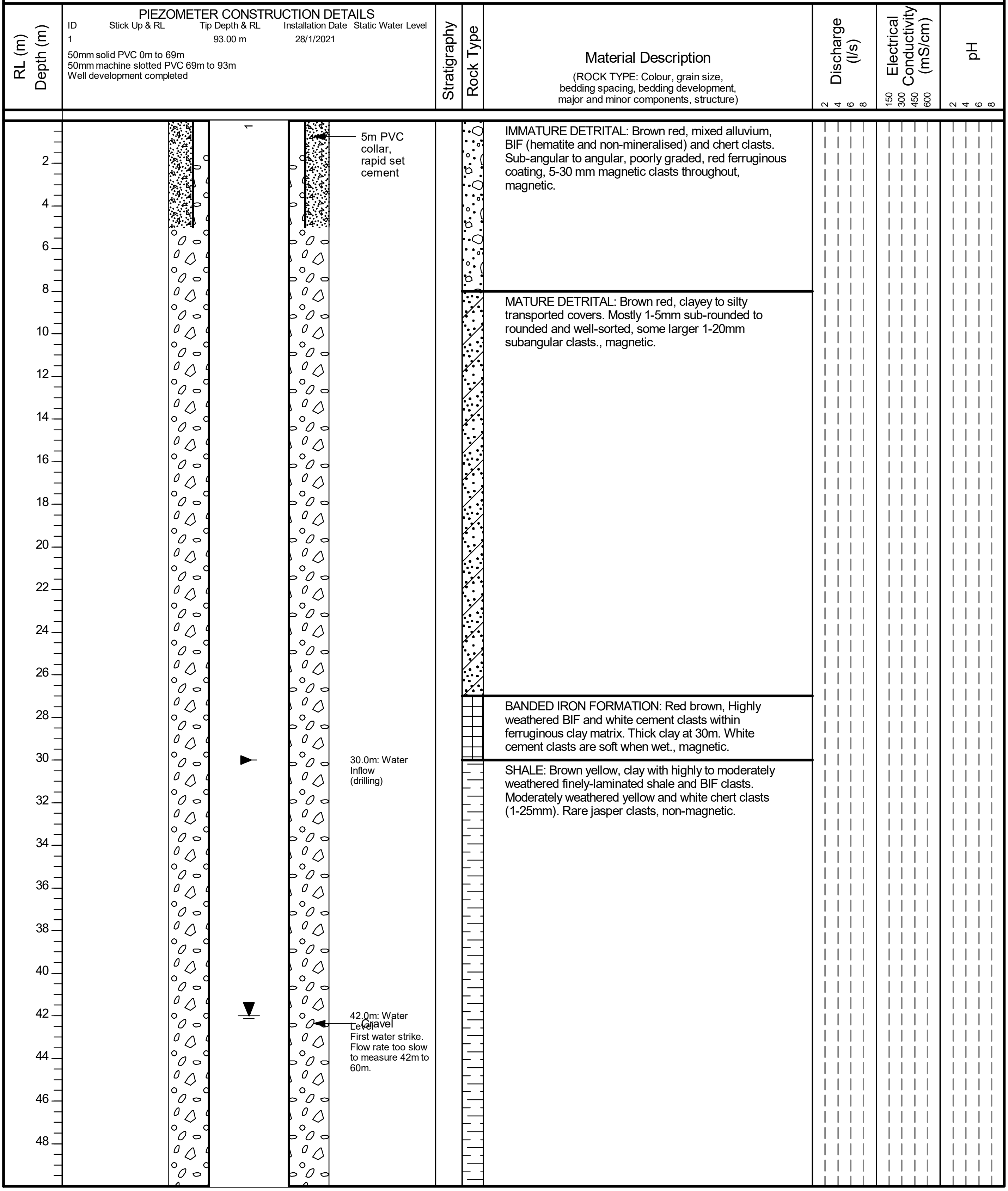
Monitoring Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	96 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In a creek/river bed	Easting:	691445
Date hole commenced:	26/01/21	Inclination/Azimuth:	-90° /	Northing:	7476609
Date hole complete:	28/01/21	Surface R.L.:		Logged by:	Ming Wu

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		93.00 m	28/1/2021	

50mm solid PVC 0m to 69m
50mm machine slotted PVC 69m to 93m
Well development completed



Material Description
(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

IMMATURE DETRITAL: Brown red, mixed alluvium, BIF (hematite and non-mineralised) and chert clasts. Sub-angular to angular, poorly graded, red ferruginous coating, 5-30 mm magnetic clasts throughout, magnetic.

MATURE DETRITAL: Brown red, clayey to silty transported covers. Mostly 1-5mm sub-rounded to rounded and well-sorted, some larger 1-20mm subangular clasts., magnetic.

BANDED IRON FORMATION: Red brown, Highly weathered BIF and white cement clasts within ferruginous clay matrix. Thick clay at 30m. White cement clasts are soft when wet., magnetic.

SHALE: Brown yellow, clay with highly to moderately weathered finely-laminated shale and BIF clasts. Moderately weathered yellow and white chert clasts (1-25mm). Rare jasper clasts, non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH15/TH9 (MB8)

Sheet 2 of 2

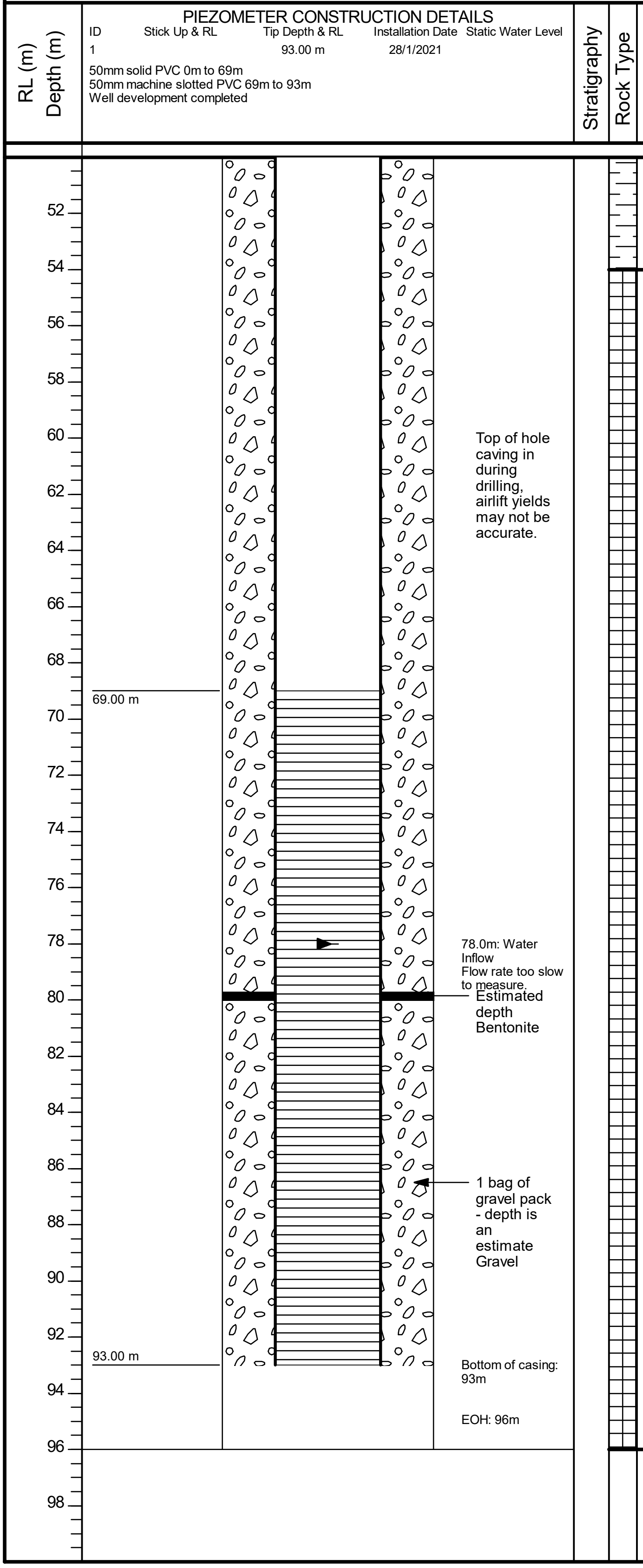
Monitoring Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	96 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In a creek/river bed	Easting:	691445
Date hole commenced:	26/01/21	Inclination/Azimuth:	-90° /	Northing:	7476609
Date hole complete:	28/01/21	Surface R.L.:		Logged by:	Ming Wu

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		93.00 m	28/1/2021	

50mm solid PVC 0m to 69m
50mm machine slotted PVC 69m to 93m
Well development completed

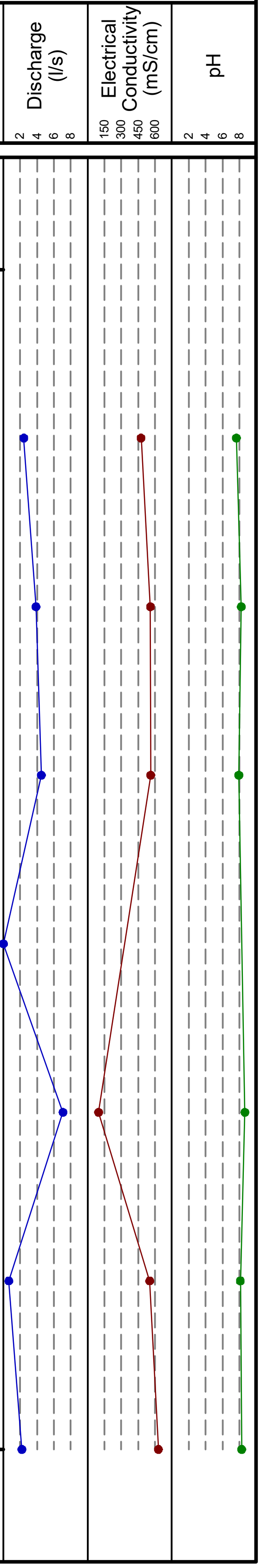


Material Description

(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

SHALE: Brown yellow, clay with highly to moderately weathered finely-laminated shale and BIF clasts. Moderately weathered yellow and white chert clasts (1-25mm). Rare jasper clasts, non-magnetic. *CONTINUED*

BANDED IRON FORMATION: Red black, moderately to slightly weathered angular to subangular BIF (mm-scale laminae) & chert clasts (1-20mm), minor leached cherty BIF. Strongly magnetic. Some shale clasts (1-5 mm). Very hard rock noted at 72-78m. Fractures at 85, 86, 88, 91, 94m, magnetic.



Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH16/TH10 (MB6)

Sheet 1 of 2

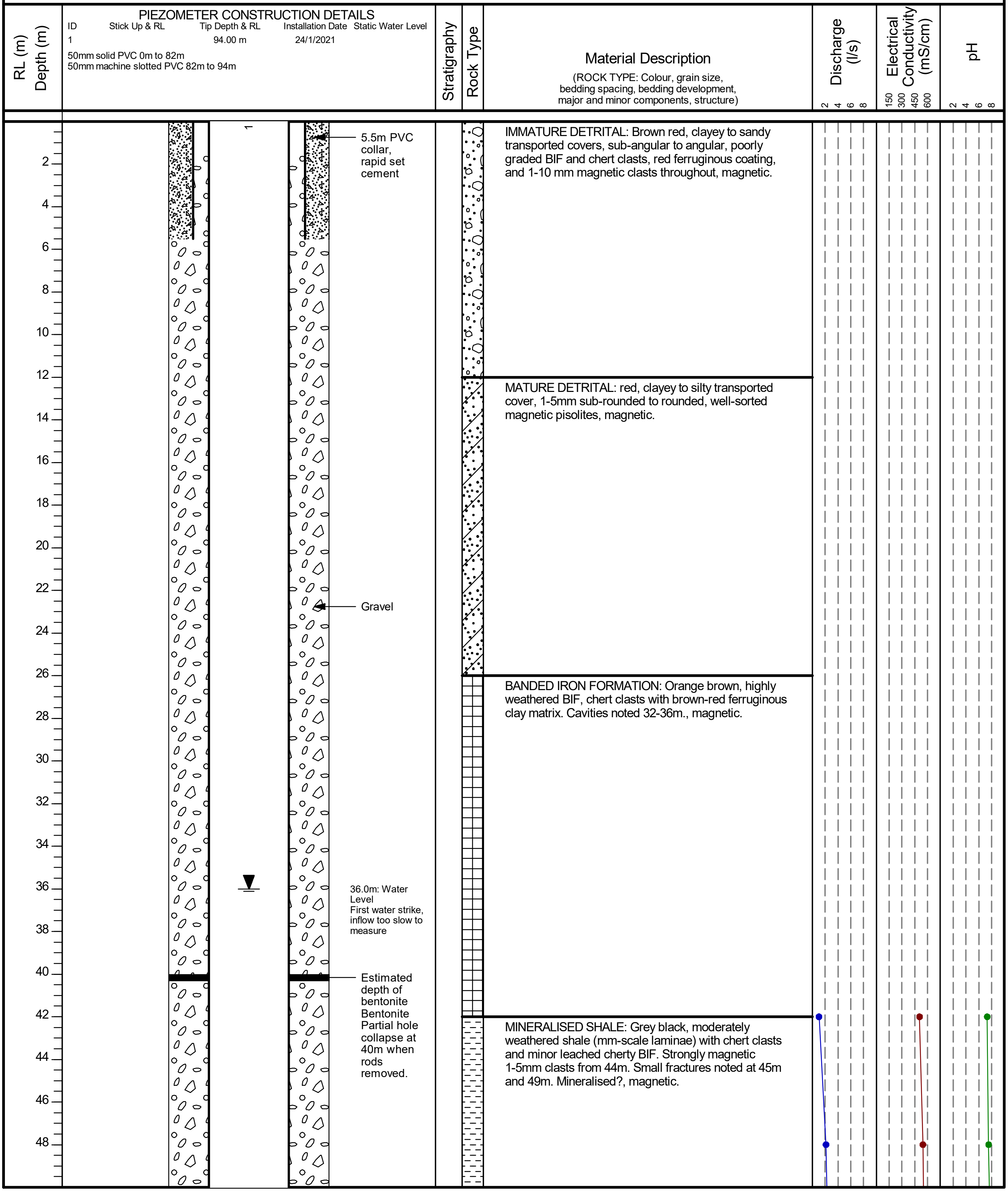
Monitoring Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	96 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In a creek/river bed	Easting:	691472
Date hole commenced:	21/01/21	Inclination/Azimuth:	-90° /	Northing:	7476794
Date hole complete:	24/01/21	Surface R.L.:		Logged by:	Ming Wu

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		94.00 m	24/1/2021	

50mm solid PVC 0m to 82m
50mm machine slotted PVC 82m to 94m



5.5m PVC collar, rapid set cement

Gravel

36.0m: Water Level
First water strike, inflow too slow to measure

Estimated depth of bentonite
Bentonite
Partial hole collapse at 40m when rods removed.

IMMATURE DETRITAL: Brown red, clayey to sandy transported covers, sub-angular to angular, poorly graded BIF and chert clasts, red ferruginous coating, and 1-10 mm magnetic clasts throughout, magnetic.

MATURE DETRITAL: red, clayey to silty transported cover, 1-5mm sub-rounded to rounded, well-sorted magnetic pisolites, magnetic.

BANDED IRON FORMATION: Orange brown, highly weathered BIF, chert clasts with brown-red ferruginous clay matrix. Cavities noted 32-36m., magnetic.

MINERALISED SHALE: Grey black, moderately weathered shale (mm-scale laminae) with chert clasts and minor leached cherty BIF. Strongly magnetic 1-5mm clasts from 44m. Small fractures noted at 45m and 49m. Mineralised?, magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH16/TH10 (MB6)

Sheet 2 of 2

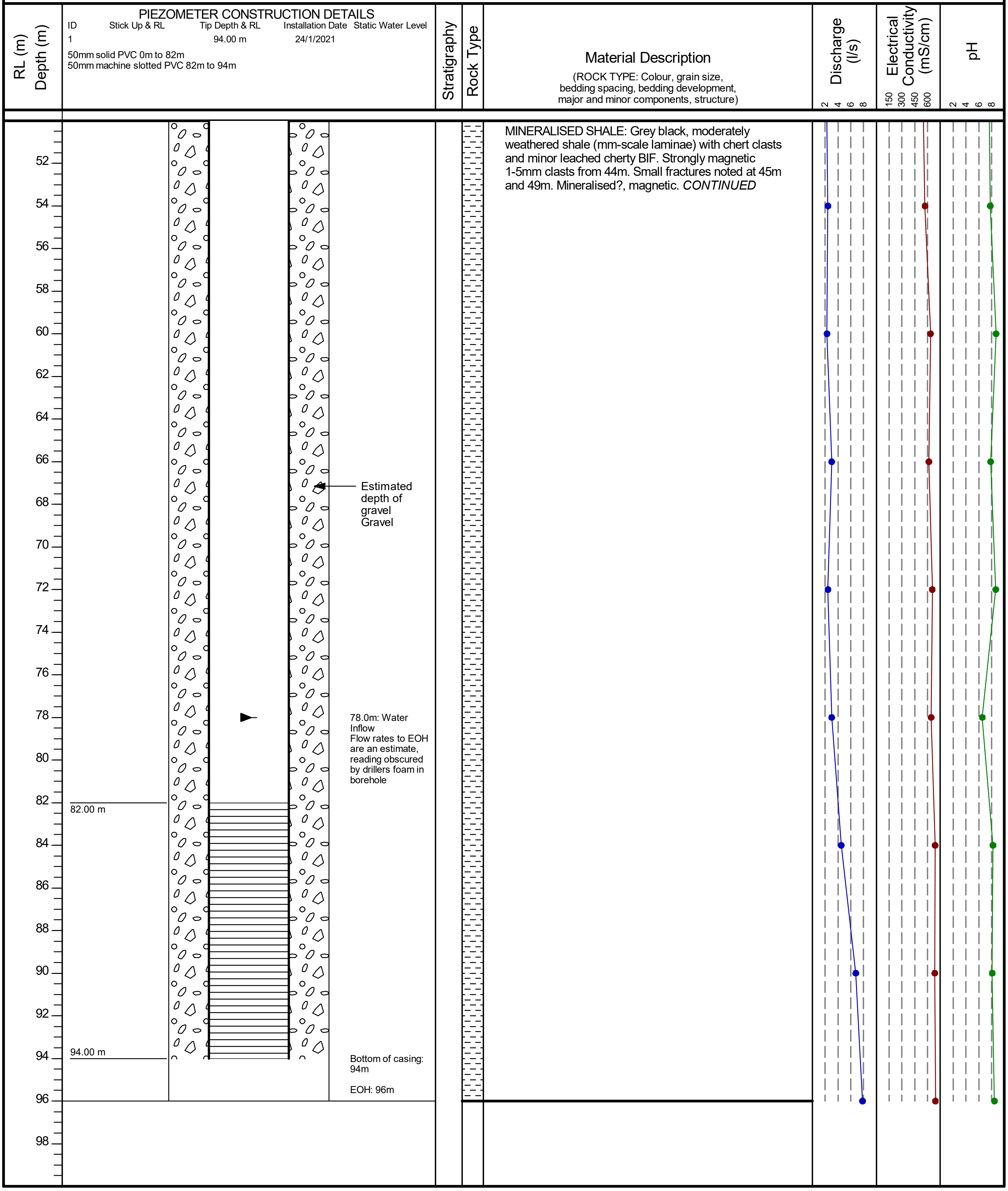
Monitoring Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	96 m
Drilling subcontractor:	Egan Drilling	Borehole location:	In a creek/river bed	Easting:	691472
Date hole commenced:	21/01/21	Inclination/Azimuth:	-90° /	Northing:	7476794
Date hole complete:	24/01/21	Surface R.L.:		Logged by:	Ming Wu

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		94.00 m	24/1/2021	

50mm solid PVC 0m to 82m
50mm machine slotted PVC 82m to 94m



Material Description
(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

MINERALISED SHALE: Grey black, moderately weathered shale (mm-scale laminae) with chert clasts and minor leached cherty BIF. Strongly magnetic 1-5mm clasts from 44m. Small fractures noted at 45m and 49m. Mineralised?, magnetic. *CONTINUED*

Estimated depth of gravel
Gravel

78.0m: Water Inflow
Flow rates to EOH are an estimate, reading obscured by drillers foam in borehole

Bottom of casing: 94m

EOH: 96m

Refer to Explanation Sheets Attached for Classification Systems

PSM

Monitoring Bore

Borehole ID

BH19/TH15 (MB7)

Sheet 1 of 3

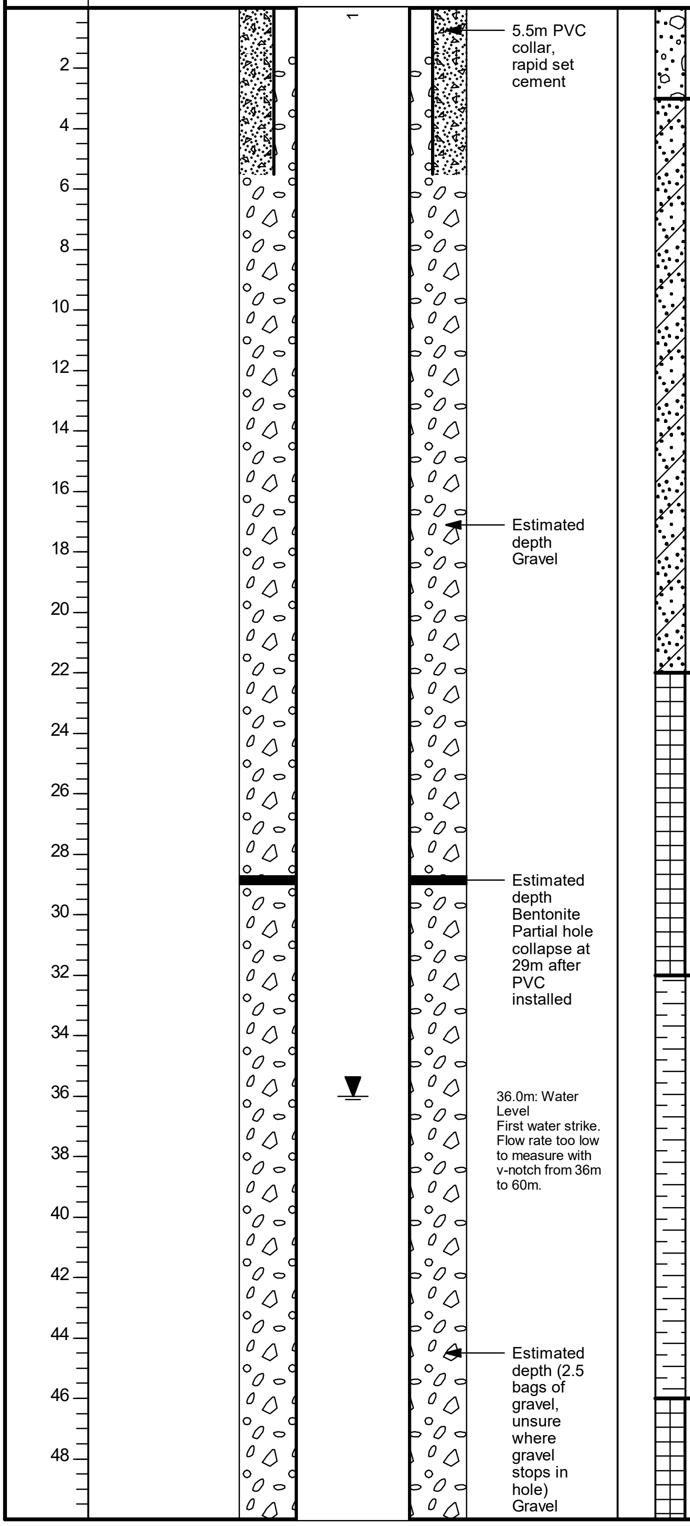
Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	120 m
Drilling subcontractor:	Egan Drilling	Borehole location:	North of laydown area	Easting:	692222
Date hole commenced:	24/01/21	Inclination/Azimuth:	-90° /	Northing:	7477477
Date hole complete:	26/01/21	Surface R.L.:		Logged by:	Ming Wu

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		118.00 m		

50mm solid PVC 0m to 94m
50mm machine slotted PVC 94m to 118m
Well development completed

RL (m) Depth (m) | Stratigraphy | Rock Type | Material Description (ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure) | Discharge (l/s) 2 4 6 8 | Electrical Conductivity (mS/cm) 150 300 450 600 | pH 2 4 6 8



5.5m PVC collar, rapid set cement

Estimated depth Gravel

Estimated depth Bentonite Partial hole collapse at 29m after PVC installed

36.0m: Water Level First water strike. Flow rate too low to measure with v-notch from 36m to 60m.

Estimated depth (2.5 bags of gravel, unsure where gravel stops in hole) Gravel

IMMATURE DETRITAL: Brown red, clayey to sandy transported cover, sub-angular to angular, poorly sorted BIF and chert clasts, 1-10 mm magnetic clasts throughout, magnetic.

MATURE DETRITAL: red, clayey to silty transported cover, 1-5mm sub-rounded to rounded, well-sorted, magnetic.

BANDED IRON FORMATION: Red brown, highly weathered, poorly sorted clasts (1-10mm) with brown-red ferruginous clay matrix. Increasing amount of white rock/cement clasts after 27m, non-magnetic.

CLAY: Yellow brown, clay with highly weathered clasts. Soft white clasts that break up during washing, likely highly weathered shale. Small fractures at 43, 44, 50 & 51m, non-magnetic.

BANDED IRON FORMATION: Red black, moderately weathered magnetic BIF with chert clasts, minor leached cherty BIF. Hematite and goethite clasts present. Abundant bleached shale 72m to 77m (60% of chips), magnetic.

Refer to Explanation Sheets Attached for Classification Systems

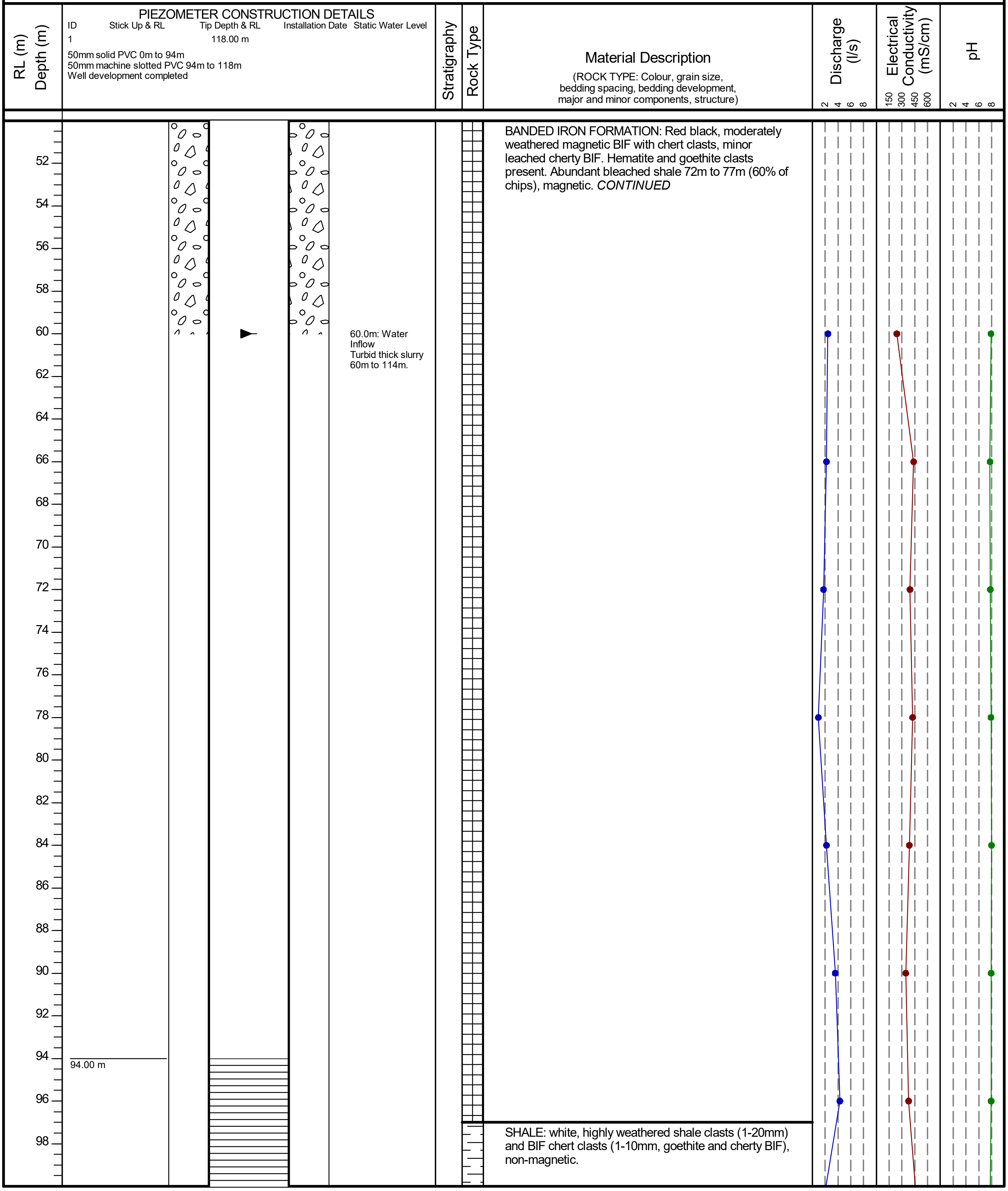
Monitoring Bore

Borehole ID

BH19/TH15 (MB7)

Sheet 2 of 3

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	120 m
Drilling subcontractor:	Egan Drilling	Borehole location:	North of laydown area	Easting:	692222
Date hole commenced:	24/01/21	Inclination/Azimuth:	-90° /	Northing:	7477477
Date hole complete:	26/01/21	Surface R.L.:		Logged by:	Ming Wu



PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		118.00 m		

50mm solid PVC 0m to 94m
50mm machine slotted PVC 94m to 118m
Well development completed

60.0m: Water Inflow
Turbid thick slurry 60m to 114m.

Material Description
(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

BANDED IRON FORMATION: Red black, moderately weathered magnetic BIF with chert clasts, minor leached cherty BIF. Hematite and goethite clasts present. Abundant bleached shale 72m to 77m (60% of chips), magnetic. *CONTINUED*

SHALE: white, highly weathered shale clasts (1-20mm) and BIF chert clasts (1-10mm, goethite and cherty BIF), non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH19/TH15 (MB7)

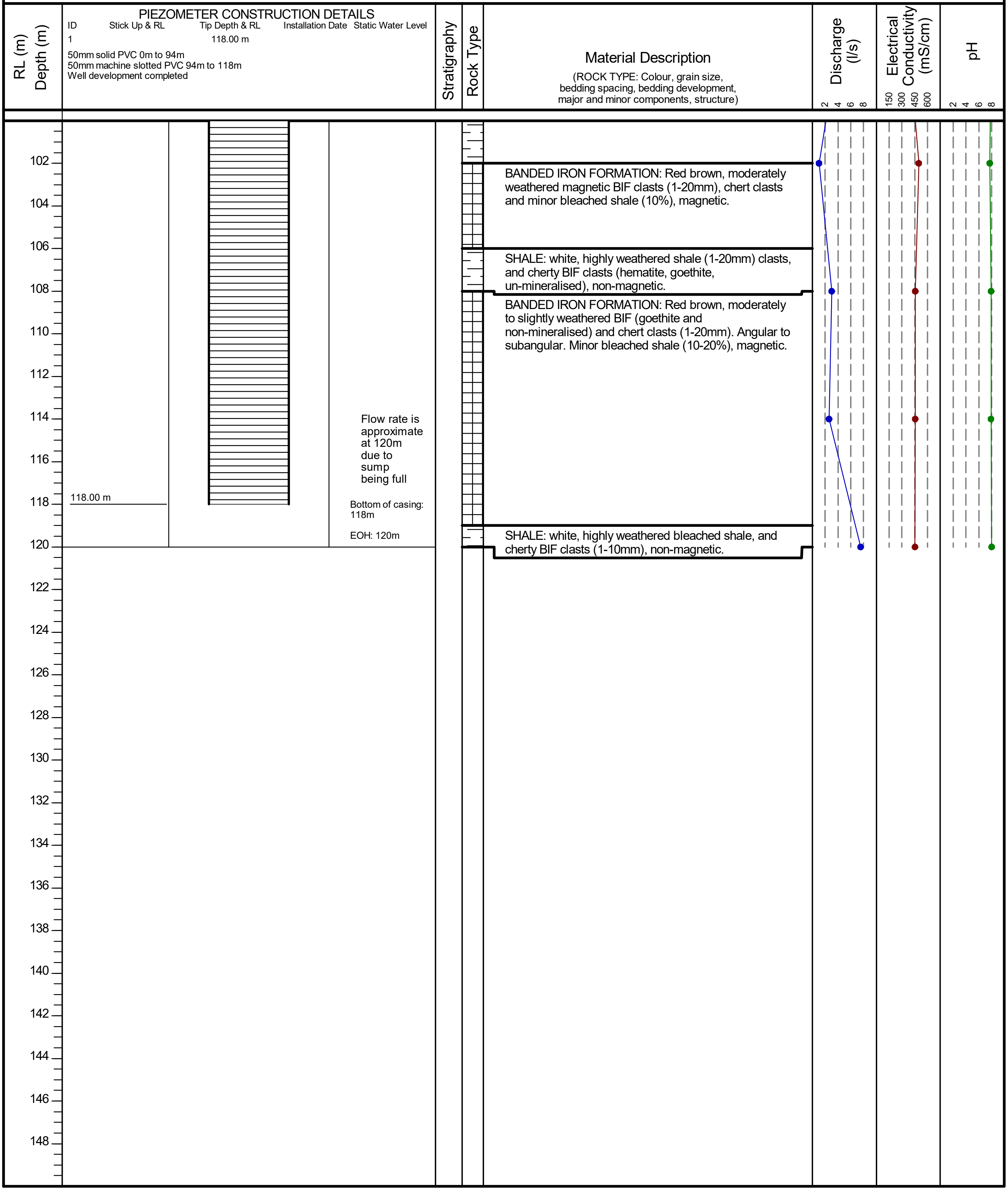
Sheet 3 of 3

Monitoring Bore

Job No: PSM4241
Client: MRL
Project: Lamb Creek Hydrogeology Inv.
Drilling subcontractor: Egan Drilling
Date hole commenced: 24/01/21
Date hole complete: 26/01/21

Drill information: AustEX-X400
Hole diameter: 203 mm
Datum: GDA94 Zone 50
Borehole location: North of laydown area
Inclination/Azimuth: -90° /
Surface R.L.:

Drilling Method: RAB
Hole Depth: 120 m
Easting: 692222
Northing: 7477477
Logged by: Ming Wu



PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		118.00 m		

50mm solid PVC 0m to 94m
50mm machine slotted PVC 94m to 118m
Well development completed

Flow rate is approximate at 120m due to sump being full

Bottom of casing: 118m

EOH: 120m

Material Description
(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

BANDED IRON FORMATION: Red brown, moderately weathered magnetic BIF clasts (1-20mm), chert clasts and minor bleached shale (10%), magnetic.

SHALE: white, highly weathered shale (1-20mm) clasts, and cherty BIF clasts (hematite, goethite, un-mineralised), non-magnetic.

BANDED IRON FORMATION: Red brown, moderately to slightly weathered BIF (goethite and non-mineralised) and chert clasts (1-20mm). Angular to subangular. Minor bleached shale (10-20%), magnetic.

SHALE: white, highly weathered bleached shale, and cherty BIF clasts (1-10mm), non-magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Borehole ID

BH20/TH20 (MB9)

Sheet 1 of 2

Monitoring Bore

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	96 m
Drilling subcontractor:	Egan Drilling	Borehole location:	North-east of laydown	Easting:	694477
Date hole commenced:	04/02/21	Inclination/Azimuth:	-90° /	Northing:	7477617
Date hole complete:	06/02/21	Surface R.L.:		Logged by:	Ming Wu

RL (m) Depth (m)

PIEZOMETER CONSTRUCTION DETAILS

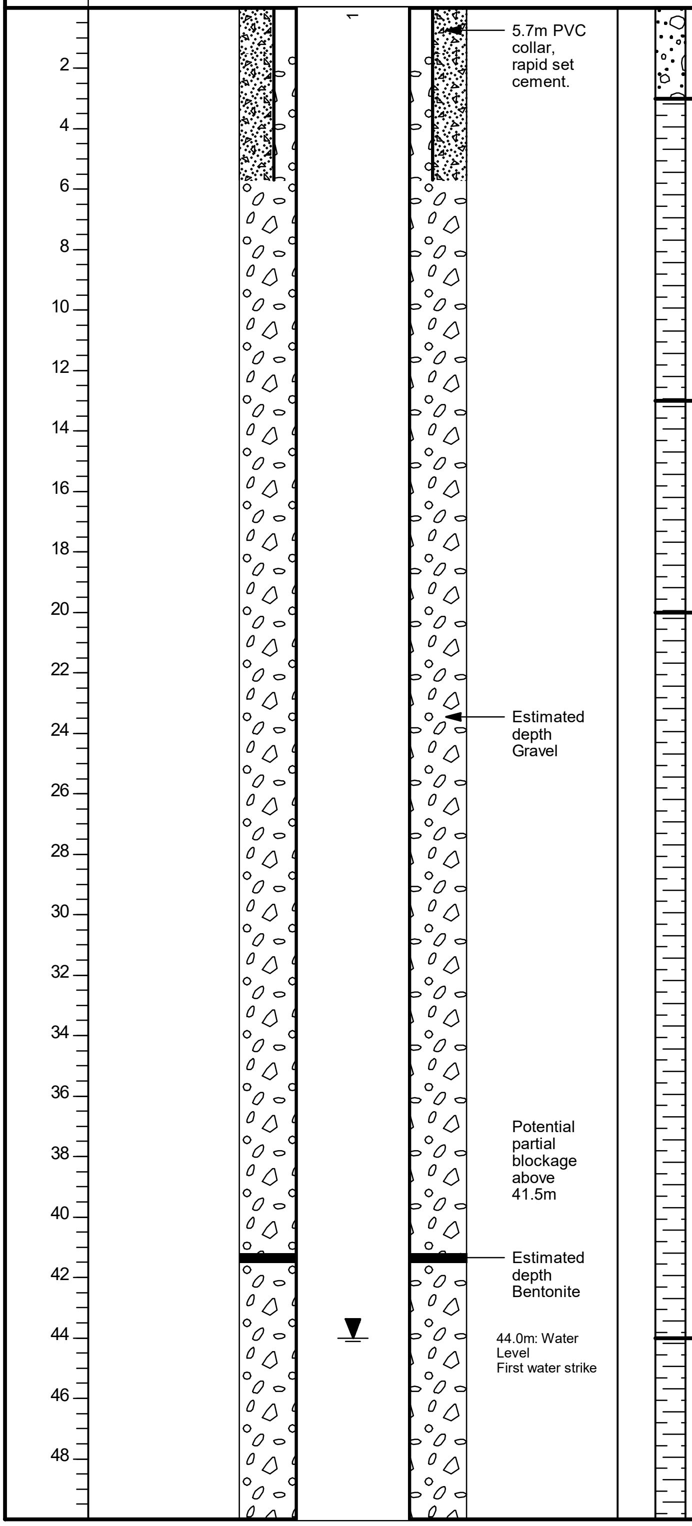
ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		96.00 m	5/2/2021	

50mm solid PVC 0m to 84m
50mm machine slotted PVC 84m to 96m
Well development completed

Stratigraphy | Rock Type

Material Description
(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

Discharge (l/s) 2 4 6 8 | Electrical Conductivity (mS/cm) 150 300 450 600 | pH 2 4 6 8



IMMATURE DETRITAL: Brown red, clayey to sandy transported cover, sub-angular to angular, poorly graded BIF and chert clasts, 1-10 mm magnetic clasts throughout, magnetic.

