FRIEDA RIVER

Frieda River Limited

Sepik Development Project

Environmental Impact Statement

Appendix 4 – Sepik Development Project Regional Groundwater Assessment

SDP-6-G-00-01-T-003-013

coffey
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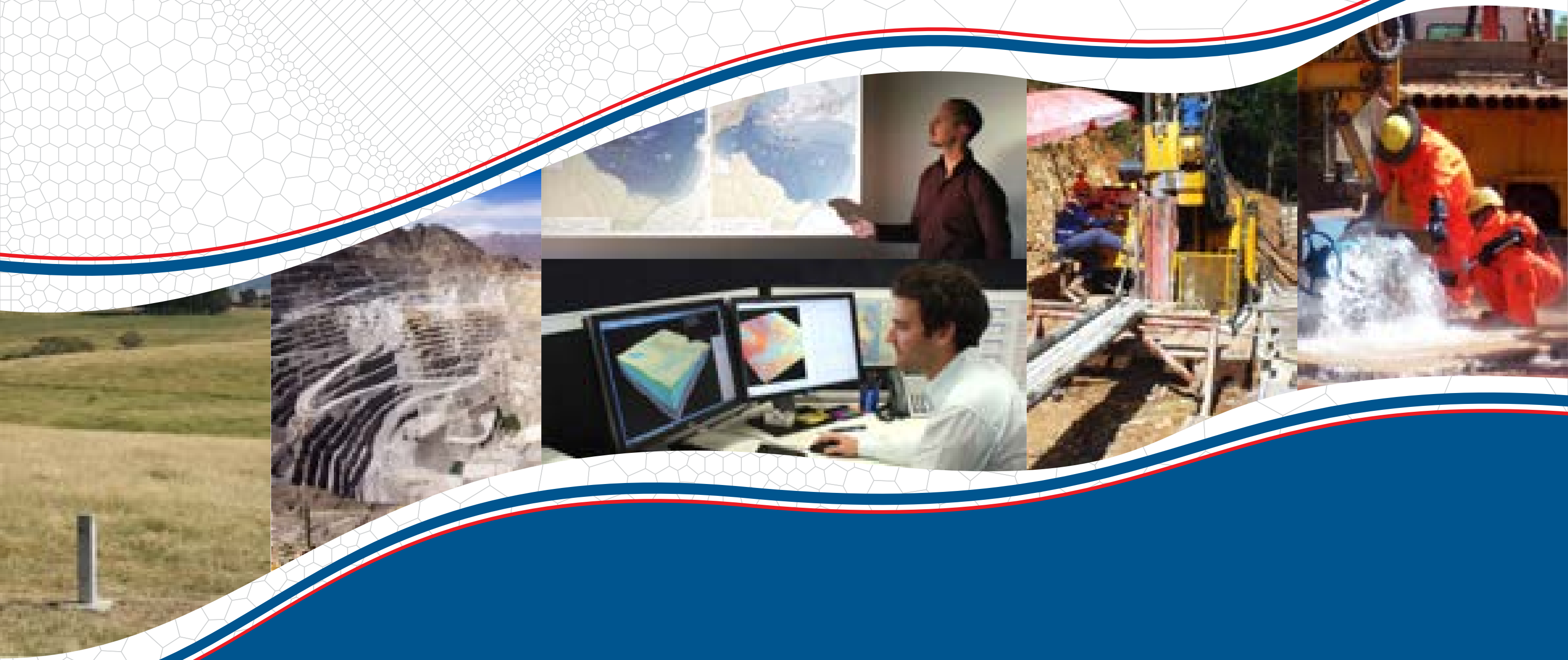
Australasian Groundwater and
Environmental Consultants Pty Ltd



Report on

Sepik Development Project
Regional Groundwater Assessment

Prepared for
Coffey Environments Australia Pty Ltd

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Executive summary

A regional groundwater assessment has been completed for the Sepik Development Project. The main activities associated with the development of the project include mining of the Horse-Ivaal-Trukai, Ekwai, and Koki (HITEK) porphyry copper-gold deposit via three open-pits and placing waste rock and tailings in the integrated storage facility (ISF).

The open-pits will be mined at an average rate of 44 million tons (Mt) per year of ore and will have an approximate 33 year life with an additional 6-year implementation period. The Horse-Ivaal-Trukai (HIT) open-pit will be approximately 2.6 km long and 2.4 km wide, the Ekwai open-pit will be 0.8 km long and 0.6 km wide and the Koki open-pit will be 0.7 km long and 0.9 km wide. The open-pits will cover approximately 520 hectares (ha).

The ISF is proposed to be located in the Frieda River Valley downstream of the mine site. The engineered ISF will store approximately 3,500 Mt of tailings and waste rock with a final embankment height of approximately 187 m (RL 235 m), with an average operating water level of RL 210 m.

Significant field investigations were carried out to establish groundwater level and pore pressure monitoring sites within the study area. These observations were coupled with hydraulic testing (packer tests and slug tests) and water quality sampling (surface water, groundwater, and rain water) to characterise the groundwater regime and provide the basis for a conceptual model.

A calibrated numerical model was developed to predict groundwater level drawdown, open-pit inflows, groundwater mounding, change in baseflow, and post closure groundwater recovery. The numerical model was developed on the conceptual understanding and used observed hydraulic parameters and measurements to constrain acceptable steady state and transient calibrations. Mining of the open-pits and the operation of the ISF was simulated by the model throughout operations and post closure.

The model predicts open-pit inflows in the order of 10 ML/day to 28 ML/day for the combined open-pits. Groundwater flow will report to the open-pits and it will form a temporary sink during operations. Groundwater drawdown and depressurisation from the open-pits will extend some 5 km to 6 km from the centre of the open-pits and is largely localised in the Nena River catchment. Drawdown will encroach into the Ok Binai catchment.

Operation of the open-pits will induce changes in baseflow to the surface water systems. The Nena River catchment is predicted to experience up to 15.5 ML/day baseflow reduction (19% of modelled baseflow), whereas the Ekwai Creek catchment is predicted to reduce by 5 ML/day (100% of modelled baseflow). The Ok Binai has a baseflow reduction up to 2.6 ML/day (less than 3% of modelled baseflow). No change is predicted for Oma Creek.

