Ground Doctor Pty Ltd

Groundwater Impact Assesment

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Brooklyn Quarry
1643 Oxyley Highway
Walcha, NSW

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On Behalf Of:
Mr Scott Robert Blake

11 August 2020
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EXECUTIVE SUMMARY

A Development Application (DA.10.2020.3) was lodged with Walcha Council by Mr Scott Robert Blake and Mr Brian James Blake (the "Applicants") for the establishment of a hard rock quarry at 1643 Oxley Highway, Walcha, NSW (the Site). Ground Doctor Pty Ltd (Ground Doctor) was commissioned by the Applicants to conduct a Groundwater Impact Assessment of the proposed development.

The proposed quarry excavation would be trapezoidal in shape with a total area of approximately 1.65ha. The excavation would have an average length (north-south) of approximately 160m, average width (east-west) of approximately 100m and would be approximately 30m deep. The proposed quarry will be excavated to a maximum depth of 1130m AHD. Groundwater was identified in basalt within the quarry footprint at a maximum elevation of approximately 1146m AHD. The proposed development would intersect the water table and is an aquifer interference activity as defined by the NSW Aquifer Interference Policy (2012b).

Ground Doctor assessed the site setting and available groundwater data to identify existing groundwater users, environmental receptors and culturally sensitive groundwater features within a 2km radius of the site.

High priority groundwater dependent ecosystems or high priority cultural groundwater sites were not identified within 2km of the proposed quarry.

Four existing groundwater works were identified within a 2 km radius of the proposed quarry excavation. The identified bores were located more than 1500m from the proposed excavation. Available data for the identified bores indicated that standing water levels in the bores were at least 20m lower than the maximum proposed depth of excavation. The bore identified within "Mt Pleasant" was separated from the proposed quarry by the Great Dividing Range and was within a different catchment and a different groundwater management unit to the proposed quarry.

Five monitoring bores were installed within or close to the footprint of the proposed quarry excavation. Groundwater levels were measured at each bore. Falling head and rising head slug tests were performed on four of the five bores to assess hydraulic conductivity of aquifer material within and surrounding the proposed quarry excavation.

A conceptual site model was developed based on available groundwater and topographical data. The proposed quarry excavation would be located approximately 200m south of the Great Dividing Range. The ground surface around the proposed quarry falls steeply to the to the south east, south and west. The surface elevation was more than 100m below the base of the proposed excavation less than 500m to the south east and south of the quarry. Groundwater elevation data showed a steep groundwater gradient to the south east, south and west of the proposed quarry, consistent with steeply sloping surface topography.

An analytical model was adopted to predict steady state drawdown impacts and groundwater inflow to the open excavation at the completion of quarrying. The model predicted drawdown impacts would extend approximately 132m north of the proposed excavation. Groundwater inflow was estimated to be 1.16m^3/day.

Model prediction showed good agreement with observed real world drawdown in basalt within the quarry footprint, which was already draining to the south due to the presence of a natural void (a deep valley) to the south.

The modelled groundwater inflow to the excavation is less than the expected evaporation rate from the open excavation. There is also potential for any groundwater inflow to drain through the floor of the excavation, as the base of the proposed excavation remains elevated above the valley to the south. Mechanical dewatering of the excavation is unlikely to be required. Any water accumulation in the excavation could be used in quarry operations or used as stock water at the completion of the development.

Direct take (e.g. pumping for beneficial use) or indirect take of groundwater (e.g. losses to evaporation) are required to be licenced. The annual groundwater inflow to the open excavation would be less than 2ML. The Applicant would need to source commercial use entitlement to take 2ML from the New England Fold Belt (Murray Darling Basin) groundwater management unit prior to intersecting the water table. The NSW Department of Industry Planning and Environment website (https://www.industry.nsw.gov.au/water/allocations-availability/water-accounting/usage-dashboard, 7 August 2020) indicates that there is 11384ML allocated within the New England Fold Belt (Murray Darling Basin) groundwater unit. It would be possible for the Applicants to obtain the required groundwater entitlement prior to intersecting the water table.

The project involves blasting, crushing and screening of excavated rock. The proposed activities have little if any potential to add contaminants that could adversely change groundwater quality. Operation of plant and machinery and use of nitrogen containing explosives poses a similar risk to groundwater quality as existing agricultural use of the Site and adjoining land. Potential risks to water quality can be managed by implementing appropriate procedures for storage and use of chemicals, refuelling and maintenance of plant and machinery and implementing appropriate spill response plans.

The information presented in this report indicates that the groundwater impacts associated with the proposed development would not exceed the Level 1 "*minimum impact considerations*" outlined in the NSW Aquifer Interference Policy (NSW DPI, 2012b). Therefore, groundwater impacts associated with the project are acceptable.

1 Introduction

A Development Application (DA.10.2020.3) was lodged with Walcha Council by Mr Scott Robert Blake and Mr Brian James Blake (the "Applicants") for the establishment of a hard rock quarry at 1643 Oxley Highway, Walcha, NSW (the Site). Ground Doctor Pty Ltd (Ground Doctor) was commissioned by the Applicants to conduct a Groundwater Impact Assessment of the proposed development.

The location of the proposed quarry is shown relative to the regional setting in *Figure 1* of *Annex A*. *Figure 2* of *Annex A* shows the proposed location of the quarry excavation relative to surrounding property boundaries and topography.

1.1 Project Description

This Development Application seeks consent to establish a hard rock quarry and processing plant to produce approximately 450,000 tonnes of quarry material.

The material extracted from the quarry will comprise gravel and hard rock, which will be processed through a crushing and screening plant before being stockpiled and sold.

The proposal would include the following activities.

- Excavation of soil and rock from the proposed extraction area using a combination of drill and blast and mechanical excavation to a maximum depth of approximately 30m (maximum depth of excavation of 1130m AHD).

- Crushing and screening of extracted material within the footprint of the excavation to produce a range of quarry products.

- Loading and transportation of extracted material to market from the Site via the Oxley Highway.

- Construction and use of surface water management structures, including sediment basins and diversion banks.

- Rehabilitation of the Site to achieve a land compatible with existing agricultural use.

The proposed quarry excavation would be trapezoidal in shape with a total area of approximately 1.65ha. The excavation would have an average length (north-south) of approximately 160m, average width (east-west) of approximately 100m and would be approximately 30m deep. The maximum depth of excavation corresponds to a relative elevation of 1130m AHD. The proposed footprint of the quarry excavation is shown in *Figure 2* of *Annex A*.

1.2 Study Area

Potential for quarries to impact groundwater relate primarily to intersection of groundwater within the extraction area. This Groundwater Impact Assessment focusses on the proposed quarry excavation and the area within a 2km radius of the proposed excavation, which is referred to as the Study Area.

1.3 Assessment Objectives

The objectives of this assessment were to:

- identify and describe the groundwater resources within the Study Area that have potential to be impacted by the proposed development;

- identify proposed development activities that have potential to impact on the quality and/or quantity of groundwater available within the Study Area; and

- identify potential impacts to groundwater and assess the acceptability of the impacts using relevant NSW groundwater impact assessment guidance.

1.4 Scope of Work

Ground Doctor completed the following work.

- Reviewed legislation and guidance relevant to groundwater management to identify potential constraints and requirements on the proposed development.

- Reviewed available groundwater bore data, geological information and topographic data to assess the location and characteristics of groundwater aquifers located within the Study Area.

- Identified and described available groundwater bore data to assess existing groundwater users within the Study Area.

- Installed 5 groundwater monitoring bores to assess subsurface conditions within and adjacent to the proposed quarry excavation.

- Measured and recorded standing water levels within each monitoring bore.

- Conducted falling head and rising head slug tests at 4 monitoring bore locations to estimate the hydraulic conductivity of soil and rock within and adjacent to the proposed quarry excavation.

- Used an analytical model to predict the likely extent of drawdown around the proposed excavation and estimate groundwater inflow to the open excavation.

- Conducted a qualitative review of potential impacts to groundwater quality associated with the proposed development.

- Presented the results of the Groundwater Impact Assessment in this report.

1.5 Limitations of this Report and Authorisation

The findings of this report are based on the Scope of Work outlined in *Section 1.4* and described in more detail in the following sections of this Report. Ground Doctor performed the services in a manner consistent with the normal level of care and expertise exercised by members of the environmental consulting profession. No warranties, express or implied are made.

The results of this assessment are based upon the information documented and presented in this report. All conclusions and recommendations regarding the proposed development are the professional opinions of Ground Doctor personnel involved with the project, subject to the qualifications made above. While normal assessments of data reliability have been made, Ground Doctor assumes no responsibility or liability for errors in any data obtained from regulatory agencies, statements from sources outside of Ground Doctor, or developments resulting from situations outside the scope of work detailed in this Report.

The results of this assessment are based on the conditions identified at the time the works were undertaken. Ground Doctor will not be liable to revise the report to account for any changes in site characteristics, regulatory requirements, assessment criteria or the availability of additional information, subsequent to the issue date of this Report.

2 Existing Environment

2.1 Site Location

The proposed quarry is located within the "Brooklyn" property, about 16km west of Walcha, as shown *Figure 1* of *Annex A*. The proposed quarry excavation would be situated within Lot 103 DP 753846 and Lot 2 DP 1173956 (see *Figure 2* of *Annex A*).

2.2 Existing Site Features and Use

The proposed quarry is situated within an agricultural property that is used to graze sheep and cattle. Gently sloping parts of the site have been cleared to promote pasture growth. Steeper parts of the site remain heavily wooded.

The Brooklyn homestead is located approximately 700m to the north east of the proposed quarry excavation. Potable water supply is by rainwater captured on the rooves of the dwelling and sheds.

Stock water is sourced for several small dams scattered across the Site. A spring fed dam is situated approximately 750m east of the proposed quarry excavation.

2.3 Surrounding Land-uses

The Site is situated within an area which is predominantly agricultural land used for livestock grazing purposes. The nearest residences to the proposed quarry excavation are:

- "Yarooga Park", more than 1,150 metres to the north.
- "Mt Pleasant", more than 1,500 metres to the north east.
- "Yarooga", more than 1,700 metres to the north west.
- Village of Walcha Road, more than 2,200 metres to the north west.

Registered groundwater works were identified close to the dwelling at "Yarooga". Registered groundwater works were not identified at "Yarooga Park" or "Mt Pleasant". A groundwater bore was identified at "Mt Pleasant" during a visit to the property in the course of the assessment. Groundwater works within the Study Area are discussed in more detail in *Section 2.6*.

2.4 Topography and Drainage

The topography close to the proposed quarry is illustrated in the orthophoto map presented as *Figure 2* of *Annex A*. *Figure 3* of *Annex A* shows the regional topography.

The proposed quarry is situated approximately 200m south of the Great Divide. The proposed quarry excavation is situated within the Murray Darling Basin. Land on the northern side of the Great Divide is part of the Macleay River catchment and flows to the Pacific Ocean. The approximate location of the Great Divide is marked on *Figure 3* of *Annex A*.

The Great Divide is at an elevation of approximately 1166m AHD at its closest point to the proposed quarry excavation. The average ground elevation within the quarry footprint is approximately 1160m AHD.

The proposed quarry excavation is situated at the southern end of a ridgetop with a gentle gradient (approximately 3-5%) in a general north to south direction. Land immediately to the south and south east of the proposed quarry excavation falls steeply to the south and south east. The gully to the south east of the proposed excavation is at an elevation of 1030m AHD approximately 420m to the south east of the excavation, and 1000m AHD approximately 560m south of the excavation (average gradients ranging from 28-30%). These gullies drain into Surveyors Creek at a point approximately 1200m to the south west of the proposed quarry excavation.

Surveyors Creek flows into the Macdonald River, which is the primary regional drainage feature. The Macdonald River is situated approximately 4300m to the south west of the proposed quarry excavation at its closest point.

Land on the western side of the proposed quarry excavation falls steeply to the south west toward Surveyors Creek. The south western slopes fall to a height of approximately 970m AHD less than 1300m to the south west of the proposed excavation (an average gradient of approximately 14%).

An oblique aerial photography with marked spot heights is presented as *Figure 4* of *Annex A* and illustrates the steep topography to the south of the proposed quarry excavation.

Land to the north east of the Great Divide slopes gently in a general north easterly direction toward Bergen-op-zoom Creek. Bergen-op-Zoom Creek is at an elevation of 1100m AHD approximately 1900m to the north east of the proposed quarry excavation (an average gradient of less than 4%).

2.5 Geology

The Geological Survey of NSW (1973) "*Manilla" 1:250,000 Geological Series Sheet 56-9*" indicates that the proposed quarry is situated on undifferentiated "*cherts, jaspers, quartzites, conglomerates, greywackes, argillites, phyllites, spilites, limestones and volcanics*". The mapping marks areas of tertiary "*basalt flows and plugs*" close to the site. The scale of mapping is large and has not properly captured the location and extent of tertiary basalt.

Exposed basalt is visible at the ground surface across a large portion of the proposed quarry excavation and on the surrounding elevated ridgetops.

Several test pits were excavated by the Applicants within and close to the proposed quarry excavation in early 2020. Five boreholes were drilled within or close to the proposed quarry excavation in June and July 2020 as part of this Groundwater Impact Assessment. Borehole locations are shown relative to the proposed quarry outline in *Figure 5* of *Annex A*.

Four bores MB1, MB2, MB3, and MB5 were drilled close to the top of the ridge.

Trenching and drilling of the quarry footprint and surrounds has identified shallow reddish clay soil immediately overlying relatively fresh (unweathered) Tertiary basalt. Boreholes indicated basalt is up to 37.0 metres thick (at MB1) in the immediate vicinity of the quarry excavation.

Observed variations include some minor proportions of volcaniclastic/pyroclastic rocks (ash and agglomerate) exposed during test trenching and drilling, as well as relatively small nearby exposures of vesicular basalt.

Drilling suggests that there is a relatively persistent layer of clay underlying the basalt at about 1124m AHD within the proposed quarry excavation footprint. This shows a mottled colour and texture similar to volcaniclastic rocks exposed in test pits. The identified clay layer was present approximately 8m below the maximum depth of the proposed quarry excavation.

MB4 was drilled to the east of the proposed quarry excavation on south east slopes at an elevation of approximately 1136m AHD. Clay, possible weathered chert or phyllite, was encountered to a depth of approximately 25.5m below ground level. A dark grey rock with quartz veins (suspected to be greywacke) was identified from 25.5 to the base of the borehole at 28m below ground level.

In Landform Evolution in the Armidale-Uralla Region, New South Wales (Connelly, 1983) concludes that tertiary basalt ridgetops within the New England are the result of valley flows of lava that resulted in subsequent inversion of the landscape, as surface water flowed around the sides of the basalt and subsequently eroded the surrounding material. Based on this theory of landscape formation Connelly (1983) indicates that alluvium is encountered beneath or within basalt flows in many locations, as basalt flows occurred valleys in which alluvium had previously accumulated.

Alluvium was not encountered in boreholes MB1 - MB5. Alluvium containing coarse rounded gravel can be seen at or near the ground surface to the north east of the proposed quarry excavation, in the vicinity of the Brooklyn residence.

A spring is located approximately 750m to the east of the proposed quarry excavation. The spring appears to be associated with an exposed alluvial unit on the eastern side of the separate basalt capped ridge to the east of the proposed quarry excavation. The spring has provided reliable and continuous water supply for Brooklyn in the time that it has been occupied by Mr Brain James Blake (an Applicant). The spring occurs at an elevation of approximately 1035m AHD.

2.6 Hydrogeology

2.6.1 Relevant Groundwater Management Unit

The proposed quarry excavation would be located within the "New England Fold Belt (Murray Darling Basin)" groundwater management unit. The take of groundwater from this unit is managed under the "*Water Sharing Plan for the NSW Murray Darling Fractured Rock Sources 2011*".

The groundwater management unit boundary is the Great Dividing Range. The area on the eastern side of the Great Dividing Range falls within the "*New England Fold Belt (Coastal)*" groundwater management unit.

Figure 3 of *Annex A* shows the groundwater management unit boundary relative to the proposed quarry excavation.

2.6.2 Registered Groundwater Works

Ground Doctor conducted a search of the NSW Water groundwater works database (https://realtimedata.waternsw.com.au, 5 August 2020) for registered groundwater works located within an approximate 2km radius of the proposed quarry.

Figure 6 of *Annex A* shows the location of registered bores relative to the proposed quarry location and the relevant groundwater management unit boundary.

The search identified three registered groundwater works within the 2km search radius. The three identified bores were located within "Yarooga" to the north west of the proposed quarry. Work summary forms for other bores outside of the 2km search area were also reviewed.

A summary of the registered bore details is presented as *Table B1* of *Annex B*. Groundwater Work Summary Forms for the identified registered works are also presented in *Annex B*.