CLAY: Brown yellow, highly to extremely weathered geothite clasts with yellow clay matrix (weathered shale?), some highly weathered chert and hematite clasts, subangular 1-10mm, non-magnetic.

SHALE: Brown red, clayey to sandy clasts with massive texture (extremely weathered shale?). Minor BIF and chert clasts, non-magnetic.

CLAY: Brown yellow, extremely weathered bleached shale(?) and fine clays. Minor BIF clasts throughout, 2-15mm highly magnetic, hematite dominated to 40m, becomes goethite dominated 41m to 43m. Very poor sample return and very fine clays washing away., non-magnetic.

SHALE: Brown green, highly weathered bleached shale with magnetic BIF and chert clasts, magnetic.

Refer to Explanation Sheets Attached for Classification Systems

Monitoring Bore

Borehole ID

BH20/TH20 (MB9)

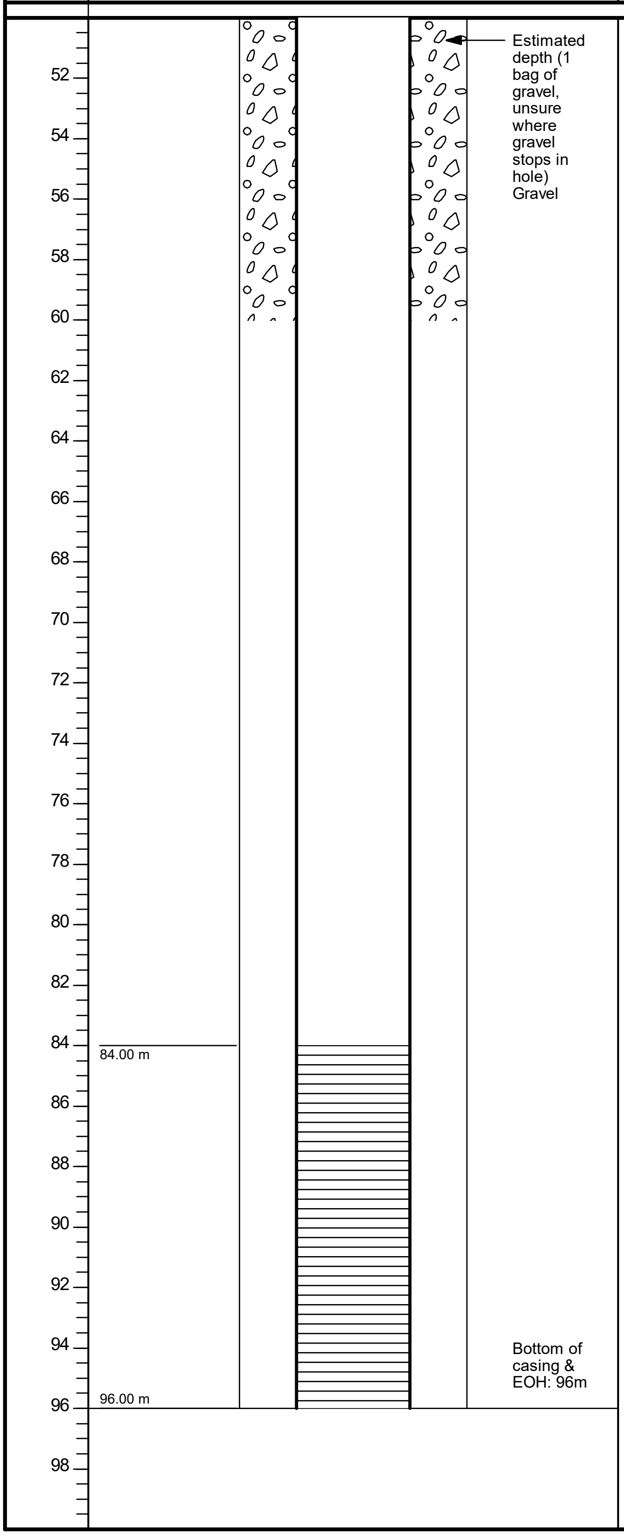
Sheet 2 of 2

Job No:	PSM4241	Drill information:	AustEX-X400		
Client:	MRL	Hole diameter:	203 mm	Drilling Method:	RAB
Project:	Lamb Creek Hydrogeology Inv.	Datum:	GDA94 Zone 50	Hole Depth:	96 m
Drilling subcontractor:	Egan Drilling	Borehole location:	North-east of laydown	Easting:	694477
Date hole commenced:	04/02/21	Inclination/Azimuth:	-90° /	Northing:	7477617
Date hole complete:	06/02/21	Surface R.L.:		Logged by:	Ming Wu

PIEZOMETER CONSTRUCTION DETAILS

ID	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1		96.00 m	5/2/2021	

50mm solid PVC 0m to 84m
50mm machine slotted PVC 84m to 96m
Well development completed



Stratigraphy | Rock Type

Material Description

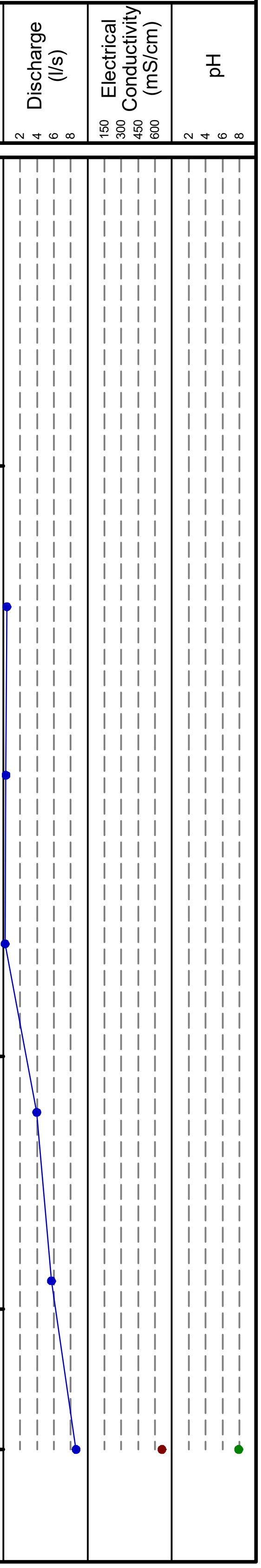
(ROCK TYPE: Colour, grain size, bedding spacing, bedding development, major and minor components, structure)

SHALE: Brown green, highly weathered bleached shale with magnetic BIF and chert clasts, magnetic. *CONTINUED*

SHALE: Green grey, fresh to slightly weathered, uniform texture throughout. Unusual 'speckled' texture due to lack of fine lamination(?), non-magnetic.

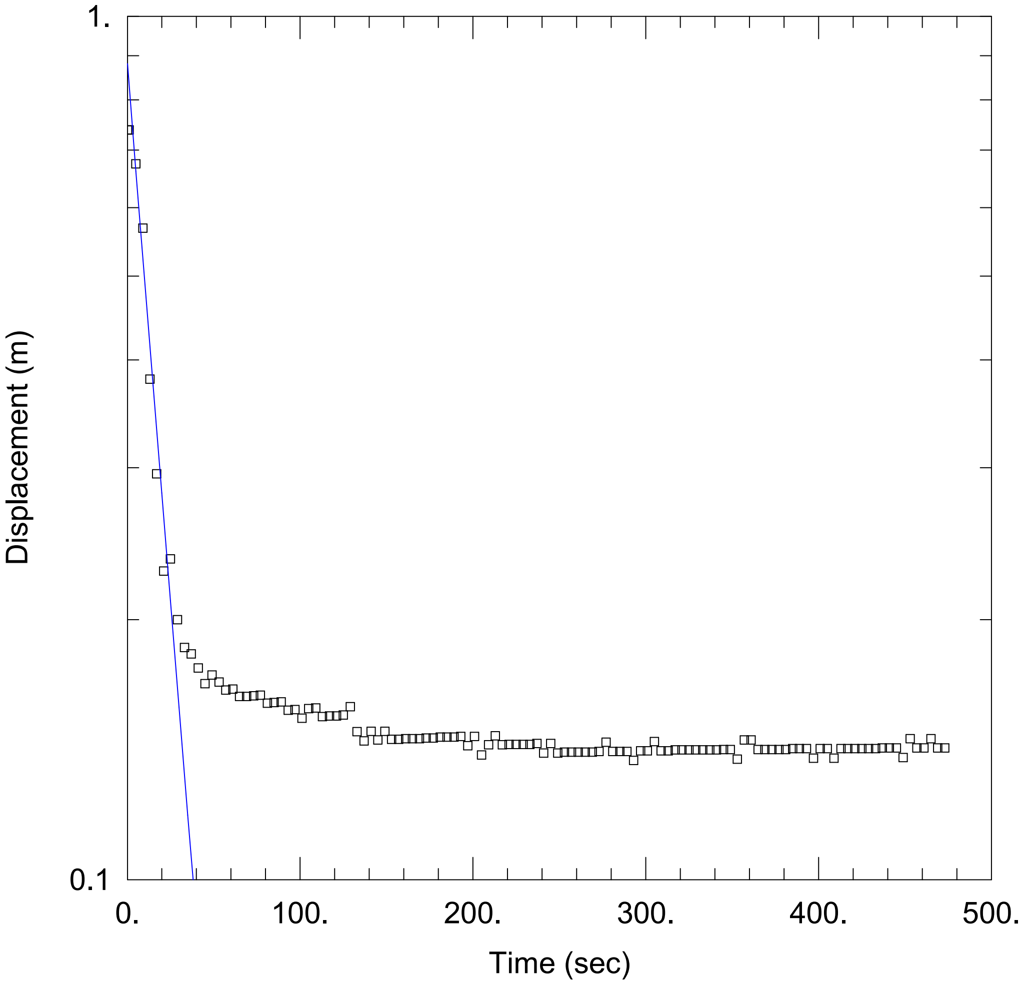
BANDED IRON FORMATION: Red grey, moderately weathered BIF and grey shale clasts (1-20mm). Some completely weathered goethite nodules (weathered shale?) between 91m and 94m. Completely fractured ground, magnetic.

CHERT: Grey white, moderately weathered chert with BIF (hematite) clasts (1-15mm). Completely fractured ground, non-magnetic.



Refer to Explanation Sheets Attached for Classification Systems

Appendix B
Slug Test Analyses



WELL TEST ANALYSIS

Data Set: N:\...\BH1_40L_4sec_09022021_BR.aqt
Date: 03/23/21
Time: 16:04:03

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

Saturated Thickness: 50.53 m
Anisotropy Ratio (Kz/Kr): 1.

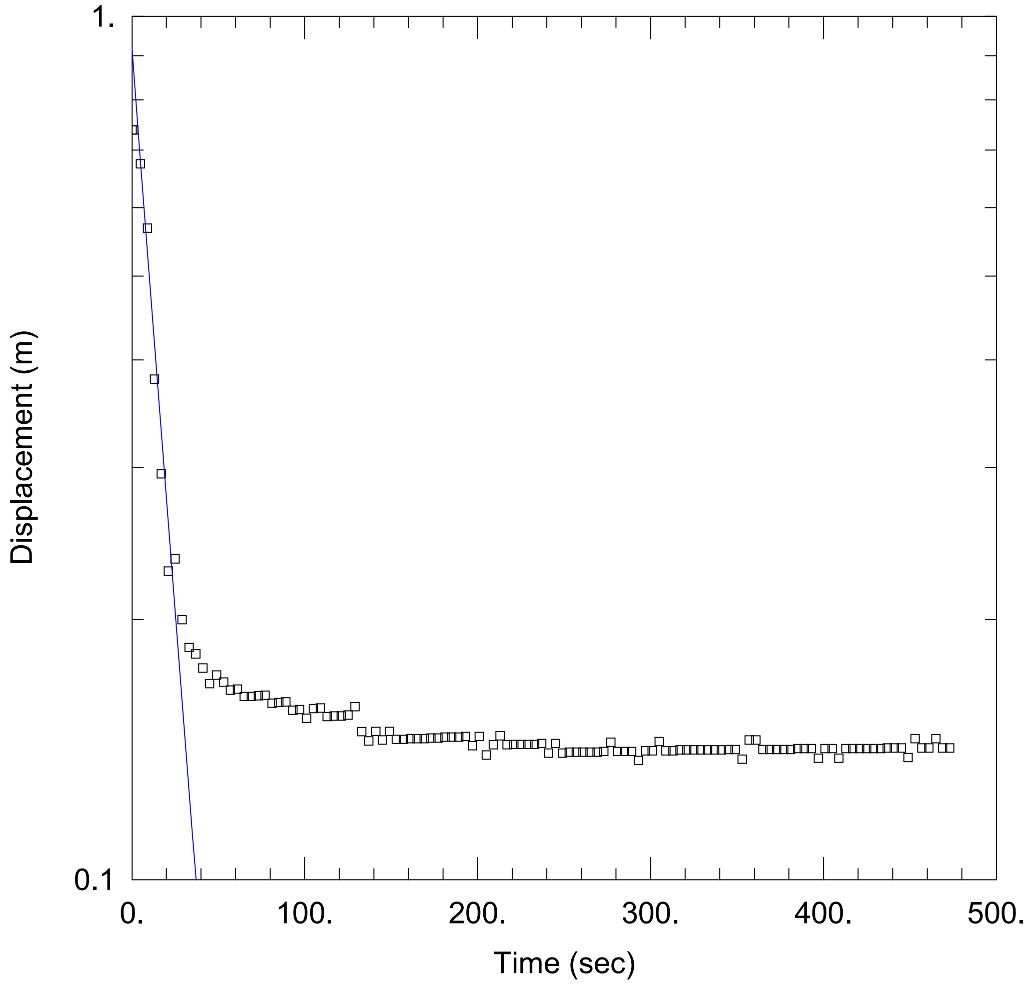
WELL DATA (BH1/TH14 (MB2))

Initial Displacement: 0.7382 m
Static Water Column Height: 35.53 m
Total Well Penetration Depth: 35.53 m
Screen Length: 6. m
Casing Radius: 0.025 m
Well Radius: 0.0715 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.9669 m/day
y0 = 0.8809 m



WELL TEST ANALYSIS

Data Set: N:\...\BH1_40L_4sec_09022021_Hvorslev.aqt
Date: 03/23/21 Time: 16:06:34

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

Saturated Thickness: 50.53 m
Anisotropy Ratio (Kz/Kr): 1.

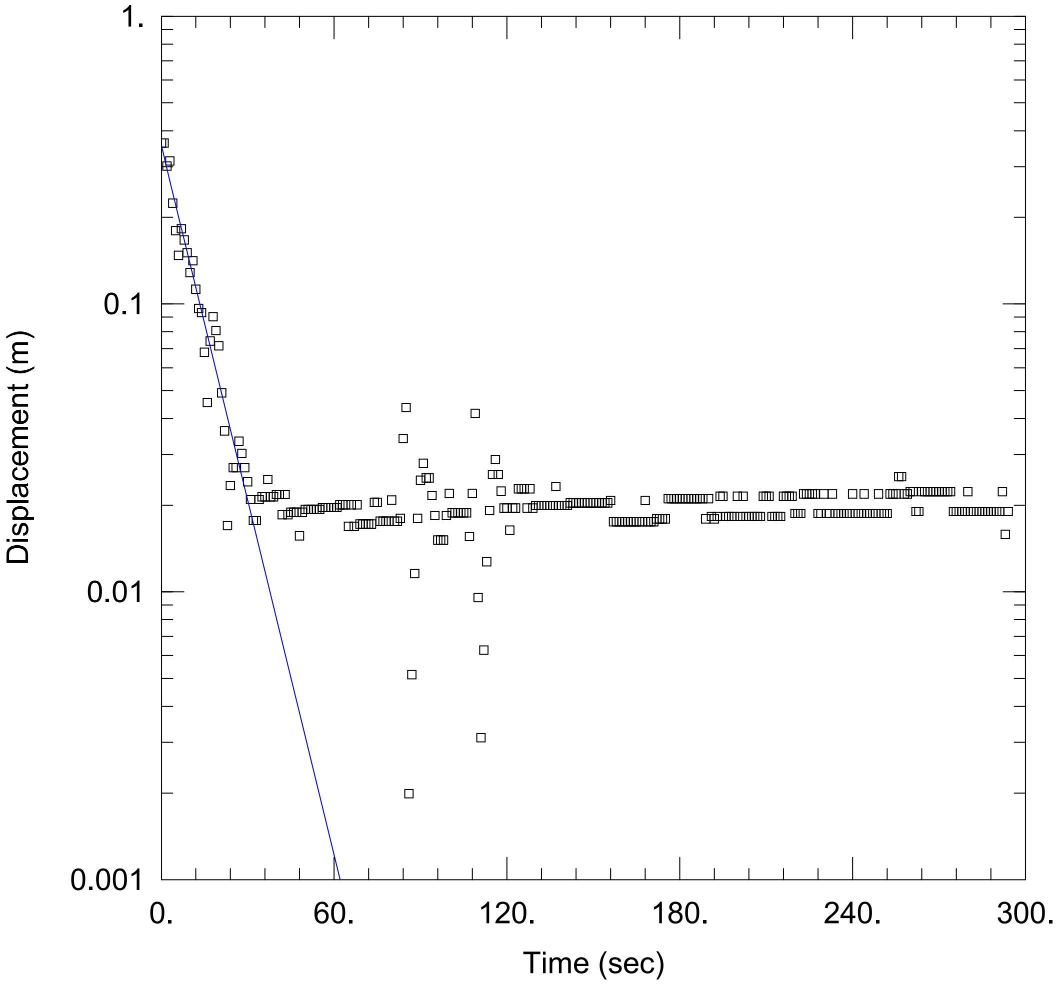
WELL DATA (BH1/TH14 (MB2))

Initial Displacement: 0.7382 m
Static Water Column Height: 35.53 m
Total Well Penetration Depth: 35.53 m
Screen Length: 6. m
Casing Radius: 0.025 m
Well Radius: 0.0715 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 1.191 m/day
y0 = 0.9151 m



WELL TEST ANALYSIS

Data Set: N:\...\BH3_40L_1sec_09022021_BR.aqt
Date: 03/23/21 Time: 16:13:58

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

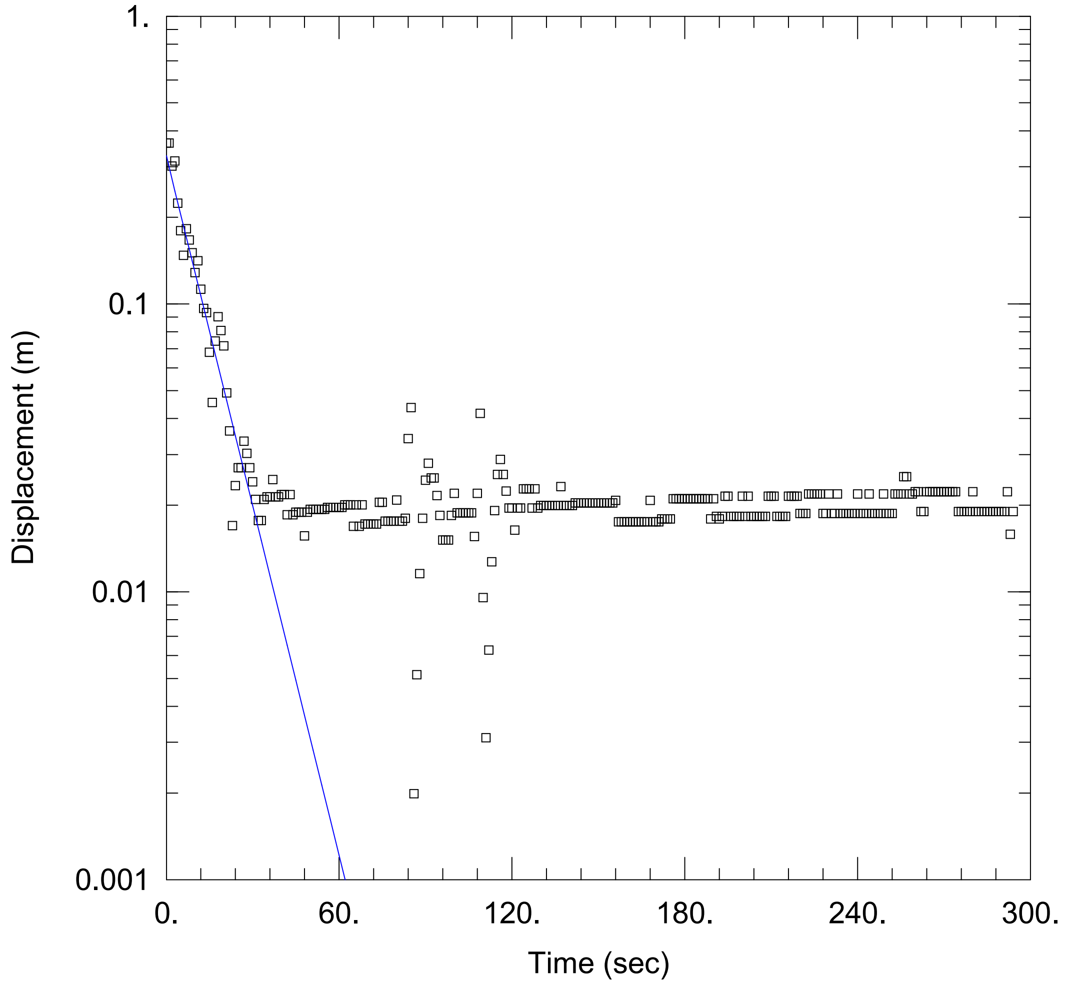
Saturated Thickness: 45.3 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH3/TH12 (MB3))

Initial Displacement: 0.3622 m
Static Water Column Height: 31.3 m
Total Well Penetration Depth: 31.3 m
Screen Length: 6. m
Casing Radius: 0.025 m
Well Radius: 0.0715 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 1.578 m/day
y0 = 0.3552 m



WELL TEST ANALYSIS

Data Set: N:\...\BH3_40L_1sec_09022021_Hvorslev.aqt
Date: 03/23/21 Time: 16:13:09

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

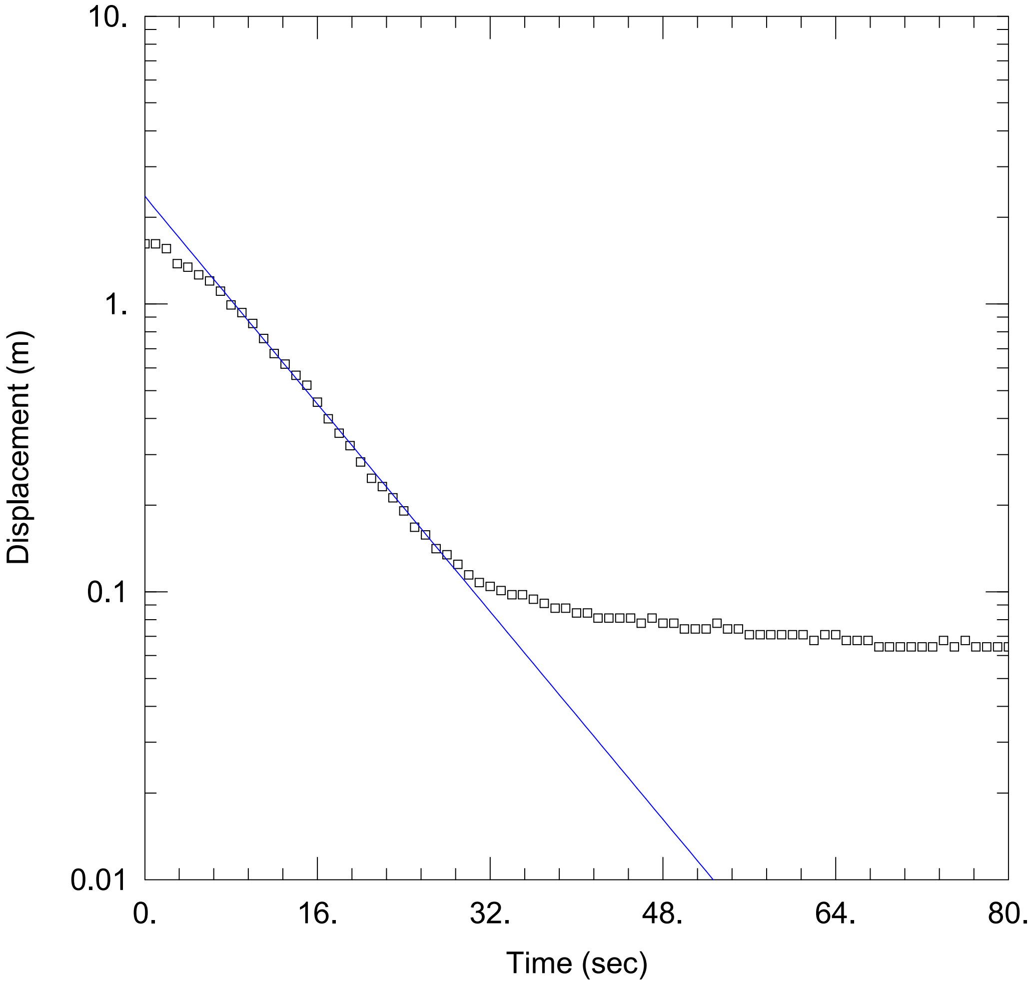
Saturated Thickness: 45.3 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH3/TH12 (MB3))

Initial Displacement: 0.3622 m
Total Well Penetration Depth: 31.3 m
Casing Radius: 0.025 m
Static Water Column Height: 31.3 m
Screen Length: 6. m
Well Radius: 0.0715 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 1.858 m/day
y0 = 0.3269 m



WELL TEST ANALYSIS

Data Set: N:\...\BH4b_40L_1sec_10022021_BR.aqt
Date: 03/23/21 Time: 16:18:23

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

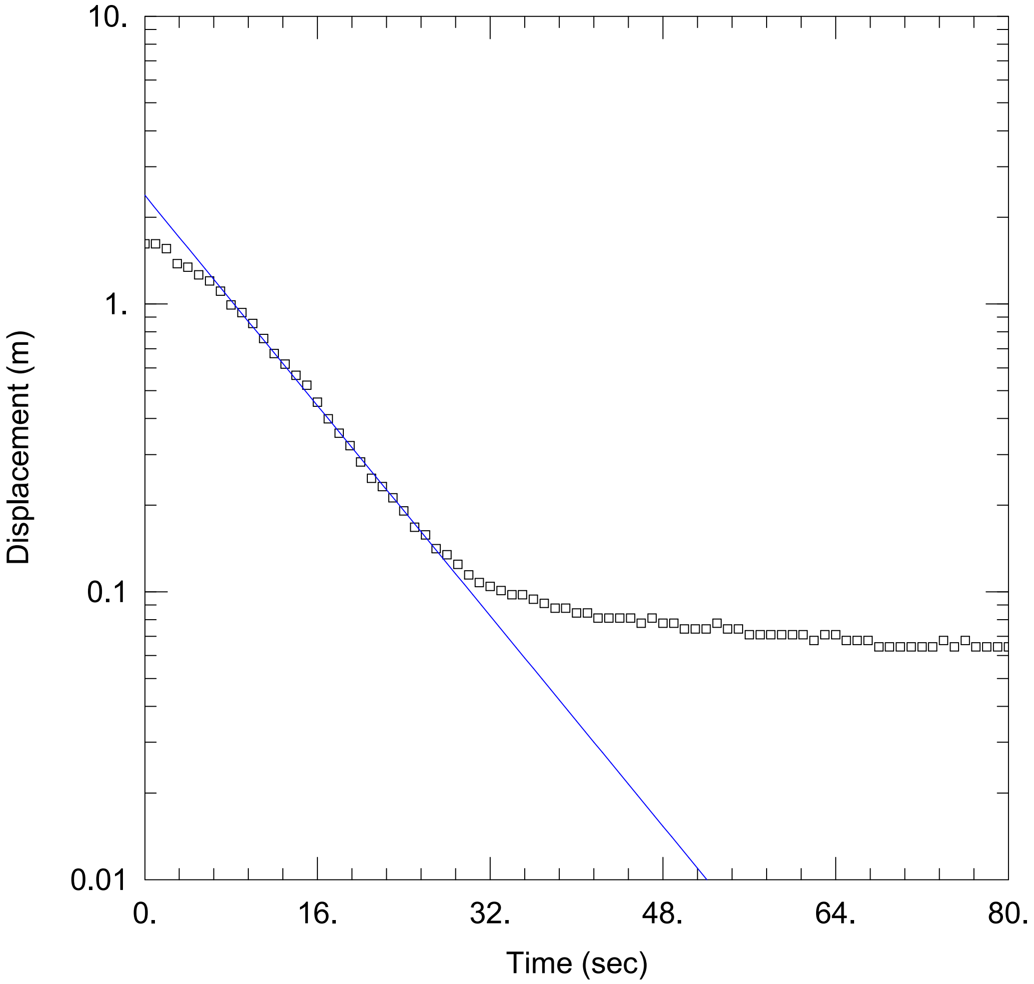
Saturated Thickness: 47.3 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH4B/TH16 (MB4))

Initial Displacement: 1.62 m
Static Water Column Height: 42.3 m
Total Well Penetration Depth: 42.3 m
Screen Length: 6. m
Casing Radius: 0.025 m
Well Radius: 0.0715 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 1.846 m/day
y0 = 2.368 m



WELL TEST ANALYSIS

Data Set: N:\...\BH4b_40L_1sec_10022021_Hvorslev.aqt
Date: 03/23/21 Time: 16:19:01

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

Saturated Thickness: 47.3 m
Anisotropy Ratio (Kz/Kr): 1.

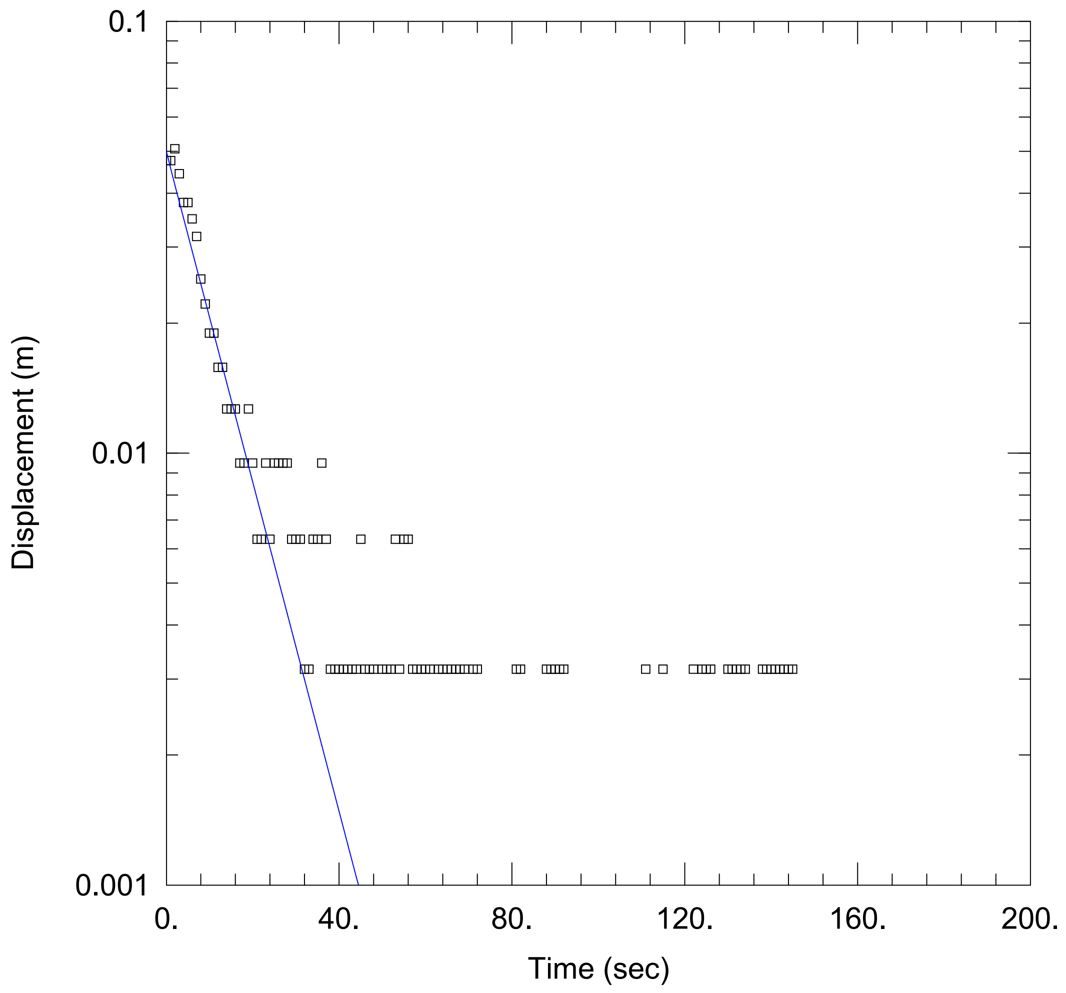
WELL DATA (BH4B/TH16 (MB4))

Initial Displacement: 1.62 m
Total Well Penetration Depth: 42.3 m
Casing Radius: 0.025 m
Static Water Column Height: 42.3 m
Screen Length: 6. m
Well Radius: 0.0715 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 2.097 m/day
y0 = 2.388 m



WELL TEST ANALYSIS

Data Set: N:\...\BH5_40L_1sec_10022021_Hvorslev.aqt
Date: 03/23/21 Time: 16:22:35

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

Saturated Thickness: 28.6 m
Anisotropy Ratio (Kz/Kr): 1.

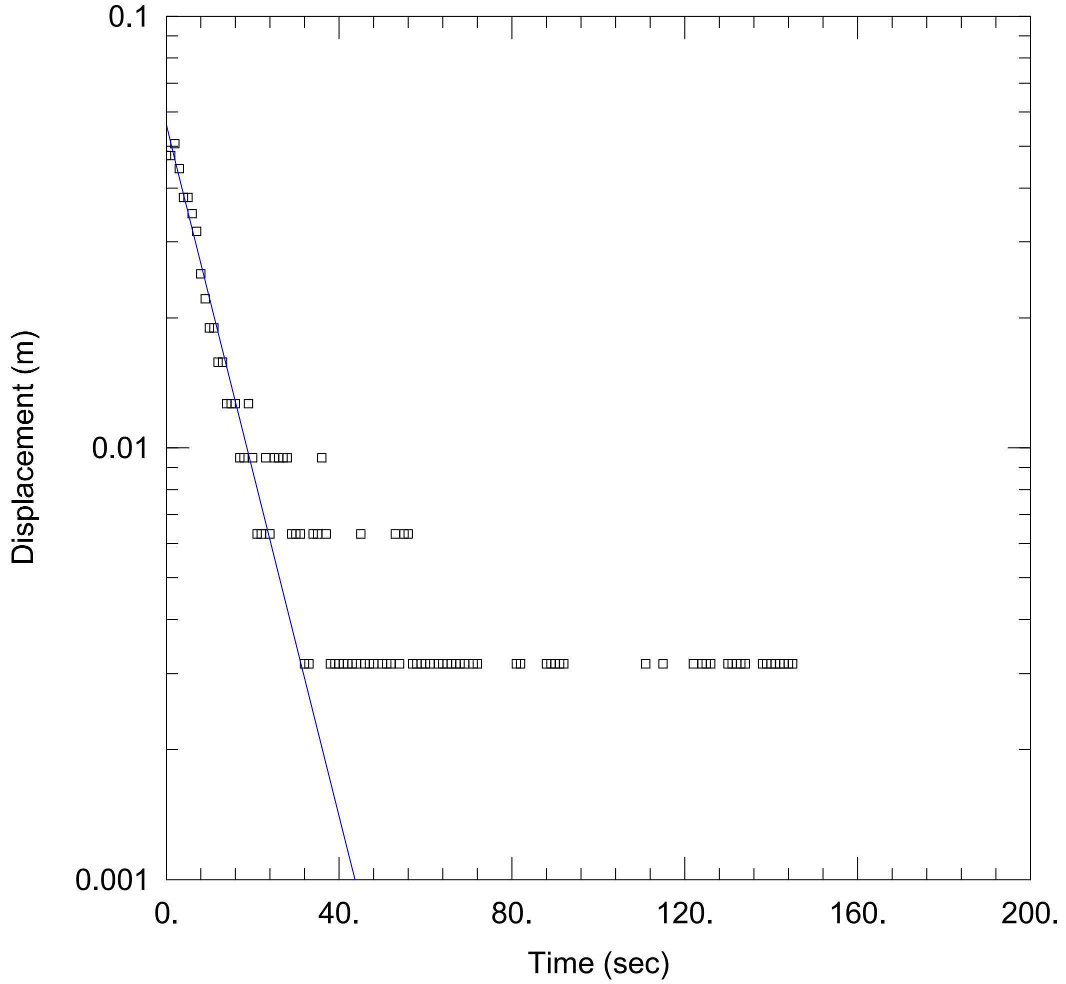
WELL DATA (BH5/TH19 (MB1))

Initial Displacement: 0.04753 m
Total Well Penetration Depth: 20.6 m
Casing Radius: 0.025 m
Static Water Column Height: 20.6 m
Screen Length: 6. m
Well Radius: 0.0715 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 1.752 m/day
y0 = 0.04978 m



WELL TEST ANALYSIS

Data Set: N:\...\BH5_40L_1sec_10022021_Hvorslev.aqt
Date: 03/23/21 Time: 16:21:30

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

Saturated Thickness: 28.6 m
Anisotropy Ratio (Kz/Kr): 1.