The open voids will rapidly fill post closure to the spill point elevation of approximately RL 449 m (HIT / Ekwai combined open void) and RL 548 m (Koki open void). The open voids will behave as a flow through window in the water table and will remain a sink for all upstream groundwater flow. All downstream flow will report to the ISF catchment.

The ISF will create mounding during operations and post closure, however, with the steep topography surrounding the ISF, groundwater movement will predominantly be toward the ISF. The only groundwater movement away from the ISF will occur via the ISF embankment. Particle tracking indicates that the rate of movement of any potential contaminant is highly likely to be slow with the maximum particle movement predicted to be in the order of 2,500 m after 2,000 years.

Report on

Sepik Development Project
Regional Groundwater Assessment

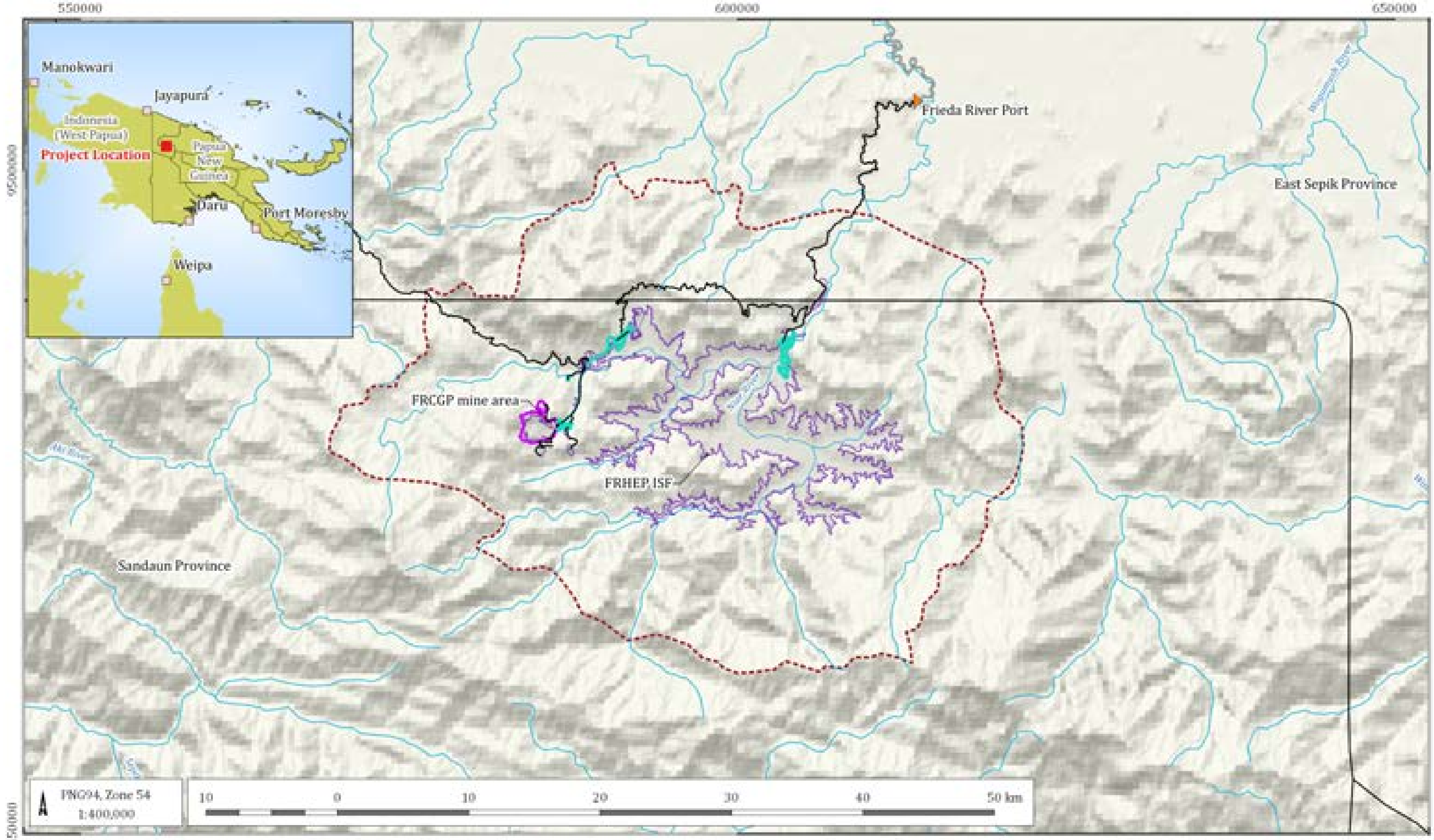
1 Introduction

Frieda River Limited (FRL) is currently assessing the Sepik Development Project (the project) in Papua New Guinea (PNG). The project is located in north-western PNG, on the border of the Sandaun (West Sepik) Province and the East Sepik Province (Figure 1.1). The project is being developed by Frieda River Limited (FRL) (a Papua New Guinea incorporated company owned by copper and gold producer PanAust Limited) on behalf of the joint venture between FRL (80%) and Highlands Frieda Limited (HFL) (a wholly owned subsidiary of Highlands Pacific Limited [HPL]) (20%).

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) was engaged by Coffey Services Australia Pty Ltd (Coffey) to complete a scope of works to support the Environmental Impact Statement (EIS) which included the following tasks:

- conducting a regional hydrogeological assessment;
- developing a conceptual hydrogeological model;
- developing and calibrating a regional scale numerical groundwater flow model;
- undertaking predictive groundwater modelling of open-pits and the integrated storage facility (ISF) which forms part of the Frieda River Hydroelectric Project (FRHEP);
- estimating open-pit seepage / inflows;
- assessing the post closure behaviour and recovery of water within the open-pits and ISF; and
- providing a technical report to be contained within the EIS as an appendix.

For the purposes of this assessment, the study area (Figure 1.1) refers to the extent of the numerical groundwater model domain.