Borelogs for the three registered bores identified within "Yarooga" (GW051673, GW051674 and GW900215) indicate that the borehole intersected water in fractured granite in the upper 22-40m of the subsurface. Ground Doctor used the mapped surface elevation at each bore location to estimate the relative elevation of the water bearing granite (see *Table B1* of *Annex B*). Estimates ranged from 1088m AHD to 1010m AHD, which were at least 40m lower than the proposed maximum depth of excavation within the proposed quarry. Similarly, recorded standing water levels in the registered bores were at least 30m lower than the proposed maximum depth of excavation within the proposed quarry.

Groundwater work GW306340 was located approximately 3400m to the north east of the proposed quarry. GW308002 was located approximately 3600m to the east of the proposed quarry. Borelogs indicate that these boreholes encountered water in basalt. Estimates of groundwater elevation at these location were less than 1100m AHD, at least 30m below the maximum depth of excavation within the proposed quarry.

2.6.3 Other Groundwater Information

An unregistered bore was identified at "Mt Pleasant", approximately 1600m to the east north east of the proposed quarry. The bore at Mt Pleasant was made apparent by Ms Janet Norton (resident at Mt Pleasant), who submitted an objection related to the proposed development. Ground Doctor visited the site on 1 July 2020 to assess the bore. Ms Norton would not allow Ground Doctor to measure the depth of the bore or the standing water level. Ms Norton supplied a copy of a letter prepared by Armidale Pumps and Irrigation indicating that the bore was 27m deep, had a standing water level of 10m below ground level and a "flow rate" or 29L per minute. A borehole log was not available for the bore. The surrounding geology and the construction of the bore was not known. A second bore was located less than 20m away but had been decommissioned.

The mapped surface elevation at the "Mt Pleasant" bore is less than 1120m AHD. Based on the information supplied by Ms Janet Norton, the groundwater elevation at the Mt Pleasant bore was less than 1110m AHD, more than 20m below the maximum depth of the proposed quarry.

A spring is located approximately 750m to the east of the proposed quarry excavation. The spring appears to be associated with a narrow band of exposed gravelly clay on the eastern side of the separate basalt capped ridge to the east of the proposed quarry excavation. The spring is elevated above the valley floor and has been exposed by natural erosion of the gully to the south.

The spring has provided reliable and continuous water supply for Brooklyn in the time that it has been occupied by Mr Brain James Blake (one of the Applicants). The spring occurs at an elevation of approximately 1035m AHD, approximately 5m above maximum depth of the proposed quarry excavation.

The absence of similar features along similar slopes to the east and west suggests the spring is associated with a narrow alluvial channel, rather than a regional feature.

2.6.4 Monitoring Bores

Ground Doctor installed 5 groundwater monitoring bores within and close to the proposed quarry excavation in June and July 2020. Borehole locations are shown relative to the proposed quarry outline in *Figure 5* of *Annex A*. Borehole and monitoring well construction logs are presented as *Annex C*.

Four bores MB1, MB2, MB3, and MB5 were drilled close to the top of the ridge with the aim of characterising the groundwater conditions within and surrounding the proposed quarry excavation.

With the exception of a thin topsoil layer, basalt and weathered basalt was encountered throughout MB1, MB2 and MB5.

MB4 was located to the south east to obtain additional groundwater elevation data that would help establish a robust conceptual model of potential groundwater impacts.

Monitoring bore installation, gauging and hydraulic conductivity testing is outlined in *Section 3*.

2.7 Groundwater Dependant Ecosystems

The "*Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011"* did not list any high priority groundwater dependant ecosystems within 2km of the proposed quarry excavation.

Ground Doctor conducted a search of the BOM Groundwater Dependant Ecosystems Database (http://www.bom.gov.au/water/groundwater/gde/map.shtml, 5 August 2020). There were no "aquatic groundwater dependant ecosystems" mapped within 2km of the proposed quarry. There were no "subterranean groundwater dependant ecosystems" mapped within 2km of the proposed quarry.

There were areas of low to high potential "terrestrial groundwater dependant ecosystems" identified within the Study Area. Heavily wooded areas to the west, south and east of the proposed quarry were mapped as having high potential groundwater dependence.

2.8 Culturally Significant Groundwater Sites

Culturally significant sites that rely on groundwater were not identified within 2km of the proposed quarry excavation.

2.9 Contamination Sources

Ground Doctor conducted a search of the NSW EPA list of sites notified under Section 60 of the Contaminated Land Management (CLM) Act 1997. The search was conducted on 5 August 2020. There were no notifications listed land within a 2km radius of the proposed quarry excavation. Ground Doctor did not identify any potential sources of significant land contamination in the immediate surrounds of the proposed quarry excavation.

2.10 Acid Sulphate Soils

The proposed quarry would be situated within basalt on an elevated ridgeline. Acid sulphate soils are not of concern in this environment and have not been mapped within the Study Area.

3 Quarry Site Groundwater Investigation

3.1 Monitoring Bore Locations

Monitoring bore locations are shown relative to topography and the proposed quarry location in *Figure 5* of *Annex A*. Borehole and monitoring well construction logs are presented as *Annex C*.

Four bores MB1, MB2, MB3, and MB5 were drilled close to the top of the ridge with the aim of characterising the groundwater conditions within and surrounding the proposed quarry excavation. MB1 was positioned immediately west of the proposed quarry. MB2 was located at the southern margin of the proposed quarry. MB3 was located close to the north east extent of the quarry. MB5 was located within the quarry footprint.

MB4 was located approximately 140m to the south east to obtain additional groundwater elevation data that would help establish a robust conceptual model of the groundwater environment.

3.2 Monitoring Bore Installation

Groundwater monitoring wells were installed by Mr Georgel Ivan (Ivan Drilling), NSW Class 6 Driller's Licence No. 2199 under the supervision of Ground Doctor hydrogeologist, Mr James Morrow. Monitoring bore installation works were undertaken between 30 June 2020 and 3 July 2020.

Borehole depths, screened intervals and groundwater elevation data are summarised in *Table 1*.

Table 1: Groundwater Monitoring Bore Construction and Water Level Summary

Bore ID	Depth (m bgl)	Bottom Elevation (m AHD)	Screened Interval (m bgl)	Surface Elevation	SWL (m bgl)	SWL (m AHD)
MB1	38.5m	1121.5	14.5-38.5m	1160	14.5	1145.5
MB2	33.0m	1123.0	18.0-33.0m	1156	20.2	1135.8
MB3	30.0m	1131.0	14.0-30.0m	1161	16.4	1144.6
MB4	28.0m	1108.0	16.0-28.0m	1136	20.6	1115.4
MB5	32.0m	1128.0	21.5-32.0m	1160	15.9	1144.1

Boreholes were drilled using air rotary (down hole hammer) drilling methods and were advanced to depths ranging from 28m to 38.5m below ground level. Ground Doctor aimed to characterise the subsurface at least 5m below the base of the proposed quarry excavation. MB1 and MB2 reached the desired depth and ended more than 7m below the maximum depth of the proposed excavation. Clay was encountered in lower part of MB3. The clay was not suited to drilling with percussion methods and the borehole had to be ended at 30m below ground level, approximately 1m above the maximum depth of the proposed quarry excavation. MB5 was drilled approximately 2m beyond the maximum depth of the proposed excavation. MB4 reached a depth that was approximately 22m below the maximum depth of the proposed excavation.

Ground Doctor logged drill cuttings at 1 m intervals throughout each borehole. There was no obvious water strike in borehole MB1, MB2, MB3 and MB5. At these locations the only sign water had been encountered was a small amount of moisture on the surface of drill cuttings, which was typically only noticeable after rod changes. These boreholes did not produce water flow during drilling.

A notable water strike was observed at MB4. A water bearing feature was encountered in greywacke at a depth of approximately 27m below ground level which produced minor water flow during drilling.

Groundwater monitoring wells were installed in accordance with the National Uniform Drillers Licencing Committee (2012) "*Minimum Construction Requirements for Water Bores in Australia*".

Groundwater wells were constructed of screw fit 50mm ID Class 18 uPVC screen and casing. The screen was mechanically slotted.

Given the absence of notable and definite water strike in MB1, MB2, MB3 and MB5, monitoring bores were installed with a long screened interval which extended above the depth of the first moisture observation in each borehole.

The borehole annulus was filled with 3-5mm washed rounded river gravel to a depth of at least 0.5m higher that the top of the screened interval. A bentonite seal at least 3m thick was placed above the gravel pack. The remainder of the borehole annulus was filled with drill cuttings. Monitoring bores were completed with stickup of approximately 0.6m at the ground surface. A steel monument was installed over each monitoring bore.

Monitoring bores were developed after installation by air lifting for approximately 20 minutes. Air lifing typically removed a large slug of water that had accumulated in the borehole after casing instalment. Once the initial slug of water had been removed there was little if any sustained water flow.

3.3 Groundwater Levels

Monitoring bores were left undisturbed for a period of approximately 4 weeks after installation. Ground Doctor gauged each monitoring well on 31 July 2020. Ground Doctor measured to depth to water from the top of PVC casing using an electronic dip meter. The height of top of PVC casing above ground level was also measured so that the measured water level could be converted to metres below ground level.

The digital elevation model (2m ground elevation contours) was used to approximate the groundwater elevation relative to the AHD.

Measured standing water levels are presented in *Table 1*.

3.4 Hydraulic Conductivity Estimation

Ground Doctor conducted falling head and rising head tests at monitoring bores located within and close to the proposed quarry excavation (MB1, MB2, MB3 and MB5) so that the average hydraulic conductivity of the aquifer could be estimated.

The standing water level was measured in each monitoring bore prior to any disturbance of the water column. A water level logger, set to record water depth every 2 seconds was hung approximately 5m below the standing water level. A weighted blank PVC slug (approximately 1.8L volume) was lowered into the monitoring bore quickly until it was fully submerged below the standing water level. Changes in water level were recorded by the water level logger as well as being gauged manually with an electronic dip meter. Water level changes were recorded for approximately 1 hour.

The slug was removed from the bore and water level response was recorded for a period of approximately 1 hour. This process was repeated at each of the tested monitoring bores.

Drilling observations indicated that groundwater encountered within the footprint of the proposed quarry and in the immediate surrounds was within an unconfined aquifer. In MB1, MB2 and MB5 a clay layer was encountered at the base of the borehole and was considered representative of an aquiclude. The monitoring bores were considered to have fully penetrated the aquifer.

The Bouwer and Rice (1976) method was used to estimate aquifer hydraulic conductivity in each of the tested bores. Hydraulic conductivity was estimated using both falling and rising head data from each tested bore.

Estimates of hydraulic conductivity (K) from slug test are summarised in *Table 2*. Plots of groundwater displacement vs time for each of the tests is presented as *Annex D*.

Table 2: Hydraulic Conductivity Estimates from Falling and Rising Head Tests

Bore ID and Test	K (m/sec)	K (m/day)
MB01 - Falling Head	0.00000014	0.012096
MB01 - Rising Head	0.00000005	0.004320
MB02 - Falling Head	0.00000002	0.001728
MB02 - Rising Head	0.00000016	0.013824
MB03 - Falling Head	0.00000005	0.004320
MB03 - Rising Head	0.00000003	0.002592
MB05 - Falling Head	0.00000005	0.004320
MB05 - Rising Head	0.00000004	0.003456
Average	**0.000000068**	**0.005832**

3.5 Conceptual Groundwater Model

Groundwater was encountered in basalt and weathered basalt within the footprint of the proposed quarry excavation. Drilling observation combined with measured standing water levels indicate that the aquifer encountered is unconfined.

Observed standing water levels within or close to the proposed quarry excavation footprint varied from approximately 1146m AHD (MB1) to 1136m AHD (MB2).

The standing water level at MB4 was approximately 1115m AHD, some 15 m below the base of the proposed quarry excavation and 31m lower than the standing water level at MB1. Available water level data shows a steep hydraulic gradient which appears similar to surface topography. Data was not collected to the south west of the proposed quarry but it is assumed a similar fall would be evident in this direction.

The measured groundwater elevation at MB1 (approximately 1146m AHD) is high relative to the surrounding terrain and on this basis it is assumed that groundwater observed in the monitoring bores comes from recharge which occurs on the surrounding ridgeline only. The potential recharge zone is the area of land with elevation above 1146m AHD, and this is limited to a narrow strip along the Great Divide.

The observed hydraulic gradient between MB1 and MB2 indicates that basalt within the proposed excavation has relatively low hydraulic conductivity.

The steep fall in groundwater elevation at the southern end of the proposed quarry excavation is attributed to discharge from lower slopes to the west, south and east of the proposed quarry. Springs are not evident on these slopes. Seepage would be relatively low given the measured low hydraulic conductivity of the basalt unit and underlying clay. It is inferred that some seepage from lower slopes is lost to evaporation or evapotranspiration and that some water discharges from lower slopes, or through the subsurface, to Surveyors Creek or feeder drainages.

The groundwater divide is likely to be located close to the Great Dividing Range.

Drawdown impacts would only occur once the proposed quarry is excavated below the water table. This is not expected to occur for the first several years of operation, as the annual production rate is capped at 29,000m^3.

At its maximum depth, the northern end of the quarry excavation will be approximately 16 metres below the pre-development water table and the south east corner will be approximately 6m below the pre-development water table. Maximum drawdown impacts would occur when the quarry reached its maximum depth (1130m AHD) and maximum extent.

The measured groundwater elevation at MB4 was approximately 15m lower than the proposed maximum depth of the quarry excavation. This indicates that the water table is at an elevation well below the base of the proposed excavation a relatively short distance to the east, south and west of the proposed excavation. This means there is little if any potential for radial flow of groundwater toward the open excavation from the east, south and west. Groundwater beneath these areas already flows to areas with lower potential (where the water table is less than 1130m AHD) further to the east, south and west.

Once a new equilibrium (steady state) condition is established flow to the open excavation will be limited to flow from basalt along the northern wall of the excavation. Water flowing into the excavation will be groundwater recharge that has occurred on elevated ridgeline to the north of the excavation only.

Flow is unlikely to occur through the base of the open excavation. Once the water level is lowered at the northern end of the excavation, groundwater will establish a new equilibrium condition, but will maintain flow downwards and toward much lower terrain to the south east, south and west of the excavation.

Potential groundwater flow into the open excavation, and the maximum extent of drawdown beneath the ridge to the north, will be limited by the hydraulic conductivity of the basalt immediately adjacent to the proposed excavation, and the amount of groundwater recharge which occurs within the zone of depression.

The existing environment could be considered an excellent physical model of the proposed quarry. If it is assumed the existing deep valley to the south of the quarry represents a large excavation (created by erosion), then the observed water level gradient across the monitoring bores show how the basalt aquifer responds at the edge of an excavation. The groundwater gradient observed across MB1, MB5 and MB2 is indicative of the gradient that will develop to the north of the completed quarry excavation.

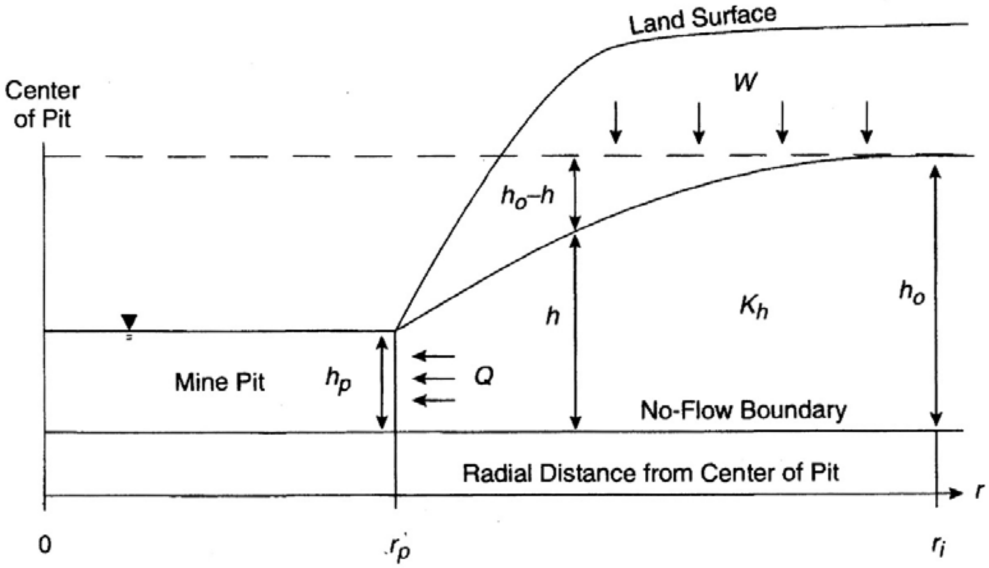
Figure 7 of *Annex A* shows the inferred groundwater elevation (based on observed groundwater elevation around the proposed excavation) on topographic cross sections traversing the proposed quarry excavation before development and at the completion of quarrying.