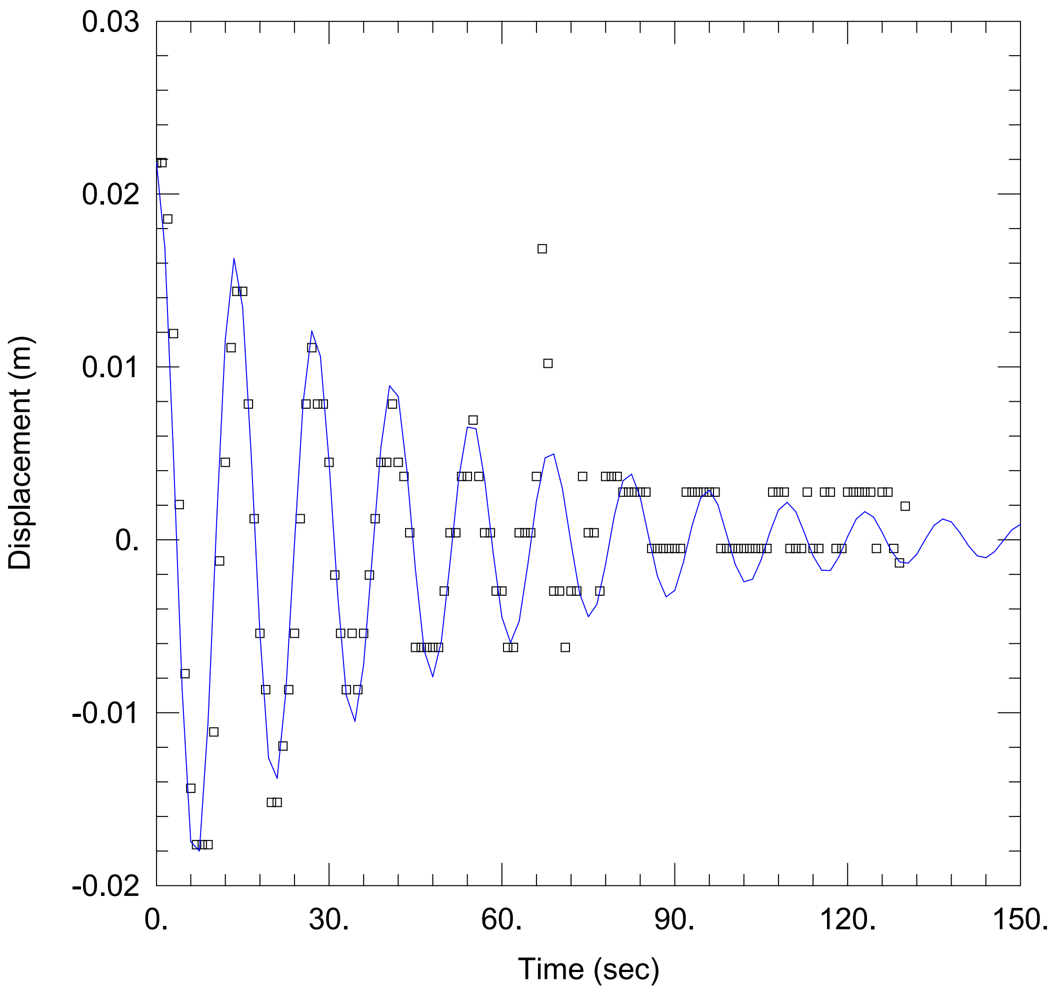
WELL DATA (BH5/TH19 (MB1))

Initial Displacement: 0.04753 m
Static Water Column Height: 20.6 m
Total Well Penetration Depth: 20.6 m
Screen Length: 6. m
Casing Radius: 0.025 m
Well Radius: 0.0715 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 1.836 m/day
y0 = 0.05594 m



WELL TEST ANALYSIS

Data Set: N:\...\BH6_40L_1sec_10022021.aqt
Date: 03/03/21 Time: 10:05:51

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

Saturated Thickness: 63.3 m
Anisotropy Ratio (Kz/Kr): 1.

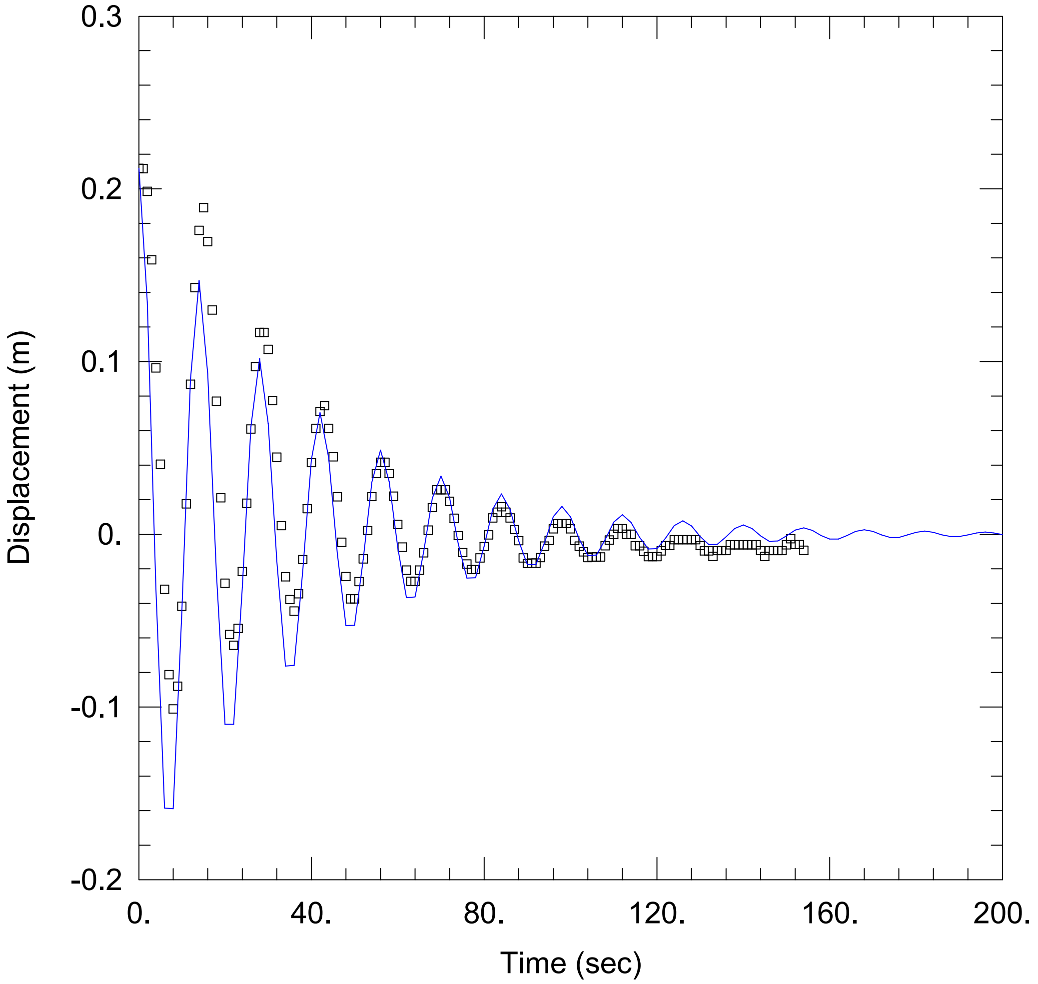
WELL DATA (BH6/TH8 (MB5))

Initial Displacement: 0.0218 m
Total Well Penetration Depth: 52.8 m
Casing Radius: 0.025 m
Static Water Column Height: 52.8 m
Screen Length: 12. m
Well Radius: 0.0715 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Springer-Gelhar

K = 72.11 m/day
Le = 46.37 m



WELL TEST ANALYSIS

Data Set: N:\...\BH10_40L_1sec_11022021.aqt
Date: 03/03/21 Time: 09:58:35

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

Saturated Thickness: 58.6 m
Anisotropy Ratio (Kz/Kr): 1.

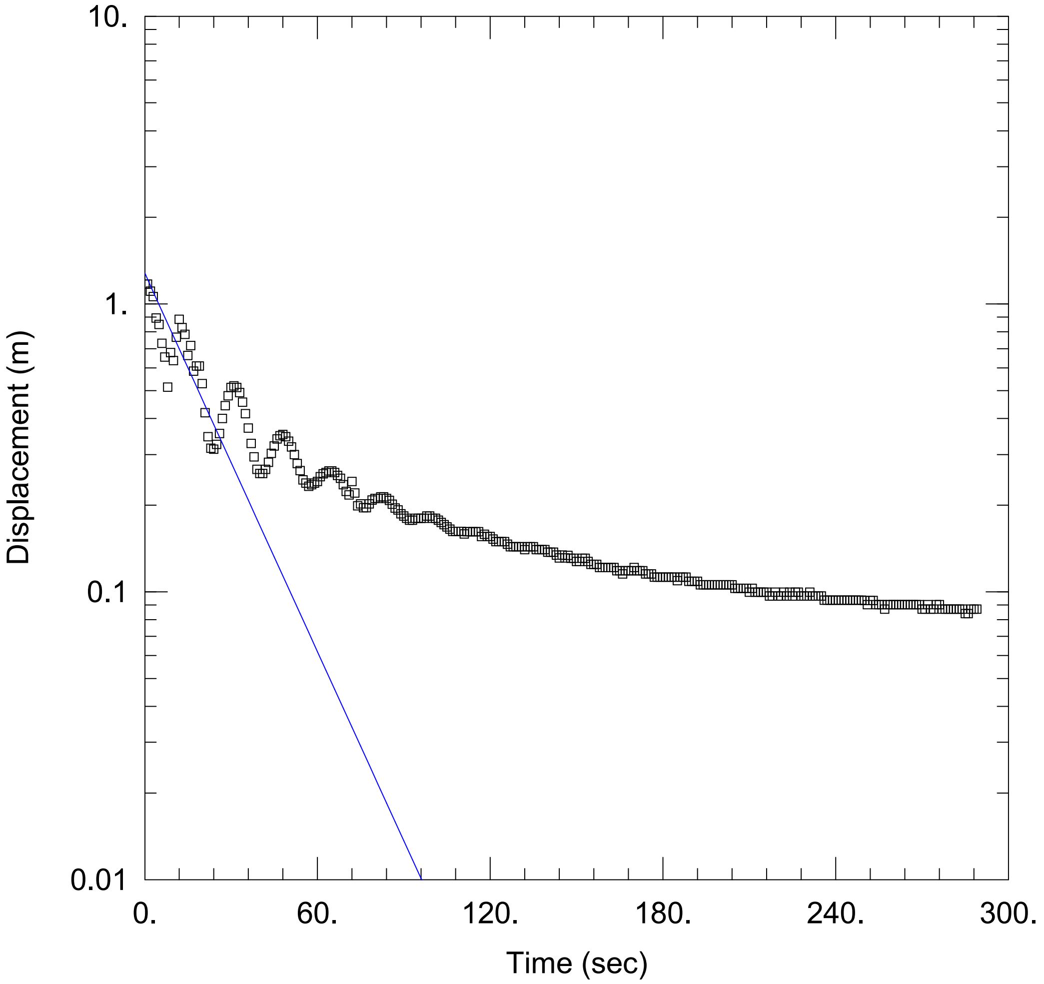
WELL DATA (BH10/TH4 (MB10))

Initial Displacement: 0.212 m
Total Well Penetration Depth: 55.57 m
Casing Radius: 0.025 m
Static Water Column Height: 55.57 m
Screen Length: 12. m
Well Radius: 0.0715 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Springer-Gelhar

K = 53.03 m/day
Le = 48.47 m



WELL TEST ANALYSIS

Data Set: N:\...\BH19_40L_1sec_10022021_BR.aqt
Date: 03/23/21 Time: 16:36:23

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

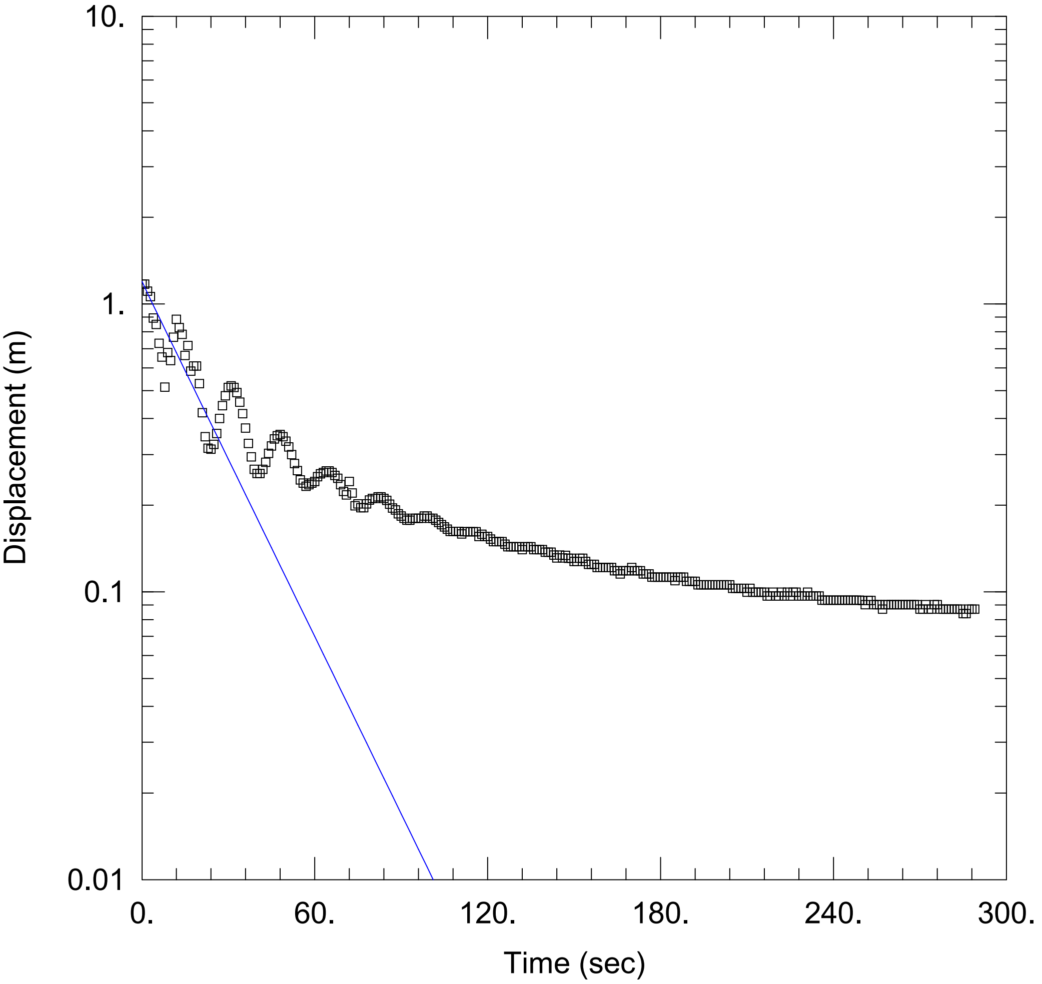
Saturated Thickness: 95.32 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH19/TH15 (MB7))

Initial Displacement: 1.172 m
Static Water Column Height: 93.32 m
Total Well Penetration Depth: 93.32 m
Screen Length: 24. m
Casing Radius: 0.025 m
Well Radius: 0.1015 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.2767 m/day
y0 = 1.28 m



WELL TEST ANALYSIS

Data Set: N:\...\BH19_40L_1sec_10022021_Hvorslev.aqt
Date: 03/23/21 Time: 16:37:13

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

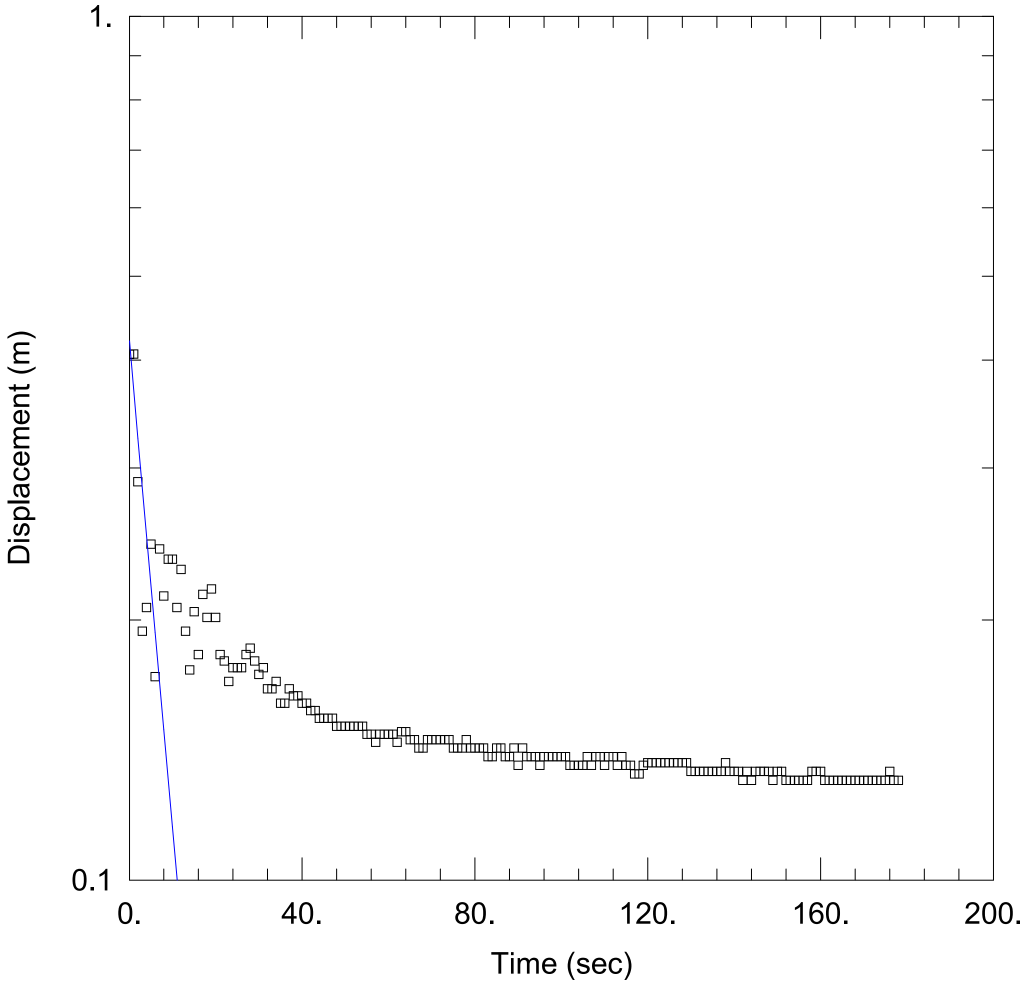
Saturated Thickness: 95.32 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH19/TH15 (MB7))

Initial Displacement: 1.172 m
Static Water Column Height: 93.32 m
Total Well Penetration Depth: 93.32 m
Screen Length: 24. m
Casing Radius: 0.025 m
Well Radius: 0.1015 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 0.2909 m/day
y0 = 1.195 m



WELL TEST ANALYSIS

Data Set: N:\...\BH20_40L_1sec_11022021_BR.aqt
Date: 03/23/21 Time: 16:28:10

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

Saturated Thickness: 49.34 m
Anisotropy Ratio (Kz/Kr): 1.

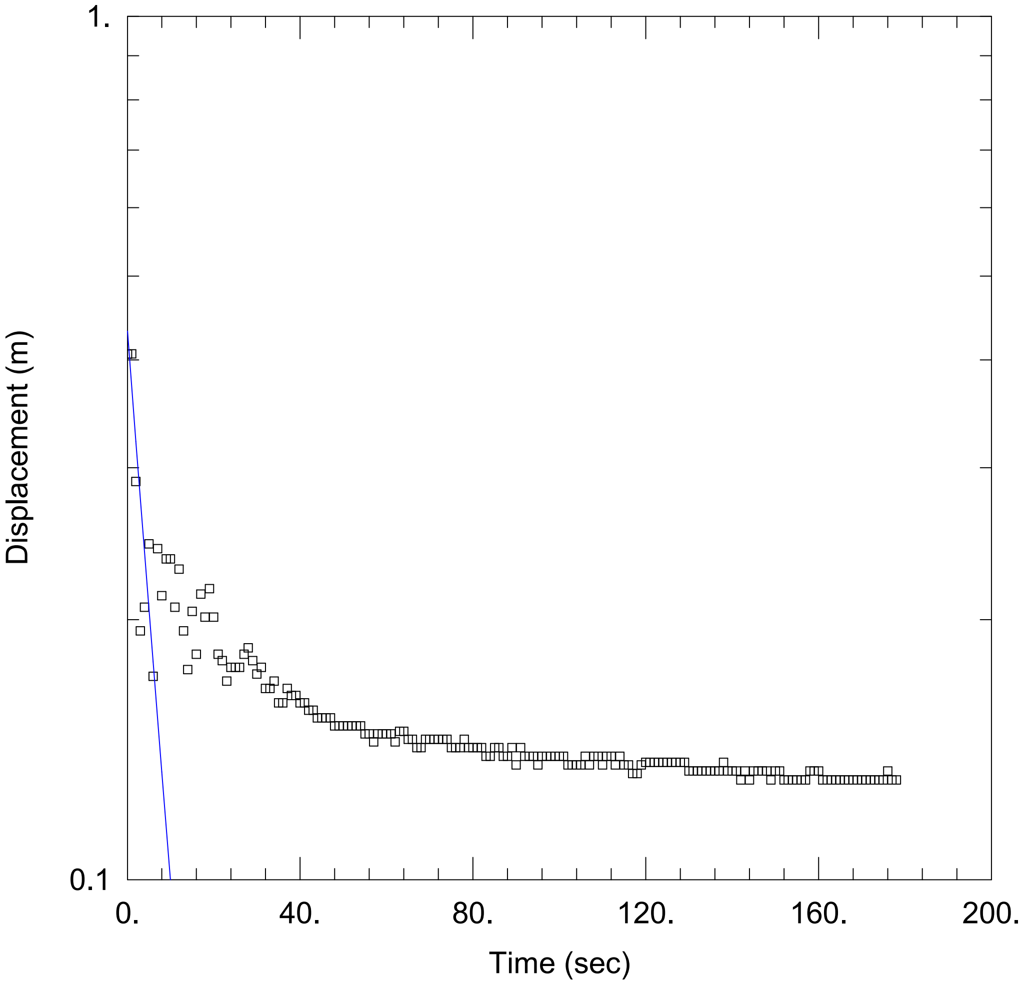
WELL DATA (BH20/TH20 (MB9))

Initial Displacement: 0.406 m
Static Water Column Height: 49.34 m
Total Well Penetration Depth: 61.34 m
Screen Length: 24. m
Casing Radius: 0.025 m
Well Radius: 0.1015 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.7147 m/day
y0 = 0.4209 m



WELL TEST ANALYSIS

Data Set: N:\...\BH20_40L_1sec_11022021_Hvorslev.aqt
Date: 03/23/21 Time: 16:28:44

PROJECT INFORMATION

Company: PSM
Client: MRL
Project: PSM4241
Location: Lamb Creek
Test Well: BH1
Test Date: 11 Feb 2021

AQUIFER DATA

Saturated Thickness: 49.34 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH20/TH20 (MB9))

Initial Displacement: 0.406 m
Total Well Penetration Depth: 61.34 m
Casing Radius: 0.025 m
Static Water Column Height: 49.34 m
Screen Length: 24. m
Well Radius: 0.1015 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 1.018 m/day
y0 = 0.4317 m

Appendix C
Airlift Yields and Groundwater Levels

Table C1 – Scenario Dewatering Rates

Hole ID	Date	Depth (m bgl)	Yield (L/sec)	Comments
LC20RC038	16/1/2021	48		Water strike. (Dipped water level before airlift: 48.7 m bgs.)
		54		No water return
		60	0.29	
		66	0.28	
		72	0	Flow observed at the beginning and receded to nil after about 30 sec.
		78	0.48	
		84	0.81	
LC20RC083	16/1/2021	-	-	Dipped water level before airlift: 49.5 m bgs. No water return at all and minor amount of water from cyclone. From observation of the sample piles, there could be cavities between 4 and 6 m and between 54 to 60 m. Borehole collapsed at 35.3 m bgs after airlift.

Table C2 – Scenario Dewatering Rates

Hole ID	Easting (m E)^1	Northing (m N)^1	Ground RL (m)	Hole Depth (m)	Measurement Date	Depth to Water (m bgl)	Static Water Head (m RL)	Collapsed	Depth of Collapse (m bgl)
LCK20RC001	691950	7475805	716	40	15/12/2020	Dry	-	-	-
LCK20RC003	691950	7475705	716.5	66	15/12/2020	43.79	672.7	-	-
LCK20RC004	691950	7475655	717	62	15/12/2020	-	-	Y	23.56
LCK20RC005	691950	7475605	717	62	15/12/2020	-	-	Y	29.1
LCK20RC007	692000	7476205	712	66	15/12/2020	-	-	Y	31.24
LCK20RC008	692000	7476055	714	72	15/12/2020	-	-	Y	38.21
LCK20RC012	692000	7475655	717.6	66	15/12/2020	44.72	672.9	-	-
LCK20RC017	692050	7475805	717	102	16/12/2020	-	-	Y	42.36
LCK20RC021	691900	7475605	717	66	15/12/2020	-	-	Y	26.88
LCK20RC022	692100	7475905	716.9	66	16/12/2020	44.42	672.5	-	-
LCK20RC033	692200	7475950	720	84	14/12/2020	-	-	Y	36.05
LCK20RC058	692300	7475605	724.5	60	16/12/2020	51.44	673.1	-	-
LCK20RC064	692350	7475955	721.0	66	16/12/2020	48.38	672.6	-	-
LCK20RC066	692350	7475855	723	60	16/12/2020	-	-	Y	47.75
LCK20RC075	692400	7475955	723.5	66	15/12/2020	50.96	672.6	-	-
LCK20RC076	692400	7475855	725	60	15/12/2020	-	-	Y	26.19
LCK20RC089	692650	7476305	725.9	84	15/12/2020	53.17	672.7	-	-
LCK20RC123	692500	7476305	719.3	54	15/12/2020	46.2	673.1	-	-
LCK20RC125	692500	7476105	724	84	16/12/2020	-	-	Y	-
LCK20RC128	692550	7475955	740.1	84	16/12/2020	65.67	674.4	-	-
LCK20RC136	692650	7476005	756	90	16/12/2020	-	-	Y	37.3
LCK20RC138	692600	7476255	724	90	15/12/2020	-	-	Y	58.1
LCK20RC142	692650	7476205	734	108	15/12/2020	-	-	Y	21.02

Appendix D
Groundwater Quality Analyses

Table D1 – Scenario Dewatering Rates

Analyte	Units	Limit of Reporting	BH1	BH2	BH3	BH4B	BH5	BH6	BH7	BH10	BH11	BH15	BH16	BH19	BH20
Field pH[1]			7.2 - 8.1	7.7 – 8.0	8.3	-	8.0	7.9 – 8.3	7.9 – 8.2	7.2 – 7.9	7.8 – 8.2	7.6 – 8.7	7.3 – 8.7	7.8 – 8.0[1] 8.25[2]	7.9[2]
Field electrical conductivity[1]	µS/cm		373 - 580	317 – 385	748	-	590	453 – 723	585 – 655	112 – 633	338 – 623	97 – 629	506 – 692	240– 496[1] 535.5[2]	661[2]
Perfluoroalkyl Sulfonic Acids															
Perfluorobutane sulfonic acid (PFBS)	µg/L	0.0005	-	-	-	<0.0005	-	-		<0.0005	-	<0.0005	<0.0005	<0.0005	-
Perfluorohexane sulfonic acid (PFHxS)	µg/L	0.0005	-	-	-	<0.0005	-	-		<0.0005	-	<0.0005	<0.0005	<0.0005	-
Perfluorooctane sulfonic acid (PFOS)	µg/L	0.0002	-	-	-	<0.0016	-	-		<0.0002	-	<0.0002	<0.0002	<0.0002	-
Perfluoroalkyl Carboxylic Acids															
Perfluorobutanoic acid (PFBA)	µg/L	0.002	-	-	-	<0.002	-	-		<0.002	-	<0.002	<0.002	<0.002	-
Perfluoropentanoic acid (PFPeA)	µg/L	0.0005	-	-	-	<0.0005	-	-		<0.0005	-	<0.0005	<0.0005	<0.0005	-
Perfluorohexanoic acid (PFHxA)	µg/L	0.0005	-	-	-	<0.0005	-	-		<0.0005	-	<0.0005	<0.0005	<0.0005	-
Perfluoroheptanoic acid (PFHpA)	µg/L	0.0005	-	-	-	<0.0016	-	-		<0.0005	-	<0.0005	<0.0005	<0.0005	-
Perfluorooctanoic acid (PFOA)	µg/L	0.0005	-	-	-	<0.0005	-	-		<0.0005	-	<0.0005	<0.0005	<0.0005	-
Fluorotelomer Sulfonic Acids															
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	µg/L	0.001	-	-	-	<0.001	-	-		<0.001	-	<0.001	<0.001	<0.001	-
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	µg/L	0.001	-	-	-	<0.001	-	-		<0.001	-	<0.001	<0.001	<0.001	-
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	µg/L	0.001	-	-	-	<0.001	-	-		<0.001	-	<0.001	<0.001	<0.001	-
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	µg/L	0.001	-	-	-	<0.001	-	-		<0.001	-	<0.001	<0.001	<0.001	-
PFAS Sums															
Sum of PFHxS and PFOS	µg/L	0.0002	-	-	-	<0.0002	-	-		<0.0002	-	<0.0002	<0.0002	<0.0002	-
Sum of PFAS (WA DER List)	µg/L	0.0002	-	-	-	<0.0002	-	-		<0.0002	-	<0.0002	<0.0002	<0.0002	-

Addendum A
Closure Planning

1. Introduction

This addendum presents the assessment of the post-closure groundwater head recovery post-mining in context to informing pit-lake levels for the Lamb Creek Mine. The assessment reflects that the mined void will not be backfilled and hence will form the closure landform.

The Lamb Creek Mine is shown on Figure A-1, inclusive of pit outline and network of monitoring bores and production bores. Figure A-2 shows the production bore locations under higher resolution.

2. Post-Closure Groundwater Head Recovery

The pit at the Lamb creek Mine extends below the baseline water table at 672 m AHD. Therefore, during mining drawdown of the water table will occur due to groundwater abstraction. After mining, the groundwater abstraction will cease, and groundwater heads will recover. This recovery will be primarily driven by transient water balances of the mined void. As the heads gradually recover a pit-lake will form in the mined void. Ultimately, the pit-lake will attain a dynamic equilibrium (steady-state) largely controlled by the balance between recharge fluxes and evaporation losses from the pit-lake, hence dependent on the pit-lake surface area. Typically, the evaporation losses from the pit-lake are comparatively large and contribute to the mined void forming a long-terms groundwater sink, with associated residual drawdown of the water table being a function of the recharge catchment area required to offset the evaporation losses.

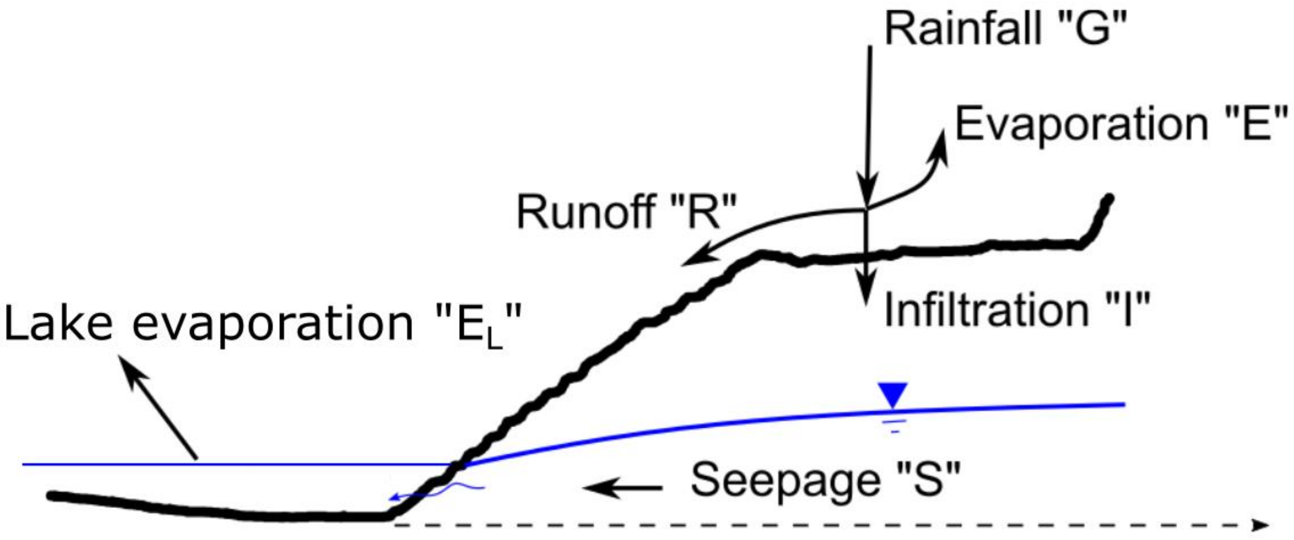
This section presents the simulation of the long-term transient water mass balances for the pit-lake used to predict the pit-lake levels under dynamic equilibrium and consequential residual drawdowns.

2.1 Water Mass Balance Model

A water mass balance model of the mined void was developed. The objectives of the water mass balance model included:

- Estimation of the period for water table recovery
- Dynamic equilibrium pit-lake levels
- Amplitudes of residual drawdown imposed by the pit-lake
- Sensitivity of water balance factors on residual drawdown.

Predictions of the long-term pit-lake levels was made by estimation of the processes of runoff, evaporation, and seepage in a transient mass balance model of the mined void. The model incorporated the incremental storage volumes and surface areas of the mined void required to reasonably represent the changes in mass balance as the pit-lake level rises. Inset 1 shows a broad conceptual model of the water balance components.



Inset 1: Schematic of Hydrological Inflows and Outflows Controlling Pit-Lake Levels

Predictions of the long-term pit-lake levels was made by estimation of the processes of runoff, evaporation, and seepage in a transient mass balance model of the mined void. For all simulations it was assumed that the mined void retained the mined storage, with no backfill.

The hydrological components of the water mass balance model are discussed below.

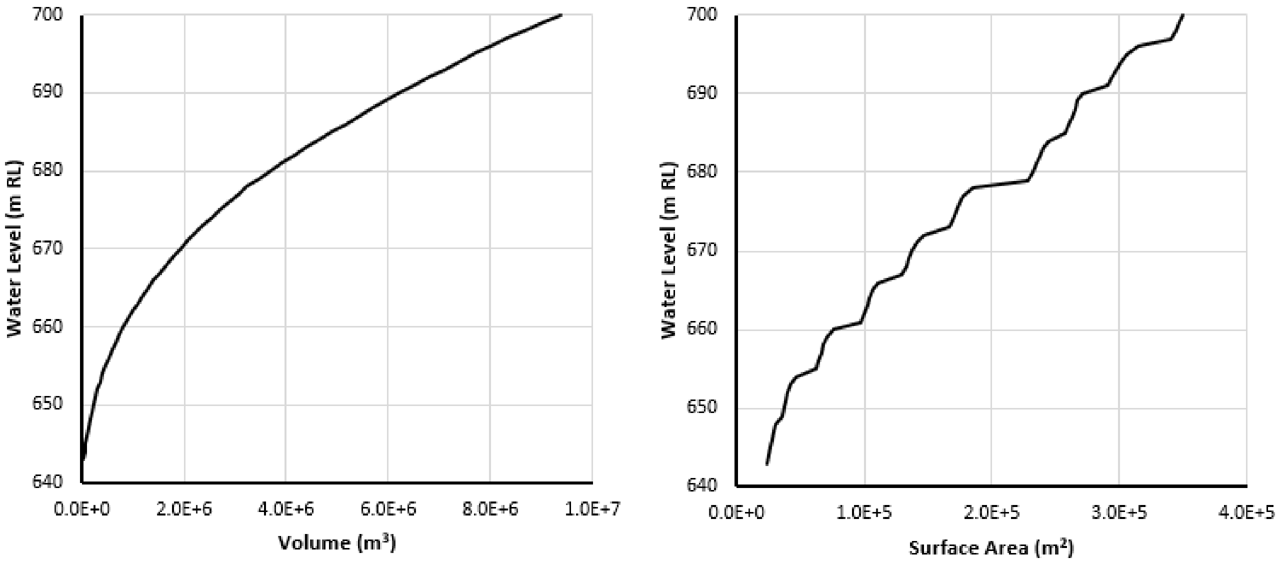
2.1.1 Model Approach

The model incorporated a daily time-step, with inflows, outflows and changes in storage calculated for each day. The inflow was estimated by predicting the rainfall and the groundwater seepage. Rainfall had the majority contribution to inflows. The outflow is primarily driven by the evaporation. The change pit-lake storage was then estimated by calculating the difference between the total inflows and outflows.

2.1.2 Model Parameters

2.1.2.1 Stage-Storage Curve

The incremental volumes and surface areas of the mined void are shown in Inset 2.



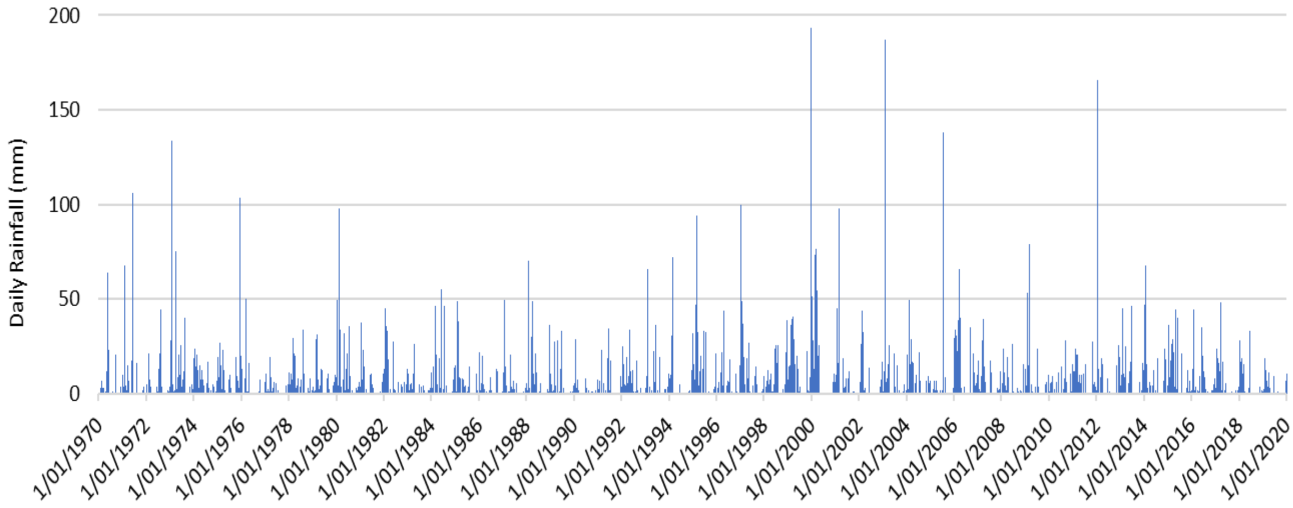
Inset 2: Pit Storage and Surface Area Characteristics

2.1.2.2 Rainfall

The daily rainfall data was obtained from SILO to derive the rainfall inputs. SILO gridded data uses mathematical interpolation techniques to construct spatial grids and infill gaps in time series datasets from observation stations nearby.

Inset 3 presents the synthetic 50-year (1970 to 2020) rainfall used for inputs to the model.

Part of the rainfall precipitates directly onto the pit-lake and is converted directly to storage. Other parts will infiltrate, and the rest will be carried as runoff which will be converted directly to storage.



Inset 3: SILO Daily Rainfall (1970 to 2020)

2.1.2.3 Evaporation

Records of reliable daily evaporation rates for long-periods are not easy to obtain and for that reason the evaporation rates were characterised as a constant for each season. Evaporation record based on *Morton's Shallow Lake Evaporation* Equation (Morton, 1983a) for the site was also obtained from SILO to inform the seasonal evaporation rates. This equation was developed for evaporation over large, shallow lakes with depth less than 30 m and width more than 300 m, which is like the mined void.