LEGEND

- Province boundary
- Open-pit extent (Year 33)
- Model boundary
- Drainage
- Barging corridor
- FRHEP / ISF extent
- Mining infrastructures
- Road (proposed)

Sepik Development Project (I1051A)

AGE

Project location plan

DATE
19/07/2018

FIGURE No:
1.1

G:/Projects/I1051A.Frieda River_IESA/3_GIS/Workspaces/001_Deliverable1/01.01_I1051A_Project location plan.qgs

1.1 Project description

The project disturbance area includes the mine infrastructure footprint, including the open-pits, process plant, FRHEP, ISF, river port facility, power plant, and other ancillary infrastructure (e.g., roads, electricity transmission lines and camps). The open-pits and ISF are located within the Frieda River catchment (Figure 1.1).

The main activities associated with the development of the project include:

- Mining the Horse-Ivaal-Trukai, Ekwai, and Koki (HITEK) deposit via three open-pits at a rate of approximately 44 Mt/annum of ore and 47 Mt/annum of waste (average), with a maximum rate of 135 Mt/annum total material movements.
- Placing waste rock and tailings in a secure ISF.
- Processing ore in a conventional concentrator at a site approximately 8 km north-east of the open-pits.
- Transporting concentrate via a concentrate pipeline to the Vanimo Ocean Port.
- Development of the FRHEP to include an engineered ISF for the storage of water, construction spoil, mine waste rock and tailings, and sediment control. The FRHEP will also be used to generate hydroelectric power for the project commencing in Year 1 with a generating capacity of 400 MW.

The operation will run continuously, 24 hours per day, 7 days per week. The mine life will be approximately 33 years, with an additional 6-year implementation period. The Horse-Ivaal-Trukai (HIT) open-pit will be approximately 2.6 km long and 2.4 km wide, the Ekwai open-pit will be 0.8 km long and 0.6 km wide and the Koki open-pit will be 0.7 km long and 0.9 km wide. The open-pits will cover approximately 520 hectares (ha). The spill point elevations of the HIT and Koki open-pits will be approximately RL 449 m and RL 548 m respectively.

The ISF is proposed to be located in the Frieda River Valley downstream of the mine site. Ultimately, the ISF will store approximately 3,500 Mt of tailings and waste rock and will include diversion tunnels, coffer dams, embankment, spillway and hydroelectric power intake. The ISF will have a final embankment height of approximately 187 m (RL 235 m).

2 Objectives and scope of work

In 2015, AGE were engaged by FRL to undertake a regional groundwater assessment. The activities completed as part of this 2015 regional groundwater assessment included:

- Compilation of hydrogeological data from geotechnical investigations, including:
  - temporal head pressure data from the existing vibrating wire piezometer (VWP) network;
  - water level and artesian bore pressure records;
  - water quality data from groundwater and surface water;
  - climatic data; and
  - three dimensional geological / geotechnical models (both from the lead geotechnical consultants (Pells Sullivan Meynink - PSM) and FRL.
- Develop a conceptual hydrogeological model in the study area, including:
  - groundwater depths, including contours of groundwater levels and flow paths;
  - relationship between surface water and groundwater;
  - groundwater recharge and discharge rates; and
  - existing groundwater quality.
- Provision of input and planning on field activities including VWP installation and packer testing.
- Collection and analysis of water samples from existing and new monitoring bores, artesian exploration drill holes, and creeks.
- Develop a conceptual groundwater model to describe aquifers, aquitards, recharge mechanisms, discharge areas, and the interaction of groundwater and surface water.
- Develop a regional scale, numerical groundwater flow model capable of simulating and predicting:
  - groundwater flow;
  - groundwater inflows (volumes and quality) to the open-pits;
  - seepage rates and pathways from the Integrated Storage Facility (ISF);
  - the influence of mining on groundwater levels and stream baseflow;
  - the extent of groundwater depressurisation during mining and post-closure; and
  - track potential groundwater movement resulting from seepages post-closure.
- Develop likely strategies and methods to manage groundwater inflows during construction and into the open-pits during operation.
- Develop a groundwater monitoring program for the project's operation and following decommissioning.

Following on from this assessment, the objective of this current study is to update the 2015 groundwater assessment as part of the EIS. The most significant change to the 2015 assessment is the revised open-pit design, which now includes open-pits to access the Horse-Ivaal-Trukai, Ekwai and Koki deposits. This collection of five deposits is referred to as the HITEK deposit and is designed based on resource, geotechnical, structural and water constraints. The other significant change to the 2015 assessment is the location and extent of the ISF. In order to update the regional groundwater assessment the following scope of work was developed:

- Review the new mine design relative to the available data and the existing numerical model setup and identify any data gaps, key issues and risks that relate to groundwater. To achieve this objective the following information was reviewed:
    - the revised open-pits and ISF designs;
    - new geological or geotechnical data (if available) for the HITEK open-pits; and
    - new hydrogeological monitoring data (if available).
- Predict the regional drawdown of the revised project on the groundwater regime. The existing groundwater model was not suitable to be amended to represent the revised project. The numerical model extent was not sufficient to include the impoundment extent of the ISF. The new model therefore included a new extent and mesh, and updates representing the new mine designs and ISF and an adjusting of timing of mining for the HITEK open-pits. A transient calibration of measured groundwater heads was undertaken.

- The predictive model scenarios were designed to estimate the:
    - ranges of groundwater inflow to the study area as a function of mine position and timing, for operational and post mining phases;
    - extent of the zone of depressurisation in the country rock;
    - recovery of the groundwater system post mining; and
    - behaviour of the ISF and its influence on the surrounding groundwater systems.
- Previously, the open-pit had a spill point which dictated the post closure groundwater levels and recovery. This spill point design has changed and with several individual open-pits the post closure conditions were needed to be modified accordingly. A sensitivity analysis was carried out on the updated model as part of this regional assessment.
- Update the 2015 report to reflect the project description and activities completed. The description of the project and the existing environment presented within the previous EIS report was refined where necessary. The second part of the report is the description of the numerical modelling where the predicted drawdown, inflows, etc. are outlined. This report utilises the structure of the previous EIS, and only makes significant changes where required to address the revised project.