3.6 Analytical Modelling of Drawdown and Inflow

Based on the site setting and conceptual understanding of the site hydrogeology, Ground Doctor used a one dimensional analytical model to estimate the potential maximum extent of drawdown impacts to the north of the proposed quarry.

Arnold et al., (2003) derive a steady state one dimensional analytical solution for estimating groundwater flow to a quarry excavated into a steep hillside. Arnold et al., (2003) adopts solutions outlined by (Marinelli and Niccoli, 2000), which estimates groundwater flow to a circular excavation, but instead applies these solutions to an excavation represented as a straight line along a hillside.

In this situation the quarry excavation intercepts groundwater from the upgradient (northern) hillside only. This simplified analytical model would be appropriate given the site topographic setting and observed pre-development groundwater elevation data. A conceptual diagram of the Marinelli and Niccoli (2000) analytical model is shown as Diagram 1.



Drawing 1: Concept Drawing Showing Flow to Circular Open Pit From Horizontal Flow from the Excavation Wall (Marinelli and Niccoli, 2000)

The saturated thickness of the aquifer above the mine base can then be calculated at distance (x) from the excavation using the following equation:

$$h = \sqrt{h_m + \frac{W}{K_h}[2x_i x - x^2]}$$

Flow to the quarry excavation can be estimated by the equation:

$$Q = Wx_i$$

where:

K_h – *Horizontal hydraulic conductivity value for the aquifer.*

h – *saturated thickness of the aquifer at a distance x from the quarry face.*

W – *groundwater recharge rate.*

h_m – *the saturated thickness above the quarry base at the quarry face.*

x_i – *the maximum distance of influence (i.e. where drawdown = 0m).*

x – *the distance upgradient (north) of the quarry face.*

Q – *Flow to the excavation per unit length of upgradient quarry face.*

The analytical solution is valid for groundwater flow systems that meet the following assumptions:

- The geological materials are homogenous and isotropic.
- Groundwater flow is steady state, unconfined, horizontal and perpendicular to the quarry wall.
- Recharge is uniformly distributed at the water table, and all recharge within the distance of influence is captured by the quarry excavation.
- The upgradient (northern) quarry wall is approximated as a straight line.
- The static pre-development water table is approximately horizontal.

- The base of the excavation is coincident with the base of the aquifer, and there is no flow through the quarry bottom.

The following assumptions were used to generate a solution.

K_h = 0.006 m/day (average estimate from slug tests).

W = 0.000088m/day = 4% of average rainfall of 0.808m/year or 32.3mm/year.

h_m = 1m (assumed).

Average annual rainfall was based on satistics collected at the Walcha Post Office between 1879 and 1996 and published on the Bureau of Meteorology website (www.bom.gov.au, 5 August 2020).

The portion of rainfall that recharges groundwater (W) was estimated to be 4%. This is the rate of infiltration adopted by the New England Fold Belt (Murray Darling Basin) Water Sharing Plan (NSW Department of Primary Industries, 2012). Crosby et al., (2010) reviewed groundwater recharge estimate studies across Australia. Their study provides a geometric mean of measured grouroundwater recharge rates for various surface geology across Australia. The geometric mean annual recharge for sites with volcanic surface geology is approximately 15mm/year. At the site, this equates to approximately 2% of average annual rainflall.

The upgradient (northern) face of the quarry is assumed to be approximately 100m long.

Using these inputs, the maximum extent of drawdown propagation upslope (to the north) of the excavation would be 132m. That is, there would be no change to the pre-development water table elevation 132m from the proposed excavation.

Inflow to the quarry excavation is calculated to be 1.162m^3/day or 424m^3/yr.

Drawdown impacts and inflow would not occur until the quarry reached the water table (at 1146m AHD). Drawdown impacts would increase in proportion to the depth and extent of the quarry excavation. The estimates presented above represent steady state conditions that would form once the quarry has reached its maximum depth and extent.

3.6.1 Comparison to Real Work Observations

The existing environment serves as an excellent physical model of drawdown behaviour in the basalt ridgeline close to the proposed quarry excavation. Dewatering of the basalt ridgeline already occurs naturally due to the presence of deep valleys to the south east, south and west of the proposed quarry. The groundwater elevation at MB4 indicates that the water table is lower than 1130m AHD very close to the proposed quarry footprint.

The steep gradient observed in basalt between MB1, MB5 and MB2 is caused by natural dewatering of the basalt due to drainage to the south. The aquifer to the south of the proposed quarry has been excavated by natural processes, namely erosion, leaving the basalt ridgeline exposed with potential to drain. This is essentially the same process that would occur if the proposed excavation was created, only the groundwater discharge (drainage) point would be moved approximately 200m further to the north (to the northern face of the quarry excavation).

There is an approximate 10m fall in groundwater elevation between MB1 and MB2 over a horizontal distance of approximately 110m. There is an approximate 8m fall in groundwater elevation between MB5 and MB2 over a horizontal distance of approximately 75m.

A maximum drawdown of 16m will occur at the northern face of the quarry excavation. The analytical model predicts that drawdown will extend approximately 132m to the north of the excavation. This model prediction is consistent with real world observations of aquifer behaviour indicating that the prediction is reliable.

3.6.2 Sensitivity Assessment

Ground Doctor applied a range of different assumptions to the analytical model to assess the variability of estimates for changes in model variable (K and W). The scenarios tested included the following.

K_h was varied by an order of magnitude lower and higher.

W was varied from 1% of annual rainfall to 6% of annual rainfall.

Table 3: Matrix of Calculated Drawdown Extent and Inflow For Differing Values of K and W.

	K_h=0.0006m/day	**K_h=0.006m/day**	**K_h=0.06m/day**
W = 1% Rainfall	Distance to Zero Drawdown = 84m Inflow = 0.185m^3/day	Distance to Zero Drawdown = 264m Inflow = 0.581m^3/day	Distance to Zero Drawdown = 834m Inflow = 1.835m^3/day
W = 2% Rainfall	Distance to Zero Drawdown = 59m Inflow = 0.260m^3/day	Distance to Zero Drawdown = 187m Inflow = 0.823m^3/day	Distance to Zero Drawdown = 590m Inflow = 2.596m^3/day
W = 4% Rainfall	Distance to Zero Drawdown = 42m Inflow = 0.370m^3/day	***Distance to Zero Drawdown = 132m** **Inflow = 1.162m^3/day**	Distance to Zero Drawdown = 417m Inflow = 3.670m^3/day
W = 6% Rainfall	Distance to Zero Drawdown = 34m Inflow = 0.449m^3/day	Distance to Zero Drawdown = 108m Inflow = 1.426m^3/day	Distance to Zero Drawdown = 341m Inflow = 4.501m^3/day

*Model inputs considered most indicative of actual Site conditions.

The distance that drawdown propagates is directly proportional to aquifer conductivity (K). That is, the estimated maximum extent of drawdown increases with higher hydraulic conductivity.

Increased aquifer recharge (W) decreases the maximum extent of drawdown impacts, but increases the volume of inflow.

As outlined in *Table 3*, estimates of the distance to zero aquifer drawdown range from 34m to 834m from the northern face of the quarry excavation. Estimates of groundwater inflow to the open excavation range from 0.185m^3/day to 4.501m^3/day.

All results indicate that drawdown would not impact water levels at any of the identified groundwater users within the Study Area, which are located more than 1500m from the proposed quarry and at elevations below the proposed maximum depth of the quarry.

3.7 Management of Groundwater Inflow

Groundwater would not be encountered in the proposed excavation until it reaches elevations below 1146m AHD. The proposed extraction limit for the proposed development is 29,000m^3/yr. Averaged across the proposed footprint of the quarry excavation (approximately 16,500m^2), the quarry excavation would not progress more than 2m vertically per year on average. On this basis the water table would not be intersected for a least 7 years after commencement.

The estimates of the maximum extent of drawdown and groundwater inflow presented in *Section 3.6*, represent the maximum impacts when the quarry has reached 1130m AHD and a new steady state groundwater condition has established. These would occur at the later stages of the development only.

The nearest Bureau of Meteorology gauging location to the Site that measures pan evaporation is located in Armidale (Tree Group Nursery), Gauging Site 056037. Pan evaporation data is available for the period 1997 to 2020. Evaporation data published on the Bureau of Meteorology website (www.bom.gov.au, 5 August 2020) indciated an average evaporation rate of 3.2mm/day or 1168mm/year. The climate and elevation at Armidale are comparable to the Site and the data are considered representative of evaporation at the Site.

Subtracting evaporation from annual rainfall at the Walcha Post Office Site gives an annual moisture deficit of approximately 360mm/year. The footprint of the proposed quarry excavation is approximately 16,500m^2. Applying the annual moisture deficit across this area indicates that, on average, there is potential for 5760m^3/yr of water to be lost to evaporation from the open excavation.

The upper estimate of potential groundwater inflow to the pit is 4.5m^3/day or 1643m^3/yr.

Climate data indicates that groundwater inflow to the proposed quarry excavation would be lost to evaporation and that mechanical excavation of water would not be required from the excavation. It is possible that water may accumulate in the excavation periodically after periods of above average rainfall and/or periods of low evaporation. It is anticipated that any water accumulation within the excavation could be drained to a sump and later used in quarry operations.

It is also possible that once a new equilibrium condition is established in the post development landscape, that groundwater accumulation in the base of the excavation (if this occurs) would leak through the base of the excavation and continue draining to the east, south and west, due to the large fall in surface elevation (and the water table) in these directions.

The take of groundwater (whether water is used for beneficial purposes or lost to evaporation) must be licenced. The Applicants would have to purchase existing groundwater entitlement in accordance with the rules of the "*Water Sharing Plan for the NSW Murray Darling Fractured Rock Sources 2011*" to account for direct or indirect groundwater take.

The NSW Department of Industry Planning and Environment website (https://www.industry.nsw.gov.au/water/allocations-availability/water-accounting/usage-dashboard, 7 August 2020) indicates that there is 11384ML allocated within the New England Fold Belt (Murray Darling Basin) groundwater unit. It is expected that the applicants could find existing entitlement of 2ML/year to purchase to account for any direct or indirect take of groundwater from the open excavation.

4 Groundwater Impact Assessment

4.1 Aquifer Interference

The *Water Management Act 2000* defines an aquifer interference activity as that which involves any of the following:

- the penetration of an aquifer,
- the interference with water in an aquifer,
- the obstruction of the flow of water in an aquifer,
- the taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations, and
- the disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.

The water table has been identified at an elevation of 1146m AHD within the footprint of the proposed quarry excavation, more than 14m below surface elevation. The quarry would be regarded as an aquifer interference activity once it extends below a depth of 1146m AHD. Aquifer interference activity is not expected to occur in the first several years of operation due to proposed annual extraction limits proposed by the development.

This assessment has considered worst case impacts which would occur at the end of the quarry life were the excavation is at the maximum depth and extent.

4.2 Aquifer Interference Tests

The NSW Aquifer Interference Policy (NSW DPI, 2012b) outlines "*minimum impact considerations*" for various aquifer types. If the predicted impacts are less than the "*minimal impact considerations*", then these impacts are considered acceptable.

The groundwater unit that would be impacted by the proposal is the New England Fold Belt (Murray Darling Basin). Based on estimates of aquifer hydraulic conductivity at the quarry, the unit would be described as a "*less productive",* however a bore located within the management unit within 2km of the proposed quarry had a recorded yield in excess of 5L/s. For the purpose of this impact assessment the aquifer was considered a "*highly productive fractured rock aquifer*" as defined in the policy.

The minimum impact considerations for a "*highly productive fractured rock aquifer*" are as follows.

4.2.1 Groundwater Dependent Ecosystems and Cultural Sites

1. Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any:

(a) high priority groundwater dependent ecosystem; or

(b) high priority culturally significant site – listed in the schedule of the relevant water sharing plan. A maximum of 2m decline cumulatively at any water supply work.

2. If more than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any:

(a) high priority groundwater dependent ecosystem; or

(b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan then appropriate studies will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site.

If more than 2m decline cumulatively at any water supply work then make good provisions should apply.

There are no high priority groundwater dependant ecosystems, or high priority culturally significant sites or water supply works situated within the Study Area.

4.2.2 Drawdown Impacts

1. A cumulative pressure head decline of not more than a 2m decline, at any water supply work.

2. If the predicted pressure head decline is greater than the requirement above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.

The drawdown impacts associated within the proposed development would not exceed the minimum impacts consideration for the following reasons.

- The recorded standing water levels at the identified groundwater works within 2km of the proposed quarry were less than 1110m AHD, some 20m below the maximum depth of the proposed quarry. The quarry could not impact water levels in the identified groundwater works on this basis alone.

- The predicted maximum extent of drawdown impacts is approximately 132m from the proposed excavation. Using very conservative estimates of aquifer hydraulic conductivity and low groundwater recharge the predicted maximum extent of drawdown impacts approximately 834m north of the Quarry. The nearest identified groundwater works were located more than 1500m from the proposed excavation.

- The identified groundwater work at Mt Pleasant is located within a different catchment and different groundwater management unit.

4.2.3 Water Quality

1. Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity.

2. If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.

The proposed development involves blasting, crushing and screening of excavated rock. The proposed activities have little if any potential to add contaminants that could adversely change groundwater quality.

The proposed use of explosives within the excavation has potential to introduce nutrients to the Site, which could potentially impact on the underlying water quality. This risk is considered comparable to use of fertilisers at the ground surface both within the Site and within surrounding agricultural properties and potential impacts are considered acceptable.

The development requires operation of plant at the ground surface. Spillage of fuel, lubricants and hydraulic fluids poses a risk to underlying groundwater quality. This risk would be adequately managed by the establishment of dedicated vehicle servicing and refuelling areas and appropriate management controls, which would include fast containment of spills and fast removal and containment of impacted soil and rock using on-site earth moving equipment.

Hazardous and non-hazardous chemicals to be used within the Site would be managed in accordance with the specifications of the Material and Safety Data Sheets (MSDS) and relevant management plans.

The following measures would be implemented to further minimise adverse environmental impacts associated with storage and use of reagents and chemicals within the Project Site.

- All chemicals would be stored and used in accordance with the manufacturer's instructions and the relevant MSDS.
- All liquid chemicals would be stored within an impermeable bunded area with a capacity of at least 110% of the capacity of the largest container.
- Chemicals with the potential to react with each other would not be stored in the same area to prevent any reactions between them in the event of a spill.
- Only the minimum volume of chemicals required for the ongoing operation of the quarry would be stored on-Site.
- MSDS and appropriate spill management equipment would be available in the vicinity of all chemical storage areas.
- Personnel who will use chemicals would be provided with the appropriate training in the proper handling techniques.

4.3 Aquifer Impact Assessment

Potential groundwater impacts associated with the proposed development would not exceed the Level 1 "*minimum impact considerations*" outlined in the NSW Aquifer Interference Policy (NSW DPI, 2012b). Therefore, groundwater impacts associated with the project are acceptable.

5 Conclusion

The proposed quarry will be excavated to a maximum depth of 1130m AHD. Groundwater was identified in basalt within the quarry footprint at a maximum elevation of approximately 1146m AHD. The proposed development would intersect the water table and is an aquifer interference activity as defined by the NSW Aquifer Interference Policy (2012).

Ground Doctor assessed the site setting and available groundwater data to identify existing groundwater users, environmental receptors and culturally sensitive groundwater features within a 2km radius of the site.

High priority groundwater dependent ecosystems or high priority cultural groundwater sites were not identified within 2km of the proposed quarry.

Four existing groundwater works were identified within a 2 km radius of the proposed quarry excavation. The identified bores were located more than 1500m from the proposed excavation. Available data for the identified bores indicated that standing water levels in the bores were at least 20m lower than the maximum proposed depth of excavation. The bore identified within "Mt Pleasant" was separated from the proposed quarry by the Great Dividing Range and was within a different catchment and a different groundwater management unit to the proposed quarry.

Five monitoring bores were installed within or close to the footprint of the proposed quarry excavation. Groundwater levels were measured at each bore. Falling head and rising head slug tests were performed on four of the five bores to assess hydraulic conductivity of aquifer material within and surrounding the proposed quarry excavation.

A conceptual site model was developed based on available groundwater and topographical data. The proposed quarry excavation would be located approximately 200m south of the Great Dividing Range. The ground surface around the proposed quarry falls steeply to the to the south east, south and west. The surface elevation was more than 100m below the base of the proposed excavation less than 500m to the south east and south of the quarry. Groundwater elevation data showed a steep groundwater gradient to the south east, south and west of the proposed quarry, consistent with steeply sloping surface topography.

An analytical model was adopted to predict steady state drawdown impacts and groundwater inflow to the open excavation at the completion of quarrying. The model predicted drawdown impacts would extend approximately 132m north of the proposed excavation. Groundwater inflow was estimated to be 1.16m^3/day.