Table 1 Summarises the seasonal average evaporation from 1970 to 2020.

Table 1 – Average Daily Evaporation Each Season

Season	Average Daily Evaporation[1] (mm)
Spring (September, October, and November)	5.7
Summer (December, January, and February)	6.9
Autumn (March, April, and May)	4.5
Winter (June, July, and August)	3.2
Total (annual)	**1,850**

[1] Based on Morton's Shallow Lake Evaporation Equation.

2.1.2.1 Runoff

The daily quantity of runoff was estimated considering direct rainfall on the pit and pit-lake surface areas and losses from evaporation and infiltration. The estimates were based on:

$$R = G.[A_L + n.(A_C - A_L)]$$

Where G is the daily rainfall total (in units of m/day)

A_L is the lake surface area (calculated from the lake storage volume)

A_c is the catchment area for the pit

n is a runoff proportion to approximate losses to evaporation and infiltration.

2.1.2.2 Seepage Analysis

Seepage contributes to the water mass balances if the pit-lake elevation is lower than the baseline water table. The seepage inflow rates are greatest when the pit is dry and gradually decrease with the filling of the pit-lake. The daily quantity of seepage was calculated using a Dupuit assumption for radial flow:

$$S = K \frac{(h_1^2 - h_2^2)}{\ln \frac{r_1}{r_2}}$$

Where: S is the seepage flow (m^3/s)

K is an averaged hydraulic conductivity of the geology around the pit (m/s)

h_1 is the water depth (head above the pit floor (m)

r_1 is radial distance from the centre of the pit to water table intersection at the pit face (m)

h_2 is the water depth (head) at the catchment boundary (672 m AHD)

r_2 is radial distance from the centre of the pit to the catchment boundary (m).

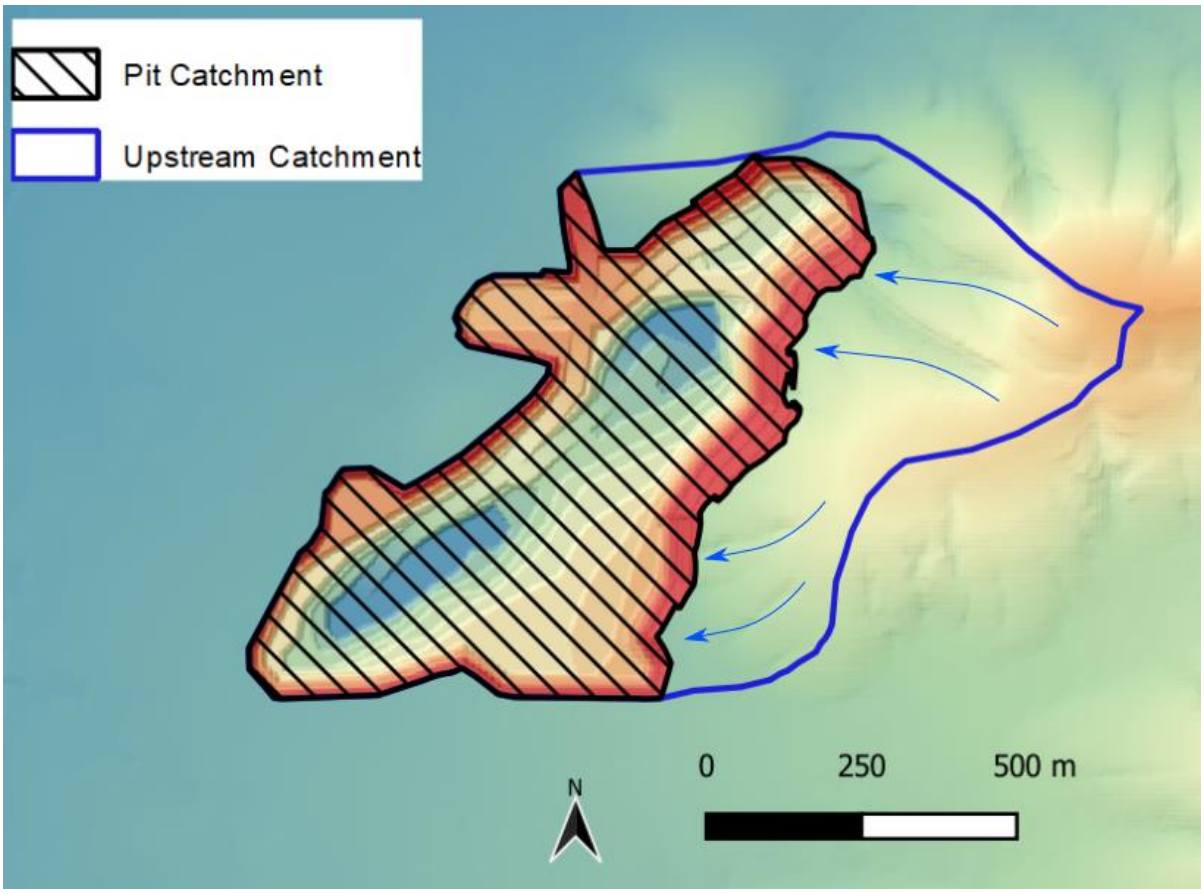
The hydraulic conductivity was assumed as 0.9 m/day based on the interpreted results of the slug tests.

2.1.2.3 Catchment Properties

Two options regarding the catchment area were considered:

- The local catchment area of the pit only
- Inclusion of runoff from the upstream slopes to the east of the pit.

The increased catchment option would accelerate the pit-lake recovery and supplement the water balance thereby limiting residual drawdown amplitudes. The catchment areas for both options are presented in Inset 4.



Inset 4: Simulated Catchments of the Pit-Lake

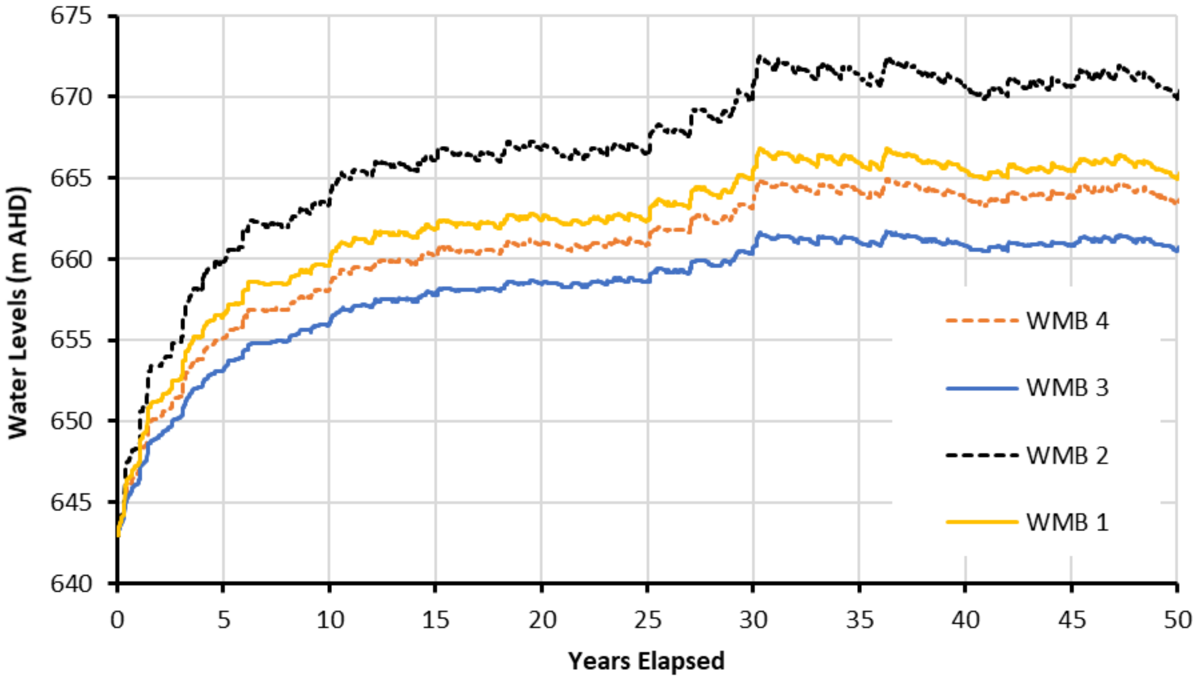
Four pit-lake scenarios were simulated, with key sensitivities being the catchment areas and runoff coefficients. Two runoff coefficients (0.7 and 0.3) were simulated to give upper- and lower-bound mass balances for the runoff. The range of the coefficients is large, due to uncertainty. This range created sensitivity analysis for the dynamic equilibrium pit-lake levels. Table 2 summarises the water mass balance model parameters for the four scenarios.

Table 2 – Summary of Simulated Model Parameters

Model ID	Pit Base (m AHD)	Runoff Coefficient	Hydraulic Conductivity (m/day)
Pit Only Catchment			
WMB 1	642	0.7	0.9
WMB 3	642	0.3	
Pit and Upstream Catchment			
WMB 2	642	0.7	0.9
WMB 4	642	0.3	

2.2 Model Predictive Results

It was envisaged a dynamic equilibrium pit lake level would establish over time as a balance between inflows from direct rainfall and catchment runoff and evaporative outflows. This equilibrium pit-lake level is important to assess the long-term residual drawdown. The predicted range of pit-lake levels is shown in Inset 5.



Inset 5: Simulated Transient Pit-lake Levels

The predicted steady-state pit-lake elevations vary from 661 to 672 m AHD for the four scenarios. The pit-lake elevations reach steady-state after about 30 years post-closure.

Higher pit-lake levels would limit the risk associated with residual drawdown. Scenario WMB 2 which includes the pit, upstream catchment, and 0.7 runoff coefficient predicts the highest elevation pit-lake at 672 m AHD which is compatible to the observed pre-mining water table. Therefore, allowing water shedding from the upstream catchment is preferred to achieve faster filling time and to reach a higher steady-state pit-lake elevation.

2.3 Residual Drawdown

The baseline water table (pre-mining) was observed at 672 m AHD. Pit-lake levels at elevations less than 672 m AHD would reflect the presence of a local groundwater sink and associated residual drawdown in the surrounds. A software program (DMB8 – derived from Walton 1979) was used to predict the lateral extents of residual drawdowns for the four water mass balance models based on radial flow in an unconfined homogenous aquifer. For these predictions, the aquifer transmissivity (150 m^2/day) and specific yield (0.01 dimensionless) were derived from the lower-bound scenario (PSM4241-004R), described as most likely. Limitations of the predictions included:

- The exclusion of recharge from rainfall
- Absence of inflows from the base of the pit, given the base of the pit extends to the low-transmissivity bedrocks if fresh BIF
- The predictions did not represent steady state, which excluded time and storage.

Based on the above assumptions the predictions would over-estimate the residual drawdown footprint. In other words, the residual drawdown risk is expected to be less than what is predicted.

Table 3 summarise the residual drawdown predictions. Predicted residual drawdowns for the WMB 1, WMB 3 and WMB 4 scenarios are shown on Figure A-3, Figure A-4, and Figure A-5, respectively. The maximum extent for the 3 m drawdown is 2 km.

Table 3 – Summary of Post-Closure Residual Drawdown

Model ID	Steady-State Pit-Lake Level (m AHD)	Local Residual Drawdown (m)	Extent of Residual Drawdown (km)		
			5 m	3 m	1 m
WMB 1	665	7	<0.1	0.4	4.5
WMB 2	672	zero	No Residual Drawdown		
WMB 3	661	11	0.3	2.0	7.0
WMB 4	664	8	0.1	0.7	6.0

2.4 Characteristics of Groundwater Sinks

Where there is persistent residual drawdown, the pit-lake would form a closed physicochemical system which will accumulate salts, nutrients, metals etc. Over time, the accumulation of mass from evaporation-concentration effects would produce higher density water in the pit-lake. Once the pit-lake elevation (as in WMB 3) or water column density (as in WMB 1, WMB 2 and WMB 4) equalises with the baseline water table heads, the pit-lake may transition to a throughflow system.

Table 4 summarises the density required in the pit-lake for the heads to equalise with the baseline heads. Densities above 1.28 are unlikely to be attained given saturated solutions would prevail.

Table 4 – Calculated Pit-Lake Density Required to Initiate Throughflow

Model ID	Steady-State Pit-Lake Level (m AHD)	Density (kg/L)
Pit Only Catchment		
WMB 1	665	1.30
WMB 3	661	1.58
Pit and Upstream Catchment		
WMB 2	672	-
WMB 4	664	1.36

3. Baseline Groundwater Quality

Groundwater sampling indicated the local source is characterised as:

- Neutral to slightly alkaline pH in the range 7.2 to 8.7
- Fresh with TDS concentrations in the range 60 to 500 mg/L (based on EC between 98 to 723 µS/cm).

Groundwater quality from nearby mining operations is dominated by a calcium / magnesium and bicarbonate type.

As the pit-lakes progressively fill, they would at least form temporary sinks, with associated accumulation of salt. As they transition to through-flow systems (scenario WMB 3), a plume of higher TDS water originating in the pit-lake would be transmitted downstream. The likely TDS concentrations in the plume have not been determined; they would be dependent on temporal, transient and cumulative factors, including heads, gradients, aquifer interfaces in the pit sidewalls, specific yields of the of the local aquifer, etc. The plume TDS concentrations would be highest on flow paths adjoining the pit-lake and progressively diminish downstream through mixing and dilution effects.

4. Conclusions and Recommendations

Observed baseline water table elevations were about 672 m AHD. Predicted steady-state pit-lake elevations vary from 661 to 672 m AHD. Higher pit-lake levels will limit the risk associated with residual drawdown. Allowing water shedding from the upstream catchment to the immediate east of the pit is one option to enhance the pit-lake water balance to promote faster filling time and attainment of higher steady-state pit-lake elevations. The WMB2 predictive scenario that include the upstream catchment, enabled the highest pit-lake elevation and likely transition to a through-flow system.

Where the pit-lake forms a groundwater sink with persistent residual drawdown, evaporation-concentration effects will characterise the pit-lake, likely contributing to the containment of high-TDS concentration waters.

the Mine Closure Plan would further consider the pit-lake water balance and risks together with further investigation of water harvesting from the adjoining catchments to supplement the water balance.

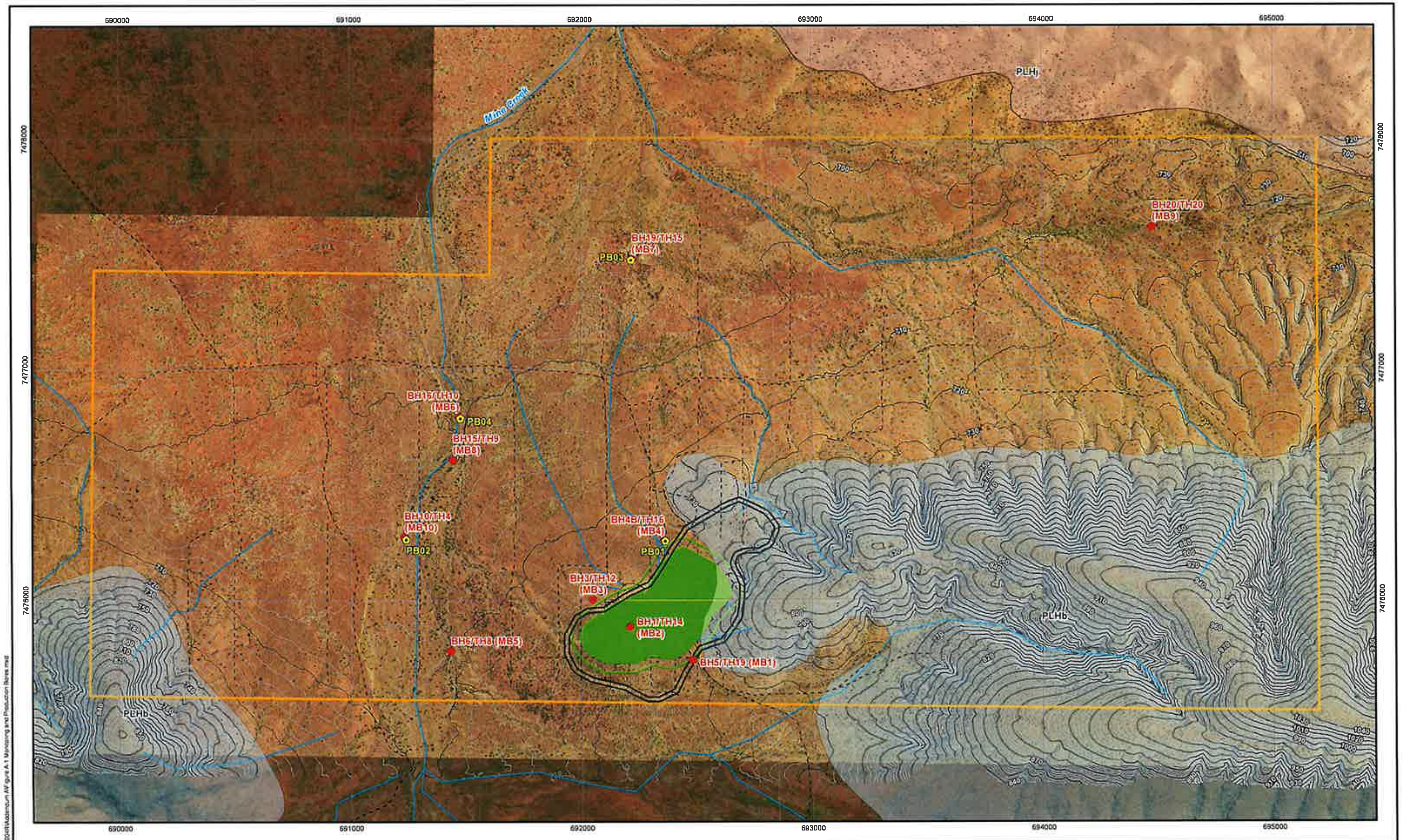
Yours Sincerely

MING WU
SENIOR HYDROGEOLOGIST

IAN BRUNNER
PRINCIPAL

Encl.

Figure A-1:	Monitoring and Production Bores
Figure A-2:	Production Bores
Figure A-3:	Post-Closure Residual Drawdown – WMB 1
Figure A-4:	Post-Closure Residual Drawdown – WMB 3
Figure A-5:	Post-Closure Residual Drawdown – WMB 4



Legend

●	Monitoring Bores
⬠	Production Bores
━	Pit Outline
━	Mineralisation (At Depth)
- - -	Tracks
☐	M47/0019
─	Drainage - Creeks
	Topography

250k WA Geology

☐	PLHj (Weeli Wooli Formation)
☐	PLHb (Brockman Iron Formation)

N

Scale 1:15,000

0 0.2 0.4 0.6 0.8 Km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50

PSM

Created By	Revision
MB	A
Date	**Paper Size**
10 Aug 2021	A3

Mineral Resources Ltd
Lamb Creek Iron Ore Project
Post-Closure Planning Scope

MONITORING AND
PRODUCTION BORES

PSM4241-004R

Figure A-1

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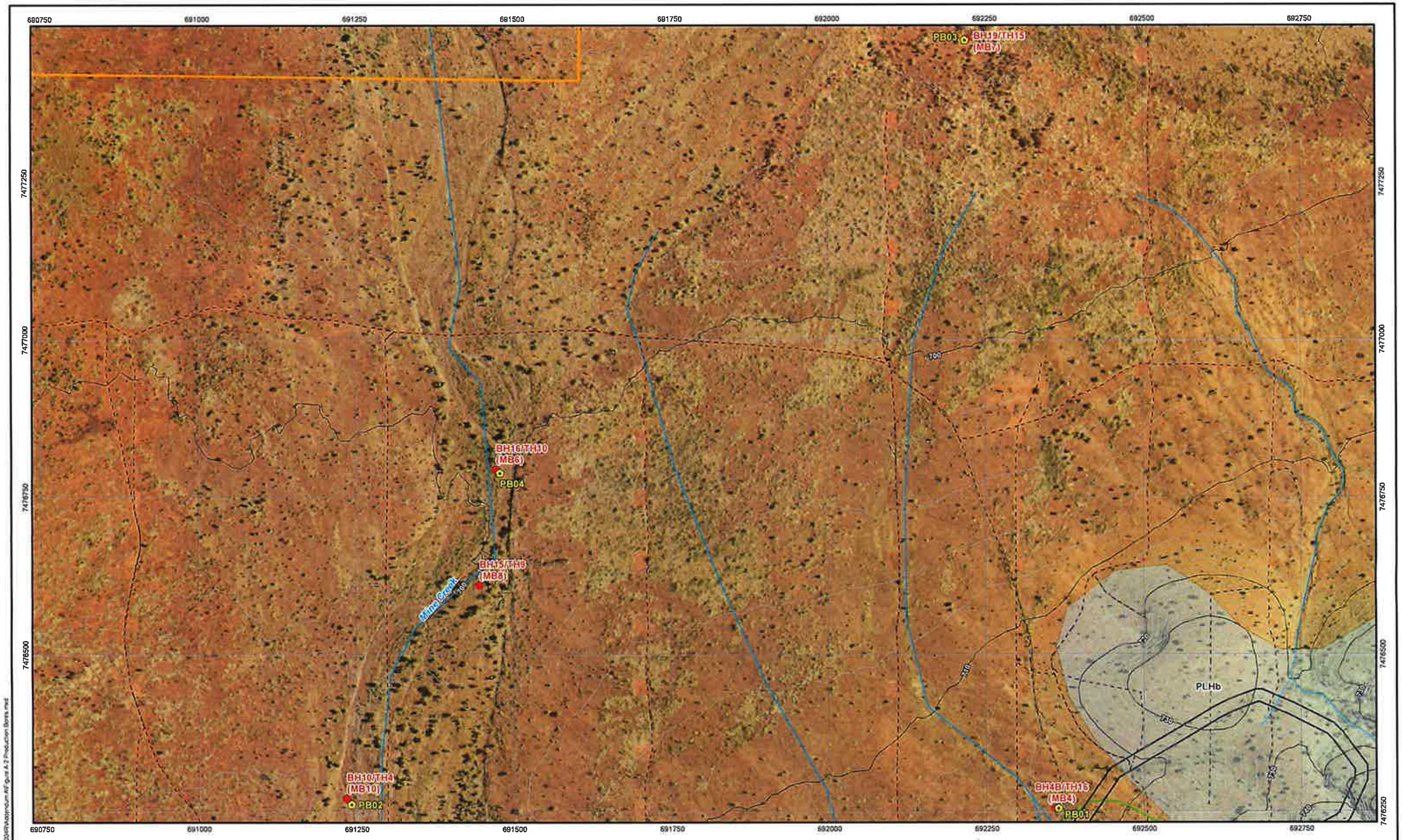

Legend

● Monitoring Bores
⬠ Production Bores
— Pit Outline
— Mineralisation (At Depth)
- - - Tracks
▭ M47/0019
— Drainage - Creeks
Topography

250k WA Geology

▭ PLHb (Brockman Iron Formation)

N

Scale 1:5,500

Map Projection: Transverse Mercator
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Grid: GDA 1994 MGA Zone 50

PSM

Created By MB	Revision A
Date 10 Aug 2021	Paper Size A3

Mineral Resources Ltd
Lamb Creek Iron Ore Project
Post-Closure Planning Scope

PRODUCTION BORES

PSM4241-004R

Figure A-2

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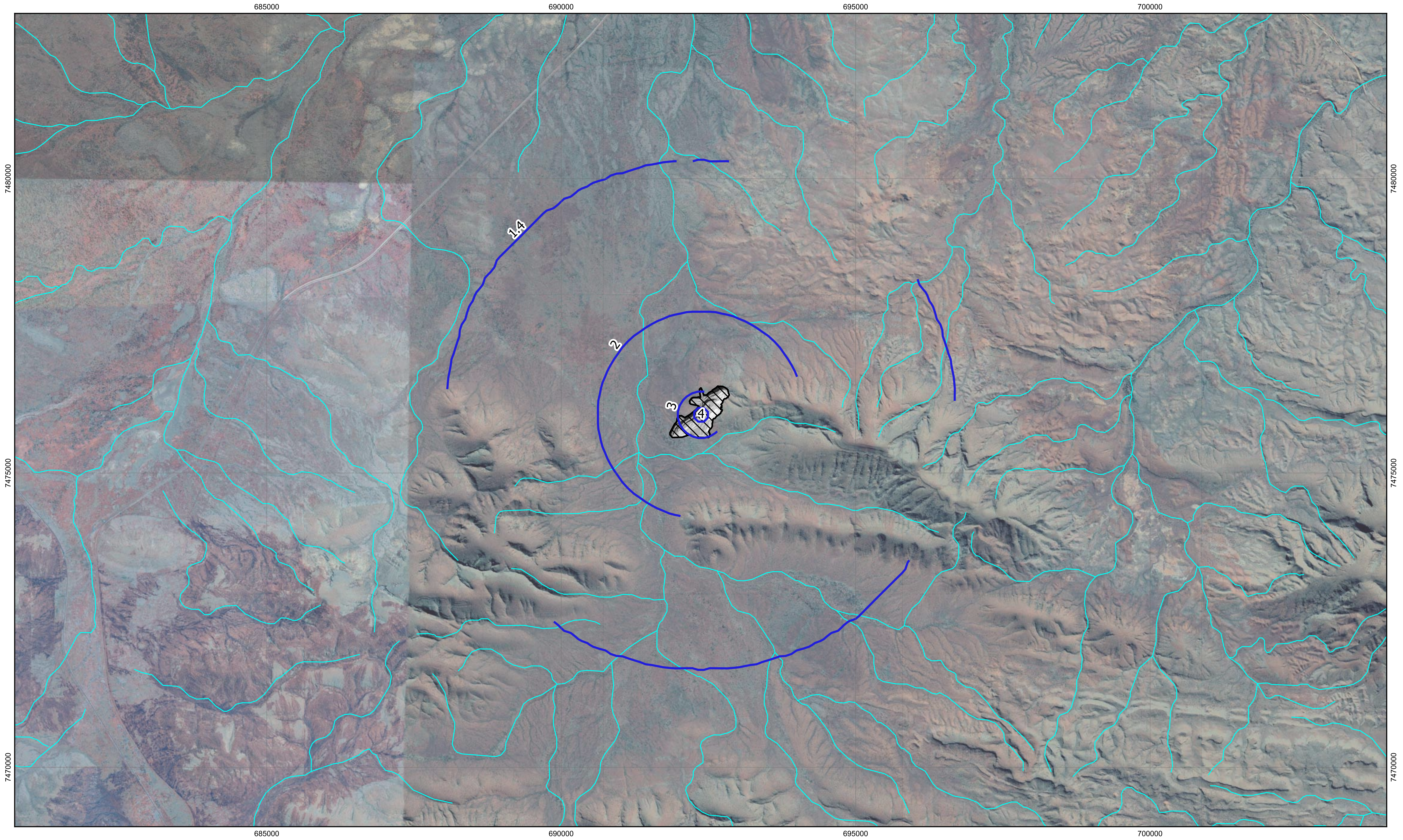

Legend

Drainage - Creeks

Residual Drawdown (m)

▨ Pit

N

Scale 1:60,000

0 0.25 0.5 0.75 1 km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 2020
Grid: GDA 2020 MGA ZONE 50

PSM

Created By: F.A

Revision: A

Date: 06 Aug 2021

Paper Size: A3

Mineral Resources Ltd
Lamb Creek Iron Ore Project
Post-Closure Planning Scope
POST-CLOSURE RESIDUAL
DRAWDOWN - WMB 1

PSM4241-004R

Figure A-3

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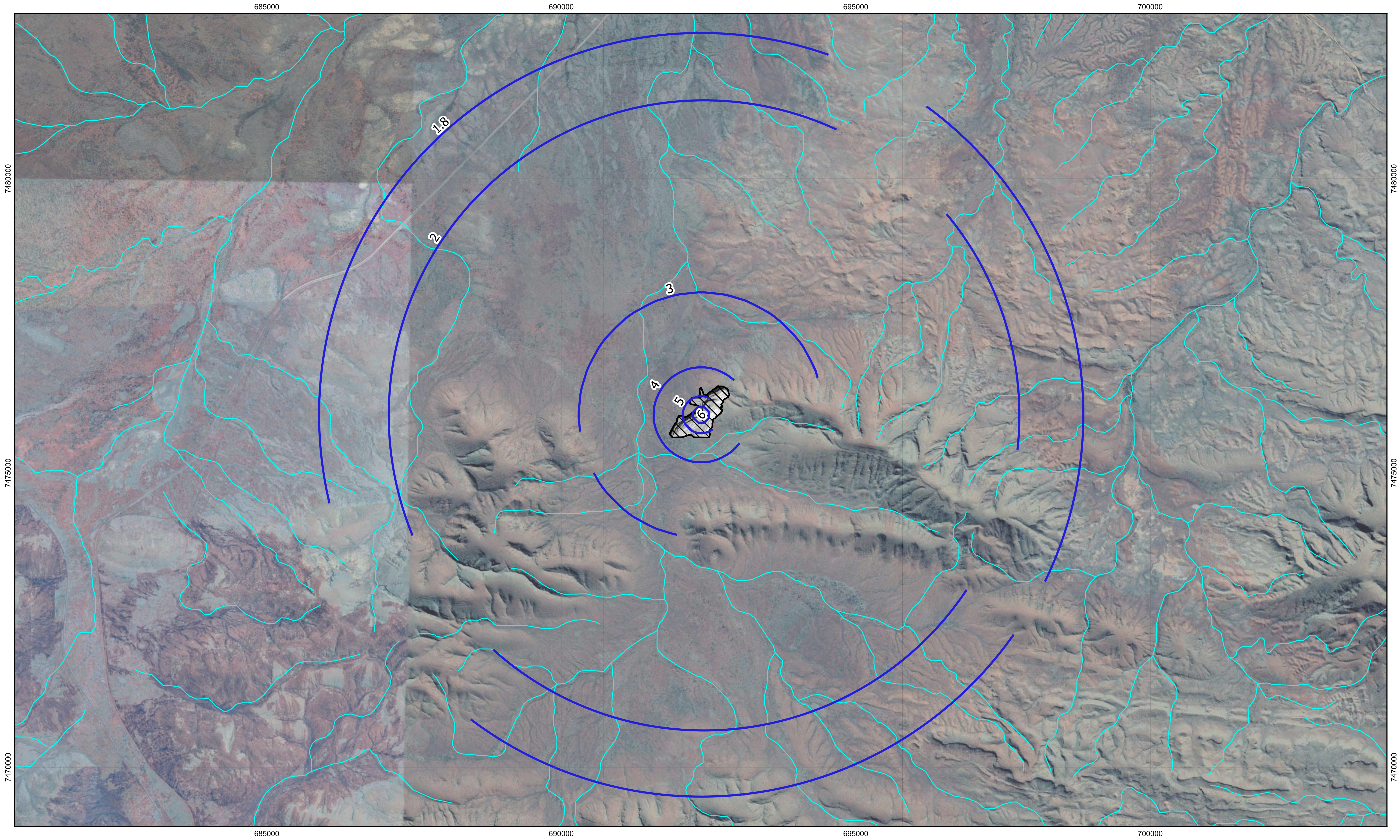

Legend

—	Drainage - Creeks
—	Residual Drawdown (m)
▨	Pit

Scale 1:60,000

0 0.25 0.5 0.75 1 km

N

Map Projection: Transverse Mercator
Horizontal Datum: GDA 2020
Grid: GDA 2020 MGA ZONE 50

PSM

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Revision: A
Date: 06 Aug 2021
Paper Size: A3

Mineral Resources Ltd
Lamb Creek Iron Ore Project
Post-Closure Planning Scope
POST-CLOSURE RESIDUAL
DRAWDOW - WMB 3

PSM4241-004R

Figure A-4

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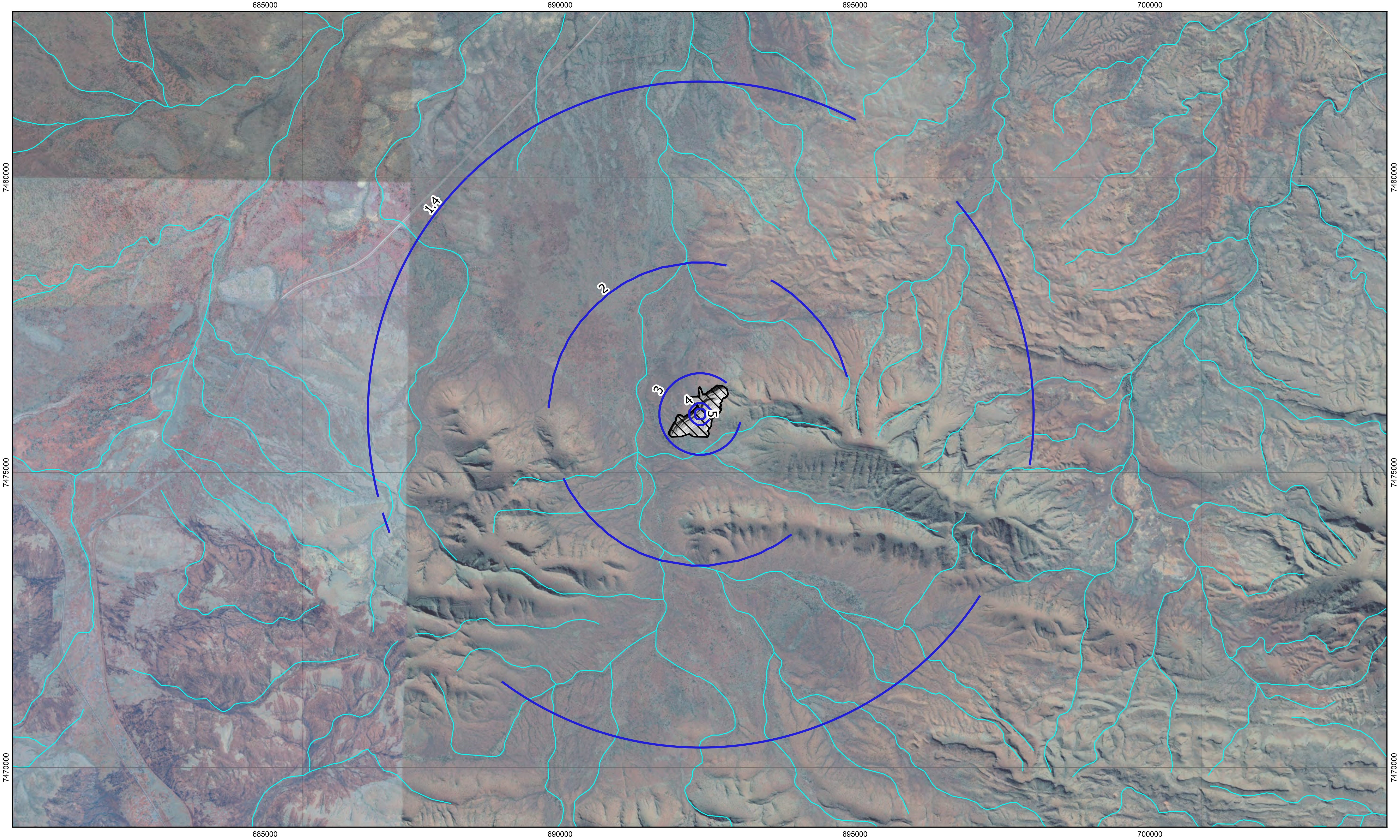

Legend

—	Drainage - Creeks
—	Residual Drawdown (m)
▨	Pit

Scale 1:60,000

N

0 0.25 0.5 0.75 1 km

Map Projection: Transverse Mercator
Horizontal Datum: GDA 2020
Grid: GDA 2020 MGA ZONE 50

P S M

Created By: F.A

Revision: A

Date: 06 Aug 2021

Paper Size: A3

Mineral Resources Ltd
Lamb Creek Iron Ore Project
Post-Closure Planning Scope
POST-CLOSURE RESIDUAL
DRAWDOW - WMB 4

PSM4241-004R

Figure A-5

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12 November 2021
Rev B

Hydrogeological Assessment of Stygofauna Sites at the Proposed Lamb Creek Mine

Background

Results from a recent stygofauna study for the Lamb Creek proposed mine (Bennelongia, 2021), showed two historical stygofauna occurrences located approximately 1.2 km west of the proposed mining area. The two stygofauna species are namely the syncarid *Brevismobathynella* BSY222 and the harpacticoid copepod *Parastenocaris sp.* B25, both of which have only been known to occur in the vicinity of the proposed mining area.

An analytical model was completed to estimate drawdown extents during the dewatering phase, and for recovery duration in the post-mining phase. Backfilling of the pit (post-mining) is planned, however as the analytical model assumes no backfilling, the results are considered conservative.

The following provides a summary of key aspects that pertain to understanding water level response at the two relevant stygofauna sites and the effect on their habitat.

Pit Backfilling

MRL plan to backfill the pit by up to a minimum of 1 m above pre-mining water level of 672 mAHD i.e., minimum 673 mAHD. If a pit is backfilled above pre-mining water levels such that there is no open water body, evaporative processes from the pit area are significantly reduced, if not completely eliminated; *Rose etal*. (2005) found that at a depth of 700 mm below surface, evaporation rates were 0.3 mm/day. With this, if the pit is backfilled and evaporative processes are eliminated, post-mining residual drawdown will only occur during the groundwater recovery phase.

Habitat of the Identified Stygofauna

The stygofauna sampling was conducted from two historical RC holes with lithological logs recording Tertiary deposits between 0-34 mbgl and the Whaleback Shale from 34-64 mbgl. Water levels from these two RC holes (at the time of sampling) were recorded in Bennelongia (2021), as being 40 and 41.5 mbgl. This provides evidence that the water level is in fact lower than the base of the Tertiary deposits and that therefore, the stygofauna habitat is within the Whaleback Shale (**Figure 1**).

The estimated minimum aquifer thickness in the Whaleback Shale is +/-24 m with the potential for a further 7.5 m in the winter season; it was noted in Bennelongia (2021) that there was a water level increase to 34 mbgl (increase of 7.5 m) between sampling rounds in March and June 2013.

The Whaleback Shale Member of the Brockman Iron Formation has been described as follows:

> “**Approximately 50 m thick consisting of thinly bedded shales with thicker chert or BIF bands, weathered with supergene enrichment of BIF bands**”

As the two stygofauna occurrences appear to occur in the Whaleback Shale, it is likely that their habitat in this area is in the weathered and supergene enriched sections of the BIF where porosity is higher. Furthermore, the thin shale beds would act as low flow hydraulic barriers. Such a scenario would likely reduce/delay drawdown in the stygofauna habitat of the Whaleback Shale during the dewatering phase.