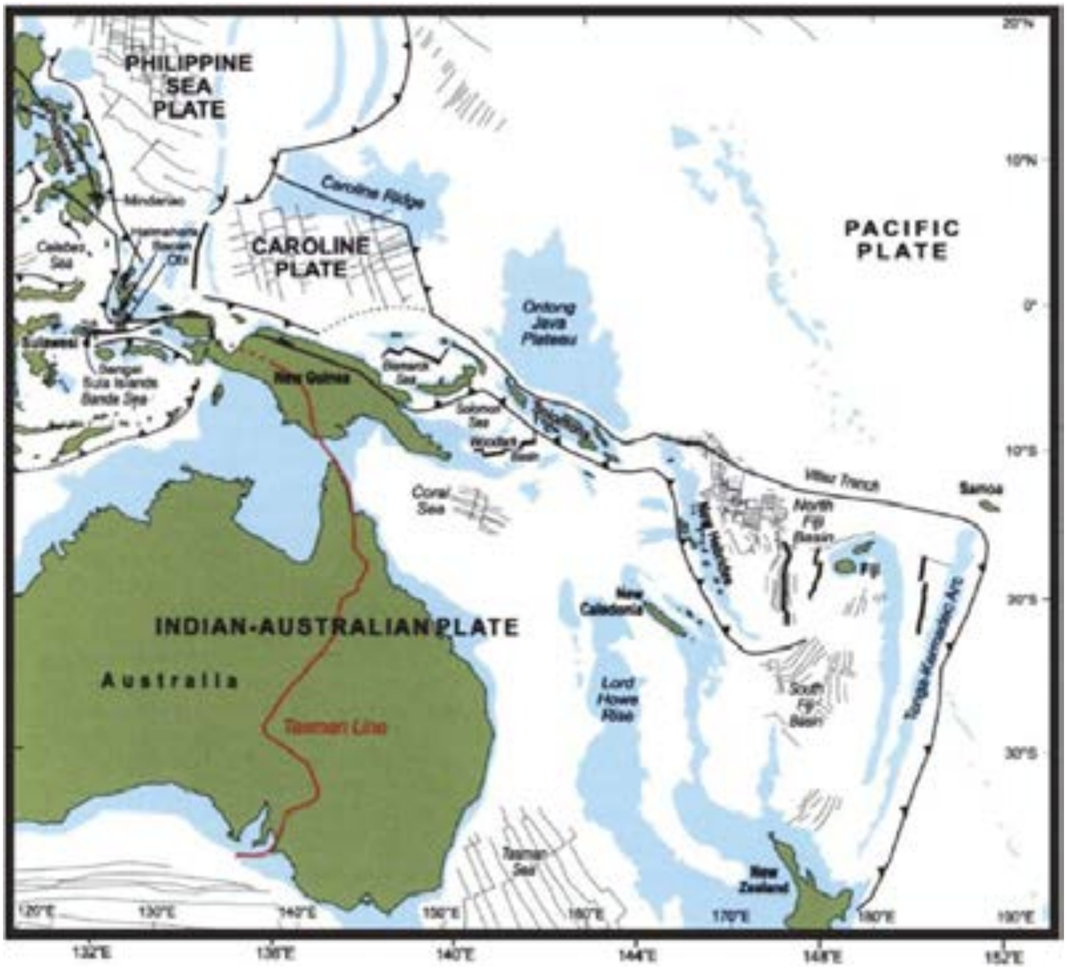
The infrastructure corridor, and any potential groundwater impacts associated with it, have not been assessed as part of this study. Any groundwater related impact along the infrastructure corridor is likely be highly localised, and would be considered low risk to the environment. Groundwater impacts associated with the infrastructure corridor will be managed through environmental management and monitoring plans.

3 Project setting

3.1 Geology

The project involves the development of a copper-gold deposit hosted within altered metasediments. A series of intrusive igneous units known as the Frieda River Igneous Complex (FRIC) are the source of the alteration.

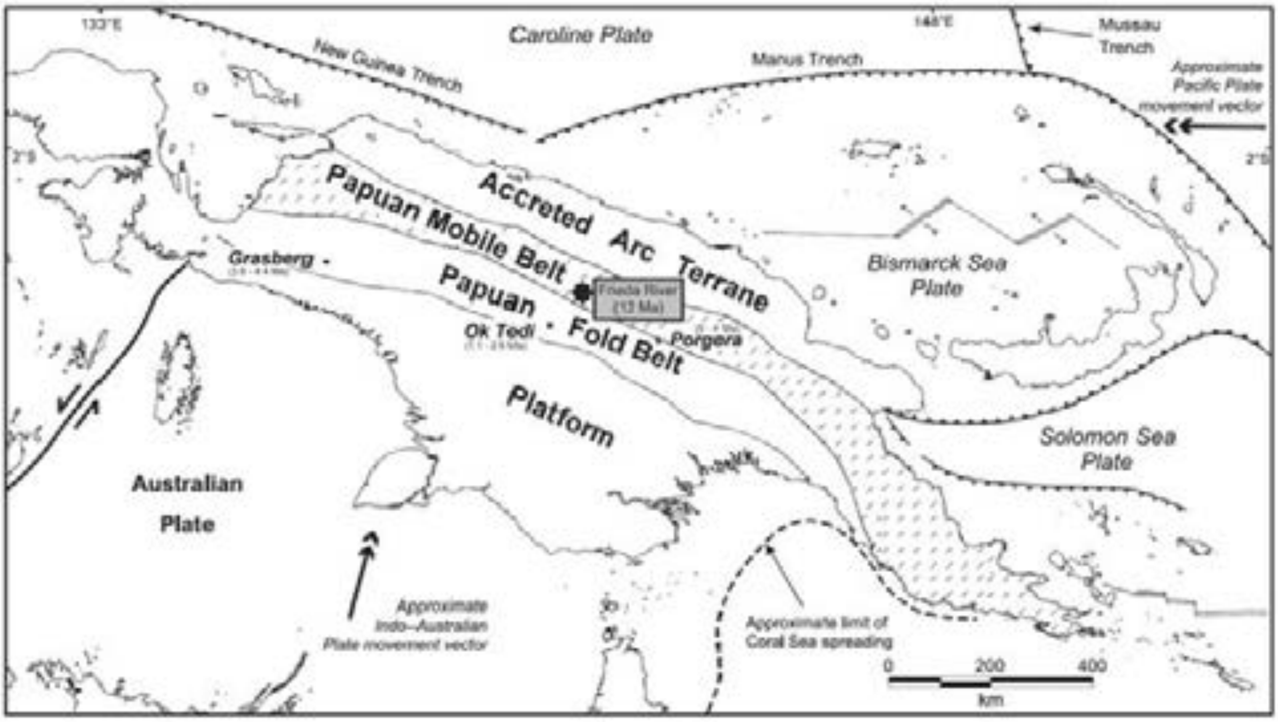
PNG is located on the northern margin of the Indo-Australian tectonic plate at a complex convergent plate boundary with the Pacific Plate, and several other smaller plates including the Philippine Sea and Caroline Plates (Figure 3.1). This tectonic boundary incorporates a complex arrangement of active subduction zones (Williamson and Hancock, 2005).