Model prediction showed good agreement with observed real world drawdown in basalt within the quarry footprint, which was already draining to the south due to the presence of a natural void (a deep valley) to the south.

The modelled groundwater inflow to the excavation is less than the expected evaporation rate from the open excavation. There is also potential for any groundwater inflow to drain through the floor of the excavation, as the base of the proposed excavation remains elevated above the valley to the south. Mechanical dewatering of the excavation is unlikely to be required. Any water accumulation in the excavation could be used in quarry operations or used as stock water at the completion of the development.

Direct take (e.g. pumping for beneficial use) or indirect take of groundwater (e.g. losses to evaporation) are required to be licenced. The annual groundwater inflow to the open excavation would be less than 2ML. The Applicant would need to source commercial use entitlement to take 2ML from the New England Fold Belt (Murray Darling Basin) groundwater management unit prior to intersecting the water table. The NSW Department of Industry Planning and Environment website (https://www.industry.nsw.gov.au/water/allocations-availability/water-accounting/usage-dashboard, 7 August 2020) indicates that there is 11384ML allocated within the New England Fold

Belt (Murray Darling Basin) groundwater unit. It would be possible for the Applicants to obtain the required groundwater entitlement prior to intersecting the water table.

The project involves blasting, crushing and screening of excavated rock. The proposed activities have little if any potential to add contaminants that could adversely change groundwater quality. Operation of plant and machinery and use of nitrogen containing explosives poses a similar risk to groundwater quality as existing agricultural use of the Site and adjoining land. Potential risks to water quality can be managed by implementing appropriate procedures for storage and use of chemicals, refuelling and maintenance of plant and machinery and implementing appropriate spill response plans.

The information presented in this report indicates that the groundwater impacts associated with the proposed development would not exceed the Level 1 "*minimum impact considerations*" outlined in the NSW Aquifer Interference Policy (NSW DPI, 2012b). Therefore, groundwater impacts associated with the project are acceptable.

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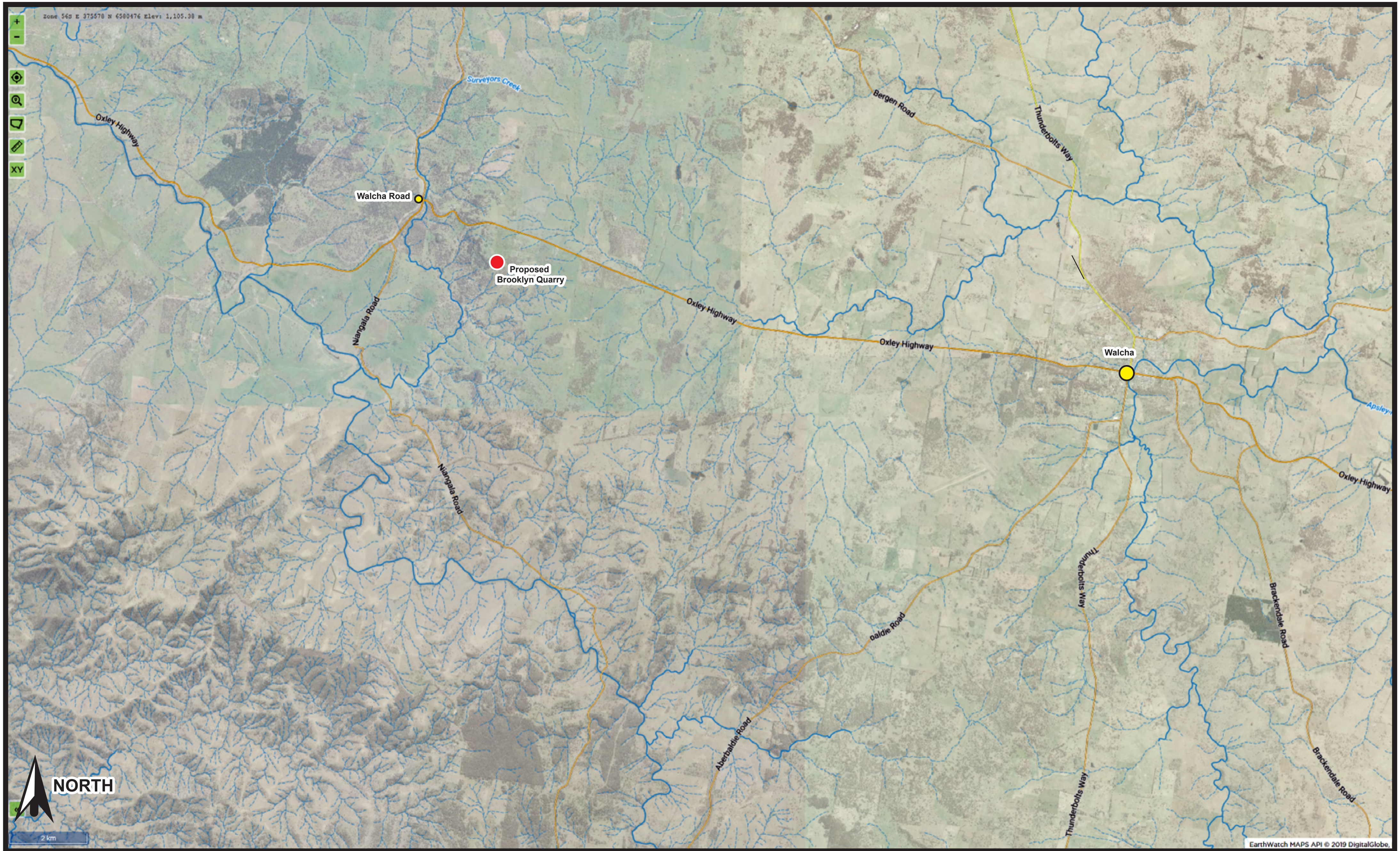
Annex A

Figures



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Project Name:	Groundwater Impact Assessment Brooklyn Quarry - 1643 Oxyley Highway, Walcha, NSW
Project Number:	2020-GD008-RP1

Figure 1

Regional Setting of Proposed Quarry Site

Map grid based on WGS84
Topographic data © NSW Dept
Finance, Services & Innovation 2020
Map drawn by M.Goodwin 2020

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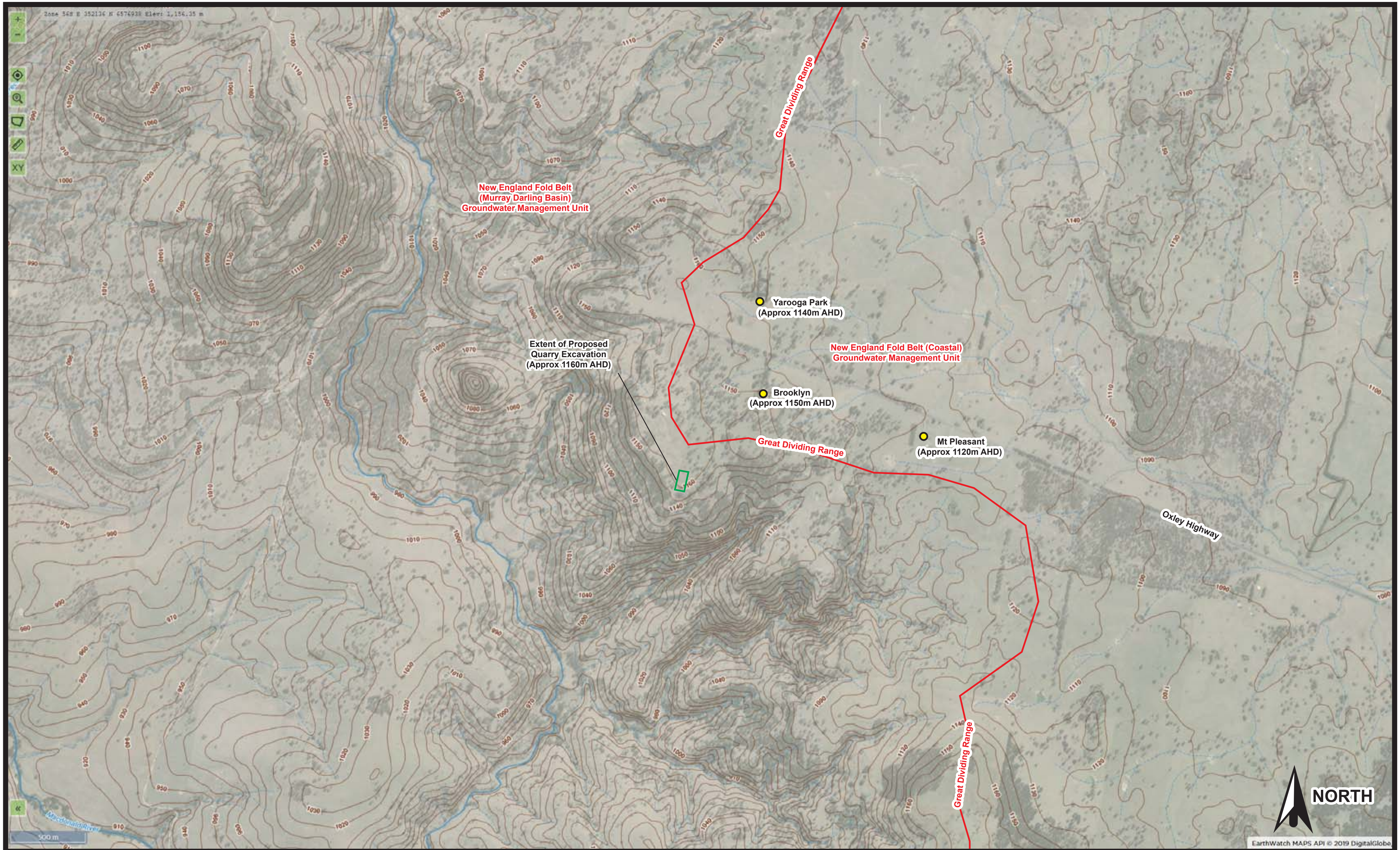
Brooklyn Quarry - 1643 Oxley Highway, Walcha, NSW

Project Number: 2020-GD008-RP1

Figure 2

Orthophoto Map Showing the Proposed Extent
of the Quarry Excavatin



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Project Name:	Groundwater Impact Assessment Brooklyn Quarry - 1643 Oxley Highway, Walcha, NSW	Figure 3
Project Number:	2020-GD008-RP1	Regional Topographic Map and Groundwater Management Units

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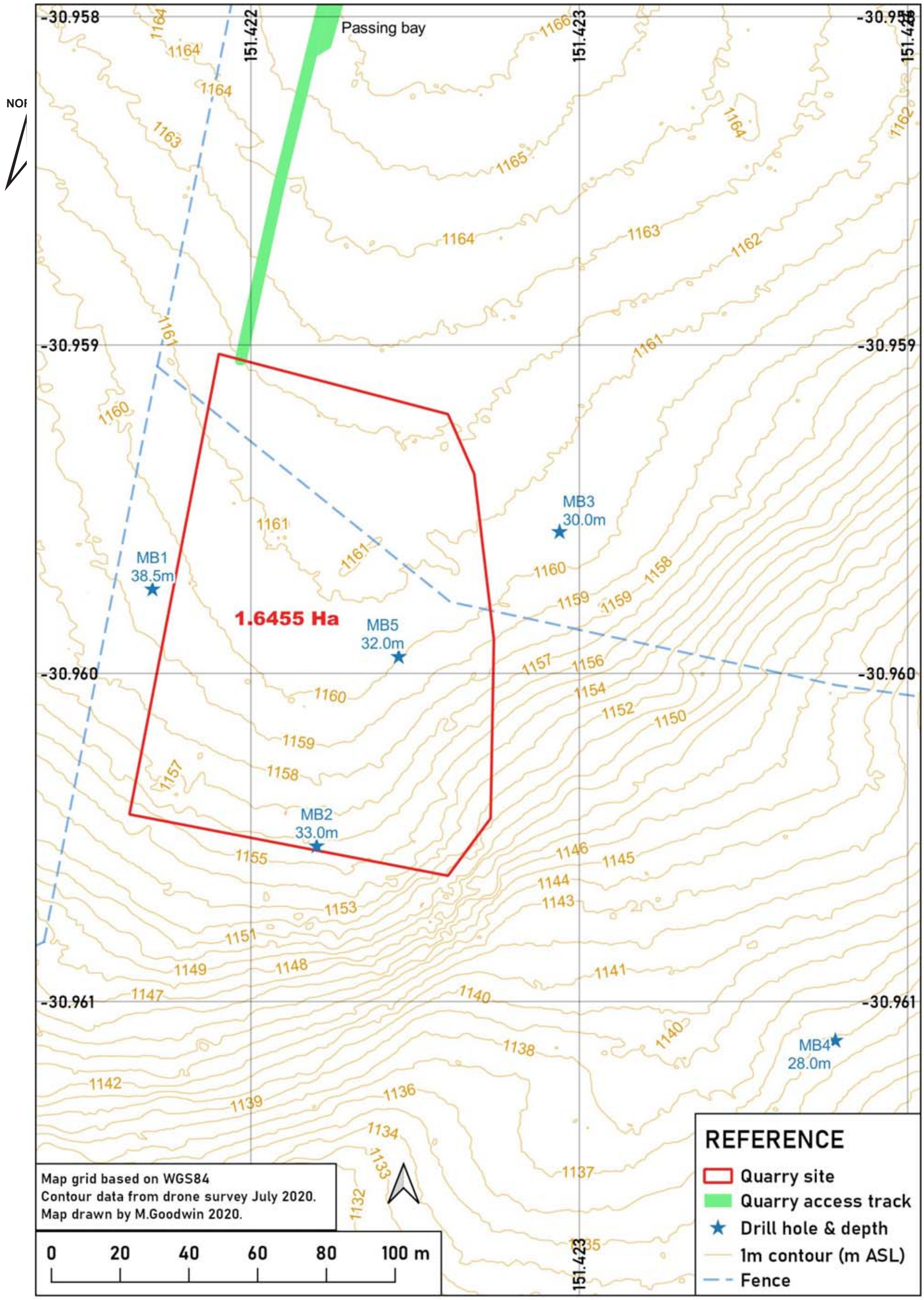
Figure 4

Oblique Aerial Photograph Looking in a Northerly Direction Across the Site and Surrounds
with Spot Heights Marked for Topographic Context



Map grid based on WGS84
Contour data from drone survey July 2020.
Map drawn by M.Goodwin 2020.