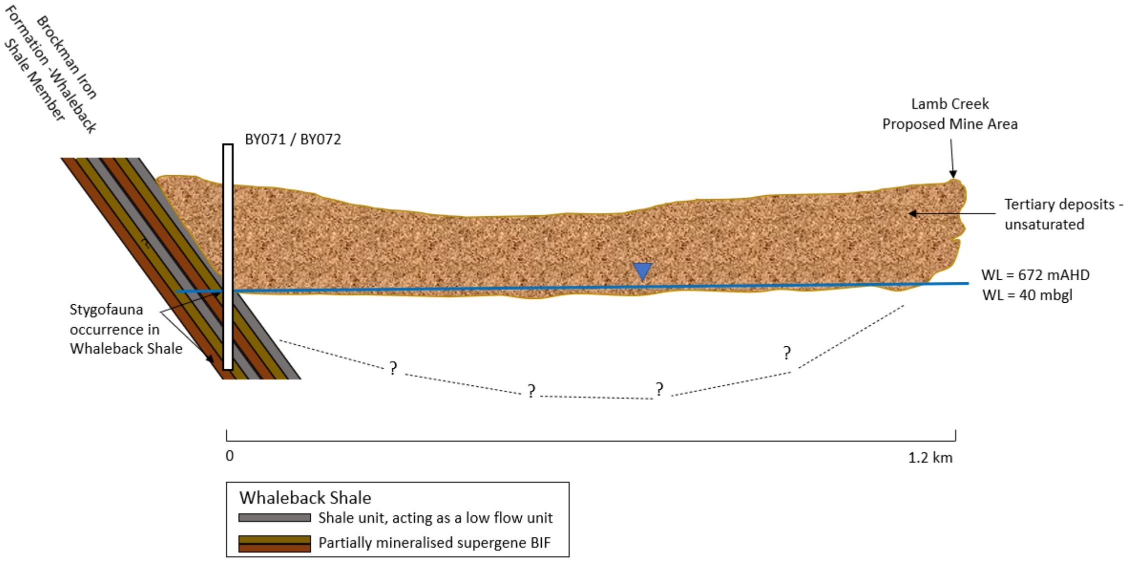

Figure 1 - Conceptual hydrogeology around the stygofauna occurrences

Analytical Model

The analytical model included surface and subsurface inflow and outflow relevant to the pit and pit catchment area (**Figure 2**). The main limitations of the model include, 1) assumed no post-mining backfilling and, 2) it did not include upstream groundwater inflow into the system. With such limitations, the dewatering drawdown contours, residual drawdown contours, and duration for groundwater recovery are considered conservative; the results of these are discussed below.

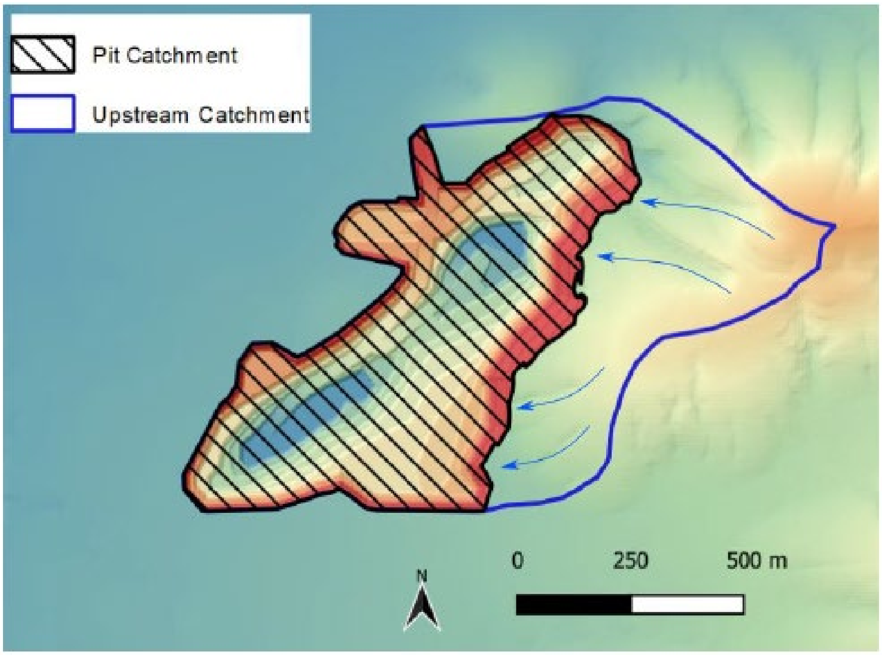

Figure 2 – Pit and Catchment Area

Dewatering Drawdown at Stygofauna Sites - Percentage of Aquifer Affected

The worst-case modelled drawdown due to **dewatering** reached 12 m at the site of stygofauna occurrences (**Figure 3**). Assuming the stygofauna habitat does not extend beyond the drawdown zone, with an estimated aquifer thickness of 24 m and a drawdown of 12 m, the percentage of stygofauna habitat affected by drawdown during the short-term mining is estimated to be **50%.**

This scenario is conservative as it assumes the stygofauna habitat is limited to the two identified occurrences only.

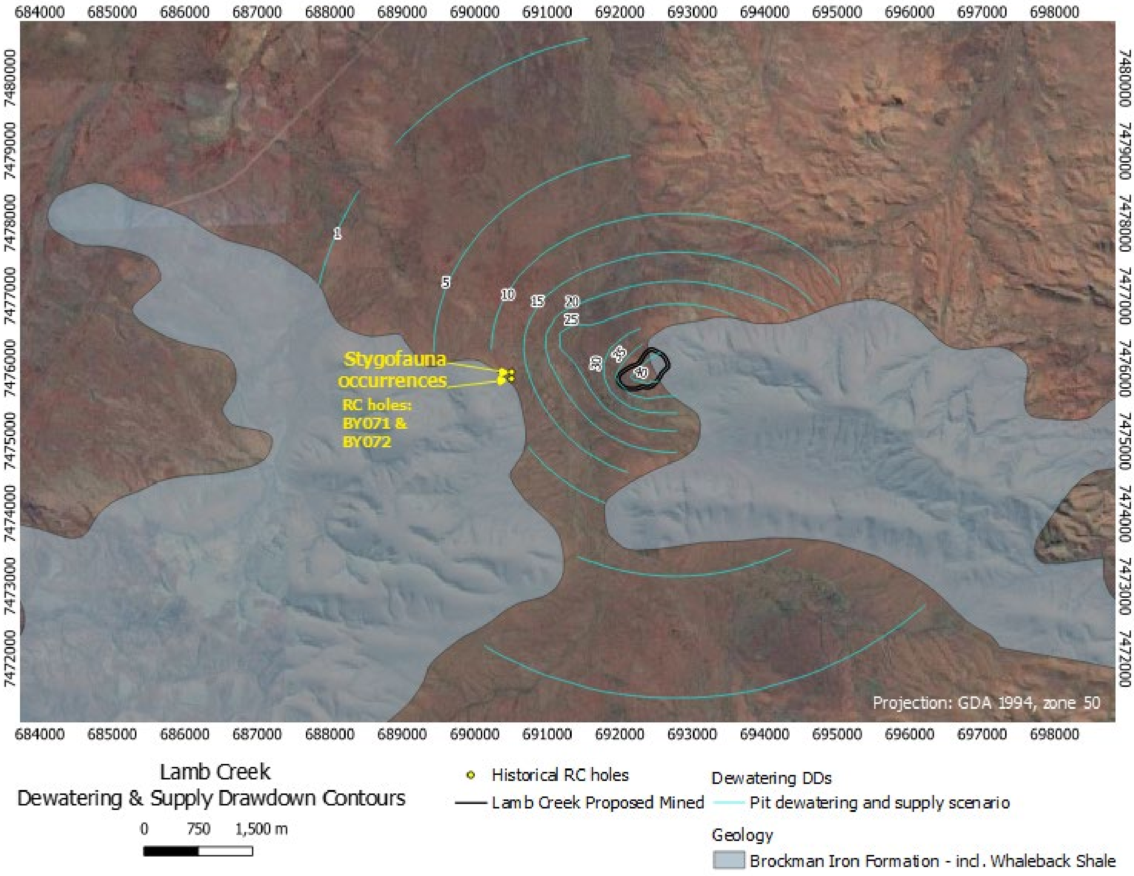

Figure 3 - Drawdown contours during dewatering and supply phase

Residual Drawdown at Stygofauna Sites – Percentage of Aquifer Affected

This scenario does not consider post-mining backfilling of the pit and therefore assumes that a full groundwater recovery will not occur.

The worst-case **residual** drawdown at the site of the stygofauna occurrences was modelled to be 2.25 m (**Figure 4**). Assuming the stygofauna habitat is entirely within the residual drawdown zone, with an estimated aquifer thickness of 24 m and a residual drawdown of 2.25 m, the percentage of stygofauna habitat affected by residual drawdown is estimated to be **9%.**

This scenario is considered unlikely as MRL plan to backfill the pit.

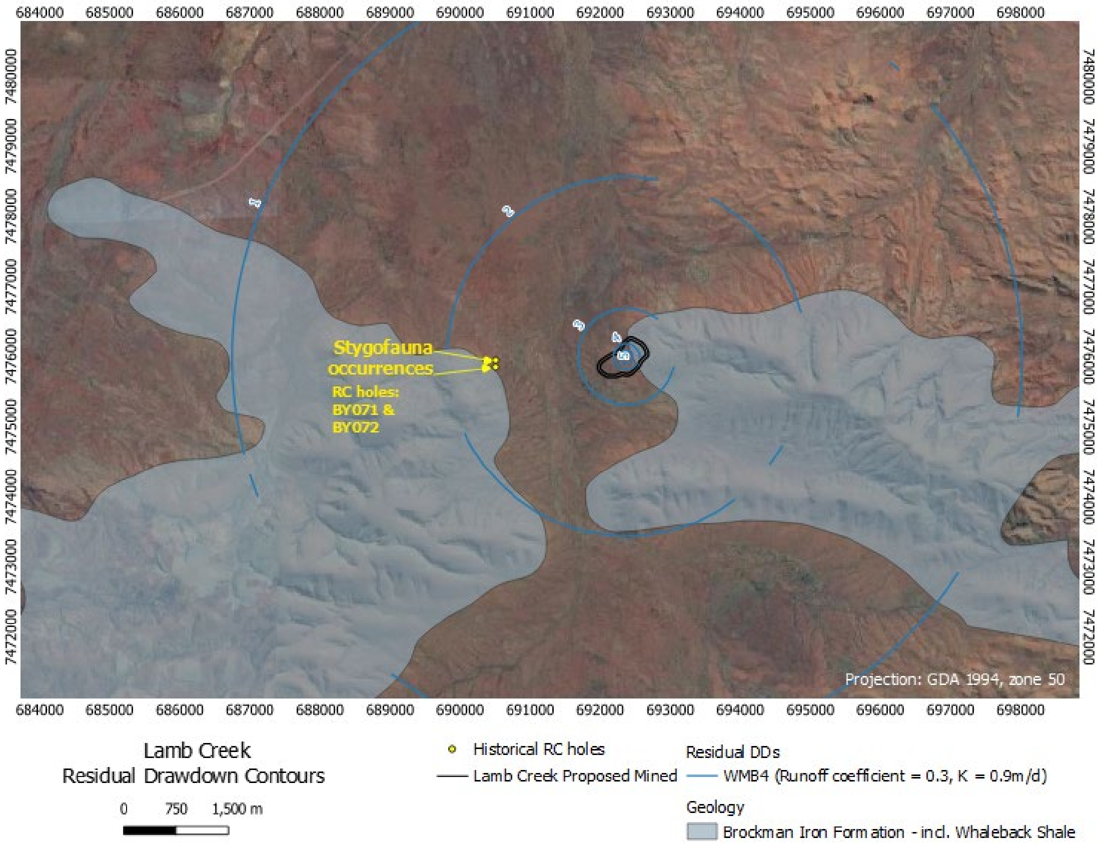

Figure 4 - Residual drawdown contours (WMB4) with stygofauna habitat Brockman Iron Formation. WMB4 results were inclusive of 'pit and upstream catchment' areas but no pit backfilling

Post-Mining Groundwater Recovery within the Pit – Sensitivity Analysis

'Post-mining groundwater recovery invariably dictates residual drawdown'.

Backfilling the pit is expected to eliminate residual post-mining drawdown after full groundwater recovery has been attained. Nevertheless, to assess potential scenarios for groundwater recovery duration, a sensitivity analysis was completed to test different hydraulic conductivity values (K=0.9, 2 & 21 m/d; actual results from slug tests) against different run-off coefficients of 0.3 and 0.7.

The results of the sensitivity analysis are summarized in **Table 1** and graphically in **Figure 5.** Reference to **Table 1** shows that with a high run-off coefficient and high hydraulic conductivity, full recovery can be attained after 5-years, after which time no residual drawdown would occur (**Figure 5**); this scenario is considered to reflect post-mining pit backfilling of which is planned by MRL.

A worst-case scenario is shown as 'Slow Recovery' in **Table 1**, reflecting the case for no pit backfill. This scenario shows that groundwater level within the pit will recover to 55% of pre-mining groundwater levels after 10 years and 73% after 30 years. This worst-case scenario assumes a very low run-off coefficient and low hydraulic conductivity, values of which are considered unlikely to be representative.

Table 1 - Pit Void Groundwater Recovery Analysis

	Location: Pit Void (no backfill) Analytical Model Results for Post Mining Groundwater Recovery		
	Full Recovery	**Moderate Recovery**	**Slow Recovery**
	WMB 2 runoff coeff. = 0.7 k = 21 m/d	WMB 4 runoff coeff. = 0.3 k = 2.0 m/d	WMB 4 runoff coeff. = 0.3 k = 0.9 m/d
Time post operations	% Recovery to Pre-mining Groundwater Levels		
2 years	80	30	25
5 years	100	60	48
10 years	recovered	70	55
20 years	recovered	75	64
30 years	recovered	80	73

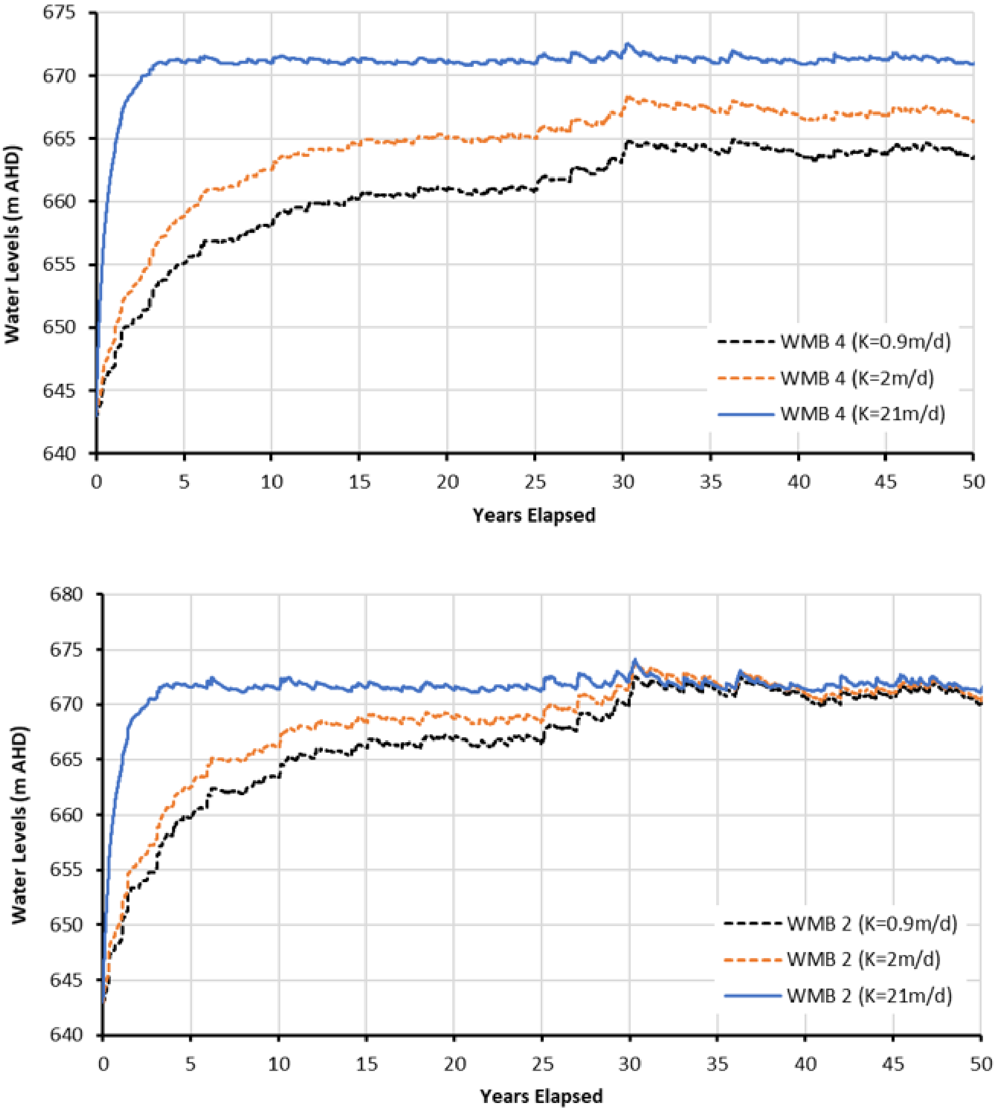

Figure 5 - Sensitivity analysis on K value for aquifer recovery; WMB4 runoff-coefficient = 0.3; WMB2 run-off coefficient = 0.7

Concluding Summary

The habitat of the two relevant stygofauna species is within the Whaleback Shale which may be partially disconnected from other parts of the groundwater system by the low-flow shale units of the Whaleback Shale. Drawdown at the stygofauna sites due to dewatering is therefore likely to be reduced and/or delayed.

Post-mining, MRL plan to backfill the Lamb Creek proposed pit to at least 1 m above pre-mining water level, resulting in no pit lake or evaporative processes. As such, once full groundwater recovey has been attained, it is expected that there will be no residual drawdown. For completeness however, drawdown contours were modelled to assess residual drawdown effects with no pit backfilling.

Drawdown contours were modelled in an analytical model for the dewatering and post-mining phases. During the short-term dewatering phase, the two stygofauna sites were modelled to be within the 12 m drawdown contours where **50%** of their immediate habitat is estimated to be affected. For the post-mining phase, if the pit is not backfilled, the stygofauna sites were within the 2.25 m residual drawdown contours where **9%** of their habitiat is estimated to be affected; pit backfilling is however planned by MRL.

For groundwater recovery within the pit (which invariably dictates residual drawdown), a sensitivity analysis on the hydraulic conductivity and run-off coefficients showed that a full groundwater recovery could be attained after 5-years, even without considering pit backfilling. As a worst-case and conservative scenario, the sensitivity analysis showed that with no pit backfilling and with low hydraulic and run-off coefficient values, groundwater levels would return to 73% of pre-mining levels after 30-years.

References

Bennelongia (2021). Lamb Creek Subterranean Fauna Survey Report. Prepared for Mineral Resources Limited. September 2021.

Gowing J.W., Konukcu F. & Rose D.A. (2005). Effect of watertable depth on evaporation and salt accumulation from saline groundwater. *Australian Journal of Soil Research* **43**(5) p565-573.

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LAMB CREEK SURFACE WATER ASSESSMENT

Prepared for ***Mineral Resources***

23 NOVEMBER 2017

Prepared by:

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Document Status

Version	Purpose of Document	Orig	Review	Review Date
a	Issued for Review	Andrew Ba Than	Rhod Wright	31/10/2017
b	Final	Andrew Ba Than	Rhod Wright	17/11/2017
c	Final	Andrew Ba Than	Rhod Wright	23/11/2017

Approval for Issue of Final Report

Name	Signature	Date
David Temple Smith		23/11/2017

Contents

Tables

(contained within report text) **Page**

Figures

(compiled at rear of report)

1. INTRODUCTION

1.1 Background

Mineral Resources Limited (MRL) proposes to develop the Lamb Creek iron ore mine located 108km northwest of Newman and about 20 km south west of BHP's Yandi iron ore mine. The mine tenement (M47/1468) is about 5.3km x 2.2km. Ore will be hauled by road-trains via a 17 km haul road connecting to the Great Northern Highway, 1.5km south of the Hamersley Iron Yandicoogina railway crossing.

The mining operation will consist of a pit, crusher, waste rock landform (WRL), top soil and vegetation stockpiles, workshop and accommodation camp, plus the haul road to Great Northern Highway. The proposed mine layout is shown in Figure 1 and Figure 2.

Iron ore will be extracted by traditional methods of drill and blast. Blasted material will be bulldozed out to a collection area for recovery by excavator and trucks, for bulk haulage to the crushing plant (crushing and screening in a dry mechanical separation operation). No chemical additives or reagents, and thus no tailings dam will be required.

The surficial geology of the area is dominated by soils, both transported and weathered in-situ (e.g. colluvium, alluvium), as well as rock outcropping. The site is intersected by numerous minor drainage channels that have been incised to shallow depth into the local topography.

The haul road will have a gravel sheeted 8m running width (in-situ material or if unsuitable, material sourced from mine overburden), plus windrows and embankments as required, and stormwater drainage structures. The road will be used for ore haulage, goods and services, and light vehicle traffic in and out of the site.

The proposed accommodation village will include up to 300 rooms, with mess and other facilities, and powered by a diesel generating plant.

1.2 Scope of Services

A desktop surface water assessment was undertaken to assess the options and requirements for surface water management at the various proposed infrastructure areas. The objective was to develop the relevant surface water scenarios and provide preliminary information on hydraulic and engineering parameters associated with the surface water management features.

The report addresses the following:

- Characterise and describe the existing surface water environment, including climate, location and size of catchments, existing drainage conditions and flow directions;
- Identify key surface water management issues and hydrological risks associated with the proposed development, particularly potential impacts from local creek lines affecting the proposed pits and waste dumps and other infrastructure locations;
- Estimation of catchments and associated flood flows at key locations throughout the site;
- A conceptual surface water management scheme to mitigate potential surface water impacts and the management measures to be put in place to minimise erosion / sedimentation, including flood protection (location of bunding and diversion drains), surface water management and sedimentation basins;
- Indicative diversion (channel / bund) dimensions in the mining areas, in particular those required to 100 year flood levels.

2. HYDROLOGY

2.1 Climate Zones

WA has three broad climate divisions. The south-west corner of WA has a Mediterranean climate, with long hot summers and wet winters, the arid interior, and the Lamb Creek area is located in the dry tropical northern part of the State, receiving summer rainfall.

2.2 Seasonal Rainfall and Evaporation

Average annual rainfall in the area is about 320-330mm (328mm at Newman, 322mm at Marrilana and 352mm at Mulga Downs). Rainfall is highly variable and annual averages of 37-862mm have been recorded, typically between 25% and 250% of the annual averages.

The majority of rainfall falls December to March, and July to November is typically quite dry.

At Port Hedland (to the north), the annual pan evaporation in the area is about 3,500mm (varying from 6.5-13mm/d winter to summer).

2.3 Intensity-Frequency-Duration (IFD)

Intensity-Frequency-Duration (IFD) data is required to characterise rainfall intensities in the area under consideration. This is generally provided by techniques in ARR (Australian Rainfall and Runoff, Institution of Engineers, 2016), a national guideline for the estimation of design flood characteristics in Australia, published by the Institution of Engineers Australia.

Information on storms exceeding the 100 year ARI event is not available in ARR, but by extrapolation, estimates can be made. The 1000 year ARI and Probable Maximum Precipitation (PMP) rainfall intensities are about 1.5x and 3.5-4x the 100 year IFDs respectively, as per Table 1.

Table 1 Average Recurrence Interval v Rainfall Duration (hours)

Average Recurrence Interval	Rainfall (mm, 1hr)	Rainfall (mm, 12hr)	Rainfall (mm, 72hr)
2	29	64	93
50	59	170	296
100	67	199	341
1000	100	300	500
PMP	250	750	1300

2.4 Flood Flows

The relevant flow catchments impacting the mine are shown on Figure 3. Peak streamflow discharges from ungauged catchments can be estimated using empirical techniques, such as those recommended in ARR. However, in preference the RAFTS runoff routing software has been used.

RAFTS is a nonlinear rainfall / runoff program, using design rainfall data derived from ARR (or actual storm events if required). The program calculates flood flows (hydrographs) by simulating rainfall over a catchment with time, removing losses to calculate the rainfall excess runoff, and then routing this runoff through the model reaches.

Relevant estimated 100 year ARI flood flows impacting the mine are shown on Figure 3 and Figure 4. Based on local trends for the area, the flood flows (as a proportion of the 100 year ARI flood) are:

Table 2 Typical Flood Flows as Proportion of the Q100 Flood

ARI (years)	Fraction of Q100 flood
2	0.05
5	0.20
10	0.33
20	0.50
50	0.77
100	1.0
PMF	7.0

3. SURFACE WATER IMPACTS

3.1 Overview

Regional stream flow in the Pilbara is ephemeral, related to intense rainfall from cyclonic activity or localised thunderstorms. Stream flow decays rapidly once rainfall has ceased, with negligible base flow.

The approximately 1.4km x 1.8km mine infrastructure area lies within the Marillana Creek catchment. A significant tributary (“North Creek”) of Marillana Creek flows north adjacent to the western boundary of the proposed operation, with an 80km² catchment at the access road crossing, then north for 7km where it joins the main Marrilana Creek channel. The river then flows 50 km east to Weeli Wolli Creek, and into the Fortescue Marsh.

The mine area has elevations ranging from about RL700m on the lower side (near North Creek) to RL800m on a ridgeline on the east side (the ridgeline tops out at RL1,064m further east). From the steeper areas in the east, most of the site is RL700-720m, with typical surface slopes of about 1%.

The tenement is impacted by mainly local, internal drainage, white drainage from the mine area flows into North Creek.

3.2 Mining Infrastructure Impact on Surface Water

Based on the layout of the mine site layout (Figure 5) in relation to surface water:

- The deposit / pit lies across minor north-west trending internal drainage / sheet flows, with possible breakout flows across the south west corner; but at the south east corner there is possible shallow break out flow across the south west corner of the site from the creek on the southern boundary (this can be protected by low bunding along the lease boundary).
- The ROM topsoil stockpiles also lie across minor north-west trending drainage / sheet flows. The flows into this area will be impacted once the pit starts to develop (interfering with some of the catchment area);
- The WRL and topsoil stockpiles will generally drain to the north, to the site boundary. The WRL will block minor drainage on the south side from the pit area;
- The ROM (north-west corner of the site) is partially impacted by 100 year North Creek flooding with sheet flows (up to 0.4m deep), while the workshop area is fully inundated (up to 0.6m deep);
- The camp is 1.5km to the west, separate and located on sloping foothills (5-10%), with a 900m long access road;
- A 17km access road to Great Northern Highway traverses foothills, with cross drainage from the hills.

3.3 North Creek Impact on Mining Infrastructure

North Creek flows adjacent to the western side of the proposed operations (refer Figure 2).

- The creek has an estimated 100 year flow of 237m³/s and a PMF of about 1700m³/s;
- The creek channel is shallow with an ill-defined main flow area 60-80m wide, and a bed gradient of ~0.7%;
- The creek would be expected to flow up to 2m deep in the 100 year flow (refer Figure 4); and up to 3.5m deep in the PMF (refer Figure 10);
- North Creek crosses the mine access road, and some drainage is required at this point (floodway, culverts) depending on the selected design flood and risk of delays associated with floodwaters overtopping the road.

4. RAINFALL ON PIT

4.1 Overview

The pit will only be impacted by local flow and potential break outflow from the watercourse (flowing west from higher ground, to the south of the site). In the progressive developmental stages of the pit, minor bunding will be required to prevent and divert surface water around the pit (or if necessary allow water to run into the pit).

The design 72 hour rain events in this location are about 341mm (100 year), 191mm (10 year) and 107mm (2 Year).

The probability that a 100 year ARI rain event would occur during a 20 year mine life is about 18%, so there is therefore an 82% chance that a 100 year storm would not occur within the mine life. It is likely (87% chance) that the 10 year event would occur within the 20 year mine life.

The pit shell will store any surface water inflows, but the impact that the water has on mining largely depends on the provisions made for flood storage. A pit base may have more than one low point at any point in time, where water can separately pond. Flooded plant and equipment, or production loss due to a flooded mining face, may be critical.

General pit stormwater management strategies include ascertaining flood storage requirements for every stage of pit development, and setting aside areas and prior workings in the lower parts of the pit to ensure that sufficient flood storage capacity is available to minimise disruption risk to operations (while leaving some upper mine areas available for work in the event of flooding).

The volume of water that accumulates in the pit and needs to be removed will increase as the pit staging unfolds i.e. as the pit footprint gets bigger (and possibly as external surface flows are impacted by surface water management measures.

4.2 Pit Flood Estimates

The final pit outline (direct rain catchment) is 35ha.

The rainfall in the area averages about 300-350mm per annum and direct rainfall collecting at the bottom of the pit would average about 15,000-20,000m^3 annually (but extremely variable from year to year).

The 10 year ARI 72 hour flood volume in the pit would be about 30,000m^3. This volume would be removed in 7 days @ 50L/s pump out rate, or 3.5 days @ 100L/s pump out rate.

The 100 year 72 hour flood volume would be about 70,000m^3. The pump out times would be about 16 days @ 50L/s, and 8 days @ 100L/s.

5. ACCESS ROAD

5.1 Road Parameters

A good road surface will generally result in lower vehicle and road maintenance costs, and increase safety. Most haul roads are gravel sheeted, but remain unsealed. Road maintenance is thus a continual activity.

Effective drainage of the pavement surface is determined by the cross fall, the longitudinal road grade and the nature of the pavement materials used to form the road. Side drains concentrate runoff from the road surface and cut batters, and in general, are necessary on both sides of the formation.

Excessive flows may initiate scour within the drain or drain outlet. There is limited scope to alter the slope of the table drain (which follows the slope of the road / natural surface), but the flow velocity may be kept within an acceptable range through varying the catchment area contributing to the drain (via spacing of turn-outs and cross drain outlets). Armouring of drains may need to be considered.

Regular turn-outs lead water out of side drains into stable depression areas, slow velocities and minimise the potential for erosion. Intervals between turn-outs should be shortened as terrain steepens, to minimise the contributing catchment area and reduce water velocity.

5.2 Creek Crossings

North Creek crosses the access road near the mine site with an estimated 100 year flood flow of 237m³/s. Further downstream (7 km), North Creek crosses the Rio Tinto Yandicoogina railway via 9no. corrugated metal pipes each of 3m diameter (rail crossings are typically designed to the 50 year ARI flood flow).

The access road route otherwise commands a total surface water catchment of about 36km² (the largest single catchment is 7-8km², refer Figure 3).

The type of drainage structure adopted at the creek crossings is generally determined by the level of flooding immunity required, i.e. the time of closure acceptable during flooding. The structure may be a floodway / floodway with culverts, or full flow culverts (or bridge if the terrain or river size warrants).

5.3 Engineering Options for Creek Crossings

5.3.1 Floodways

The objective of floodways is to allow floodwater to be conveyed across the road under controlled conditions at designated places, which are specifically designed and protected.

Trafficability of floodways depends on the combined effects of inundation depth and flow velocity over the road), but typically only flow for short periods of time. The trafficable surface may range from a natural bed crossing (requiring 4 Wheel Drive) to a paved or sealed surface (cement stabilised base course with heavy seal or a concrete surface). They are commonly used in rural roads with relatively low traffic volume, for economic reasons (where it is impractical or uneconomical to construct a bridge or culvert). Floodways have better environmental benefits than culverts which have a greater potential for erosion and scouring.

Floodways are particularly suited to flat or gently undulating terrain, where there is a trapped upstream catchment, but where drainage patterns are not well defined (general sheet flow area rather than incised water course channels). The floodway / road formation is then laid at or near natural ground surface level.

Floodways should be sited at right angles to the flow, and level with the existing stream bottom to minimise interference to the natural creek flow, and reduce bank erosion. Protection of the banks may be necessary to prevent destabilisation of the structure.

Any elevation of the road / floodway causes a weir effect, increases the downstream velocity and erosion of the downstream road batter and creek bed. Scour protection may therefore be required, in the form of rock lining.

5.3.2 Floodway with Culverts

Where there are incised creeks and / or particular vertical road profile geometry is required in order to maintain design vehicle speed, the road may be elevated across the creek. A relieving culvert can then be installed to drain and prevent standing water upstream of the floodway, softening of the subgrade and subsequent maintenance problems. and reduce the flooding time over the road (i.e. increase the level of immunity from flooding).

The invert level of the culvert and the road level should be set so that the culvert will run full before water overtops the road. A series of small culverts can carry greater flow under the road before overtopping. The culvert size is somewhat arbitrary, but as a guide, should be 600mm dia minimum (desirable) or 450mm dia (absolute minimum), and if possible carry the peak 2 year ARI flow.

5.3.3 Culverts

High capacity culverts can remove the issue of overtopping and disruption to service, but are more costly, constrict flood flows, and increase velocities and erosion potential. Culverts should be located in the middle of waterways, and conform to the slope of the natural drainage channel. Culvert entrances and exits should be (rock armour) protected from high water velocities and erosion.

5.3.4 Summary

Culverts for rail crossings are typically designed for the 50 year ARI event. High-volume roads may be similarly deigned but in the Pilbara, such design criteria can require significant culvert sizes and costs, and is probably not required or economical for a mine road. Great Northern Highway drainage is typically designed as floodways only (occasionally supplemented by a culvert) noting that significant disruption to traffic does occur during the wet season.

6. ENGINEERING CONSTRUCTION

6.1 Typical Surface Water Diversions

Construction and infrastructure should preferably lie outside 100 year ARI floodplains (operational period) and preferably outside the PMF (probable maximum flood) floodplains (post-closure period), and therefore completely avoid the need for diversion works or erosion protection.

If this is not possible, surface water diversion is required where there is interruption to surface flow patterns. Diversion structures carry flood waters via a flow path different from the natural water course, back into the original water course at a point downstream, or less desirably another water course.

Diversions consist of earth bunds and excavated channels, built with an appropriate freeboard (e.g. 1m minimum when protecting a pit). They are generally constructed using cut-to-fill (by excavating a channel on the upstream side as fill for the bund on the downstream side).

There are no strict criteria for selecting the level of flood protection. However, one criterion is for the design flood event to have a 20% probability of exceedance in the life of mine (LOM). For a 20 year LOM, a 90 year level of protection is suggested (a 100 year protection level has an 18% chance of being exceeded, and a 50 year level has a 33% chance of being exceeded).

Aside from significant flooding issues that need to be dealt with, general drainage and diversions around the site, etc. may be designed for a lower level of protection e.g. the 5-10 year flow, when temporary capacity exceedance does not matter so much.

Earth bunds typically consist of a trapezoidal shaped mound with 1V:2.5-3H side batters (slopes). The batters can be flattened for further stability if excess material is available. The bund crest width is commensurate with the height of the bund and flows.

Excavated open (trapezoidal) diversion channels typically have 1V:2H side batters (although batter slopes may vary from 1V:3H for sandy loam or porous clay; to near vertical at 1V:0.25-0.33H in solid well bedded, good quality rock in deep cuttings.

6.2 Bund Materials

Flood bunds are generally watertight for stability reasons. Soil materials may be characterised to ensure suitability, but the performance requirements for temporary water storage are not specific. The embankment would typically use the most suitable available material at the site, e.g. mine waste or diversion excavations and be constructed homogeneously (i.e. not zoned).

Some clay content is required and materials range from clayey gravels and sands (preferred), through to poorly graded sands (least preferred), and preferably contain no rock particles >75mm.

6.3 Erosion Protection

Scour in unprotected soils will typically occur when maximum velocities reach about 1.2-2m/s for clays, up to about 1.5m/s for sand, and higher for rocky material.

Rock armour can be used to protect earthworks against scouring and erosion, and can be applied where problems occur or in the long term where permissible velocities may be exceeded. Generally, it is not considered necessary to rock armour an operational embankment or channel against velocities <2m/s for the design flood event (subject to operational experience).

6.4 Pit Edge Zones

Diversion infrastructure around pit areas should be located 10m outside the area designated as a potentially unstable rock mass and susceptible to pit wall collapse. In general this distance varies depending on whether pit walls are excavated entirely in unweathered rock, in weathered rock, or in both.

6.5 Construction

Earthworks construction requirements typically entail:

- Excavate to strip depth, scarify the base in preparation for construction of an embankment;
- Maintain moisture content in the embankment material at optimum (which allows the maximum density to be achieved by the compaction equipment in use);
- Place and compact material in layers as specified (e.g. 95% SMDD (Standard Maximum Dry Density); or 92% MMDD (Modified Standard Maximum Dry Density);
- Control batter slopes to line and level.

7. EROSION AND RUNOFF

7.1 General Principles

The landscape can be subject to heavy rainfall. The potential for erosion and sedimentation offsite is increased significantly on disturbed or degraded lands, following vegetation and topsoil removal, mining activities, spoil stockpiling, and general construction activities.

Generally environmental approvals for projects that involve land and hydrological disturbance require adherence to surface water protection principles, to maintain surface water regimes, so that existing and potential uses, and the ecosystem, are protected.

7.2 Potential Surface Water Impacts

Potential surface water impacts include the interruption to existing surface water flow patterns, with the possible reduction of surface water runoff volume or water quality in the environment downstream (vegetation and fauna communities dependent on good quality water), and particularly relating to sediment laden run-off from waste dumps and stockpiles.

In addition, the storage and spillage of chemicals and hydrocarbons can also adversely impact water quality downstream. The random pooling of water around the site, and growth of invasive vegetation in low-lying areas should also be eliminated.

7.3 Management Actions

Surface water management requires consideration of each sub-catchment / drainage area, with the application of engineering surface water controls to prevent sediment (and other contaminants) from entering natural flow paths. These measures include diversions, erosion and sedimentation controls (i.e. sediment basins) and possibly dispersion mechanisms.

Management actions to mitigate the impacts of surface water flooding include:

- Avoid interference with drainage systems;
- Flood modelling to guide the location of developments and required flood protection measures (rock armour or revegetate development sites, waste dumps, etc. to protect from erosion);
- Obtain "Permit to Interfere with Bed and Banks" as required, where interfering with water courses;
- Investigate required diversions of upstream flows around structures;
- Permanent stream diversions can match the characteristics of the original natural stream;
- Construction near natural flow paths in the dry season only;
- Bund-off disturbed areas, waste dumps, stockpiles to contain surface runoff and direct it to a sediment trap or sump prior to discharge to the external environment;
- Water quality of the treated discharge may be an ‘outcome based’ criterion (Figure 6), but is typically prescriptive – the sediment trap or sump may be a dam-like structure (Figure 7 “dry” trap, or Figure 8 “wet” trap) or a smaller more localised rectangular “turkeys nest” type of structure (Figure 9, either dry with an outflow control structure, or wet without an outflow control structure;
- Fit outflow baffles to capture potentially polluted runoff (e.g. oil and grease);
- Keep vehicle movements to designated tracks;
- Maintain watercourses, install culverts, to prevent disruption of major flow paths;
- Minimise and properly manage on site solid waste disposal;

- Treat and dispose of all domestic wastewater / WWTP effluent appropriately;
- Store hazardous substances in properly bunded sites with appropriate emergency response procedures.

7.4 Assessment of Runoff Loss to the Downstream Environment

The Lamb Creek development lies within the Marillana Creek catchment. There will be an effective reduction or loss in catchment area from the mining infrastructure footprints.

Runoff volumes from infrastructure areas such as roofs, hardstands and access roads may increase from concentration and redirection of flows, but are considered to remain effectively unchanged (neutral). The runoff volume containing pits and waste dump areas is likely to decrease, due to the catchments blocked or trapped by these works.