(after: Gow *et al.*, 2002)

Figure 3.1 Tectonic setting

PNG is divided into four tectonic regions based on the Miocene to Holocene orogenesis affecting the northern part of the Australian Plate. It was this orogenesis that gave rise to the current PNG landform. Most of the northern half of PNG is made up of the Papuan Mobile Belt and the Papuan Fold Belt, comprising ophiolites of Mesozoic to Paleocene age and multi-phase intrusive and volcanic rocks (Figure 3.2). The Papuan Mobile Belt also includes distal Mesozoic-Tertiary sediments, abundant Miocene and some Cretaceous volcanic and intrusive igneous rocks and medium to high grade metamorphic rocks (Rogerson *et al.*, 1987).



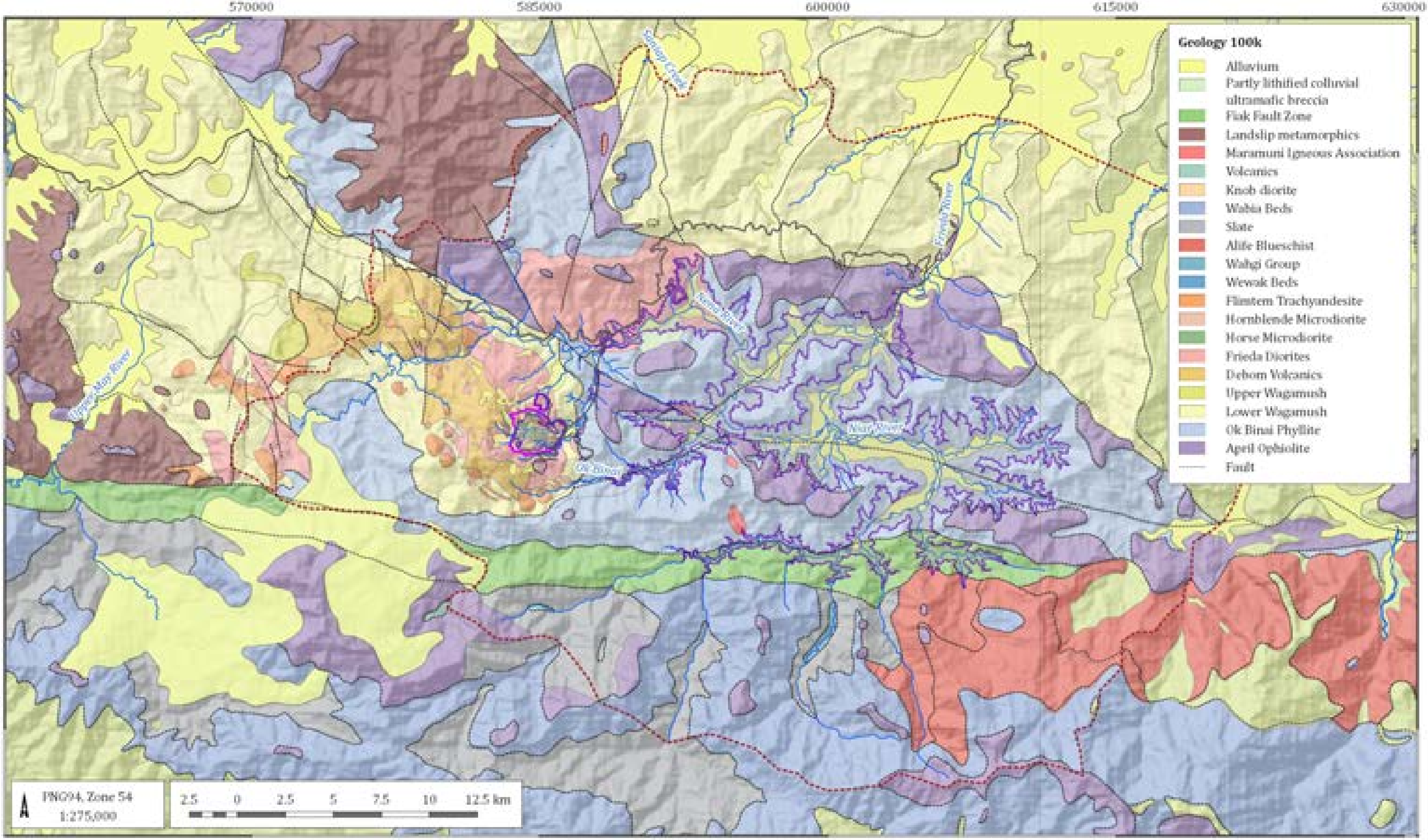
(after: Hill and Hall, 2003)

Figure 3.2 PNG tectonic zones

The study area is located on the southern margin of the Papuan Mobile Belt, a zone characterised by faulting and intense folding caused by the oblique collision of the Pacific and Indo-Australian Plates since Miocene times (Figure 3.2). Consequently, major structural trends are west-northwest (arc parallel) and east-northeast (arc normal). Deformation is dominantly brittle and concentrated in discrete fault zones. The two main regional fault structures in the area are the Frieda Fault and Fin Leonard Shultz Fault Zone (Figure 3.3). The study area is located between these two major structures.