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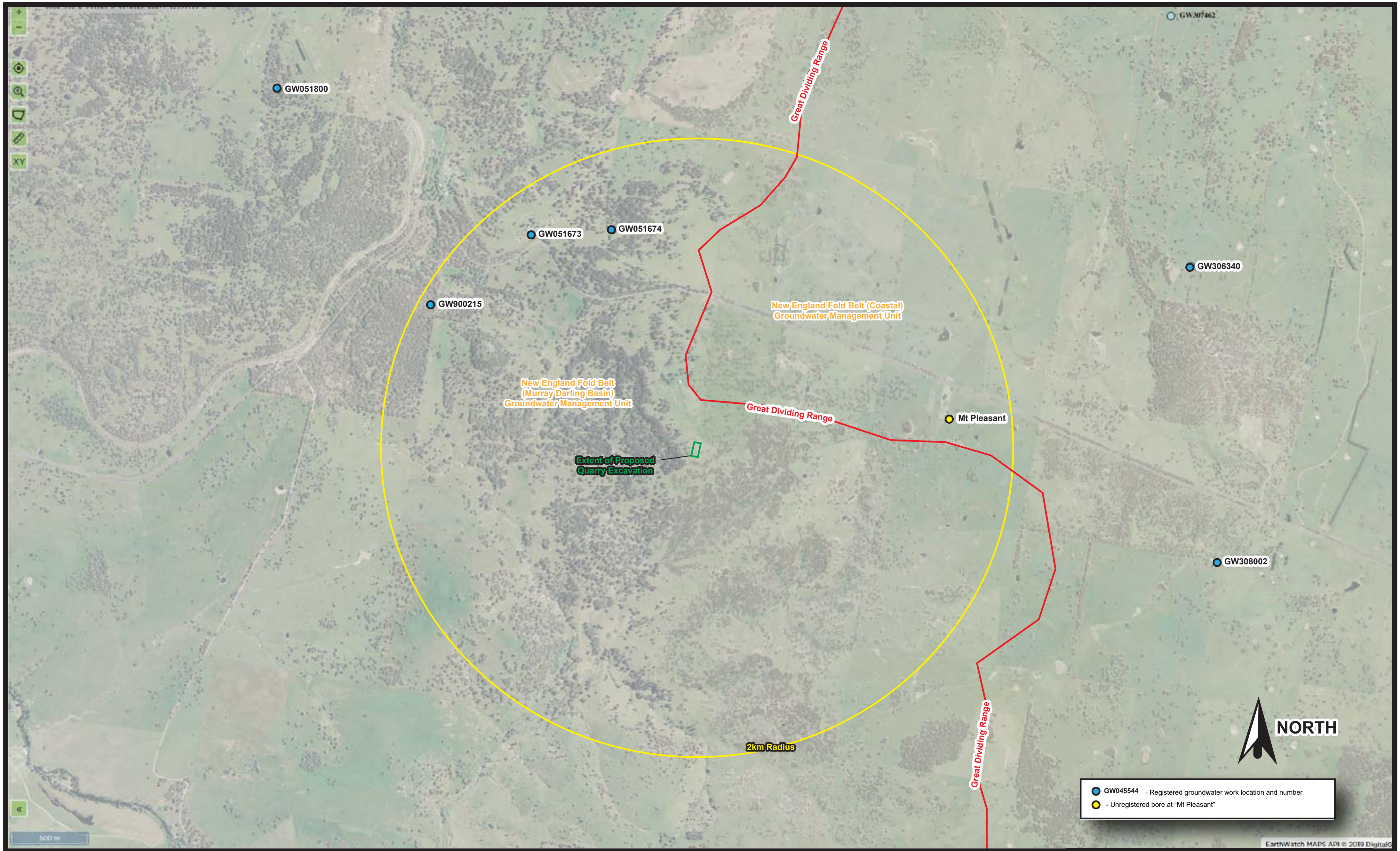
Project Name: Groundwater Impact Assessment Brooklyn Quarry - 1643 Oxley Highway, Walcha, NSW	Figure 5
Project Number: 2020-GD008-RP1	Monitoring Bore Locations annd 2m Surfacce Elevation Contours



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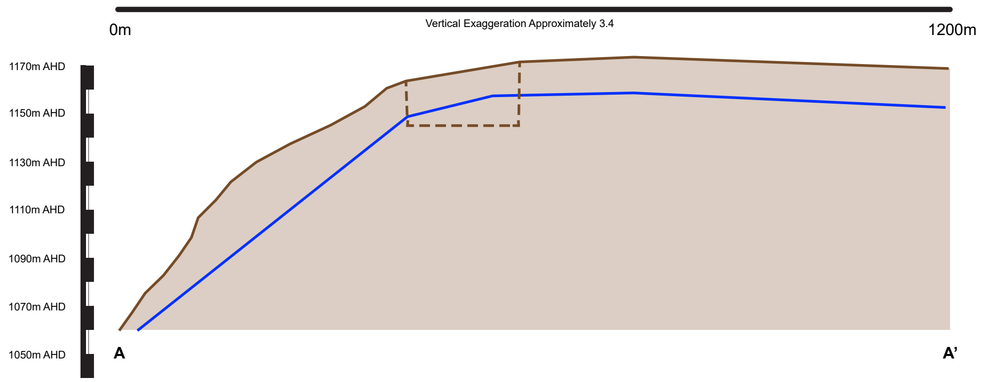
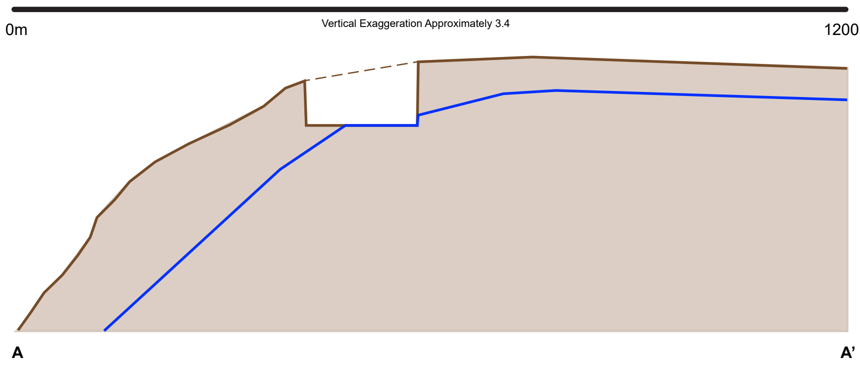
Project Number: 2020-GD008-RP1

Figure 6

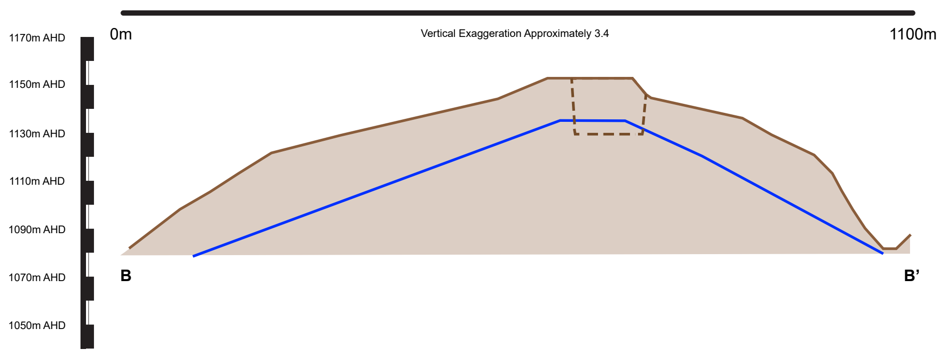
Map of Registered Groundwater Works

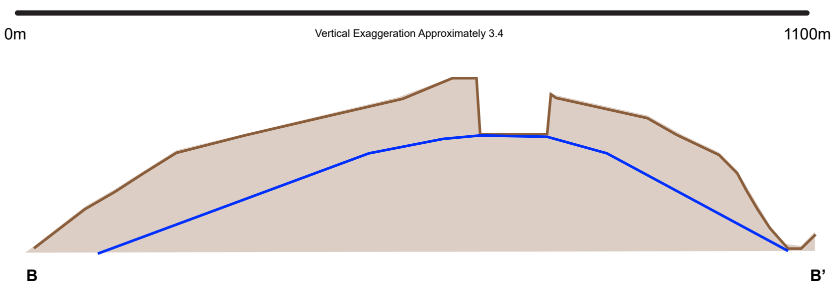


Inferred Groundwater Elevation Before Commencement



Inferred Groundwater Elevation At Completion





Ground Doctor Pty Ltd
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PO Box 6278
22 Tamworth Street
Dubbo NSW 2830

Project Name:	Groundwater Impact Assessment Brooklyn Quarry - 1643 Oxyley Highway, Walcha, NSW
Project Number:	2020-GD008-RP1

Figure 7

Topographic Cross Sections Showing Inferred Groundwater Elevation
Before Commencement and at Completion of Quarry

Annex B

Groundwater Works Summary Forms

Table B1 - Groundwater Works Summary Form Information

Work ID	Work Type	Status	Owner Type	Purpose	Complete Year	Final Depth	Drilled Depth	Salinity	Recorded SWL (m bgl)	Water Bearing Zones (WBZ)	Inferred Ground Level mAHD	Inferred SWL (mAHD)	Upper WBZ (mAHD)	Yield (L/s)	Distance from Excavation Centre	Direction	Geology Summary
GW051673	Bore	Supply Obtained	Private	Stock	1981	30.4m	30.4m	0-500ppm	-	15.2-23.7m (Unconsolidated Clay and Sand)	1085	1070	1070	-	1800m	North West	0-28.3m Clay 28.3-30.4m Granite
GW051674	Bore	-	Private	Stock	1981	42.5m	42.5m	-	-	27.4-40.7m (Granite)	1115	-	1088	6.17	1550m	North North West	0-40.7m Granite
GW900215	Bore	-	-	Stock and Domestic	1992	22.5m	22.5m	Potable	6	20-22m (Granite)	1030	1024	1010	2.5	2000m	North West	0-22.5m Granite
GW306340	Bore	Supply Obtained	Private	Stock and Domestic	2008	61.6m	61.6m	Potable	19.5	18.3-18.9m (Basalt) 54.9-61.6m (Basalt)	1115	1096	1097	0.38	3400m	North East	0-1.8mm Clay 1.8-61.6m Basalt
GW308002	Bore	Supply Obtained	Private	Stock	2018	33.5m	33.5m	Potable	14	20-22m (Basalt)	1100	1086	1080	1.13	3500m	East	0-4m Clay 4-33.5m Basalt
Mt Pleasant	Bore	-	Private	Stock and Domestic	Unknown	27m	-	-	10	Unknown	1120	1110	-	0.5	1550m	North East	Unknown

WaterNSW
Work Summary

GW051673

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 01/01/1981
Final Depth: 30.40 m
Drilled Depth: 30.40 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: 0-500 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	INGLIS	CONGI	183
Licensed:			

Region: 90 - Barwon
CMA Map: 9136-2S
River Basin: 419 - NAMOI RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6575154.000
Easting: 348143.000
Latitude: 30°56'50.3"S
Longitude: 151°24'37.0"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Annulus	Waterworn/Rounded	12.10	30.40	137			Graded
1	1	Casing	P.V.C.	0.00	30.40	137			Seated on Bottom
1	1	Opening	Slots - Vertical	12.10	30.40	137		1	Mechanically Slotted, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
15.20	23.70	8.50	Unconsolidated						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

0.00	0.31	0.31	Topsoil	Topsoil	
0.31	0.91	0.60	Clay	Clay	
0.91	1.50	0.59	Basalt Decomposed Rock	Basalt	
1.50	2.70	1.20	Clay	Clay	
2.70	23.70	21.00	Clay Loose Sandy Water Bearing	Clay	
23.70	28.30	4.60	Clay	Clay	
28.30	30.40	2.10	Granite	Granite	

***** End of GW051673 *****

WaterNSW
Work Summary

GW051674

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore open thru rock
Work Status:
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 01/01/1981
Final Depth: 42.50 m
Drilled Depth: 42.50 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	INGLIS	CONGI	17
Licensed:			

Region: 90 - Barwon
CMA Map: 9136-2S
River Basin: 419 - NAMOI RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6575192.000
Easting: 348673.000
Latitude: 30°56'49.3"S
Longitude: 151°24'57.0"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	P.V.C.	0.00	12.10	137			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
27.40	40.70	13.30	Fractured			6.17			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.20	0.20	Topsoil	Topsoil	
0.20	6.70	6.50	Granite	Granite	

6.70	27.40	20.70	Granite	Granite	
27.40	35.80	8.40	Granite Water Supply	Granite	
35.80	42.50	6.70	Quartz Water Supply	Quartz	

***** End of GW051674 *****

WaterNSW
Work Summary

GW306340

Licence: 30WA313690 **Licence Status:** CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date: **Final Depth:** 61.60 m
Completion Date: 04/03/2008 **Drilled Depth:** 61.60 m

Contractor Name: John Vincent Keen
Driller: John Vincent Keen
Assistant Driller: S V Keen

Property: PORT VIEW MAINE PTY LIMITED Walcha Rd WALCHA 2354 NSW **Standing Water Level (m):** 19.500
GWMA: - **Salinity Description:** Potable
GW Zone: - **Yield (L/s):** 0.380

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	VERNON	BERGEN OP ZOO	145//756466
Licensed:	VERNON	BERGEN OP ZOOM	Whole Lot 145//756466

Region: 30 - North Coast **CMA Map:** 9136-2S
River Basin: 206 - MACLEAY RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6575009.000 **Latitude:** 30°56'57.0"S
Elevation Source: Unknown **Easting:** 352488.000 **Longitude:** 151°27'20.6"E

GS Map: - **MGA Zone:** 56 **Coordinate Source:** GIS - Geogra

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	61.60	155			Rotary Air
1	1	Casing	Pvc Class 9	-0.30	61.60	140	126		Seated on Bottom, Riveted and Glued
1	1	Opening	Slots - Horizontal	54.90	61.60	140		0	Mechanically Slotted, PVC Class 9, Riveted and Glued, SL: 300.0mm, A: 2.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
18.30	18.90	0.60	Unknown	19.50		0.25		01:00:00	
54.90	61.60	6.70	Unknown			0.13			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.60	0.60	Topsoil	Topsoil	
0.60	1.80	1.20	Clay	Clay	
1.80	18.30	16.50	Basalt	Basalt	
18.30	61.60	43.30	Basalt	Basalt	

Remarks

04/03/2008: Form A Remarks:
Nat Carling, 18-Sept-2008: Coordinates based on location map provided with the Form A.

***** End of GW306340 *****

WaterNSW
Work Summary

GW308002

Licence: 30WA322014

Licence Status: CURRENT

Authorised Purpose(s): STOCK
Intended Purpose(s): STOCK

Work Type: Bore
Work Status: Supply Obtained
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 30/08/2018

Final Depth: 33.50 m
Drilled Depth:

Contractor Name: Cameron Drilling
Driller: Thomas Cameron
Assistant Driller: NIGEL HAWKINS

Property: Strathaven Oxley Hwy Walcha Road 2354
GWMA: -
GW Zone: -

Standing Water Level (m): 14.000
Salinity Description: Potable
Yield (L/s): 1.125

Site Details

Site Chosen By: Client

	County	Parish	Cadastre
Form A:	VERNON	BOULTON	
Licensed:	VERNON	BOULTON	Whole Lot 86//756467

Region: - (Not set)
CMA Map:

River Basin: Area/District: - Unknown
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6573067.800
Easting: 352720.700

Latitude: 30°58'00.1"S
Longitude: 151°27'28.4"E

GS Map: -
MGA Zone: 56
Coordinate Source: Map Interpre

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	6.00	200			Rotary - Percussion (Down Hole H
1		Hole	Hole	6.00	33.50	160			Rotary - Percussion (Down Hole H
1		Annulus	(Not Set)	0.00	6.00				Q:0.120m3
1	1	Casing	Pvc Class 9	-0.40	33.50	135	125		Seated on Bottom, Glued, S: 22.00-33.00m
1	1	Casing	Steel - Erw	-0.40	2.00	160	150		Welded - Butt
1	1	Opening	Perforations,Screen - Gauze/Me	0.00	0.00			0	
1	1	Opening	Slots - Vertical	20.00	25.00	135	125	0	Casing - Machine Slotted, Glued, SL: 4.0mm, A: 40.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

20.00	22.00	2.00	Unknown	14.00		1.25		00:02:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.00	3.00	CLAY, WHITE	Clay	
3.00	4.00	1.00	CLAY, GREY SANDY	Clay	
4.00	31.00	27.00	BASALT, FRACTURED	Basalt	
31.00	33.50	2.50	BASALT, HARD	Basalt	

Remarks

30/08/2018: FORM ENTERED BY DIANA SMITH 25/2/2019

***** End of GW308002 *****

WaterNSW
Work Summary

GW900215

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Final Depth: 22.50 m
Completion Date: 01/11/1992
Drilled Depth: 22.50 m

Contractor Name: TAMWORTH DRILLING CO
Driller: Garry Stanley Strudwick
Assistant Driller:

Property:
Standing Water Level (m):
GWMA:
Salinity Description: Potable
GW Zone:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	INGLIS	CONGI	222
Licensed:			

Region: 90 - Barwon
CMA Map:
River Basin: - Unknown
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Northing: 6574688.000
Latitude: 30°57'05.1"S
Elevation Source: Unknown
Easting: 347489.000
Longitude: 151°24'12.1"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	22.50	155			Rotary Air
1	1	Casing	P.V.C.	-0.50	22.50	135			Seated on Bottom, Glued
1	1	Casing	Steel	-0.50	3.00	168			Driven into Hole
1	1	Opening	Slots - Horizontal	18.00	22.00	135		1	PVC, SL: 100.0mm, A: 2.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
20.00	22.00	2.00	Unknown	6.00		2.50	22.00	01:00:00	

Drillers Log

From	To	Thickness	Drillers Description	Geological Material	Comments

(m)	(m)	(m)			
0.00	1.00	1.00	GRANITE SOIL	Unknown	
1.00	3.00	2.00	WEATHERITE GRANITE	Unknown	
3.00	22.50	19.50	GREY GRANITE ROCK WITH FRACTURES	Unknown	

***** End of GW900215 *****

Annex C

Borehole and Monitoring Bore Construction Logs

Borehole ID: MB1

Project No.: 2020-GD008

Project Name: Brooklyn Quarry Groundwater Assessment

Client: SRB Excavations Pty Ltd

Site Address: 1643 Oxley Highway, Walcha, NSW

Ground Doctor Pty Ltd

22 Tamworth Street
PO Box 6278
DUBBO NSW 2830

ph: 0407 875 302
fx: (02) 8607 8122
admin@grounddoc.com.au

SUBSURFACE PROFILE

Depth/Elev.	Description
0.0	Ground Surface
1.0	**CLAY:** Red-brown, moist, low plasticity, with basalt cobbles.
37.0	**Basalt and Weathered Basalt** Basalt with lenses of weathered basalt, dry. Weathered lenses included a mix of basalt chips, brown clay and brittle rock. Hard 1m to 6m. Softer 6-7m. Hard 7-9m. Softer and fractured 9-10m. Softer with brown clayey material interspersed with basalt chips 9-13m. Hard 13-15m. Soft / fractured 15-16m and 17-18m. Minor wet chips at 16m rod change. Change in formation at 24-37m (made drill jump), possibly bouldery basalt or vertical oriented fractures. Moist cuttings at 25m rod change and subsequent rod changes. Additional water cut at 30.0-30.5m (dust dropped). Consistently wet cuttings 31m+
38.5	**CLAY:** Mottled grey and brown, wet, medium to high plasticity.
	End of Hole at 38.5m bgl in Clay. Target Depth Reached.