Only the pit and waste dumps areas have been considered to contribute to the non-recovered runoff volume. On this basis, non-recovered runoff volume losses have been assumed as follows:

- 100% loss of runoff volume from the pit area (0.8km²);
- 50% loss of runoff volume from WRLs (0.3km², or 50% x 0.6km²);
- 50% loss of runoff volume from topsoil stockpiles (0.25km², or 50% x 0.5km²).

As such the pit and waste dump areas represent an approximately 1.4km² effective reduction in contributing catchment area to the Marillana Creek catchment area of 1,369km² (at the Flat Rocks gauging station, 20km downstream of the Lamb Creek mine). The lost Lamb Creek catchment is 0.1% of this catchment.

Assuming the reduction in catchment area is directly proportional to the reduction in runoff volume, a 0.1% potential reduction in runoff volumes would not be environmentally significant, particularly when considering the much greater natural seasonal variations in rainfall and catchment runoff.

The Lamb Creek lost catchment is only 1.8% of local North Creek catchment at the site, again not environmentally significant.

8. GENERAL GUIDELINES POST-CLOSURE

8.1 Post Closure Design Criteria

The objective of the mine closure guidelines is to ensure an effective planning process is in place throughout the life of mine, so closure is achieved in an environmentally sustainable manner and without unacceptable liability to the State (refer “Guidelines for Preparing Mine Closure Plans”, Department of Mines and Petroleum, and Environmental Protection Agency).

General mine closure principles include:

- Surface and groundwater hydrological patterns / flows not adversely affected;
- Surface and groundwater levels, and water quality reflect original levels and water chemistry;
- No long term reduction in base flow to meet local environmental values.

8.2 Land Disturbance and Rehabilitation

Mining is a temporary land use, and therefore rehabilitation objectives should be consistent with the projected future land use. Post-mining landforms consist of unconsolidated materials, dispersive, and erodible materials, combined with steep and / or long slopes, which give rise to high erosion risks, and in turn reduction in water quality downstream. Rehabilitation strategies must be integrated with mine development planning and operations, and designed to be maintenance free over the long term, to minimise the environmental impacts of the project and maximise rehabilitation success.

The objective is to rehabilitate disturbed areas to safe and stable landforms, containing endemic plant communities that approximate those that existed prior to the disturbance. These areas should be free draining, non-polluting and visually compatible with the surrounding landscape, suitable for alternative land use (such as pastoralism and heritage conservation). In particular, surface water management on reconstructed landforms is required to avoid erosion gullying, tilling, loss of surface material and factors affecting surface stability and revegetation.

8.3 Decommissioning

On completion of mining, decommissioning involves minimising sterilisation of ore reserves, rehandling of waste materials, and visual impact considerations / blending with natural landforms. It includes the removal of the remaining infrastructure and rehabilitation of areas disturbed by the mine operations, including tanks, wastes, contaminated soil, compacted surfaces e.g. old roadways, site compounds, etc.

8.4 Waste Rock Landforms (WRL)

Waste dumps are usually the landforms most prone to erosion post mining. Geomorphic principles should be applied to the design of stable landforms over the long term. These principles dictate drainage density and size of catchments, and slope angles – the incorporation of slope features that emulate natural slopes, that are in equilibrium with local conditions, rainfall, soil type, and vegetation cover.

DMP guidelines for arid regions propose that the top of the landform profile should preferably be water retaining (i.e. the top surface, berms and batters be constructed to hold the maximum expected rainfall event, provided this does not cause ground instability, or contaminated leachate and groundwater seepage). This reduces water flow and erosion down the final landform slopes. The slopes should have a maximum slope of 15-20°, with contour ripping to assist with water infiltration, application of topsoil and natural vegetation regeneration.

Rock armour can also be applied as an armour substrate to the rehabilitated slopes, and used to increase the maximum permissible runoff velocities for the exposed soil; with topsoil applied and incorporated into the armouring layer.

8.5 Monitoring

Completion criteria are agreed standards to be achieved on particular aspects of the mining operation. Progressive assessment against these agreed criteria demonstrates the relative success of rehabilitation in achieving desired outcomes, and whether the rehabilitation end point has been reached. Rehabilitation performance criteria include assessment of post-closure land use objectives, landform stability, ground water protection, and revegetation targets. Where possible, completion criteria should be developed from actual rehabilitation trials and site experience to ensure that rehabilitation methods are effective, durable and achievable.

Completion criteria should be flexible to adapt to changing circumstances, time based (trend) so rehabilitation development can be assessed as to whether it is progressing well towards a defined end point, and designed to allow effective reporting and auditing to determine the endpoint and allow sites to be relinquished.

9. CONCLUSION

The surface water management plan for the project development is summarised in Figure 5.

All drainage catchments flow northward into the major creek systems (North Creek and then Marillana Creek). Flood protection of significant infrastructure should be provided at about the 50-100 year protection level based on a 20 year life-of-mine.

The best method of water management is to locate infrastructure away from significant creeks and avoid the need for diversion works where possible. Otherwise surface water diversion is required when infrastructure lies across existing surface water flow patterns. A combination of bunds and excavated channels with an appropriate freeboard is required to carry flood waters around infrastructure via a flow path different from the natural water course. Earthworks diversions are generally constructed using cut-to-fill, but can also be all cut, or all fill.

The deposit lies at the western end of a ridge line, and the development of the pit will cut off minor catchments only, with the possibility of breakout flow from the creek draining the ridgeline.

The rainfall in the area averages about 300-350mm per annum and direct rainfall collecting at the bottom of the pit would average about 15,000-20,000m^3 annually (but extremely variable from year to year). The 10 year flood volume would be about 30,000m^3, taking about 1 week to pump out at 50L/s; and the 100 year flood would be about 70,000m^3, taking about 1 week to pump out at 100L/s.

The Lamb Creek development lies within the Marillana Creek catchment. The combined pit, WRL and topsoil footprint areas, and any catchments blocked or trapped, are likely to decrease runoff volume into Marillana Creek. The total effective catchment loss is approximated as 1.4km^2, equivalent to 0.1% of the Marrilana Creek catchment. This reduction in runoff volumes in a widely variable rainfall regime is environmentally insignificant.

There is a risk of erosion and sedimentation on disturbed and degraded landscapes. The general objective is to maintain the hydrological regimes so that existing and potential users, including ecosystems, are protected.

Storage areas (chemicals, hydrocarbons, etc.) should be located away from, or bunded off from, external surface water flows. Every point of discharge should limit erosion and transport of sediment away from the site. Discharge points should be stable and non-erosive, at existing water courses or otherwise dispersed. Where sedimentation issues occur, surface water run-off can be collected at the site boundary, behind bunded storage and as necessary passed through sedimentation basins at key low points, from which treated water can then discharge to the environment.

Monitoring during the life of mine will ensure the proposed surface water management measures are effective in maintaining the hydrological regimes in the downstream environment.

LAMB CREEK SURFACE WATER ASSESSMENT

Prepared for ***Mineral Resources***

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1. INTRODUCTION

1.1 Background

Mineral Resources Limited (MRL) proposes to develop the Lamb Creek iron ore mine located 108km northwest of Newman and about 20 km south west of BHP's Yandi iron ore mine. The mine tenement (M47/1468) is about 5.3km x 2.2km. Ore will be hauled by road-trains via a 17 km haul road connecting to the Great Northern Highway, 1.5km south of the Hamersley Iron Yandicoogina railway crossing.

The mining operation will consist of a pit, crusher, waste rock landform (WRL), top soil and vegetation stockpiles, workshop and accommodation camp, plus the haul road to Great Northern Highway. The proposed mine layout is shown in Figure 1 and Figure 2.

Iron ore will be extracted by traditional methods of drill and blast. Blasted material will be bulldozed out to a collection area for recovery by excavator and trucks, for bulk haulage to the crushing plant (crushing and screening in a dry mechanical separation operation). No chemical additives or reagents, and thus no tailings dam will be required.

The surficial geology of the area is dominated by soils, both transported and weathered in-situ (e.g. colluvium, alluvium), as well as rock outcropping. The site is intersected by numerous minor drainage channels that have been incised to shallow depth into the local topography.

The haul road will have a gravel sheeted 8m running width (in-situ material or if unsuitable, material sourced from mine overburden), plus windrows and embankments as required, and stormwater drainage structures. The road will be used for ore haulage, goods and services, and light vehicle traffic in and out of the site.

The proposed accommodation village will include up to 300 rooms, with mess and other facilities, and powered by a diesel generating plant.

1.2 Scope of Services

A desktop surface water assessment was undertaken to assess the options and requirements for surface water management at the various proposed infrastructure areas. The objective was to develop the relevant surface water scenarios and provide preliminary information on hydraulic and engineering parameters associated with the surface water management features.

The report addresses the following:

- Characterise and describe the existing surface water environment, including climate, location and size of catchments, existing drainage conditions and flow directions;
- Identify key surface water management issues and hydrological risks associated with the proposed development, particularly potential impacts from local creek lines affecting the proposed pits and waste dumps and other infrastructure locations;
- Estimation of catchments and associated flood flows at key locations throughout the site;
- A conceptual surface water management scheme to mitigate potential surface water impacts and the management measures to be put in place to minimise erosion / sedimentation, including flood protection (location of bunding and diversion drains), surface water management and sedimentation basins;
- Indicative diversion (channel / bund) dimensions in the mining areas, in particular those required to 100 year flood levels.

2. HYDROLOGY

2.1 Climate Zones

WA has three broad climate divisions. The south-west corner of WA has a Mediterranean climate, with long hot summers and wet winters, the arid interior, and the Lamb Creek area is located in the dry tropical northern part of the State, receiving summer rainfall.

2.2 Seasonal Rainfall and Evaporation

Average annual rainfall in the area is about 320-330mm (328mm at Newman, 322mm at Marrilana and 352mm at Mulga Downs). Rainfall is highly variable and annual averages of 37-862mm have been recorded, typically between 25% and 250% of the annual averages.

The majority of rainfall falls December to March, and July to November is typically quite dry.

At Port Hedland (to the north), the annual pan evaporation in the area is about 3,500mm (varying from 6.5-13mm/d winter to summer).

2.3 Intensity-Frequency-Duration (IFD)

Intensity-Frequency-Duration (IFD) data is required to characterise rainfall intensities in the area under consideration. This is generally provided by techniques in ARR (Australian Rainfall and Runoff, Institution of Engineers, 2016), a national guideline for the estimation of design flood characteristics in Australia, published by the Institution of Engineers Australia.

Information on storms exceeding the 100 year ARI event is not available in ARR, but by extrapolation, estimates can be made. The 1000 year ARI and Probable Maximum Precipitation (PMP) rainfall intensities are about 1.5x and 3.5-4x the 100 year IFDs respectively, as per Table 1.

Table 1 Average Recurrence Interval v Rainfall Duration (hours)

Average Recurrence Interval	Rainfall (mm, 1hr)	Rainfall (mm, 12hr)	Rainfall (mm, 72hr)
2	29	64	93
50	59	170	296
100	67	199	341
1000	100	300	500
PMP	250	750	1300

2.4 Flood Flows

The relevant flow catchments impacting the mine are shown on Figure 3. Peak streamflow discharges from ungauged catchments can be estimated using empirical techniques, such as those recommended in ARR. However, in preference the RAFTS runoff routing software has been used.

RAFTS is a nonlinear rainfall / runoff program, using design rainfall data derived from ARR (or actual storm events if required). The program calculates flood flows (hydrographs) by simulating rainfall over a catchment with time, removing losses to calculate the rainfall excess runoff, and then routing this runoff through the model reaches.

Relevant estimated 100 year ARI flood flows impacting the mine are shown on Figure 3 and Figure 4. Based on local trends for the area, the flood flows (as a proportion of the 100 year ARI flood) are:

Table 2 Typical Flood Flows as Proportion of the Q100 Flood

ARI (years)	Fraction of Q100 flood
2	0.05
5	0.20
10	0.33
20	0.50
50	0.77
100	1.0
PMF	7.0

3. SURFACE WATER IMPACTS

3.1 Overview

Regional stream flow in the Pilbara is ephemeral, related to intense rainfall from cyclonic activity or localised thunderstorms. Stream flow decays rapidly once rainfall has ceased, with negligible base flow.

The approximately 1.4km x 1.8km mine infrastructure area lies within the Marillana Creek catchment. A significant tributary ("North Creek") of Marillana Creek flows north adjacent to the western boundary of the proposed operation, with an 80km² catchment at the access road crossing, then north for 7km where it joins the main Marrilana Creek channel. The river then flows 50 km east to Weeli Wolli Creek, and into the Fortescue Marsh.

The mine area has elevations ranging from about RL700m on the lower side (near North Creek) to RL800m on a ridgeline on the east side (the ridgeline tops out at RL1,064m further east). From the steeper areas in the east, most of the site is RL700-720m, with typical surface slopes of about 1%.

The tenement is impacted by mainly local, internal drainage, white drainage from the mine area flows into North Creek.

3.2 Mining Infrastructure Impact on Surface Water

Based on the layout of the mine site layout (Figure 5) in relation to surface water:

- The deposit / pit lies across minor north-west trending internal drainage / sheet flows, with possible breakout flows across the south west corner; but at the south east corner there is possible shallow break out flow across the south west corner of the site from the creek on the southern boundary (this can be protected by low bunding along the lease boundary).
- The ROM topsoil stockpiles also lie across minor north-west trending drainage / sheet flows. The flows into this area will be impacted once the pit starts to develop (interfering with some of the catchment area);
- The WRL and topsoil stockpiles will generally drain to the north, to the site boundary. The WRL will block minor drainage on the south side from the pit area;
- The ROM (north-west corner of the site) is partially impacted by 100 year North Creek flooding with sheet flows (up to 0.4m deep), while the workshop area is fully inundated (up to 0.6m deep);
- The camp is 1.5km to the west, separate and located on sloping foothills (5-10%), with a 900m long access road;
- A 17km access road to Great Northern Highway traverses foothills, with cross drainage from the hills.

3.3 North Creek Impact on Mining Infrastructure

North Creek flows adjacent to the western side of the proposed operations (refer Figure 2).

- The creek has an estimated 100 year flow of 237m³/s and a PMF of about 1700m³/s;
- The creek channel is shallow with an ill-defined main flow area 60-80m wide, and a bed gradient of ~0.7%;
- The creek would be expected to flow up to 2m deep in the 100 year flow (refer Figure 4); and up to 3.5m deep in the PMF (refer Figure 10);
- North Creek crosses the mine access road, and some drainage is required at this point (floodway, culverts) depending on the selected design flood and risk of delays associated with floodwaters overtopping the road.

4. RAINFALL ON PIT

4.1 Overview

The pit will only be impacted by local flow and potential break outflow from the watercourse (flowing west from higher ground, to the south of the site). In the progressive developmental stages of the pit, minor bunding will be required to prevent and divert surface water around the pit (or if necessary allow water to run into the pit).

The design 72 hour rain events in this location are about 341mm (100 year), 191mm (10 year) and 107mm (2 Year).

The probability that a 100 year ARI rain event would occur during a 20 year mine life is about 18%, so there is therefore an 82% chance that a 100 year storm would not occur within the mine life. It is likely (87% chance) that the 10 year event would occur within the 20 year mine life.

The pit shell will store any surface water inflows, but the impact that the water has on mining largely depends on the provisions made for flood storage. A pit base may have more than one low point at any point in time, where water can separately pond. Flooded plant and equipment, or production loss due to a flooded mining face, may be critical.

General pit stormwater management strategies include ascertaining flood storage requirements for every stage of pit development, and setting aside areas and prior workings in the lower parts of the pit to ensure that sufficient flood storage capacity is available to minimise disruption risk to operations (while leaving some upper mine areas available for work in the event of flooding).

The volume of water that accumulates in the pit and needs to be removed will increase as the pit staging unfolds i.e. as the pit footprint gets bigger (and possibly as external surface flows are impacted by surface water management measures.

4.2 Pit Flood Estimates

The final pit outline (direct rain catchment) is 35ha.

The rainfall in the area averages about 300-350mm per annum and direct rainfall collecting at the bottom of the pit would average about 15,000-20,000m^3 annually (but extremely variable from year to year).

The 10 year ARI 72 hour flood volume in the pit would be about 30,000m^3. This volume would be removed in 7 days @ 50L/s pump out rate, or 3.5 days @ 100L/s pump out rate.

The 100 year 72 hour flood volume would be about 70,000m^3. The pump out times would be about 16 days @ 50L/s, and 8 days @ 100L/s.

5. ACCESS ROAD

5.1 Road Parameters

A good road surface will generally result in lower vehicle and road maintenance costs, and increase safety. Most haul roads are gravel sheeted, but remain unsealed. Road maintenance is thus a continual activity.

Effective drainage of the pavement surface is determined by the cross fall, the longitudinal road grade and the nature of the pavement materials used to form the road. Side drains concentrate runoff from the road surface and cut batters, and in general, are necessary on both sides of the formation.

Excessive flows may initiate scour within the drain or drain outlet. There is limited scope to alter the slope of the table drain (which follows the slope of the road / natural surface), but the flow velocity may be kept within an acceptable range through varying the catchment area contributing to the drain (via spacing of turn-outs and cross drain outlets). Armouring of drains may need to be considered.

Regular turn-outs lead water out of side drains into stable depression areas, slow velocities and minimise the potential for erosion. Intervals between turn-outs should be shortened as terrain steepens, to minimise the contributing catchment area and reduce water velocity.

5.2 Creek Crossings

North Creek crosses the access road near the mine site with an estimated 100 year flood flow of 237m³/s. Further downstream (7 km), North Creek crosses the Rio Tinto Yandicoogina railway via 9no. corrugated metal pipes each of 3m diameter (rail crossings are typically designed to the 50 year ARI flood flow).

The access road route otherwise commands a total surface water catchment of about 36km² (the largest single catchment is 7-8km², refer Figure 3).

The type of drainage structure adopted at the creek crossings is generally determined by the level of flooding immunity required, i.e. the time of closure acceptable during flooding. The structure may be a floodway / floodway with culverts, or full flow culverts (or bridge if the terrain or river size warrants).

5.3 Engineering Options for Creek Crossings

5.3.1 Floodways

The objective of floodways is to allow floodwater to be conveyed across the road under controlled conditions at designated places, which are specifically designed and protected.

Trafficability of floodways depends on the combined effects of inundation depth and flow velocity over the road), but typically only flow for short periods of time. The trafficable surface may range from a natural bed crossing (requiring 4 Wheel Drive) to a paved or sealed surface (cement stabilised base course with heavy seal or a concrete surface). They are commonly used in rural roads with relatively low traffic volume, for economic reasons (where it is impractical or uneconomical to construct a bridge or culvert). Floodways have better environmental benefits than culverts which have a greater potential for erosion and scouring.

Floodways are particularly suited to flat or gently undulating terrain, where there is a trapped upstream catchment, but where drainage patterns are not well defined (general sheet flow area rather than incised water course channels). The floodway / road formation is then laid at or near natural ground surface level.

Floodways should be sited at right angles to the flow, and level with the existing stream bottom to minimise interference to the natural creek flow, and reduce bank erosion. Protection of the banks may be necessary to prevent destabilisation of the structure.

Any elevation of the road / floodway causes a weir effect, increases the downstream velocity and erosion of the downstream road batter and creek bed. Scour protection may therefore be required, in the form of rock lining.

5.3.2 Floodway with Culverts

Where there are incised creeks and / or particular vertical road profile geometry is required in order to maintain design vehicle speed, the road may be elevated across the creek. A relieving culvert can then be installed to drain and prevent standing water upstream of the floodway, softening of the subgrade and subsequent maintenance problems. and reduce the flooding time over the road (i.e. increase the level of immunity from flooding).

The invert level of the culvert and the road level should be set so that the culvert will run full before water overtops the road. A series of small culverts can carry greater flow under the road before overtopping. The culvert size is somewhat arbitrary, but as a guide, should be 600mm dia minimum (desirable) or 450mm dia (absolute minimum), and if possible carry the peak 2 year ARI flow.

5.3.3 Culverts

High capacity culverts can remove the issue of overtopping and disruption to service, but are more costly, constrict flood flows, and increase velocities and erosion potential. Culverts should be located in the middle of waterways, and conform to the slope of the natural drainage channel. Culvert entrances and exits should be (rock armour) protected from high water velocities and erosion.

5.3.4 Summary

Culverts for rail crossings are typically designed for the 50 year ARI event. High-volume roads may be similarly deigned but in the Pilbara, such design criteria can require significant culvert sizes and costs, and is probably not required or economical for a mine road. Great Northern Highway drainage is typically designed as floodways only (occasionally supplemented by a culvert) noting that significant disruption to traffic does occur during the wet season.

6. ENGINEERING CONSTRUCTION

6.1 Typical Surface Water Diversions

Construction and infrastructure should preferably lie outside 100 year ARI floodplains (operational period) and preferably outside the PMF (probable maximum flood) floodplains (post-closure period), and therefore completely avoid the need for diversion works or erosion protection.

If this is not possible, surface water diversion is required where there is interruption to surface flow patterns. Diversion structures carry flood waters via a flow path different from the natural water course, back into the original water course at a point downstream, or less desirably another water course.

Diversions consist of earth bunds and excavated channels, built with an appropriate freeboard (e.g. 1m minimum when protecting a pit). They are generally constructed using cut-to-fill (by excavating a channel on the upstream side as fill for the bund on the downstream side).

There are no strict criteria for selecting the level of flood protection. However, one criterion is for the design flood event to have a 20% probability of exceedance in the life of mine (LOM). For a 20 year LOM, a 90 year level of protection is suggested (a 100 year protection level has an 18% chance of being exceeded, and a 50 year level has a 33% chance of being exceeded).

Aside from significant flooding issues that need to be dealt with, general drainage and diversions around the site, etc. may be designed for a lower level of protection e.g. the 5-10 year flow, when temporary capacity exceedance does not matter so much.

Earth bunds typically consist of a trapezoidal shaped mound with 1V:2.5-3H side batters (slopes). The batters can be flattened for further stability if excess material is available. The bund crest width is commensurate with the height of the bund and flows.

Excavated open (trapezoidal) diversion channels typically have 1V:2H side batters (although batter slopes may vary from 1V:3H for sandy loam or porous clay; to near vertical at 1V:0.25-0.33H in solid well bedded, good quality rock in deep cuttings.

6.2 Bund Materials

Flood bunds are generally watertight for stability reasons. Soil materials may be characterised to ensure suitability, but the performance requirements for temporary water storage are not specific. The embankment would typically use the most suitable available material at the site, e.g. mine waste or diversion excavations and be constructed homogeneously (i.e. not zoned).

Some clay content is required and materials range from clayey gravels and sands (preferred), through to poorly graded sands (least preferred), and preferably contain no rock particles >75mm.

6.3 Erosion Protection

Scour in unprotected soils will typically occur when maximum velocities reach about 1.2-2m/s for clays, up to about 1.5m/s for sand, and higher for rocky material.

Rock armour can be used to protect earthworks against scouring and erosion, and can be applied where problems occur or in the long term where permissible velocities may be exceeded. Generally, it is not considered necessary to rock armour an operational embankment or channel against velocities <2m/s for the design flood event (subject to operational experience).

6.4 Pit Edge Zones

Diversion infrastructure around pit areas should be located 10m outside the area designated as a potentially unstable rock mass and susceptible to pit wall collapse. In general this distance varies depending on whether pit walls are excavated entirely in unweathered rock, in weathered rock, or in both.

6.5 Construction

Earthworks construction requirements typically entail:

- Excavate to strip depth, scarify the base in preparation for construction of an embankment;
- Maintain moisture content in the embankment material at optimum (which allows the maximum density to be achieved by the compaction equipment in use);
- Place and compact material in layers as specified (e.g. 95% SMDD (Standard Maximum Dry Density); or 92% MMDD (Modified Standard Maximum Dry Density);
- Control batter slopes to line and level.

7. EROSION AND RUNOFF

7.1 General Principles

The landscape can be subject to heavy rainfall. The potential for erosion and sedimentation offsite is increased significantly on disturbed or degraded lands, following vegetation and topsoil removal, mining activities, spoil stockpiling, and general construction activities.

Generally environmental approvals for projects that involve land and hydrological disturbance require adherence to surface water protection principles, to maintain surface water regimes, so that existing and potential uses, and the ecosystem, are protected.

7.2 Potential Surface Water Impacts

Potential surface water impacts include the interruption to existing surface water flow patterns, with the possible reduction of surface water runoff volume or water quality in the environment downstream (vegetation and fauna communities dependent on good quality water), and particularly relating to sediment laden run-off from waste dumps and stockpiles.

In addition, the storage and spillage of chemicals and hydrocarbons can also adversely impact water quality downstream. The random pooling of water around the site, and growth of invasive vegetation in low-lying areas should also be eliminated.

7.3 Management Actions

Surface water management requires consideration of each sub-catchment / drainage area, with the application of engineering surface water controls to prevent sediment (and other contaminants) from entering natural flow paths. These measures include diversions, erosion and sedimentation controls (i.e. sediment basins) and possibly dispersion mechanisms.

Management actions to mitigate the impacts of surface water flooding include:

- Avoid interference with drainage systems;
- Flood modelling to guide the location of developments and required flood protection measures (rock armour or revegetate development sites, waste dumps, etc. to protect from erosion);
- Obtain "Permit to Interfere with Bed and Banks" as required, where interfering with water courses;
- Investigate required diversions of upstream flows around structures;
- Permanent stream diversions can match the characteristics of the original natural stream;
- Construction near natural flow paths in the dry season only;
- Bund-off disturbed areas, waste dumps, stockpiles to contain surface runoff and direct it to a sediment trap or sump prior to discharge to the external environment;
- Water quality of the treated discharge may be an ‘outcome based’ criterion (Figure 6), but is typically prescriptive – the sediment trap or sump may be a dam-like structure (Figure 7 “dry” trap, or Figure 8 “wet” trap) or a smaller more localised rectangular “turkeys nest” type of structure (Figure 9, either dry with an outflow control structure, or wet without an outflow control structure;
- Fit outflow baffles to capture potentially polluted runoff (e.g. oil and grease);
- Keep vehicle movements to designated tracks;
- Maintain watercourses, install culverts, to prevent disruption of major flow paths;
- Minimise and properly manage on site solid waste disposal;

- Treat and dispose of all domestic wastewater / WWTP effluent appropriately;
- Store hazardous substances in properly bunded sites with appropriate emergency response procedures.

7.4 Assessment of Runoff Loss to the Downstream Environment

The Lamb Creek development lies within the Marillana Creek catchment. There will be an effective reduction or loss in catchment area from the mining infrastructure footprints.

Runoff volumes from infrastructure areas such as roofs, hardstands and access roads may increase from concentration and redirection of flows, but are considered to remain effectively unchanged (neutral). The runoff volume containing pits and waste dump areas is likely to decrease, due to the catchments blocked or trapped by these works.

Only the pit and waste dumps areas have been considered to contribute to the non-recovered runoff volume. On this basis, non-recovered runoff volume losses have been assumed as follows:

- 100% loss of runoff volume from the pit area (0.8km^2);
- 50% loss of runoff volume from WRLs (0.3km^2, or 50% x 0.6km^2);
- 50% loss of runoff volume from topsoil stockpiles (0.25km^2, or 50% x 0.5km^2).

As such the pit and waste dump areas represent an approximately 1.4km^2 effective reduction in contributing catchment area to the Marillana Creek catchment area of 1,369km^2 (at the Flat Rocks gauging station, 20km downstream of the Lamb Creek mine). The lost Lamb Creek catchment is 0.1% of this catchment.

Assuming the reduction in catchment area is directly proportional to the reduction in runoff volume, a 0.1% potential reduction in runoff volumes would not be environmentally significant, particularly when considering the much greater natural seasonal variations in rainfall and catchment runoff.

The Lamb Creek lost catchment is only 1.8% of local North Creek catchment at the site, again not environmentally significant.

8. GENERAL GUIDELINES POST-CLOSURE

8.1 Post Closure Design Criteria

The objective of the mine closure guidelines is to ensure an effective planning process is in place throughout the life of mine, so closure is achieved in an environmentally sustainable manner and without unacceptable liability to the State (refer "Guidelines for Preparing Mine Closure Plans", Department of Mines and Petroleum, and Environmental Protection Agency).

General mine closure principles include:

- Surface and groundwater hydrological patterns / flows not adversely affected;
- Surface and groundwater levels, and water quality reflect original levels and water chemistry;
- No long term reduction in base flow to meet local environmental values.

8.2 Land Disturbance and Rehabilitation

Mining is a temporary land use, and therefore rehabilitation objectives should be consistent with the projected future land use. Post-mining landforms consist of unconsolidated materials, dispersive, and erodible materials, combined with steep and / or long slopes, which give rise to high erosion risks, and in turn reduction in water quality downstream. Rehabilitation strategies must be integrated with mine development planning and operations, and designed to be maintenance free over the long term, to minimise the environmental impacts of the project and maximise rehabilitation success.

The objective is to rehabilitate disturbed areas to safe and stable landforms, containing endemic plant communities that approximate those that existed prior to the disturbance. These areas should be free draining, non-polluting and visually compatible with the surrounding landscape, suitable for alternative land use (such as pastoralism and heritage conservation). In particular, surface water management on reconstructed landforms is required to avoid erosion gullying, tilling, loss of surface material and factors affecting surface stability and revegetation.

8.3 Decommissioning

On completion of mining, decommissioning involves minimising sterilisation of ore reserves, rehandling of waste materials, and visual impact considerations / blending with natural landforms. It includes the removal of the remaining infrastructure and rehabilitation of areas disturbed by the mine operations, including tanks, wastes, contaminated soil, compacted surfaces e.g. old roadways, site compounds, etc.

8.4 Waste Rock Landforms (WRL)

Waste dumps are usually the landforms most prone to erosion post mining. Geomorphic principles should be applied to the design of stable landforms over the long term. These principles dictate drainage density and size of catchments, and slope angles – the incorporation of slope features that emulate natural slopes, that are in equilibrium with local conditions, rainfall, soil type, and vegetation cover.

DMP guidelines for arid regions propose that the top of the landform profile should preferably be water retaining (i.e. the top surface, berms and batters be constructed to hold the maximum expected rainfall event, provided this does not cause ground instability, or contaminated leachate and groundwater seepage). This reduces water flow and erosion down the final landform slopes. The slopes should have a maximum slope of 15-20°, with contour ripping to assist with water infiltration, application of topsoil and natural vegetation regeneration.

Rock armour can also be applied as an armour substrate to the rehabilitated slopes, and used to increase the maximum permissible runoff velocities for the exposed soil; with topsoil applied and incorporated into the armouring layer.

8.5 Monitoring

Completion criteria are agreed standards to be achieved on particular aspects of the mining operation. Progressive assessment against these agreed criteria demonstrates the relative success of rehabilitation in achieving desired outcomes, and whether the rehabilitation end point has been reached. Rehabilitation performance criteria include assessment of post-closure land use objectives, landform stability, ground water protection, and revegetation targets. Where possible, completion criteria should be developed from actual rehabilitation trials and site experience to ensure that rehabilitation methods are effective, durable and achievable.

Completion criteria should be flexible to adapt to changing circumstances, time based (trend) so rehabilitation development can be assessed as to whether it is progressing well towards a defined end point, and designed to allow effective reporting and auditing to determine the endpoint and allow sites to be relinquished.

9. CONCLUSION

The surface water management plan for the project development is summarised in Figure 5.

All drainage catchments flow northward into the major creek systems (North Creek and then Marillana Creek). Flood protection of significant infrastructure should be provided at about the 50-100 year protection level based on a 20 year life-of-mine.

The best method of water management is to locate infrastructure away from significant creeks and avoid the need for diversion works where possible. Otherwise surface water diversion is required when infrastructure lies across existing surface water flow patterns. A combination of bunds and excavated channels with an appropriate freeboard is required to carry flood waters around infrastructure via a flow path different from the natural water course. Earthworks diversions are generally constructed using cut-to-fill, but can also be all cut, or all fill.

The deposit lies at the western end of a ridge line, and the development of the pit will cut off minor catchments only, with the possibility of breakout flow from the creek draining the ridgeline.

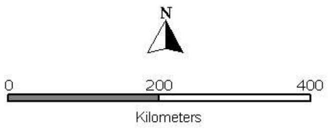
The rainfall in the area averages about 300-350mm per annum and direct rainfall collecting at the bottom of the pit would average about 15,000-20,000m^3 annually (but extremely variable from year to year). The 10 year flood volume would be about 30,000m^3, taking about 1 week to pump out at 50L/s; and the 100 year flood would be about 70,000m^3, taking about 1 week to pump out at 100L/s.

The Lamb Creek development lies within the Marillana Creek catchment. The combined pit, WRL and topsoil footprint areas, and any catchments blocked or trapped, are likely to decrease runoff volume into Marillana Creek. The total effective catchment loss is approximated as 1.4km^2, equivalent to 0.1% of the Marrilana Creek catchment. This reduction in runoff volumes in a widely variable rainfall regime is environmentally insignificant.

There is a risk of erosion and sedimentation on disturbed and degraded landscapes. The general objective is to maintain the hydrological regimes so that existing and potential users, including ecosystems, are protected.

Storage areas (chemicals, hydrocarbons, etc.) should be located away from, or bunded off from, external surface water flows. Every point of discharge should limit erosion and transport of sediment away from the site. Discharge points should be stable and non-erosive, at existing water courses or otherwise dispersed. Where sedimentation issues occur, surface water run-off can be collected at the site boundary, behind bunded storage and as necessary passed through sedimentation basins at key low points, from which treated water can then discharge to the environment.

Monitoring during the life of mine will ensure the proposed surface water management measures are effective in maintaining the hydrological regimes in the downstream environment.