The study area is characterised by steep-sided valleys, the orientation of which is driven by the local geology and structure. These valleys have a veneer of colluvium and alluvium comprising sands / gravels adjacent to surface channels and silts / clays distal to surface water features. These unconsolidated deposits can be in excess of 30 m thick.

Figure 3.3 shows the interpreted geology of the HITEK deposit, compiled from various sources. The FRIC and associated volcanism (Debom Volcanics) intruded two basement units. The oldest basement rock is the Ok Binai Phyllite (Upper Cretaceous-Eocene) and the overlying sedimentary sequences of Mid-Miocene Wogamush Formation (Figure 3.3). The FRIC consists of five distinct phases of intrusion that are the Koki Diorite Porphyry, Frieda Diorite Porphyry, Horse Microdiorite, Knob Diorite, and Flimtem Trachyandesite (oldest to youngest). At intrusive contacts, the sediments are hornfelsed, brecciated, and in places host skarn and porphyry mineralisation. These mineralised zones, which are primarily related to west-northwest-trending stocks and dykes of Horse Microdiorite bodies, comprise the project ore body.



LEGEND
Model boundary
Open-pit extent (Year 33)
FRHEP / ISF extent
Road (proposed)
Drainage

Geology 100k - Geological Survey of Papua New Guinea 100k Map Sheets + PSM geological model + alluvium digitised by AGE

AGE

Sepik Development Project (I1051A)

Regional geology and major fault zones

DATE
19/07/2018

FIGURE No:
3.3

3.1.1 Alteration

On a local scale, alteration types are broadly collated into three facies groups (FRP FS, 2011):

- **Country rock**
  The country rock alteration includes hornfels, propylitic and skarn types. This alteration is largely related to the regional metamorphism of the Ok Binai Phyllite and contact metamorphism that predates mineralisation.
- **Epithermal**
  The epithermal style alteration is considered to have actively generated throughout the history of the FRIC, mostly post-dating the porphyry mineralisation facies. This alteration is characterised by supergene chalcocite and covellite and primary enargite in the Debom Volcanics and the barren, high arsenic, zones in the west of the deposit.
- **Porphyry mineralisation**
  The porphyry mineralisation alteration is where the original hornblende-biotite-quartz-magnetite diorite has undergone initial potassic alteration resulting in replacement of hornblende by biotite plus magnetite. The copper has been deposited mostly as fine grained aggregates of bornite and chalcopyrite associated with the mafics in the diorite. Copper grades throughout the potassic alteration are typically 0.4% copper; however can be as high as 1% copper.

3.1.2 Weathering

A deep weathering profile has developed throughout the deposit (FRP FS, 2011) and three key weathering types are logged in drill core:

- the zone of total oxidation (TOX);
- the zone of partial oxidation (POX); and
- the Gypsum-anhydrite (dissolution) surface (GAS).

The TOX is defined by the complete oxidation of all sulphide minerals in the rock mass. The zone is typically red-brown, deeply weathered and friable. The TOX is almost invariably barren, having had all gold and base metals leached from it. The POX is a zone comprising mixed oxides and sulphides. It is generally grey to brown and contains both primary and supergene sulphide minerals.

The GAS layer, consisting of anhydrite and gypsum, represents the shallowest occurrence of anhydrite in drill core. Anhydrite is a late-stage, vein-hosted mineral occurring widely through the deposit. The anhydrite surface is the point below which anhydrite ($CaSO_4$) and its weathering product Gypsum ($CaSO_4.H_2O$) are found in drill core. This surface is a weathering effect above which the water-soluble minerals gypsum and anhydrite have been dissolved from the rock. The rock units comprising this layer are considerably more competent and less fractured than overlying units. Rock quality designation (RQD) values above the GAS are generally less than 40%, whereas below the GAS, RQD is typically greater than 80%. This layer is related to the alteration / weathering of the intrusive units and is not likely to extend outside of the limits of the FRIC.

The depth of weathering outside of the open-pits varies from:

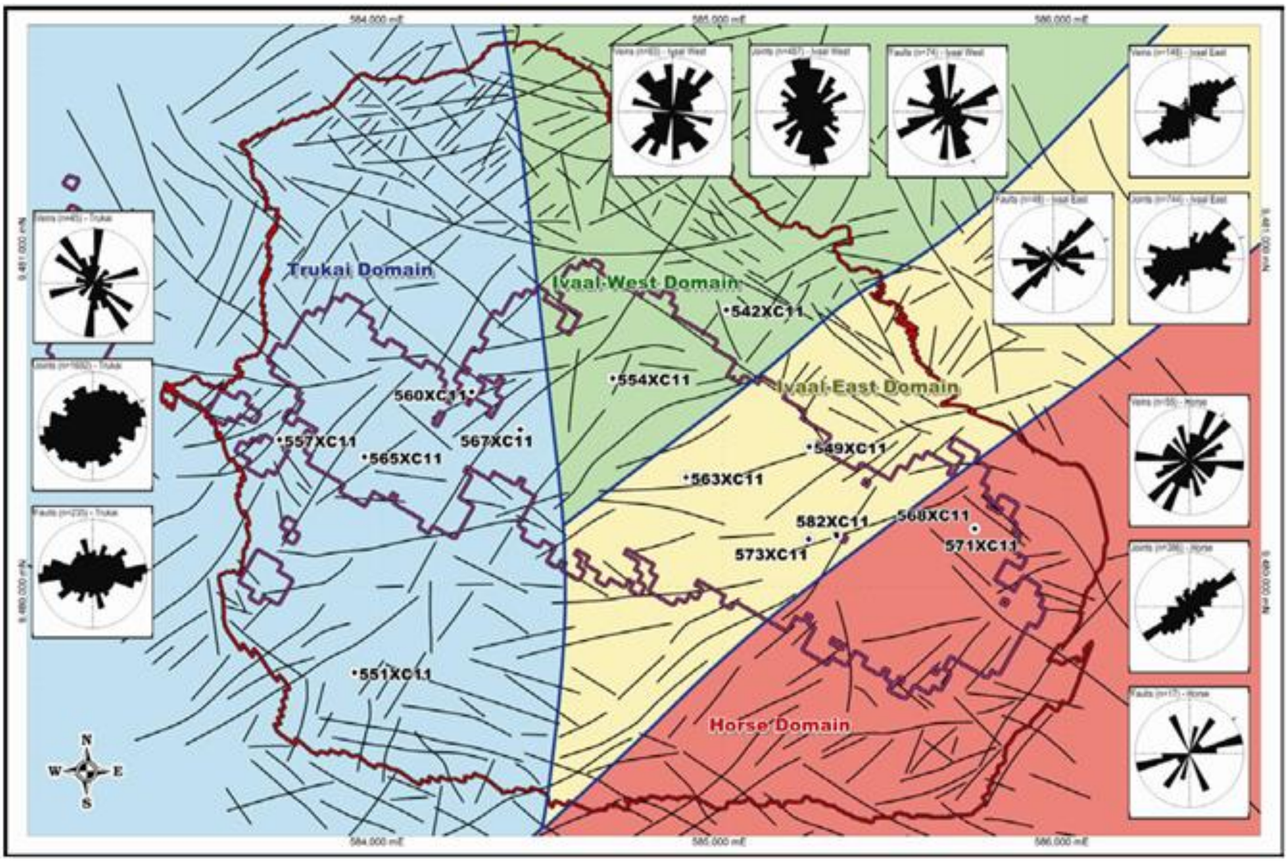
- 3 m to 5 m in some of the Wogamush and ultrabasic rocks;
- 10 m to 15 m in the Ok Binai Phyllite; to
- 30 m plus in diorites away from the ore body.