Depth (m): -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39

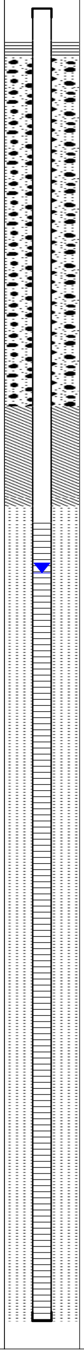
SAMPLE

Sample ID

PID / Odour

CONSTRUCTION

Well Diagram



Materials Used

Approx. 1m Stickup at Surface With Steel Monument

Concrete (0.0-0.5m bgl)

50mm ID CLass 18 PVC Blank Casing Screw Fit (-1.0-14.5m bgl)

Annulus backfilled with Drill Cuttings (0.5-11.0m bgl)

Annulus filled with Bentonite Pellets (11-14m bg)

Annulus filled with 3-7mm Rounded River Gravel (14.0-38.5m bgl).

50mm ID Class 18 PVC Screen Screw Fit (14.5-38.5m bgl)

Drilled By: Ivan Drilling (Georgel Ivan)

Drill Method: Air Rotary DHH

Drill Date: 30 June 2020

Hole Size: 90mm

Datum:

Sheet: 1 of 1

Borehole ID: MB2

Project No.: 2020-GD008

Project Name: Brooklyn Quarry Groundwater Assessment

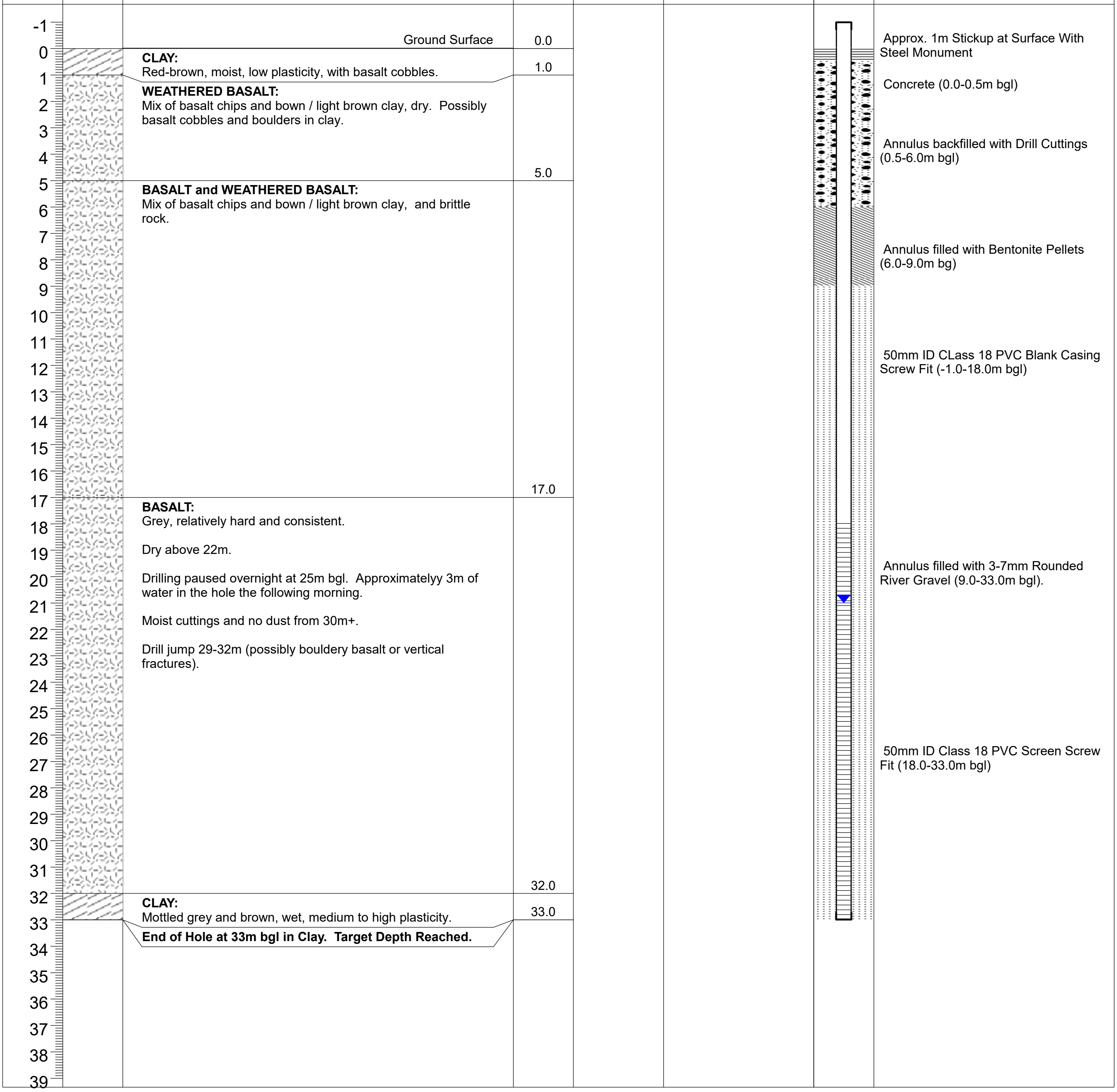
Client: SRB Excavations Pty Ltd

Site Address: 1643 Oxley Highway, Walcha, NSW

Ground Doctor Pty Ltd

22 Tamworth Street
PO Box 6278
DUBBO NSW 2830

ph: 0407 875 302
fx: (02) 8607 8122
admin@grounddoc.com.au



SUBSURFACE PROFILE				SAMPLE		CONSTRUCTION	
Depth (m)	Symbol	Description	Depth/Elev.	Sample ID	PID / Odour	Well Diagram	Materials Used
-1		Ground Surface	0.0				Approx. 1m Stickup at Surface With Steel Monument
0		**CLAY:** Red-brown, moist, low plasticity, with basalt cobbles.	1.0				Concrete (0.0-0.5m bgl)
1		**WEATHERED BASALT:** Mix of basalt chips and bown / light brown clay, dry. Possibly basalt cobbles and boulders in clay.	5.0				Annulus backfilled with Drill Cuttings (0.5-6.0m bgl)
5		**BASALT and WEATHERED BASALT:** Mix of basalt chips and bown / light brown clay, and brittle rock.	17.0				Annulus filled with Bentonite Pellets (6.0-9.0m bg) 50mm ID CLass 18 PVC Blank Casing Screw Fit (-1.0-18.0m bgl)
17		**BASALT:** Grey, relatively hard and consistent. Dry above 22m. Drilling paused overnight at 25m bgl. Approximatelyy 3m of water in the hole the following morning. Moist cuttings and no dust from 30m+. Drill jump 29-32m (possibly bouldery basalt or vertical fractures).	32.0				Annulus filled with 3-7mm Rounded River Gravel (9.0-33.0m bgl). 50mm ID Class 18 PVC Screen Screw Fit (18.0-33.0m bgl)
32		**CLAY:** Mottled grey and brown, wet, medium to high plasticity.	33.0				
33		**End of Hole at 33m bgl in Clay. Target Depth Reached.**					

Drilled By: Ivan Drilling (Georgel Ivan)

Drill Method: Air Rotary DHH

Drill Date: 30 June 2020 and 1 July 2020

Hole Size: 90mm

Datum:

Sheet: 1 of 1

Borehole ID: MB3

Project No.: 2020-GD008

Project Name: Brooklyn Quarry Groundwater Assessment

Client: SRB Excavations Pty Ltd

Site Address: 1643 Oxley Highway, Walcha, NSW

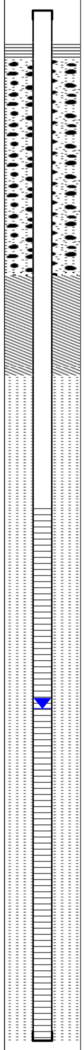
Ground Doctor Pty Ltd

22 Tamworth Street
PO Box 6278
DUBBO NSW 2830

ph: 0407 875 302
fx: (02) 8607 8122
admin@grounddoc.com.au

SUBSURFACE PROFILE | SAMPLE | CONSTRUCTION

Depth/Elev.	Description	Sample ID	PID / Odour
0.0	Ground Surface		
0.5	**CLAY:** Dark brown, moist, medium plasticity..		
2.0	**CLAY:** Mottle red-brown and light brown, dry, medium plasticity.		
4.2	**CLAY:** Mottled brown and grey, medium plasticity, dry.		
7.0	**WEATHERED BASALT:** Basalt boulders in light brown and grey clay, dy.		
12.5	**BASALT:** Grey, dry, hard.		
19.0	**CLAY:** Orange-brown, brown and red, dry, low plasticity, silty 12.5-14.0m. Wet 14-15m - sticking to drill stem but not making water flow.		
30.0	**CLAY:** Mottled light brown and red-brown below 19.0m Poor cutting return below 19m. Water added to clean cuttings from borehole.		
	End of Hole at 30m bgl in Clay. Down Hole Hammer Could Not Advance Further in Clay.		



Materials Used

Approx. 1m Stickup at Surface With Steel Monument

Concrete (0.0-0.5m bgl)

Annulus Filled with Drill Cuttings (0.5-7.0m bgl)

Annulus filled with Bentonite Pellets (7.0-10.0m bg)

50mm ID Class 18 PVC Blank Casing Screw Fit (-1.0-14.0m bgl)

Annulus filled with 3-7mm Rounded River Gravel (10.0-30.0m bgl).

50mm ID Class 18 PVC Screen Screw Fit (14.0-30.0m bgl)

Drilled By: Ivan Drilling (Georgel Ivan)

Drill Method: Air Rotary DHH

Drill Date: 1-2 July 2020

Hole Size: 90mm

Datum:

Sheet: 1 of 1

Borehole ID: MB4

Project No.: 2020-GD008

Project Name: Brooklyn Quarry Groundwater Assessment

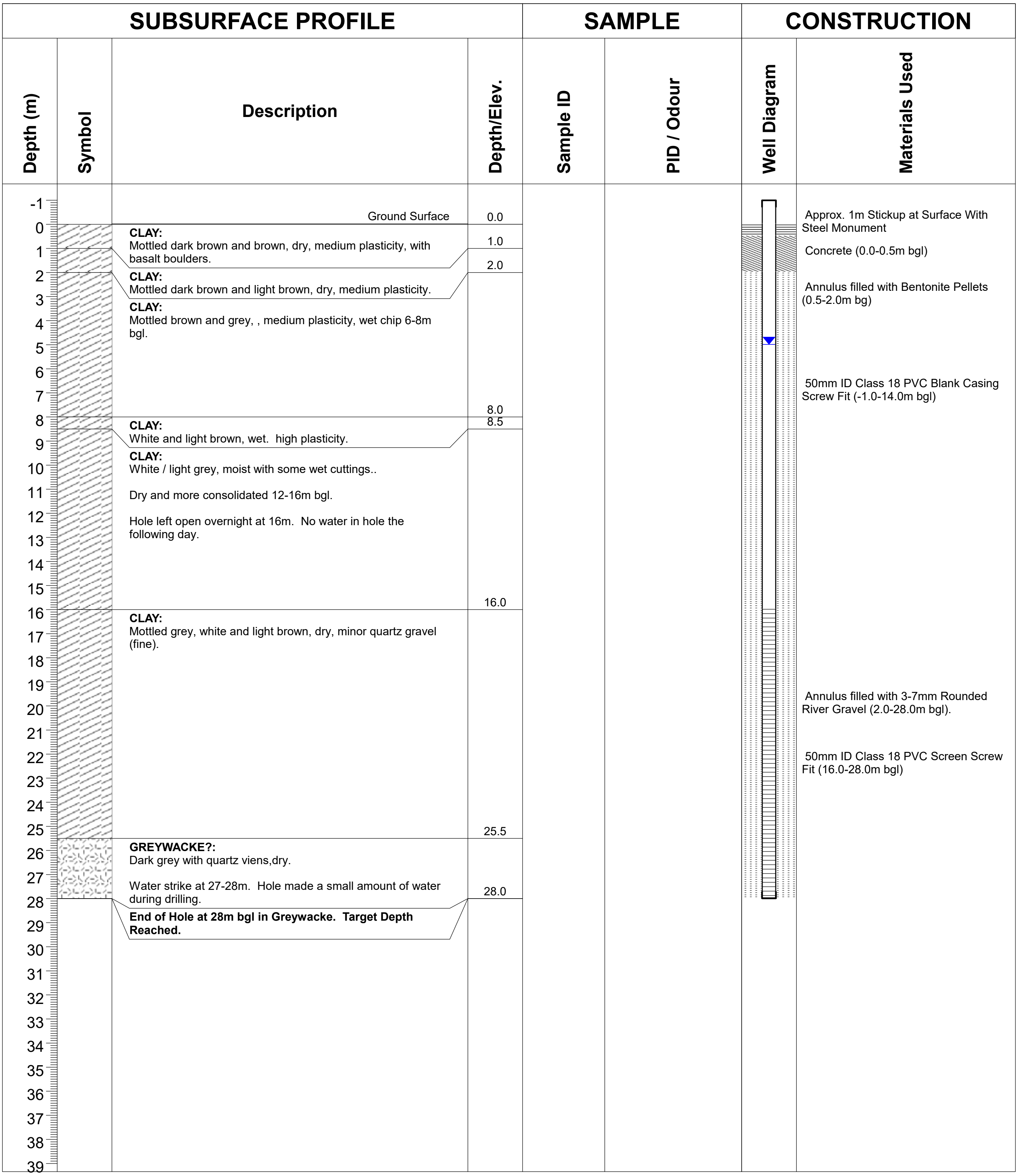
Client: SRB Excavations Pty Ltd

Site Address: 1643 Oxley Highway, Walcha, NSW

Ground Doctor Pty Ltd

22 Tamworth Street
PO Box 6278
DUBBO NSW 2830

ph: 0407 875 302
fx: (02) 8607 8122
admin@grounddoc.com.au



Description	Depth/Elev.
Ground Surface	0.0
CLAY: Mottled dark brown and brown, dry, medium plasticity, with basalt boulders.	1.0
CLAY: Mottled dark brown and light brown, dry, medium plasticity.	2.0
CLAY: Mottled brown and grey, , medium plasticity, wet chip 6-8m bgl.	8.0
CLAY: White and light brown, wet. high plasticity.	8.5
CLAY: White / light grey, moist with some wet cuttings.. Dry and more consolidated 12-16m bgl. Hole left open overnight at 16m. No water in hole the following day.	16.0
CLAY: Mottled grey, white and light brown, dry, minor quartz gravel (fine).	25.5
GREYWACKE?: Dark grey with quartz viens,dry. Water strike at 27-28m. Hole made a small amount of water during drilling.	28.0
End of Hole at 28m bgl in Greywacke. Target Depth Reached.	

Materials Used

Approx. 1m Stickup at Surface With Steel Monument

Concrete (0.0-0.5m bgl)

Annulus filled with Bentonite Pellets (0.5-2.0m bg)

50mm ID Class 18 PVC Blank Casing Screw Fit (-1.0-14.0m bgl)

Annulus filled with 3-7mm Rounded River Gravel (2.0-28.0m bgl).

50mm ID Class 18 PVC Screen Screw Fit (16.0-28.0m bgl)

Drilled By: Ivan Drilling (Georgel Ivan)

Drill Method: Air Rotary DHH

Drill Date: 2-3 July 2020

Hole Size: 90mm

Datum:

Sheet: 1 of 1

Borehole ID: MB5

Project No.: 2020-GD008

Project Name: Brooklyn Quarry Groundwater Assessment

Client: SRB Excavations Pty Ltd

Site Address: 1643 Oxley Highway, Walcha, NSW

Ground Doctor Pty Ltd

22 Tamworth Street
PO Box 6278
DUBBO NSW 2830

ph: 0407 875 302
fx: (02) 8607 8122
admin@grounddoc.com.au

SUBSURFACE PROFILE

Depth (m): -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39

Description	Depth/Elev.
Ground Surface	0.0
CLAY: Red-brown, moist, low plasticity, with basalt cobbles.	1.0
BASALT and WEATHERED BASALT: Mix of basalt chips and bown / light brown clay, and brittle rock. In various layers throughout. Dry.	17.0
BASALT: Grey, relatively hard and consistent. Dry above 22m.	23.0
BASALT and WEATHERED BASALT: Mix of basalt chips and bown / light brown clay, and brittle rock. In various layers throughout. First moisture at 25m rod change. Wet cuttings below 26m and no dust. Cuttings becoming clayier with depth below 23m.	31.0
CLAY: Mottled grey and brown, wet, medium to high plasticity.	32.0
End of Hole at 32m bgl in Clay. Target Depth Reached.	