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DRAWN:	AB	REVISION:	A
DATE:	31/10/17	JOB NO:	EWP72691

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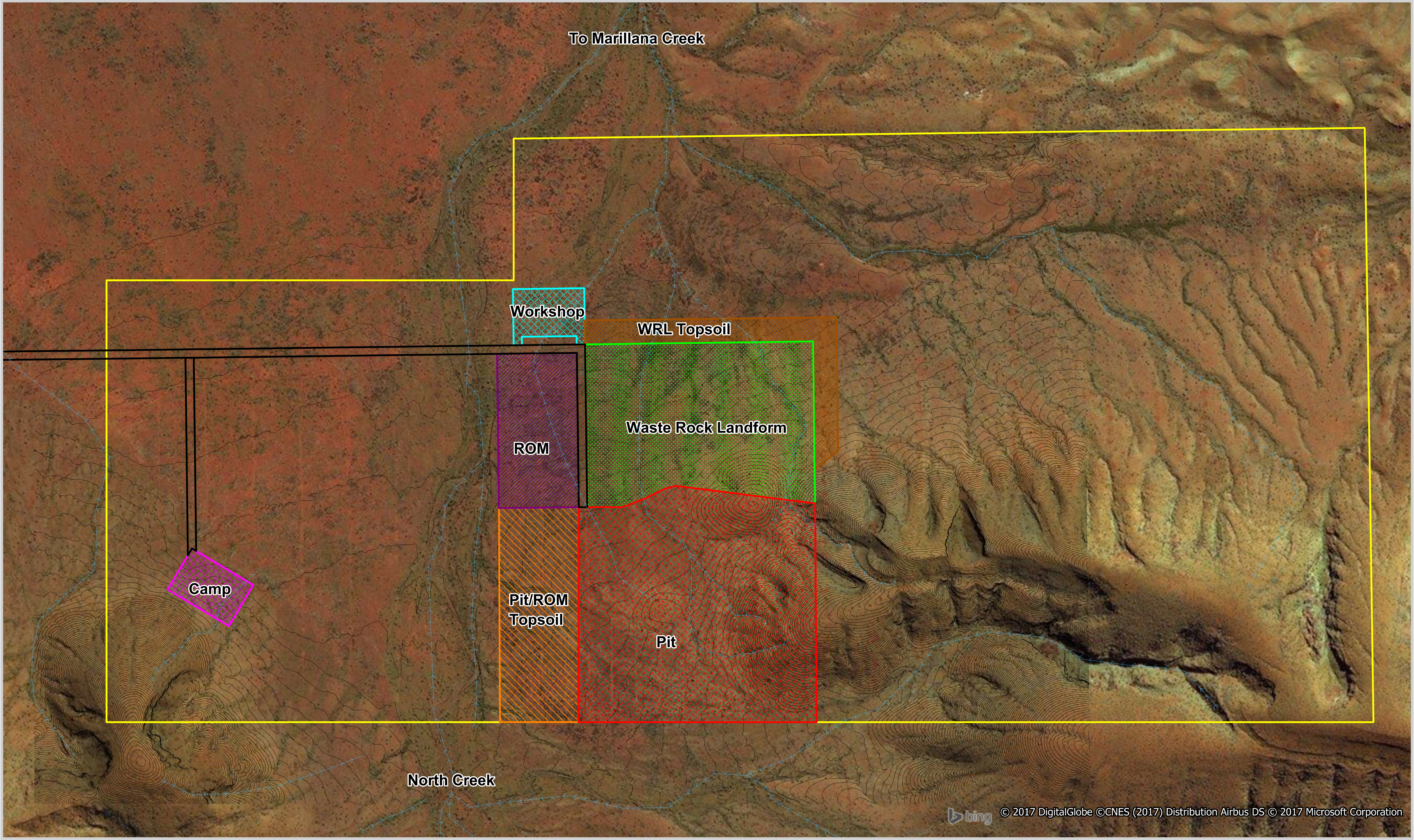
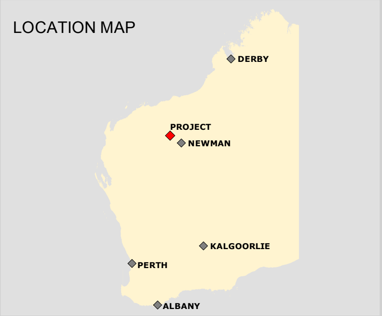
FIGURE 1

REGIONAL LOCATION PLAN

Location: F:\Jobs\EWP72691.001 - Lamb Creek Surface Water Study\Spatial_Data\MapInfo\Workspaces\Lamb Creek_Figure1



LOCATION MAP



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LEGEND

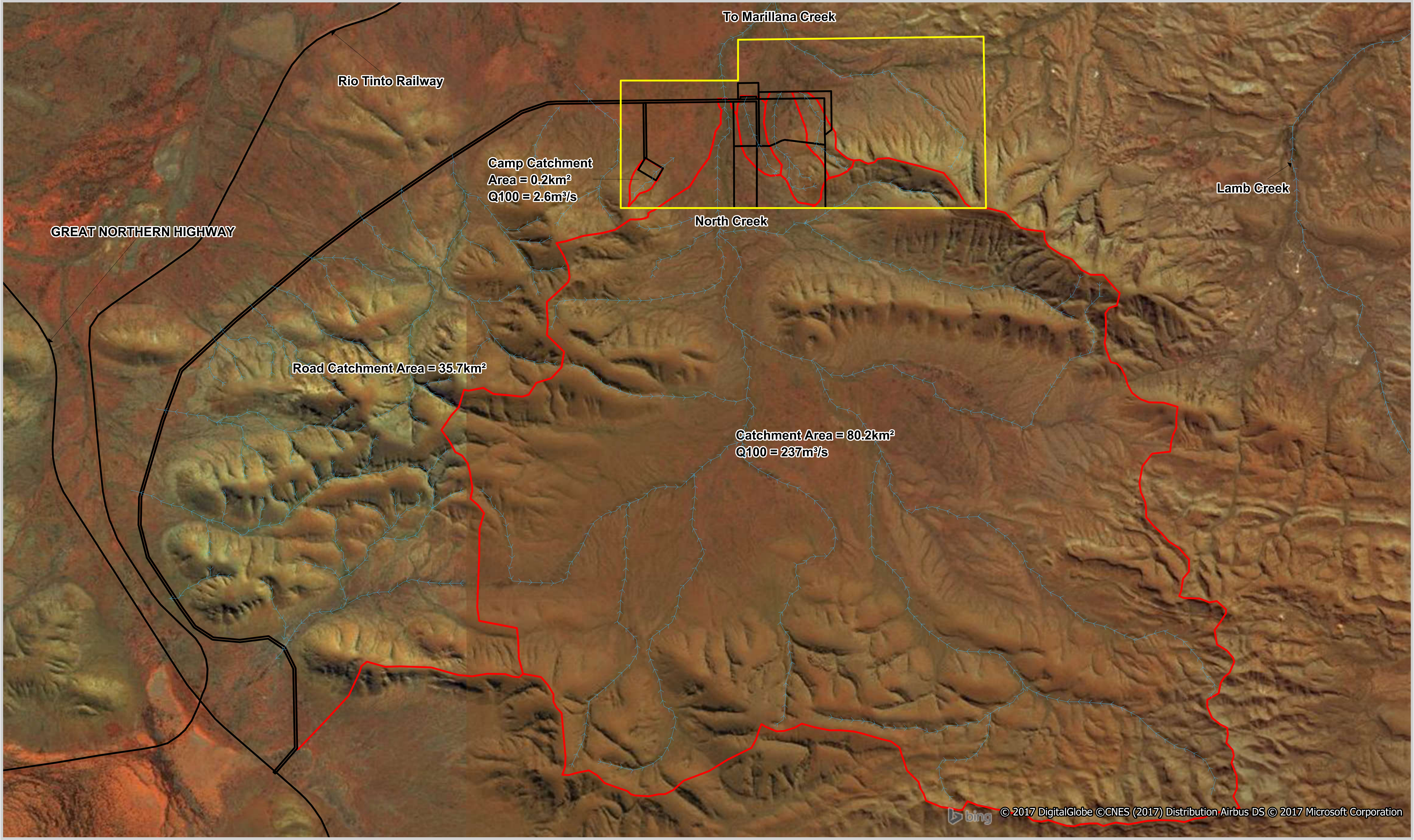
▭	Lease Boundary
═	Indicative Haul Road
→	Flow Paths

RPS

FIGURE 2

GENERAL LAYOUT

Location: F:\Jobs\EWP72691.001 - Lamb Creek Surface Water Study\Spatial_Data\MapInfo\Workspaces\Lamb Creek_Figure2



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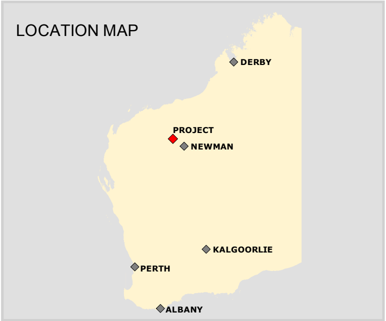
LOCATION MAP



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LEGEND

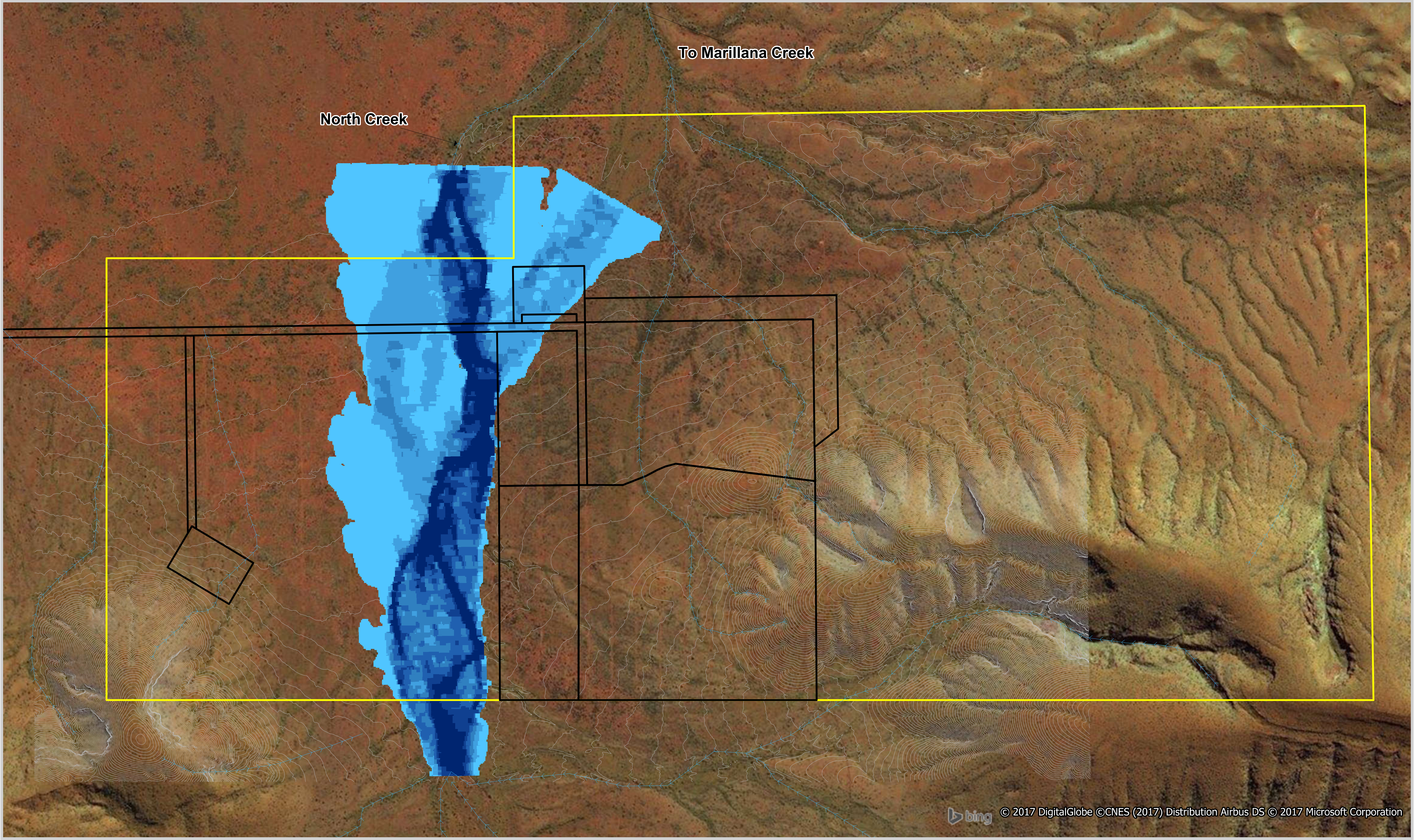
▭	Catchment Area
▭	Lease Boundary
▭	Lamb Creek Mine Infrastructure
→	Flow Paths

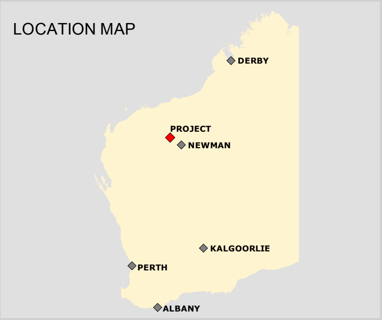
RPS

FIGURE 3

SURFACE WATER CATCHMENTS

Location: F:\Jobs\EWP72691.001 - Lamb Creek Surface Water Study\Spatial_Data\MapInfo\Workspaces\Lamb Creek_Figure3





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REVISION:	A
JOB NO:	EWP72691

LEGEND

▭	Lease Boundary
▭	Lamb Creek Mine Infrastructure
→	Flow Paths

Water Depth (m)

■	1.0 to 2.57 (max)
■	0.8 to 1.0
■	0.6 to 0.8
■	0.4 to 0.6
■	0.2 to 0.4
■	0 to 0.2

RPS

FIGURE 4

100YR FLOOD DEPTHS PRE-DEVELOPMENT

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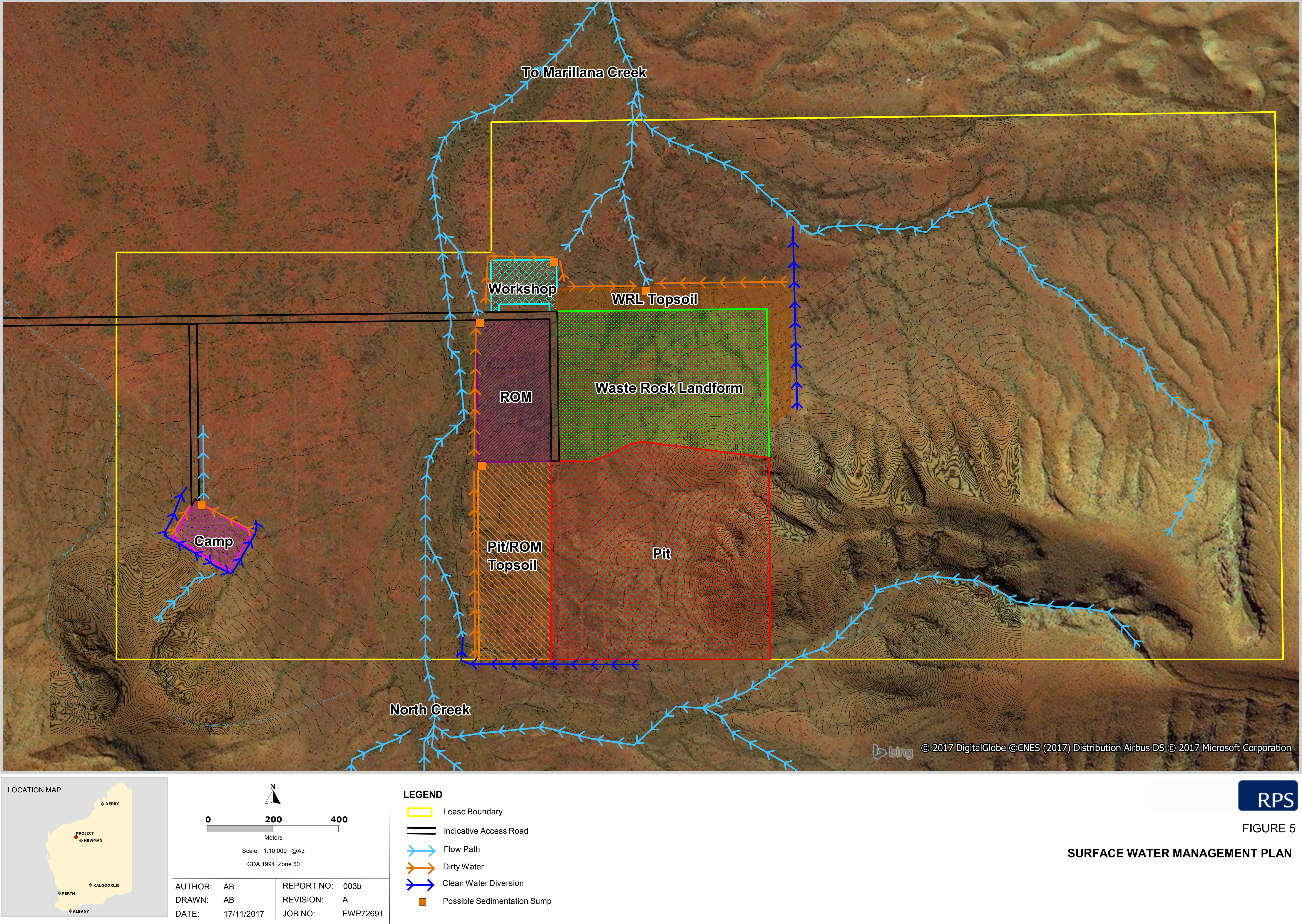

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DATE:	17/11/2017	JOB NO:	EWP72691

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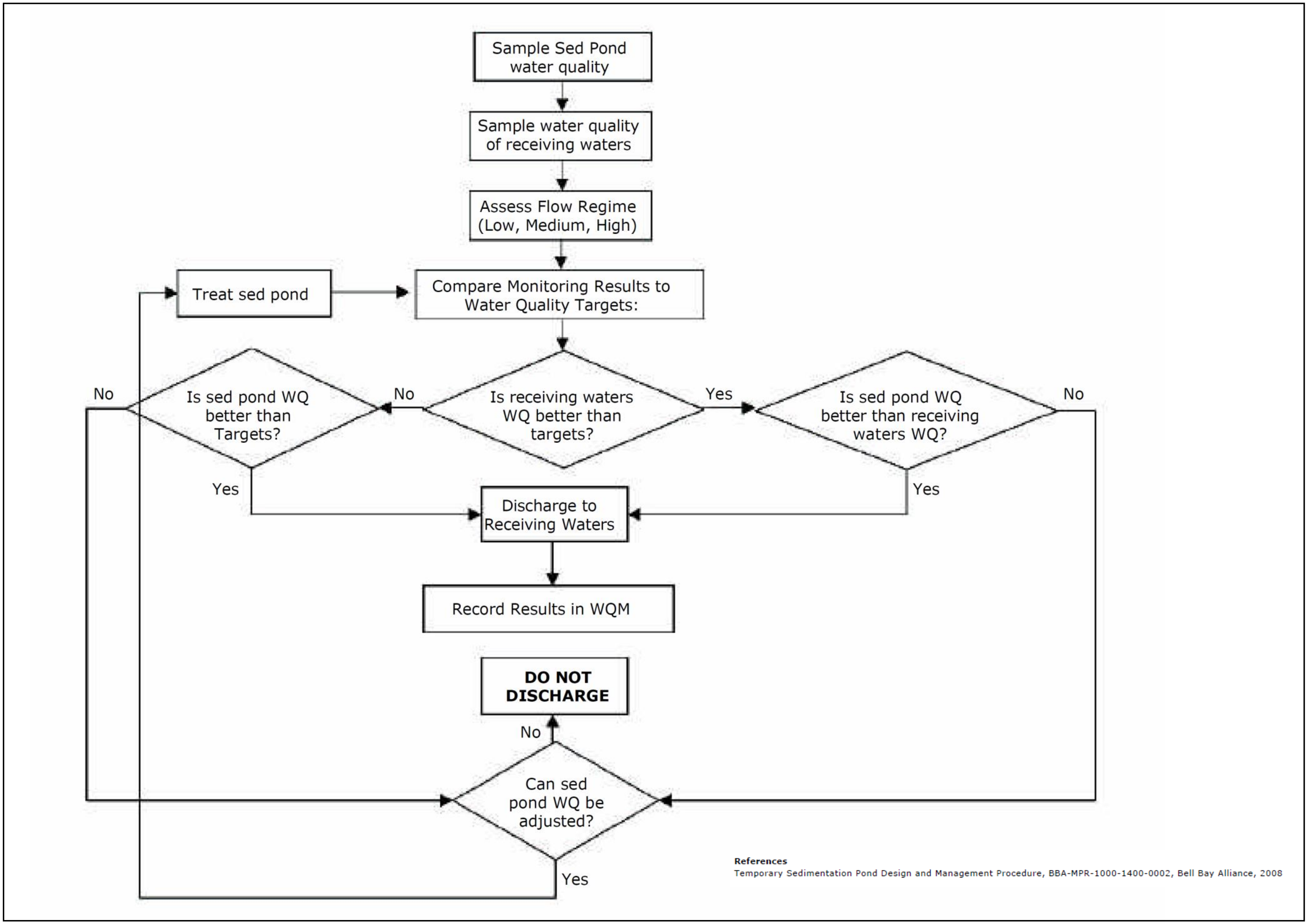
FIGURE 5

SURFACE WATER MANAGEMENT PLAN



References

Temporary Sedimentation Pond Design and Management Procedure, BBA-MPR-1000-1400-0002, Bell Bay Alliance, 2008

31/10/2017

FLOWCHART FOR DISCHARGE OF WATER OFFSITE FIGURE 6

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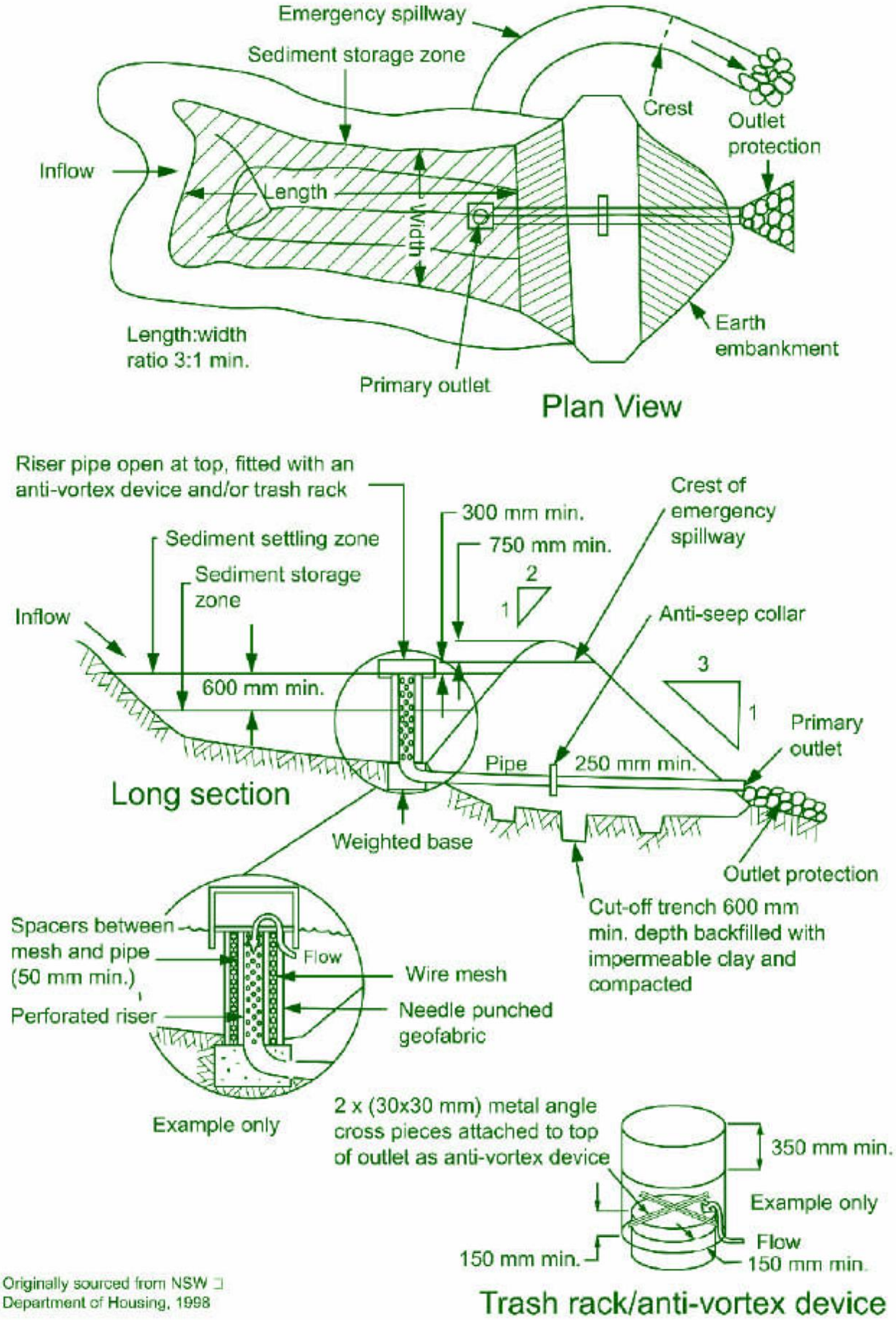
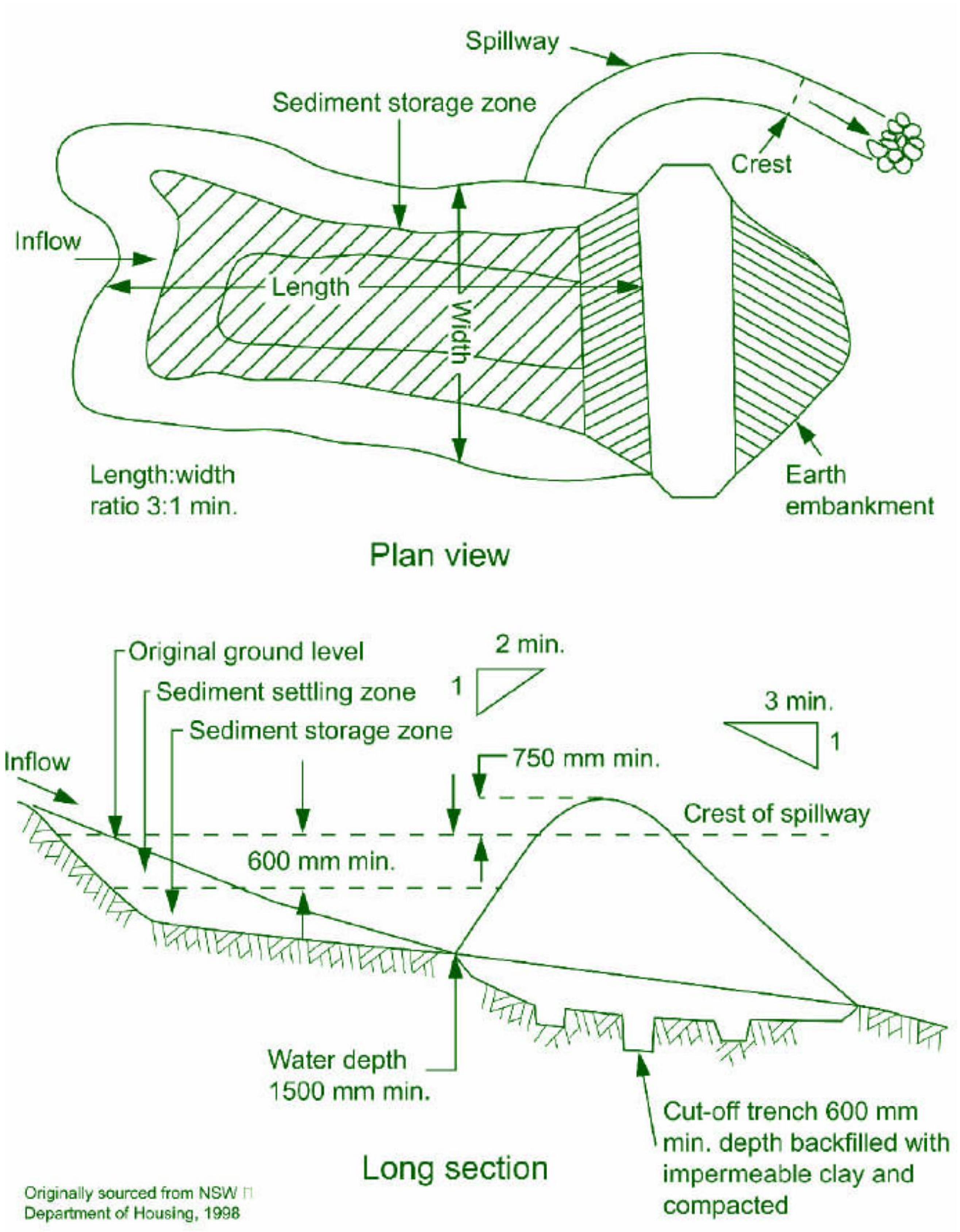


Originally sourced from NSW
Department of Housing, 1998

TYPICAL DRY SEDIMENTATION BASIN WITH OUTLET FIGURE 7



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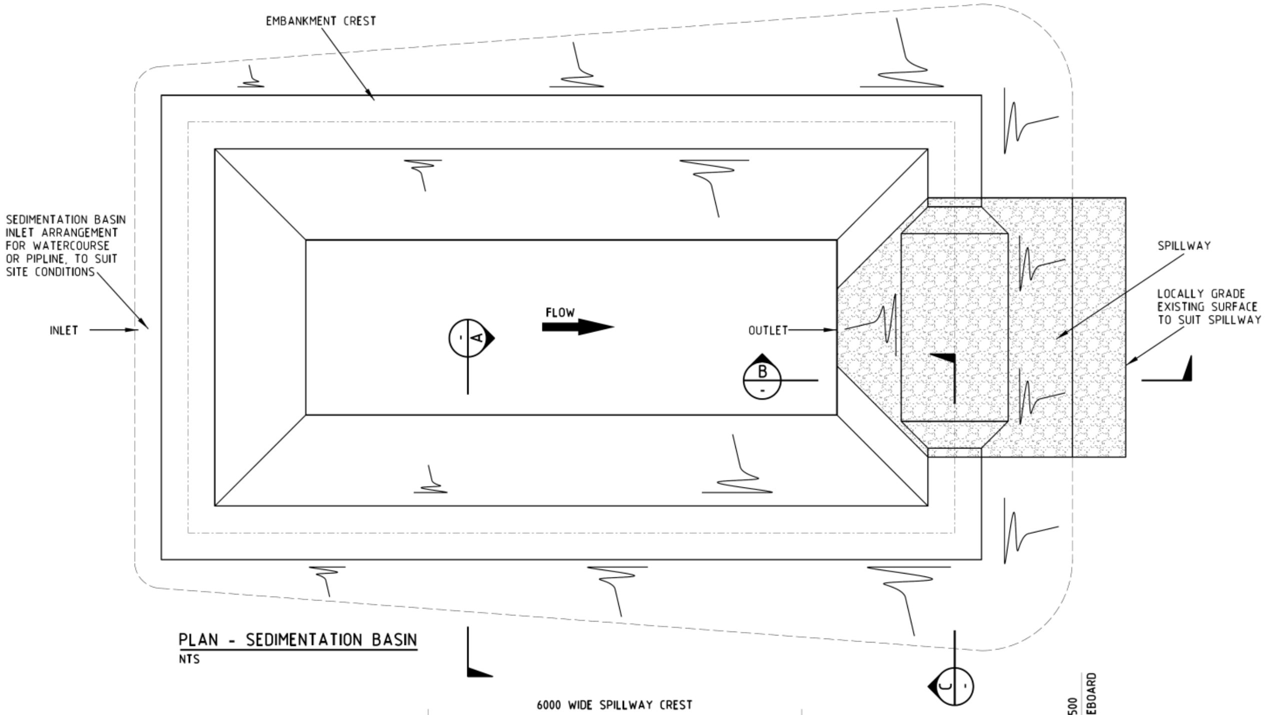
Department of Housing, 1998

TYPICAL WET SEDIMENT BASIN FIGURE 8



PLAN - SEDIMENTATION BASIN
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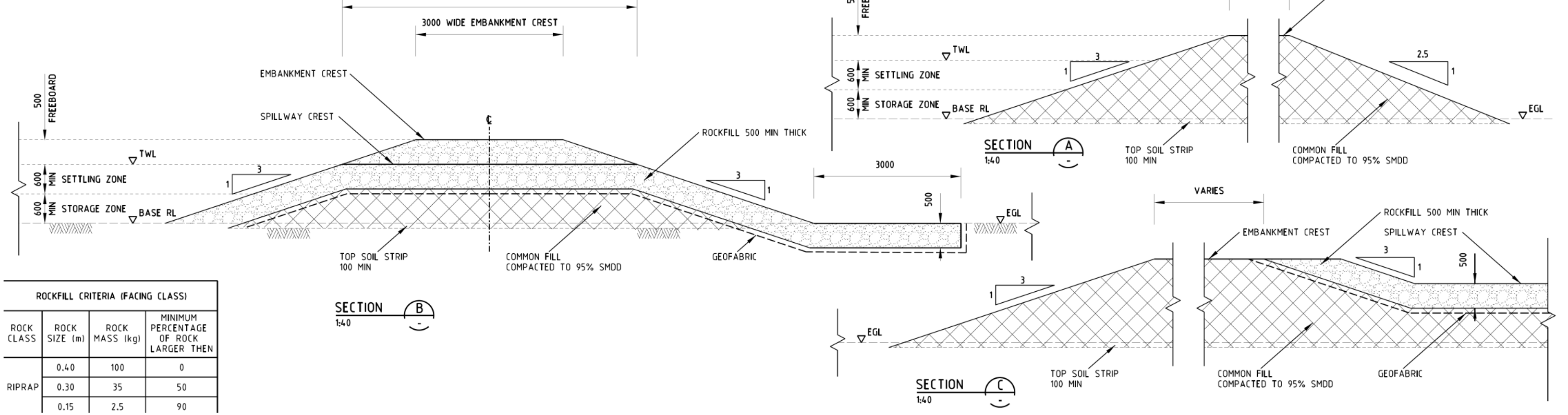
GENERAL NOTES:

1. SEDIMENT BASINS ARE TYPICALLY CONSTRUCTED AS SMALL EARTHEN DAMS, SIMILAR TO "FARM DAMS".
2. BASINS TO BE CONSTRUCTED USING THE MOST SUITABLE AVAILABLE MATERIAL AT THE SITE, BUT ARE TYPICALLY LOCAL CLAYS, SANDS AND GRAVELS (SHOULD CONTAIN 20-30% CLAY WITH SAND, SILT AND SOME GRAVEL, AND NO ROCKS GREATER THAN 75mm SIZE).
3. THE MOST EFFICIENT SHAPE IS A LENGTH TO WIDTH RATIO OF 3:1 TO 8:1
4. THE INLET AND DISCHARGE POINTS TO BE LOCATED OPPOSITE FOR MAXIMUM INTERNAL FLOW LENGTH.
5. BAFFLES MAY BE USED, IF NECESSARY, TO PREVENT SHORT CIRCUITING.
6. AS THE BASIN FILLS WITH SEDIMENT, IT SHOULD NOT ENCOURAGE RE-ENTRAINMENT AND SCOUR OF SETTLED SEDIMENT.
7. THE REQUIRED BASIN TOP WATER SURFACE AREA (m×) ~ 21 X Ac (CATCHMENT AREA IN HA). NOTE 25% VOLUMETRIC RUNOFF ASSUMED, THE AMOUNT OF RUNOFF CAN VARY WITH CATCHMENT CHARACTERISTICS.
8. FOR EMBANKMENT HEIGHTS UP TO 3m, SIDE SLOPES TO BE 3:1 (H : V) UPSTREAM AND 2.5 : 1 DOWNSTREAM OR FLATTER. MINIMUM CREST WIDTH 3m.
9. SEDIMENT BASINS, SPILLWAYS AND FREEBOARD MUST BE DESIGNED TO WITHSTAND PEAK RUNOFF FROM A DESIGN STORM IN THE WATERCOURSE (TYPICALLY 100 YEAR ARI EVENT FOR A LONG TERM BASIN).
10. THE INFLOW CHANNEL TO BE STABILISED SO THAT IT DOES NOT ERODE THE BASIN EMBANKMENTS.
11. THE CREST LEVEL FOR THE SPILLWAY SHOULD BE THE HIGHEST FEASIBLE (ALLOWING FOR FREEBOARD) TO MAXIMISE THE STORAGE VOLUME WITHIN THE BASIN WITHOUT CAUSING UNDUE BACKWATER IN THE INFLOW CHANNEL.
12. THE PRINCIPAL MAINTENANCE ACTIVITY FOR SEDIMENT BASINS IS THE REMOVAL OF SEDIMENT.
13. HYDROLOGY AND HYDRAULIC CHECKS TO BE CARRIED OUT BY QUALIFIED ENGINEER PRIOR TO CONSTRUCTION.



SECTION B
1:40

SECTION A
1:40

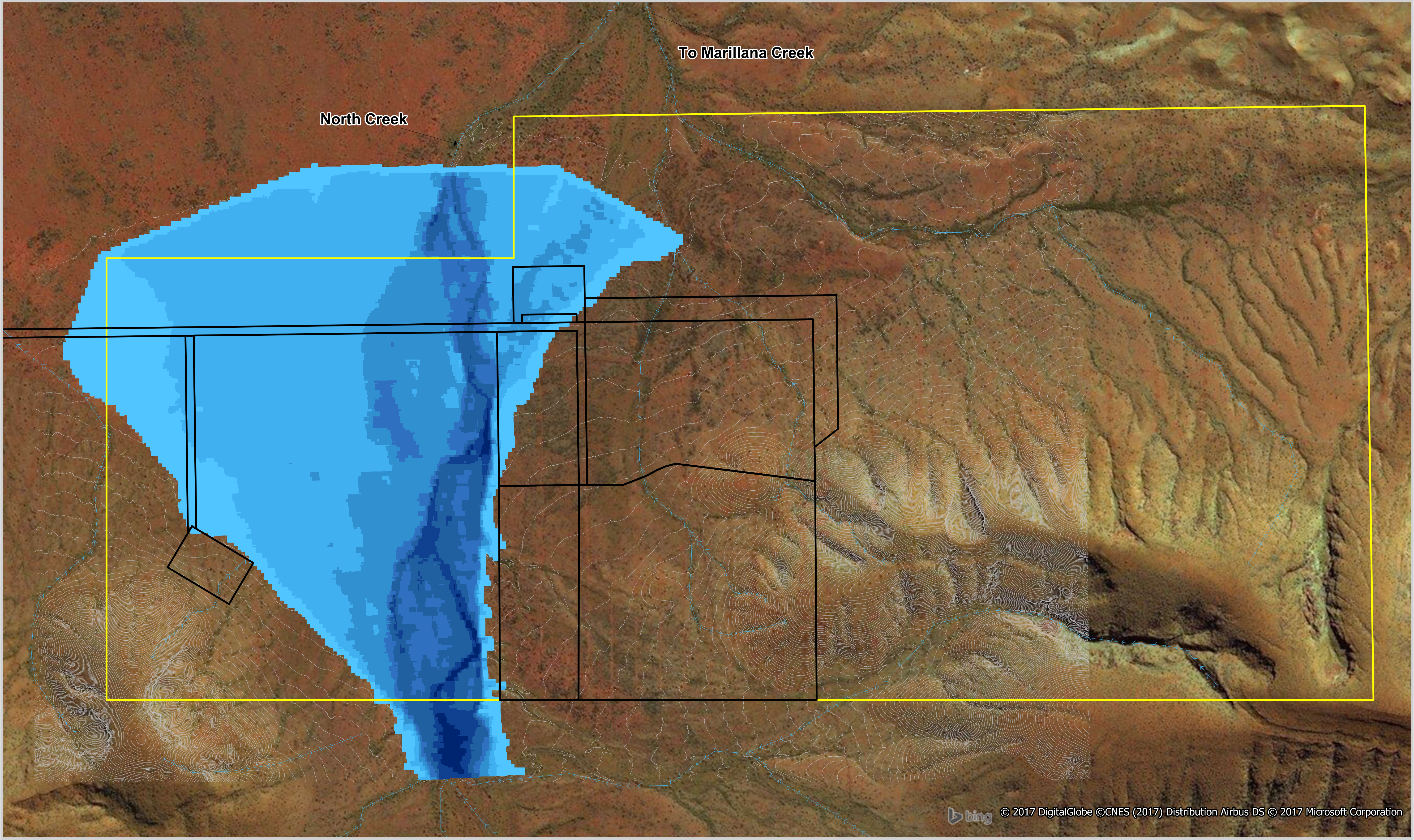
SECTION C
1:40

ROCKFILL CRITERIA (FACING CLASS)			
ROCK CLASS	ROCK SIZE (m)	ROCK MASS (kg)	MINIMUM PERCENTAGE OF ROCK LARGER THEN
	0.40	100	0
RIPRAP	0.30	35	50
	0.15	2.5	90

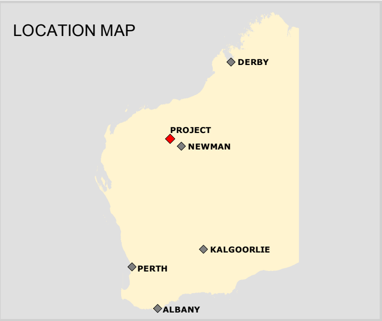
RPS
31/10/2017

TYPICAL LARGE TURKEYS NEST SEDIMENT BASIN FIGURE 9

F:\Jobs\EWP72691.001 - Lamb Creek Surface Water Study\Report\003a Figures



LOCATION MAP



N

0 300 600

Meters

Scale: 1:15,000 @A3

GDA 1994 Zone 50

AUTHOR: AB
DRAWN: AB
DATE: 17/11/2017

REPORT NO: 003b
REVISION: A
JOB NO: EWP72691

Location: F:\Jobs\EWP72691.001 - Lamb Creek Surface Water Study\Spatial_Data\MapInfo\Workspaces\Lamb Creek_Figure10

LEGEND

🟨	Lease Boundary
⬜	Lamb Creek Mine Infrastructure
→	Flow Paths

Water Depth (m)	
🟦	3.0 to 3.8 (max)
🟦	2.5 to 3.0
🟦	2.0 to 2.5
🟦	1.5 to 2.0
🟦	1.0 to 1.5
🟦	0.5 to 1.0
🟦	0 to 0.5

RPS

FIGURE 10

PMF FLOOD DEPTHS
PRE-DEVELOPMENT

Level 4, 56 William Street
Perth WA 6000

Tel +61 8 9322 9733
www.aq2.com.au

AQ2 Pty Ltd
ABN 38 164 858 075

Memo

To	Enrico Chedid/Adam Parker	**Company**	Mineral Resources Ltd (MRL)
From	Brieland	**Job No.**	326C
Date	07/07/2021	**Doc No.**	006 b
Subject	Lamb Creek Surface Water Monitoring Installation and Monitoring Data Review – December 2020 to February 2021		

Enrico,

Please find below a technical memo documenting the installation of surface water monitoring stations at Lamb Creek and our subsequent review of the monitoring data collected for the period of December 2020 to April 2021.

1. OVERVIEW

MRL proposed to install a surface water monitoring network at the proposed Lamb Creek mine site to collect Baseline hydrological information at the site. AQ2 assisted with identification of potential surface water monitoring locations based on a desktop review of the proposed mining layout and topography information.

In December 2020, AQ2 completed a site visit at Lamb Creek to complete the following activities:

- Ground truth proposed surface water monitoring station installation locations.
- Install two new surface water monitoring stations consisting of a pressure transducer and water quality mounting kit.

In February 2021, water samples from the mounting kits were collected and data from the loggers was downloaded. This memo summarizes the activities completed and provides a high-level review of the collected data.

2. MONITORING STATION INSTALLATION

2.1 Planning, Access and Logistics

Prior to attending site, the following tasks were completed:

- Desktop review of installation locations for planning purposes based on mine layout plans and site topography information.
- Concept design of monitoring stations (refer Figure 1).
- Procurement and fabrication of equipment not provided by MRL (monitoring station housings).
- Inductions and health, safety and environment planning for the site visit.

Exploration activities at Lamb Creek began in July 2020. At the time of the visit to install the surface water monitoring stations, multiple drill rigs were present on site, though they did not impact site access to the surface water monitoring installation locations.