Within the ore body, significant weathering and hydrothermal alteration extends to depths greater than 50 m.

3.1.3 Local scale structure

Four fault-bounded structural domains have been identified (Figure 3.4). These domains are identified as having distinct alteration or mineralisation styles across their boundaries (FRP FS, 2011). Figure 3.4 shows the fault strike orientations are primarily:

- NW-SE in the Horse and Ivaal domains;
- N-S in the Ivaal West domain; and
- E-W in the Trukai domain.



(after: FRP FS, 2011)

Figure 3.4 Structural domains[1]

The local structure appears to be a combination of thrust type structures and shear faults. These structures tend to behave differently based on their development methodology. Thrust type structures tend to be closed and / or tight structures; whereas, shear zones tend to be less tight.

The dykes, denominated Flintem Dykes, located to the south-east of the deposit are oriented NE-SW and parallel to the structure orientation in the area. These dykes are amongst the more recent intrusive units in the area and likely pose a barrier to groundwater flow toward the south-west of the deposit.

[1] The red outline shown on Figure 3.4 represents the footprint of a previous (out dated) open-pit design. This open-pit design has been superseded by the footprints of the open-pits presented within Figure 3.3 and the remainder of this regional groundwater assessment. The purple outline represents the 0.2 Cu percent in surface.

3.2 Climate

Nine rainfall stations are present at the site and have recorded daily rainfall between 1995 to 1999 and 2008 to 2015 (Table 3.1). The locations of the rainfall stations are presented in Figure 3.5.

Table 3.2 presents monthly average rainfall data for a selection of the rainfall recording stations (SRK, 2016) as well as monthly average actual evaporation.

Table 3.1 Climate stations

Rain gauge	Creek / river	Location	Catchment	UTM coordinates		Elevation (RL m)	Available data
				Easting	Northing		
105R03	Oma Creek	Top Oma Creek	Nena	578860	9486369	1062	2008 - 2015
1053WS	Nena River	Nena AWS	Nena	579857	9485084	840	2008 - 2015
105R07	Nena River	Middle Stolle Catchment (Nena River)	Nena	574861	9480276	850	2008 - 2015
105R10	Ok Binai	Madang Ridge (Ok Binai)	Ubai	585396	9478946	627	2008 - 2015
105200	Oma Creek	Oma Creek	Nena	581856	9487015	425	1995 – 1999, 2008 - 2015
105300	Nena River	Upstream of Nena Gorge (Upper Nena River)	Nena	578858	9484082	635	1995 – 1999, 2008 - 2015
105320	Ok Binai	Ok Binai	Ok Binai	595494	9482874	110	1995 – 1999, 2008 - 2015
105450	Frieda River	Downstream of Nena River junction (Upper Frieda River)	Frieda	602597	9485957	100	1995 – 1998, 2008 - 2015
105310	Nena River	Downstream of Ubai Creek junction (Lower Nena River)	Nena	589618	9485004	190	1995 – 1999, 2008 - 2015

Table 3.2 Mean monthly climate data

Month	Rainfall (mm)			Actual evaporation (mm)
	Oma Creek (105200)	Ok Binai (105320)	Nena River (105300)	Nena River (1053WS)
January	692	657	716	152
February	749	734	769	134
March	770	706	776	156
April	766	637	712	134
May	644	639	564	131
June	630	565	567	120
July	609	636	591	122
August	632	611	605	124
September	707	630	607	133

Month	Rainfall (mm)			Actual evaporation (mm)
	Oma Creek (105200)	Ok Binai (105320)	Nena River (105300)	Nena River (1053WS)
October	722	695	653	150
November	672	615	558	145
December	753	646	703	151
Annual*	**8,346**	**7,771**	**7,821**	**1,651**

Note ** annual average is based upon full years data only.*

The average annual rainfall is very high, ranging between 7,771 mm/year and 8,346 mm/year, which is typical of the PNG highlands. There is little seasonal trend in the monthly rainfall data. The average rainfall on a monthly and annual basis significantly exceeds evaporation (Table 3.2). The average monthly evaporation is in the order of 120 mm to 156 mm (1,651 mm/year) which is some four to six times less that the monthly rainfall in the region.