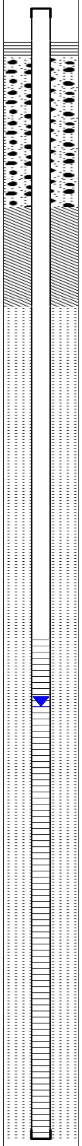
SAMPLE

Sample ID

PID / Odour

CONSTRUCTION

Well Diagram



Materials Used

Approx. 1m Stickup at Surface With Steel Monument

Concrete (0.0-0.5m bgl)

Annulus backfilled with Drill Cuttings (0.5-5.0m bgl)

Annulus filled with Bentonite Pellets (5.0-8.0m bg)

50mm ID Class 18 PVC Blank Casing Screw Fit (-1.0-21.5m bgl)

Annulus filled with 3-7mm Rounded River Gravel (8.0-32.0m bgl).

50mm ID Class 18 PVC Screen Screw Fit (21.5-32.0m bgl)

Drilled By: Ivan Drilling (Georgel Ivan)

Drill Method: Air Rotary DHH

Drill Date: 2-3 July 2020

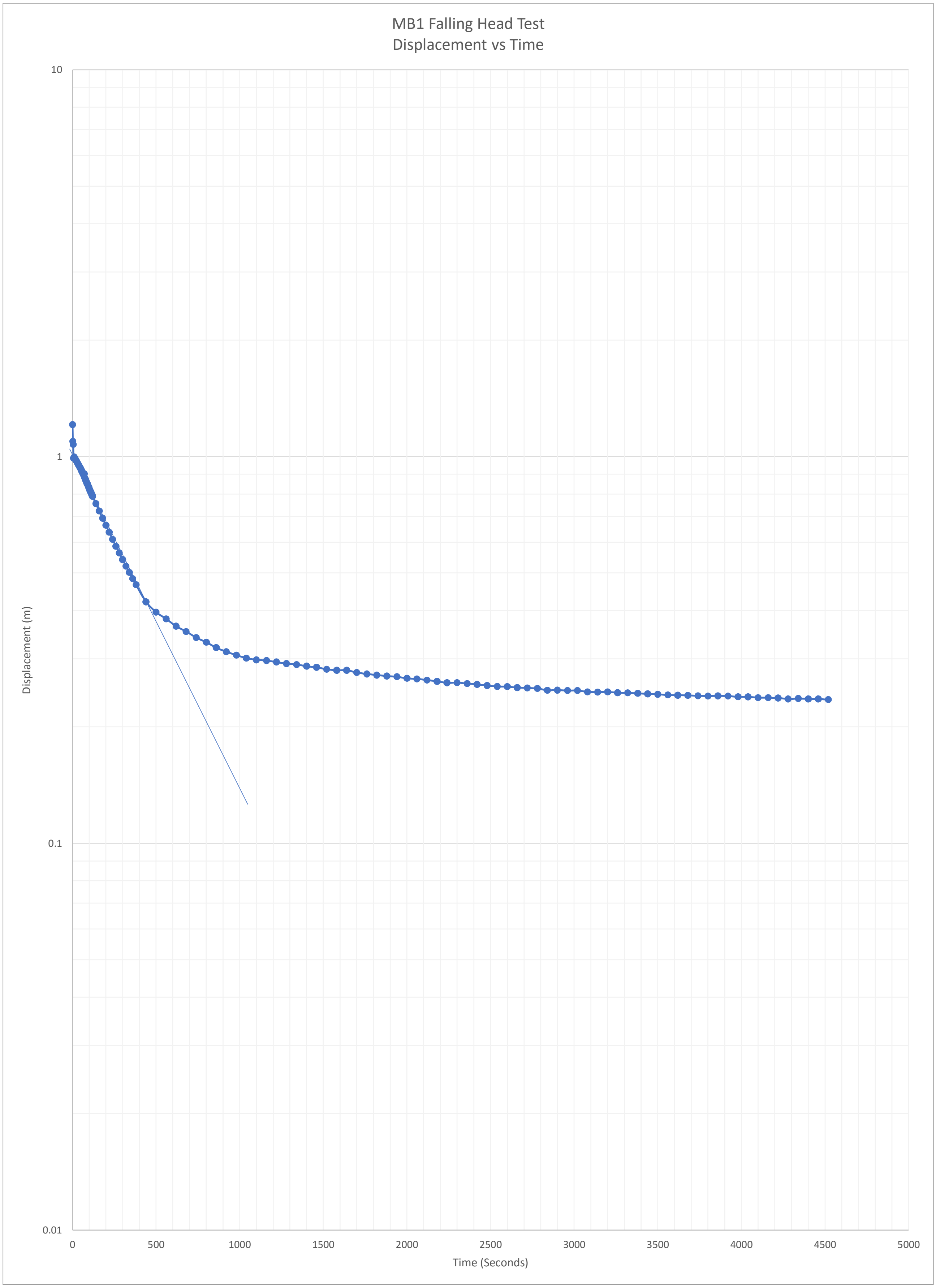
Hole Size: 90mm

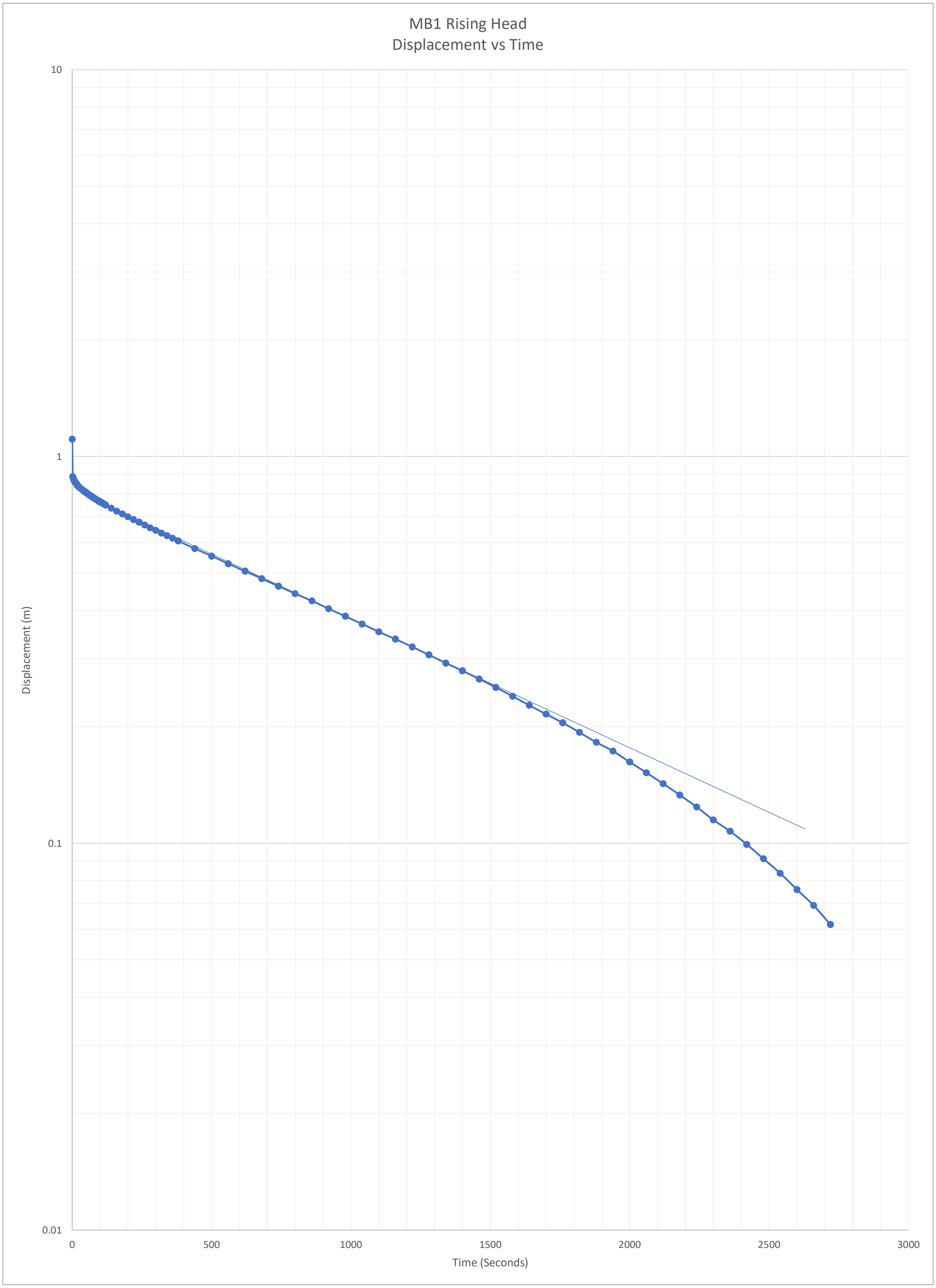
Datum:

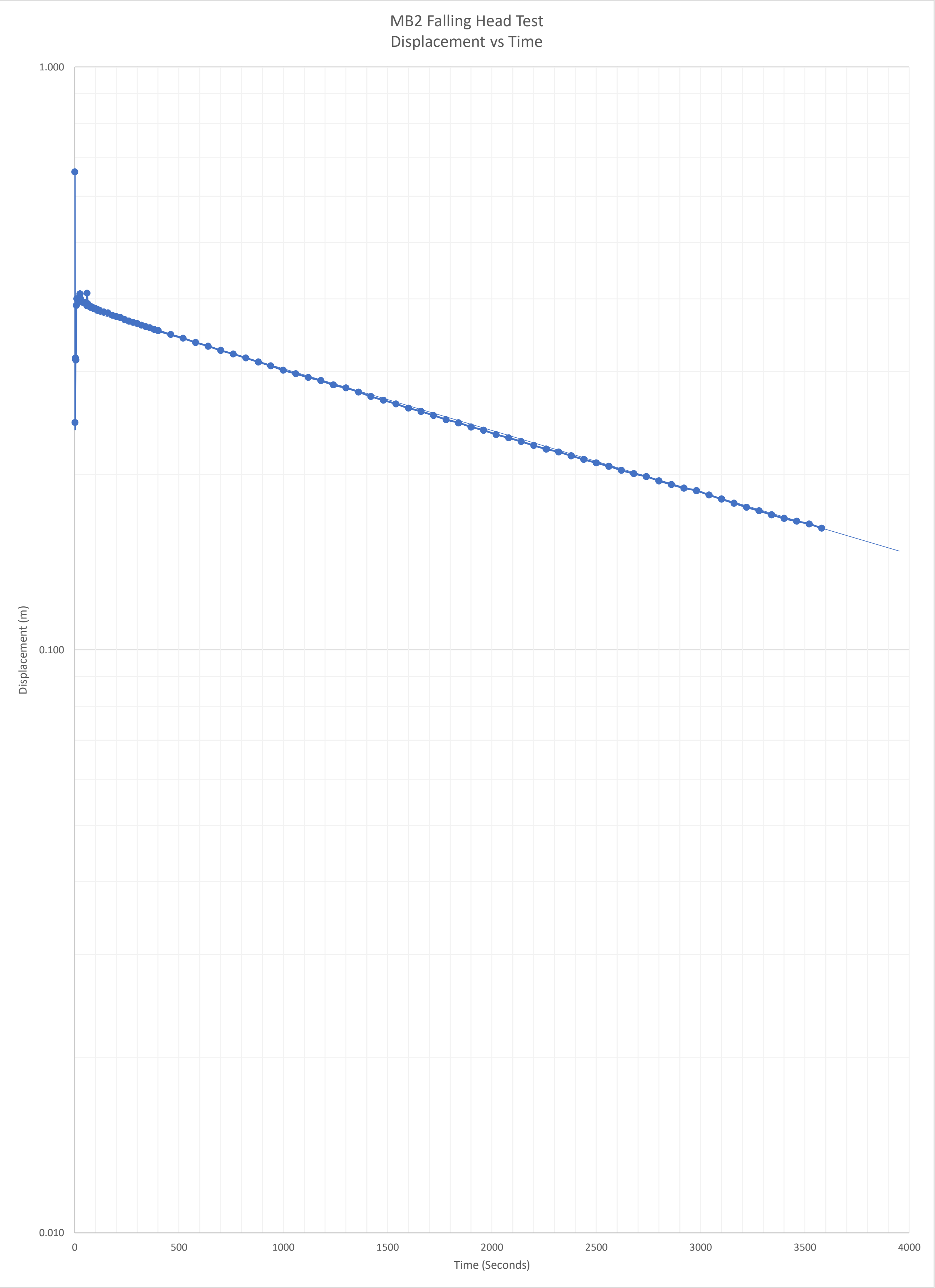
Sheet: 1 of 1

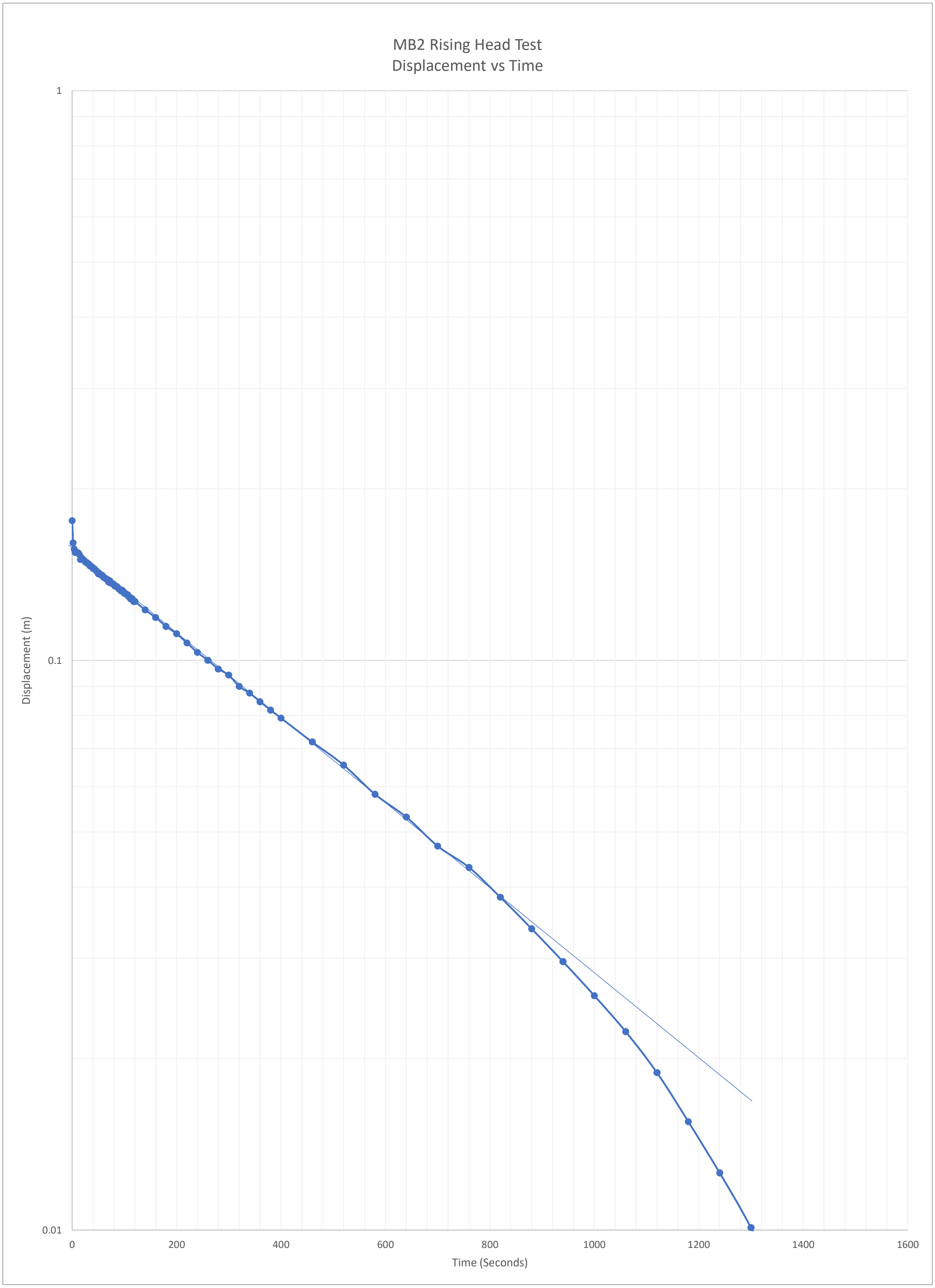
Annex D

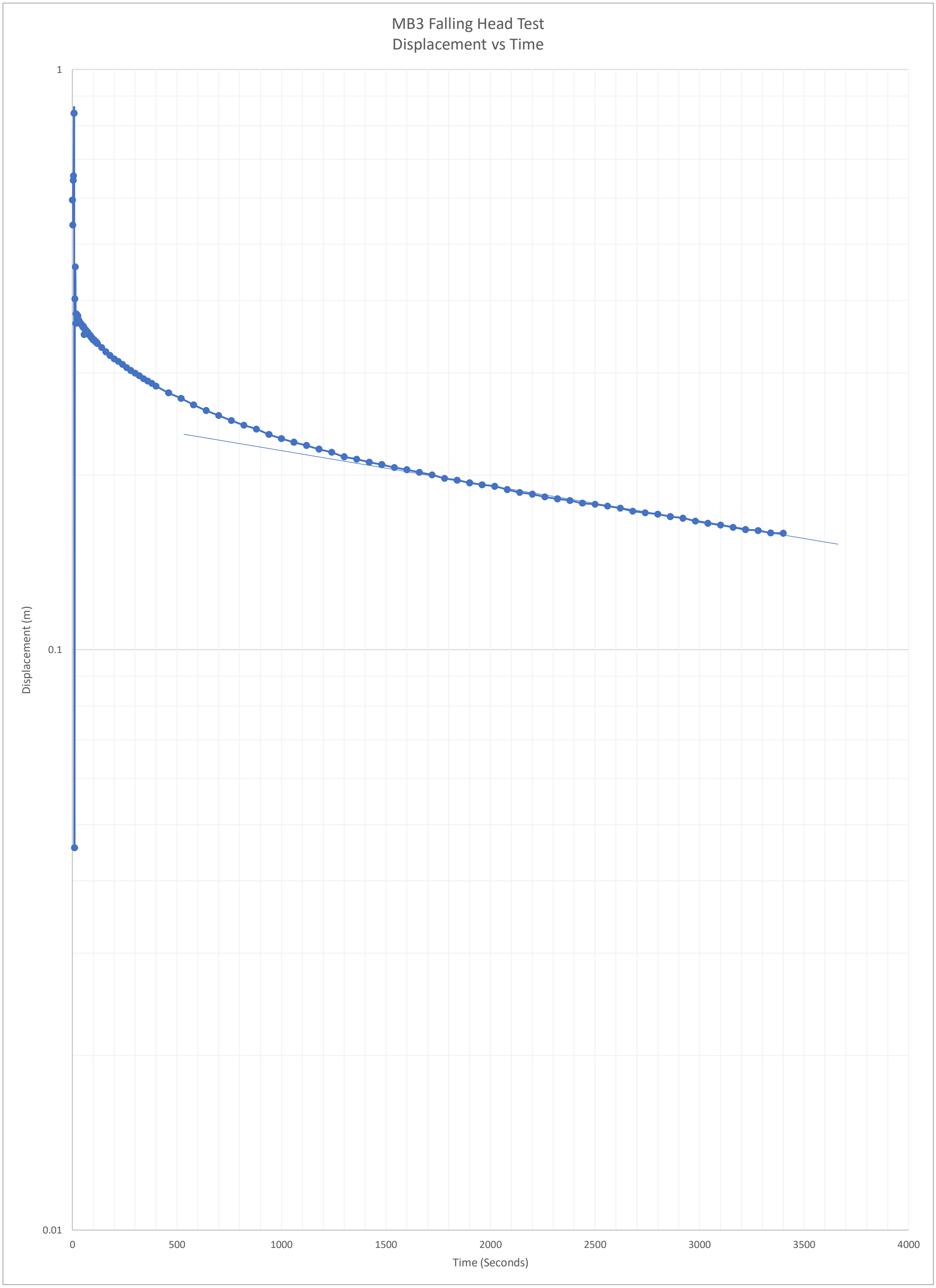
Falling aand Rising Head Test Results

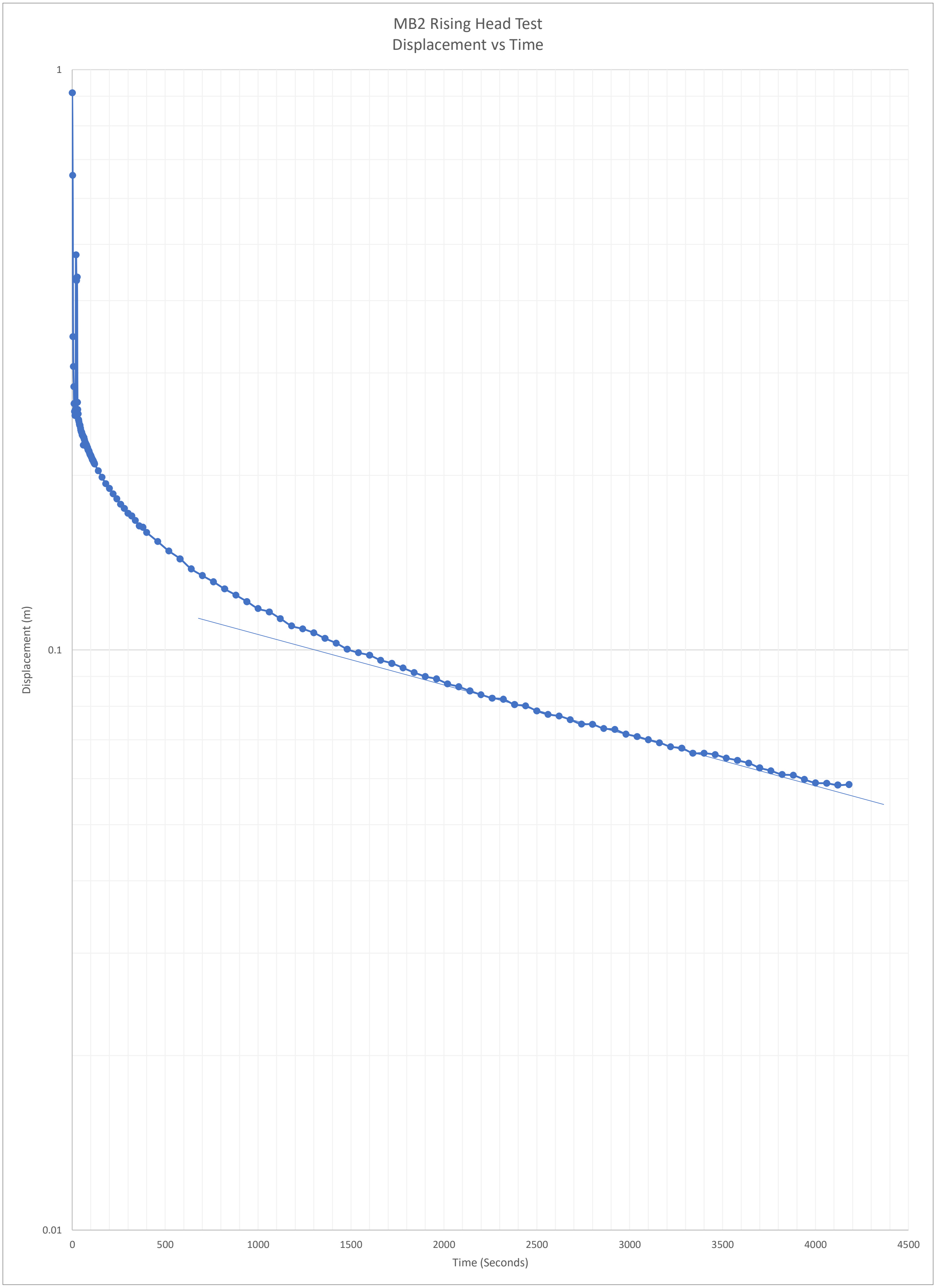

MB1 Falling Head Test
Displacement vs Time
Displacement (m)
Time (Seconds)
10
1
0.1
0.01
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

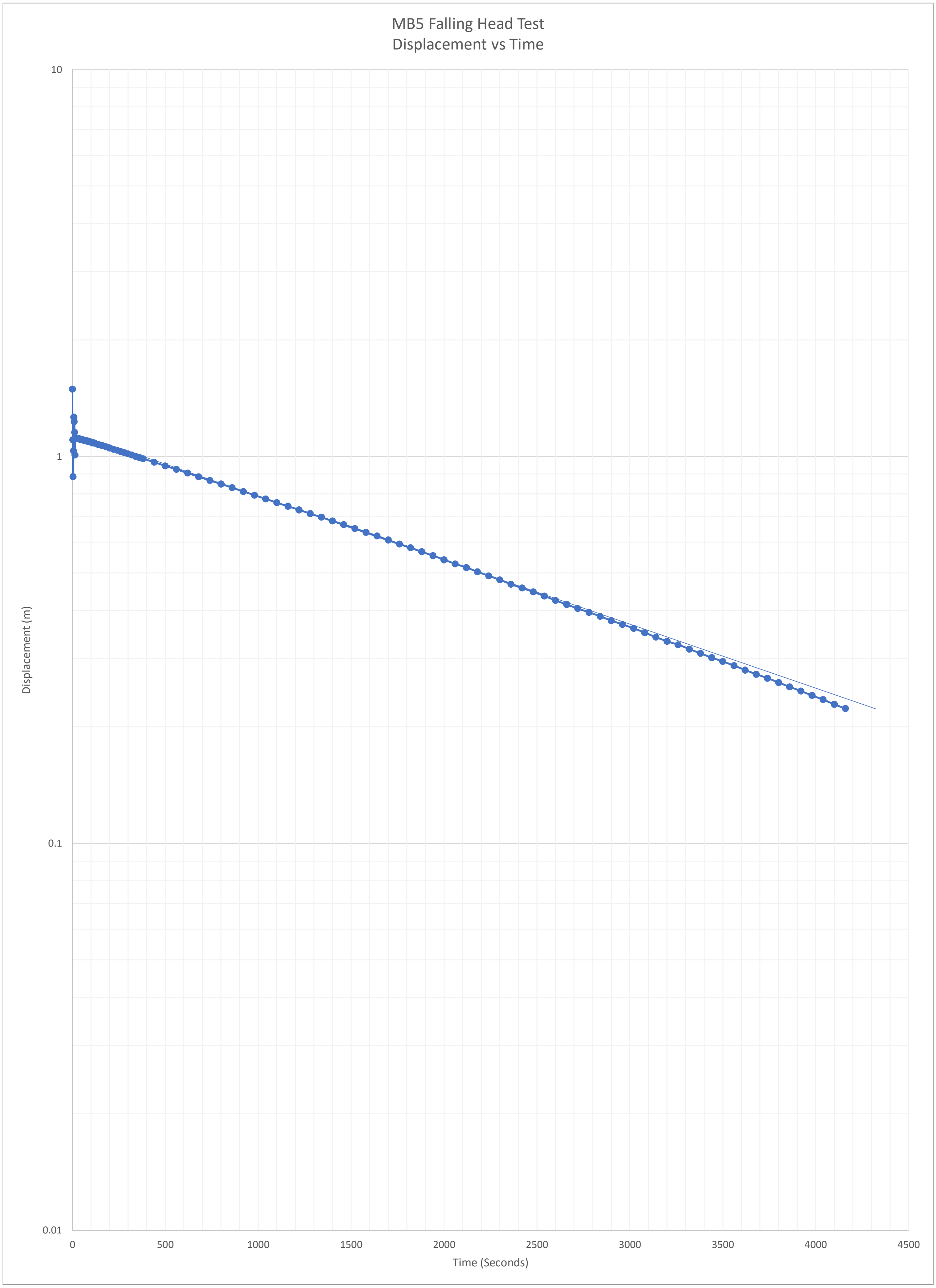

MB1 Rising Head
Displacement vs Time
Displacement (m)
10
1
0.1
0.01
0
500
1000
1500
2000
2500
3000
Time (Seconds)

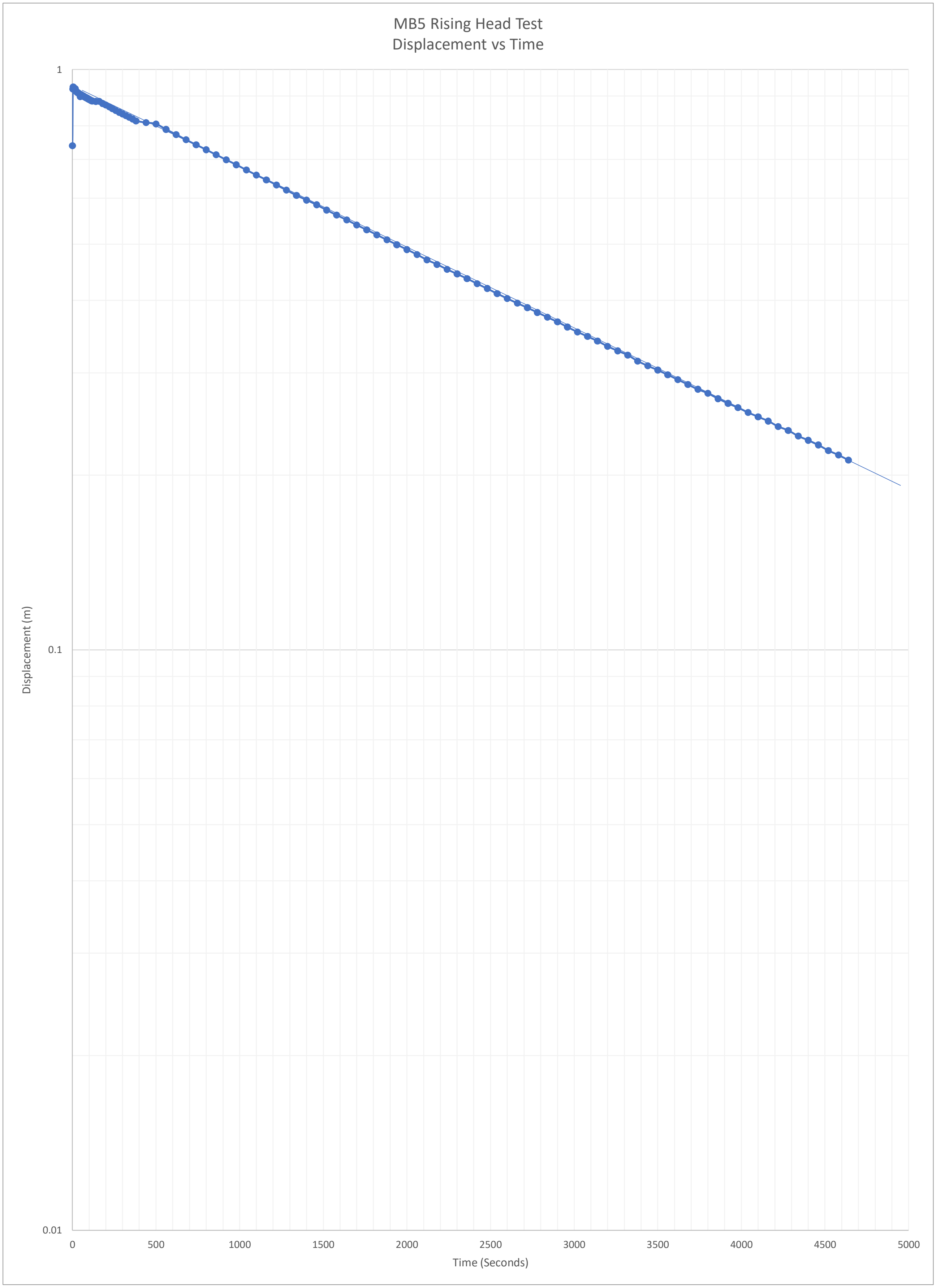

MB2 Falling Head Test
Displacement vs Time
1.000
0.100
0.010
Displacement (m)
0
500
1000
1500
2000
2500
3000
3500
4000
Time (Seconds)


MB2 Rising Head Test
Displacement vs Time
Displacement (m)
1
0.1
0.01
0
200
400
600
800
1000
1200
1400
1600
Time (Seconds)


MB3 Falling Head Test
Displacement vs Time
Displacement (m)
1
0.1
0.01
Time (Seconds)
0
500
1000
1500
2000
2500
3000
3500
4000


MB2 Rising Head Test
Displacement vs Time
Displacement (m)
1
0.1
0.01
Time (Seconds)
0
500
1000
1500
2000
2500
3000
3500
4000
4500


MB5 Falling Head Test
Displacement vs Time
10
1
0.1
0.01
Displacement (m)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Time (Seconds)


MB5 Rising Head Test
Displacement vs Time
Displacement (m)
1
0.1
0.01
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Time (Seconds)