AQ2 completed all required inductions under the supervision of Daniel Thomson (Exploration Supervisor) and was escorted by a field technician to complete the installations.

2.2 Monitoring Station Locations

The location of the two monitoring stations that were installed at the Lamb Creek project area are shown in Figure 2. The stations were positioned such that Lamb Creek South is positioned within the main drainage line close to the lease boundary on the upstream side of the project and can be used for reference water quality/flow information. Lamb Creek North was positioned in the same drainage line but at the lease boundary downstream of the proposed project development. Lamb Creek North would provide water quality/flow information at a point where the proposed operations have the potential to impact the surface water regime. Note that the mine layout includes some infrastructure which is located downstream of the Lamb Creek North gauging site, but it was not possible to install a gauging site on the creek line further downstream within the tenement boundary.

A separate barologger was installed in proximity to the Exploration office approximately 2km from the surface water installation locations.

Each monitoring station consists of a housing unit for a pressure transducer (with inbuilt data logger) and passive water sample collection system. Further details are provided below.

2.2.1 Monitoring Station Equipment

Each pressure transducer was installed within a fabricated steel housing mounted to a star picket, with Nalgene water quality mounting kits attached to the outside of the steel housing.

Each housing included the following (refer Figure 1):

- One star picket driven into the creek bed and connected to a steel housing unit.
- A further star picket installed ~1m upstream to attempt to protect the housing from debris.
- Steel housing which consisted of a 50mm square tube with slots cut to allow water entry.
- Within the steel housing, a capped PVC pipe was installed with holes drilled to allow water entry. Filter sock was wrapped around the PVC to prevent ingress of sediment to the PVC pipe.
- An In Situ Level Troll 400 pressure transducer installed within the PVC pipe (see further information below).
- 2 x 400mm lengths of rebar hammered into creek bed at 45-degree angle.
- 1 x 20kg bag of cement poured around the star picket, steel housing and rebar protruding further into the creek bed to provide further stability to the installation.

Mounting kits (with sample bottles inside) were attached to the same star picket as the logger housing at a height of approximately 300mm above the base of the creek. An installation summary is shown below in Table 1, with photos of the installations shown in Photos 1 and 2.

Table 1: Installation Summary

Site ID	Easting, Northing	Type	Depth To Sensor (mm)[1]	Installation Date
Lamb_Creek_North	691431, 7477358	Level and Quality	565	09/12/2020
Lamb_Creek_South	691234, 7475634	Level and Quality	550	09/12/2020

1-reference measurement taken from the bottom of the PVC cap to the point at which pressure readings are taken.

2.2.2 Transducer Setup

In Situ Level Troll 400 pressure transducers were installed to measure water pressure at each of the monitoring stations. Prior to installation, loggers for each site were programmed with the following data logging parameters:

- 5-minute data-collection intervals. Given the likely flashy behaviour of runoff in the catchment, a longer data-collection interval may miss important creek flow information. A finer collection interval would fill the data logger memory too quickly (see below).
- Linear sampling mode, whereby once the logger memory is full, new readings are logged by writing-over the oldest readings. With 5-minute data-collection intervals, the loggers are anticipated to have capacity to store approximately 12 months of readings.

All loggers were installed with the pressure sensor approximately level with the creek bed, with a reference measurement obtained from the top of the PVC cap to the level sensor (refer Table 1).

3. DATA COLLECTION – FEBRUARY 2021

3.1.1 Logger Downloads

The data loggers from each site were removed by Rapallo in February 2021 and provided to AQ2 for data download and validation. The barologger was located on site and the data was downloaded; it was not removed.

3.1.2 Water Sampling

In February 2021, Rapallo was engaged by MRL to retrieve water samples from the two monitoring stations. AQ2 provided instructions on sample retrieval, storage and submission to the nominated laboratory (ChemCentre). Samples were taken on 23 February and delivered to the laboratory on 04 March.

The following parameters were measured by the laboratory:

- Aluminium, total (mg/L)
- Iron, total (mg/L)
- Manganese, total (mg/L)
- Zinc, total (mg/L)
- Electrical Conductivity (mS/m)
- Nitrogen, total (mg/L)
- Turbidity (NTU)

4. DATA PROCESSING

4.1 Barometric Pressure Correction of Water Pressure Data

As the pressure transducers are non-vented, the measured values account for both the barometric pressure as well as any water pressure occurring from streamflow events. To correct the water pressure measurements for changes in atmospheric pressure, local barometric pressure records from the installed Barologger were removed from the water pressure dataset. The resulting water pressure dataset was then converted to a water depth based on an assumed density of water. AQ2 reviewed the barometric pressure data and resulting water depth datasets to ensure the measurements looked believable (see Data Validation below).

5. DATA VALIDATION

5.1 Water Pressure Data

A brief assessment of the logger data from both monitoring locations was completed to validate the logger data against rainfall data from BoM's Karijini North weather station. The Karijini North weather station is located 36km away from the Project site and the recorded rainfall may not represent site rainfall conditions.

The corrected water depths from each monitoring station are plotted against rainfall from Karijini North weather station in Figures 3 and 4. Small flow events appeared to be measured between 1st and 17th January, with three separate flow peaks appearing to occur on 01/01, 06/01 and

17/01/2021. These flow responses were consistent between the North and South monitoring station locations, with peak flow depths of about 0.12m recorded on 06/01/2021 at both stations. While the flow responses were not a result of the largest rainfall events recorded at Karijini North (75mm on 11 December 2020 and 68mm on 2 February 2021), they do coincide with smaller events that may have been more pronounced near the Lamb Creek project area.

The variability in the measured water levels that can be seen during December 2020 is indicative of the accuracy of the measurements completed. The measurements (when corrected for barometric pressure variability) oscillate with a magnitude of around 0.02m; the accuracy of the depth measurements is likely to be in the range of +/- 0.02m. This level of noise is relatively significant for the events measured (which were minor flow events) but would be less significant when the larger runoff events are recorded.

Lamb Creek South had two pressure spikes in February 2021 where one-off high-pressure measurements were recorded. These are not considered to be runoff events given the measurements did not persist for longer than one record period and were not recorded at Lamb Creek North. These data points should be removed from the baseline data set.

Given the measured flow responses at both monitoring stations were consistent and occurred during periods where rainfall was recorded in the region, the data appears reasonable. However, the measured flow depth of 0.12m would not be large enough for a streamflow event to fill the water quality sampling unit, which was positioned 0.5m above the creek bed (and pressure transducer measurement point). Given a water sample was collected from the sample bottle, there is inconsistency with the collected data.

To review these discrepancies, the following was completed:

- Test of pressure transducers.
- Inspection of water quality mounting kits and sample bottles.
- Review of water sample laboratory results.

5.2 Pressure Transducer Tests

The pressure transducers were tested to verify their operation. Each pressure transducer was submerged in a bucket of water and the recorded data (corrected for barometric pressure) was checked against measured water depths in the bucket. The test indicated that both pressure transducers were operating accurately.

5.3 Condition/Field Test of Mounting Kits/Sample Bottles

From previous experience deploying and retrieving the mounting kits and sample bottles in drainage channels in the Pilbara, there are generally high levels of sediment and debris trapped in bottles and mounting kits following runoff events. In both locations at Lamb Creek, water collected within the sample bottle when logger data indicated the intake level was not reached. Simple field tests of the kits and sample bottles indicated that water accumulation (from rainfall) on the top of the mounting kit is likely to enter the bottle. If a long-duration, low-intensity rainfall was to occur, it could potentially fill the bottle.

5.4 Water Sample Laboratory Results

The results of the laboratory water quality analysis completed on the samples collected from the water quality sampling units are shown in Figures 5 and 6, with the lab report provided in Appendix A. The results indicate that the water samples retrieved had low EC, TDS and turbidity levels. This is generally not characteristic of runoff through ephemeral creeks in the Pilbara, which often have high sediment levels.

Based on the laboratory results, it is likely that the water that collected in the sample bottles was from direct rainfall rather than from creek inflow.

5.5 Sample Collection Mounting Kit and Bottle Test

The retrieved mounting kit and collection bottle were tested by tipping a bucket of water over the top of the unit and seeing if water collected in the sample bottle. The units are supposed to only fill by water rising up from the bottom of the sample kit, but it was evident from the testing that leaks through the top and side of the unit (which could occur in a rainfall event) may fill the sample bottle.

Subsequently, we have trialled placing silicon around key points of the mounting kit and have found that this prevents ingress of water poured on the top of the mounting from filling the sample bottle.

5.6 Conclusions

Minor flow responses were observed at both Lamb Creek monitoring station locations. Based on the above validation procedures, the following conclusions were made:

- Pressure transducer appears to be recording data accurately, as testing of both loggers indicate they are recording accurate pressures when submerged at set water depths.
- While not definitive, we have concluded that it is likely that the water samples collected in the recent sampling visit were representative of rainfall rather than creek flow. It is likely that rainfall directly entered the bottle through the top of the mounting kit. This conclusion was based on the following:
    - Low EC, TDS and turbidity in water samples.
    - No sign of sediment or debris in sample bottle filter.
    - Mounting kit free any of any debris.
    - Pressure transducers measuring water levels that are not high enough to fill the sample collection bottle.

Table 2 provides a data validation summary for both locations, with Figures 5 and 6 showing water depth (adjusted for barometric pressure) vs. rainfall for the data collection period.

Table 2: Lamb Creek Water Depth Data Validation Summary

Site ID	Distance to Barologger (km)	Noted Rainfall Response	Maximum Depth (m)	Validation
Lamb_Creek_North	1.5	Likely	0.12	Yes – matches South and transducer tested
Lamb_Creek_South	1.9	Likely	0.12	Yes – matches North and transducer tested

It is felt that the water quality samples that were analysed are not representative of a sample from a creek flow event, but rather reflect the water quality of a rainfall event. At this stage, the laboratory analysis data should not be used as part of the baseline water quality set for the site as it may lead to water quality trigger values for the site being set which are unrealistic. If further samples collected (with more confidence) validate the water quality results collected to date, then the results from the current laboratory samples could be used.

6. RECOMMENDATIONS

With respect to data collection and validation, the following actions are recommended:

- Reinstall the surface water monitoring stations to gather more baseline data. These stations should remain during the operations to allow monitoring of potential impact from the mining operations to be monitored. Additional data prior to site operation can assist in developing the baseline data set for the project.

- It is understood that on 10 June 2021, the stations were reinstalled in their original locations by Bennelongia, who were conducting field surveys at Lamb Creek. Installation equipment and instructions were provided to Bennelongia by AQ2 prior to Bennelongia mobilisation. Bennelongia were instructed to install the bottom of the water quality mounting kits approximately 100mm above the base of the creek to enable collection of water samples from lower creek flow events.
- The water quality sample data that was recorded should be discarded as it is likely to be representative of rainwater and not creek flow. If this data is used as a baseline water quality dataset for comparisons with future data collection, it will appear that MRL are having an adverse impact on the surface water quality when it is potentially not the case.
- The top of the mounting kit for the sample collection bottle should be sealed with silicon to ensure that future water samples which are collected are representative of creek flow rather than rainfall. Note that the sample bottles are configured to close once they are full, such that rainfall could fill the bottle before a creek flow event occurs. On 2 July 2021, MRL field personnel sealed the top of the mounting kits at both monitoring locations to stop future ingress of rainwater.
- The intake for the sample collection bottle has been lowered (as per instructions to Bennelongia) to increase the likelihood that a sample from a runoff event can be captured.
- Data from the pressure transducer logger should be retrieved periodically. Ideally, the data would be downloaded at 6-monthly intervals (pre and post wet season).
- On future visits to retrieve water samples and/or collect logger data, **field notes** are to be recorded and should include all relevant observations such as debris height, water depth, visible flow channels, condition of the mounting kits etc.
- Checking logger data immediately after download to **'reality check'** observed trends.
- If taking water samples, **instantaneous readings** of key parameters (i.e. pH, EC, temperature) should also be taken.
- **Installation of a rain gauge** and associated data logger could be considered at Lamb Creek, which would allow comparisons of rainfall to creek responses to be completed. Rainfall in the Pilbara is typically spatially variable such that actual rainfall on the creek catchment may not be represented by the Karijini North weather station. Unless direct correlations between rainfall and runoff are required for regulatory purposes, we feel that this would not be required to support data gathered from only 2 flow monitoring stations.

We trust that this memo meets your requirements. Please contact us if you have any questions or would like us to make any changes.

Regards,

Brieland Jones	*Mark Nicholls*
Consulting Water Resources Engineer	Consulting Water Resources Engineer

Attached:
Photos
Figures
Appendix A – Water Quality Report - ChemCentre

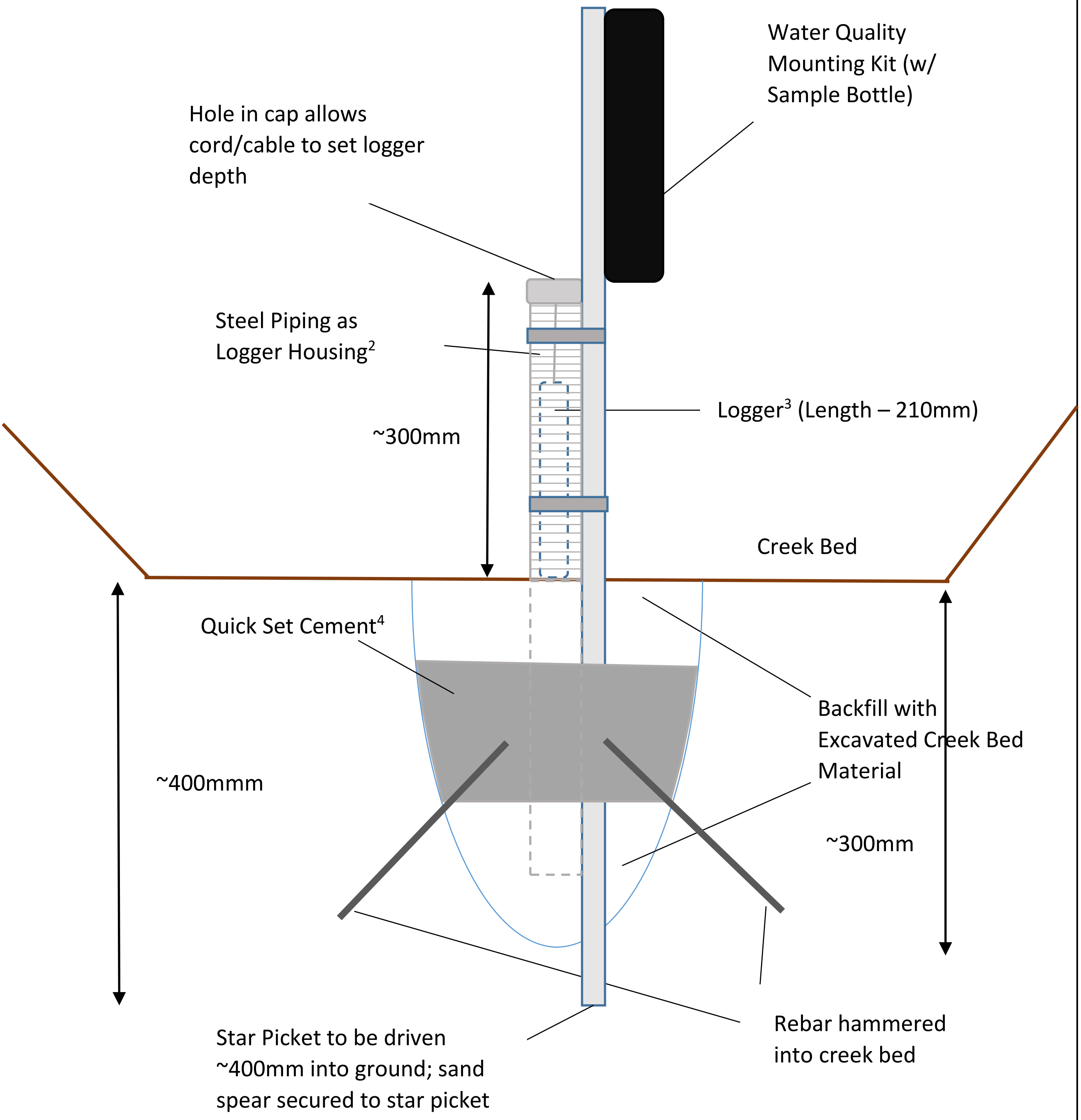
Author:	BGJ (07/07/21)
Checked:	MAN (07/07/21)
Reviewed:	MAN (07/07/21)

PHOTOS

Lamb Creek North Installation **Photo 1**

Lamb Creek South Installation **Photo 2**

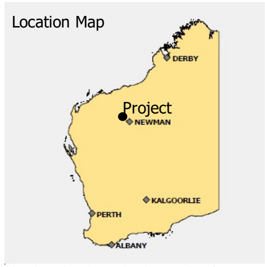
FIGURES



Notes

1 - Drawing not to scale.
2 – To be secured to star picket using band clamp.
3 – To be secured to sand spear using cord through cap; sensor to be placed level with creek bed.
4 - Approximately 1 x 20 kg bag of cement will be used per hole.

Conceptual Drawing – Logger Installation **FIGURE 1**



F:\326\4.GIS\Workspaces\SW\Proposed Surface Water Monitoring Locations.qgz

—— Proposed Mine Infrastructure

● Surface Water Monitoring Location

AUTHOR: BJ

DRAWN: BJ

DATE: 06/07/2021

REPORT No: 006b

JOB No: 326

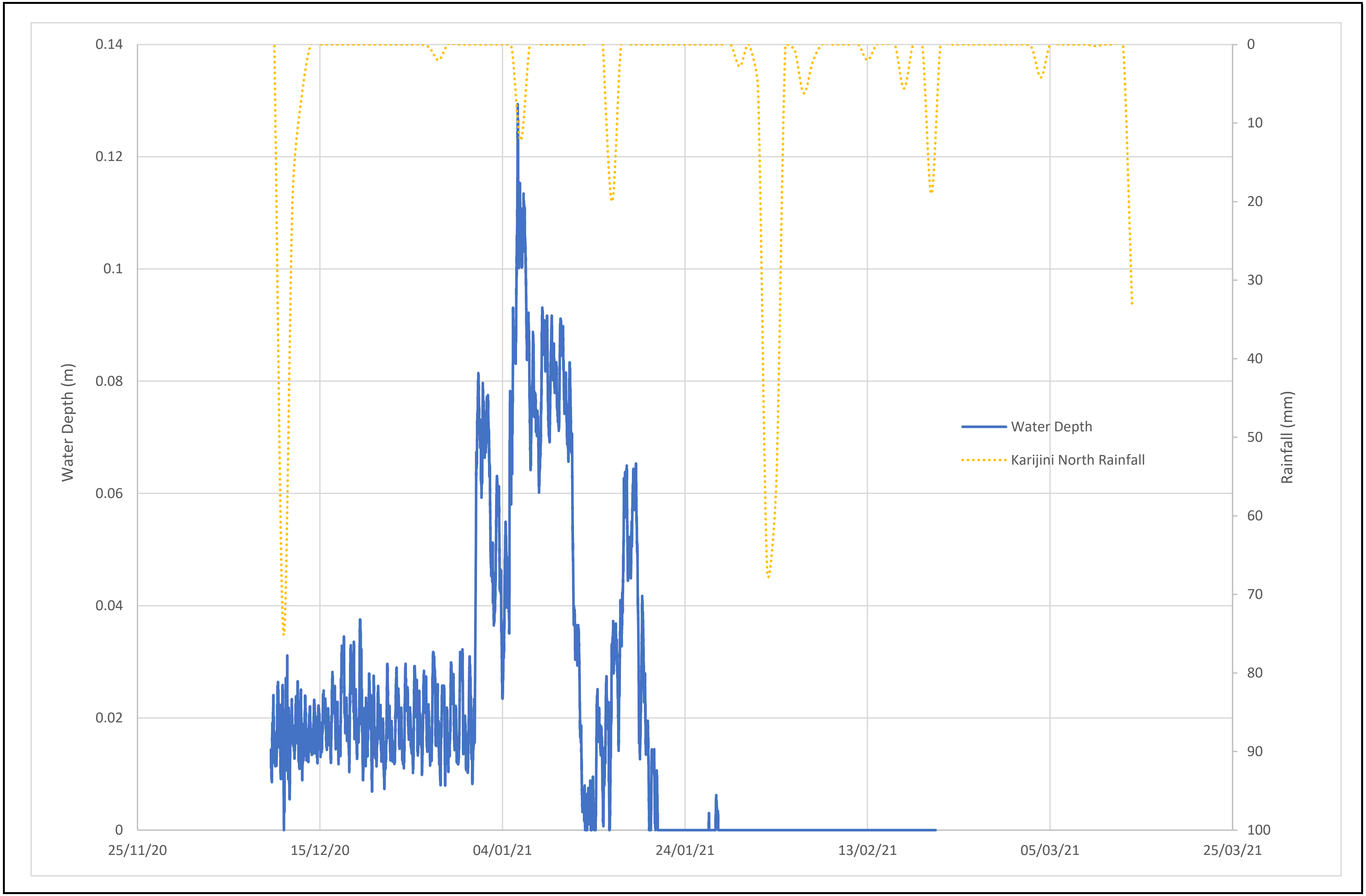
Coordinates: MGA Zone 50

Notes and Data Sources:

Aerial Imagery sourced from Google (2020)
Mine Infrastructure layout provided by MRL (July 2021)

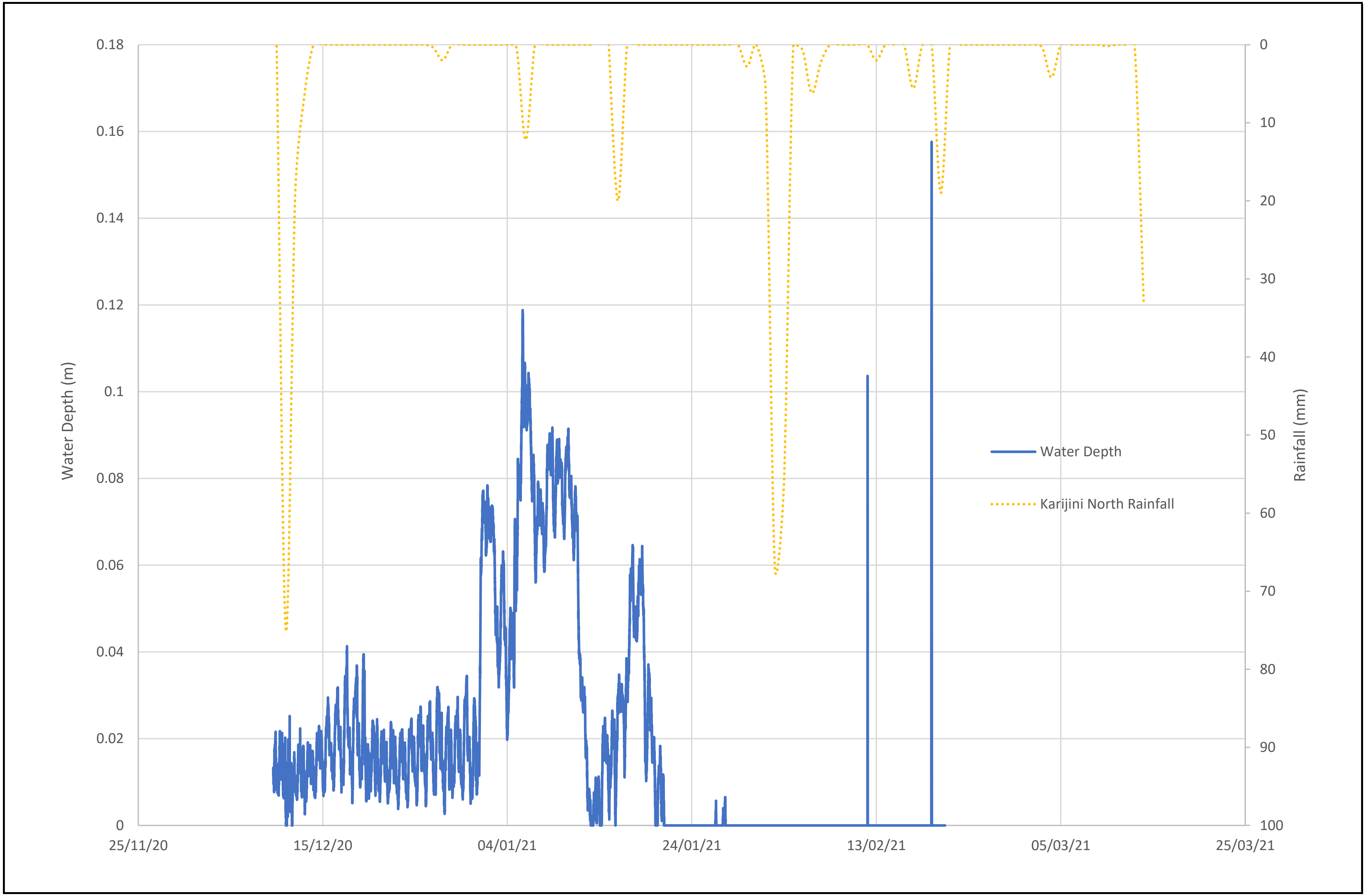
Figure 2

Surface Water Monitoring Locations



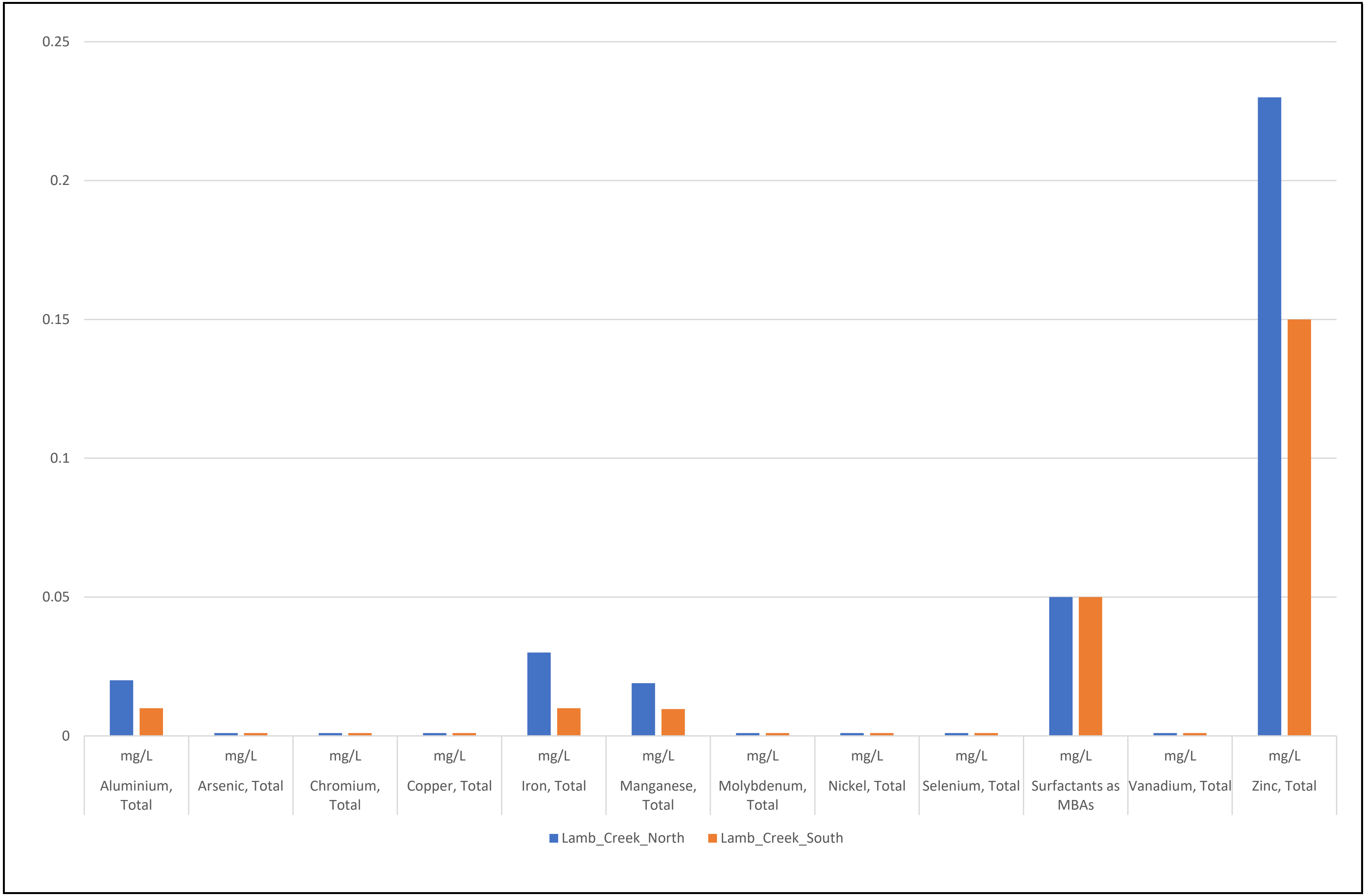
Water Depth vs. Rainfall - Lamb Creek North FIGURE 3

F:\326\3.C&R\Reports\SW Installation\[Figure 2 - Lamb Creek North.xlsx]Landscape Figure

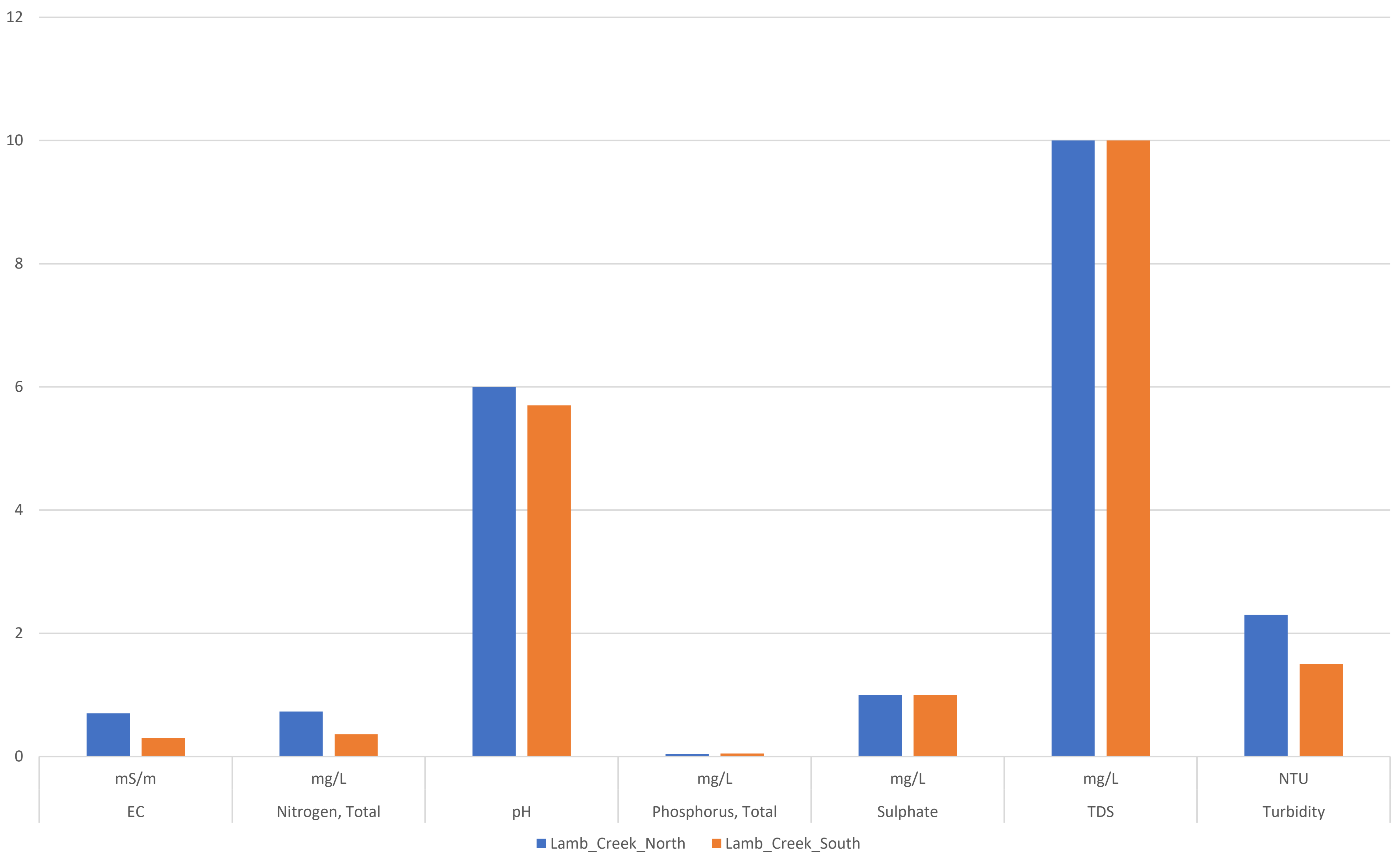


F:\326\3.C&R\Reports\SW Installation\[Figure 3 - Lamb Creek South.xlsx]Landscape Figure

Water Depth vs. Rainfall - Lamb Creek South FIGURE 4



Water Quality Results - 1 FIGURE 5



Water Quality Results - 2 FIGURE 6

F:\326\3.C&R\Reports\SW Installation\[Figure 4 - Water Quality Results 2.xlsx]2

APPENDIX A

ChemCentre

Scientific Services Division

Report of Examination

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025 - Testing, Accreditation No. 8

Chem Centre
EXPERT SOLUTIONS

Resources and Chemistry Precinct
Cnr Manning Road and Townsing Drive
Bentley
WA 6102
Bentley WA 6983

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F +61 8 9422 9801
www.chemcentre.wa.gov.au
ABN 40 991 885 705

Purchase Order: None
ChemCentre Reference: 20S3719 R0

AQ2 (Pty) Ltd
Level 4, 56 William Street
PERTH WA 6000

Attention: Brieland Jones

Report on: 2 samples received on 04/03/2021

LAB ID	**Material**	**Client ID and Description**
20S3719 / 001	water	LCSW-1 Northern location
20S3719 / 002	water	LCSW-2 Southern location

LAB ID			001	002
Client ID			LCSW-1	LCSW-2
Sampled			23/02/2021	23/02/2021
Analyte	**Method**	**Unit**		
Aluminium	iMET1WCICP	mg/L	0.019	0.006
Aluminium, total	iMET1WTICP	mg/L	0.02	<0.01
Arsenic	iMET1WCMS	mg/L	<0.001	<0.001
Arsenic, total	iMET1WTMS	mg/L	<0.001	<0.001
Cadmium	iMET1WCMS	mg/L	<0.0001	<0.0001
Cadmium, total	iMET1WTMS	mg/L	<0.0001	<0.0001
Chromium	iMET1WCMS	mg/L	<0.0005	<0.0005
Chromium, total	iMET1WTMS	mg/L	<0.001	<0.001
Copper	iMET1WCMS	mg/L	0.0004	0.0003
Copper, total	iMET1WTMS	mg/L	0.001	<0.001
Electrical Conductivity	iEC1WZSE	mS/m	0.7	0.3
Iron	iMET1WCICP	mg/L	0.020	<0.005
Iron, total	iMET1WTICP	mg/L	0.03	<0.01
Lead	iMET1WCMS	mg/L	0.0001	<0.0001
Lead, total	iMET1WTMS	mg/L	<0.0005	<0.0005
Manganese	iMET1WCMS	mg/L	0.019	0.0097
Manganese, total	iMET1WTMS	mg/L	0.019	0.0097
Mercury	iMET1WCMS	mg/L	0.0001	0.0001
Mercury, total	iMET1WTMS	mg/L	<0.0001	<0.0001
Molybdenum	iMET1WCMS	mg/L	<0.001	<0.001
Molybdenum, total	iMET1WTMS	mg/L	<0.001	<0.001
Nickel	iMET1WCMS	mg/L	<0.001	<0.001
Nickel, total	iMET1WTMS	mg/L	<0.001	<0.001
Nitrogen, total	iNP1WTFIA	mg/L	0.73	0.36
pH	iPH1WASE		6.0	5.7
Phosphorus, total	iPP1WTFIA	mg/L	0.038	0.048
Selenium	iMET1WCMS	mg/L	<0.001	<0.001
Selenium, total	iMET1WTMS	mg/L	<0.001	<0.001
Sulphate	iCO1WCDA	mg/L	<1	<1

LAB ID			001	002
Client ID			LCSW-1	LCSW-2
Sampled			23/02/2021	23/02/2021
Analyte	**Method**	**Unit**		
Surfactants as MBAS*	iSUPPTOAGAL	mg/L	<0.05	<0.05
Total dissolved solids(grav)	iSOL1WDGR	mg/L	<10	<10
Turbidity	iTURB1WCZZ	NTU	2.3	1.5
Vanadium	iMET1WCMS	mg/L	<0.0001	<0.0001
Vanadium, total	iMET1WTMS	mg/L	<0.001	<0.001
Zinc	iMET1WCICP	mg/L	0.23	0.15
Zinc, total	iMET1WTICP	mg/L	0.23	0.15
Date Analysed	iCO1WCDA		8/3/2021	8/3/2021
	iEC1WZSE		10/3/2021	10/3/2021
	iMET1WCICP		11/3/2021	11/3/2021
	iMET1WCMS		18/3/2021	18/3/2021
	iMET1WTICP		18/3/2021	11/3/2021
	iMET1WTMS		18/3/2021	18/3/2021
	iNP1WTFIA		11/3/2021	11/3/2021
	iPH1WASE		10/3/2021	10/3/2021
	iPP1WTFIA		11/3/2021	11/3/2021
	iSOL1WDGR		9/3/2021	9/3/2021
	iSUPPTOAGAL		16/3/2021	16/3/2021
	iTURB1WCZZ		9/3/2021	9/3/2021
Sample Condition			Cold	Cold

Method	**Method Description**
iCO1WCDA	Colourimetric analysis by DA (Discrete Autoanalyser).
iEC1WZSE	Electrical conductivity in water compensated to 25C.
iMET1WCICP	Total dissolved metals by ICPAES.
iMET1WCMS	Total dissolved metals by ICPMS.
iMET1WTICP	Total metals by microwave digestion and ICPAES.
iMET1WTMS	Total metals by microwave digestion and ICPMS.
iNP1WTFIA	Total Nitrogen by persulphate digestion and analysis by FIA.
iPH1WASE	pH in water by pH meter.
iPP1WTFIA	Total Phosphorus by persulphate digestion and FIA.
iSOL1WDGR	Total dissolved solids (TDS) by gravimetry, dried at 178 - 182 C.
iSUPPTOAGAL	Analysis outsourced to NMI.
iTURB1WCZZ	Turbidity of water by Nephelometer.

Methylene Blue Active Substances were subcontracted to NMI, 105 Delhi Road, North Ryde, NSW, 2133. NATA accreditation 198. A copy of their report is attached.

Analysis of the pH was outside the holding time of six hours. The results should be used as reference only.

These results apply only to the sample(s) as received. Unless arrangements are made to the contrary, these samples will be disposed of after 30 days of the issue of this report.
This report may only be reproduced in full.

*Analysis not covered by scope of ChemCentre's NATA accreditation.

Alex Martin
Chemist
SSD Inorganic Chemistry
18-Mar-2021