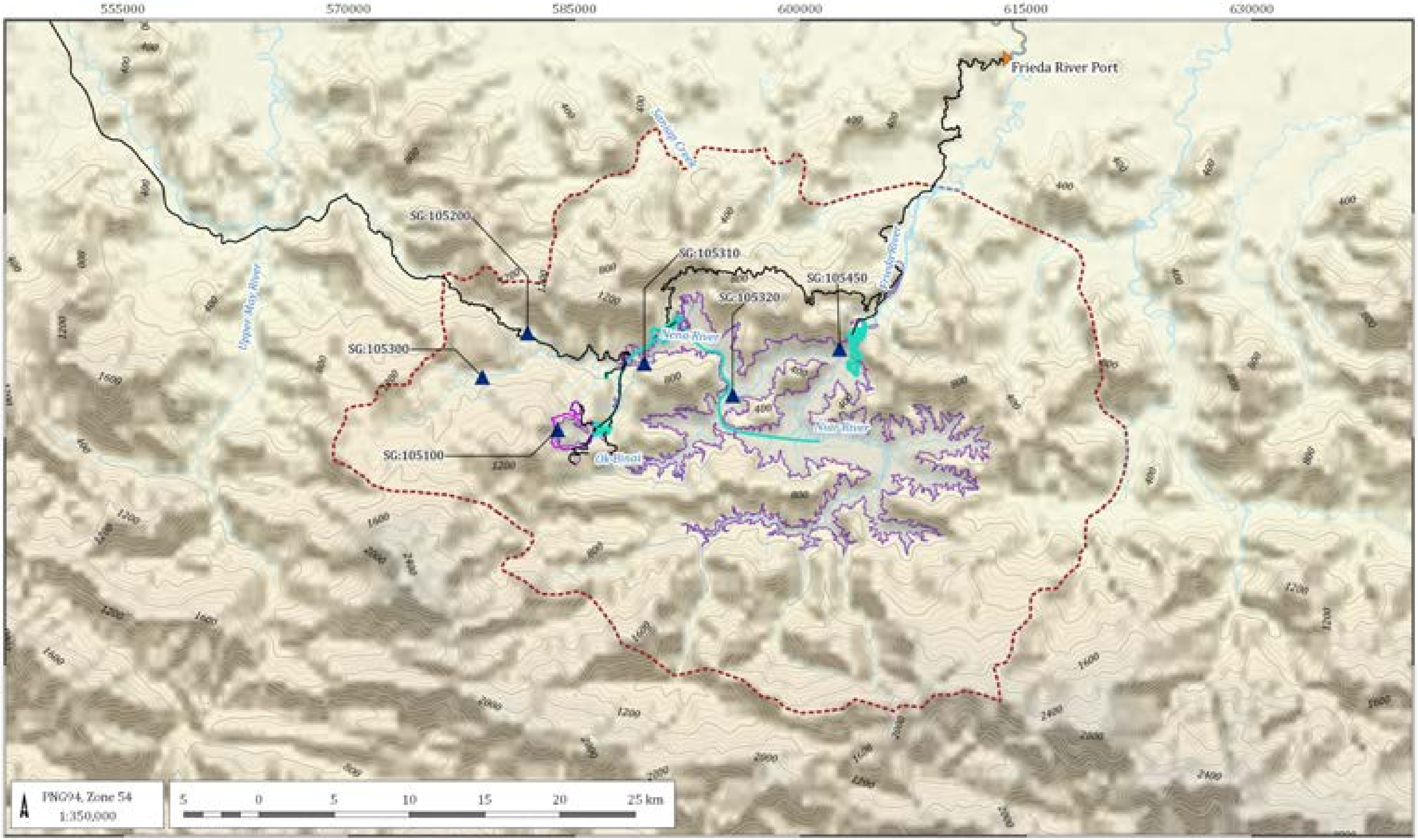
3.3 Surface water

Stream gauging data is available for the site and has been processed and supplied by Knight Piesold (KP, 2015) and SRK (2016). Similar to rainfall, data is available from four catchments for the periods 1994 to 1999 and 2008 to 2015 (Table 3.3 and Figure 3.5). KP estimated the proportion of groundwater baseflow based on the stream gauging data. Appendix A describes the use of this data to calibrate the regional groundwater flow model.

Figure 3.5 presents the drainage lines, catchments, and regional topography, which is based on LIDAR data within the open-pits area and the 30 m SRTM digital elevation data for all other areas.

Table 3.3 Stream gauging stations

Stream gauge	Creek / river	Location	Catchment area (km^2)	UTM Coordinates		Elevation (RL m)	Available data
				Easting	Northing		
SG:105100	Ekwai Creek	Ekwai Creek	3.07	583853	9480571	750	2010 - 2014
SG:105200	Oma Creek	Oma Creek	1.47	581856	9487015	425	1994 – 1999, 2008 - 2014
SG:105300	Nena River	Upstream of Nena Gorge (Upper Nena River)	98.9	578858	9484082	635	1995 – 1999, 2008 - 2015
SG:105310	Nena River	Lower Nena (Downstream of Ubai Creek Junction)	200.1	589618	9485004	190	1994 – 1999, 2008 - 2015
SG:105320	Ok Binai	Ok Binai	69	595494	9482874	110	1994 – 1999, 2008 - 2014
SG:105450	Frieda River	Downstream of Nena River junction (Upper Frieda River)	1,032	602597	9485957	100	1981 – 1992, 1994 – 1999, 2008 - 2015



LEGEND

- Model boundary
- Open-pit extent (Year 33)
- FRHEP / ISF extent
- Mining infrastructures
- Road (proposed)
- Drainage
- Major contour (400 m interval)
- Minor contour (100 m interval)
- Surface water gauge location

Sepik Development Project (I1051A)

AGE

Terrain and drainage

DATE 19/07/2018

FIGURE No: **3.5**

4 Hydrogeological regime

4.1 Monitoring network

Glencore Xstrata installed a network of 39 vibrating wire piezometers (VWP) within 19 holes around their proposed open-pit between May 2009 and May 2011. The VWP arrays were installed as a part of the pre-feasibility study (PFS). In December 2014, AGE visited the VWP arrays to assess functionality and to collect raw data.

Of the 19 VWP arrays, 12 VWPs were located during the December 2014 field program. Eleven of the VWP arrays[2] consisted of two VWP gauges[3] and one site (PSM20b) had three VWP gauges. Once located, the frequency (hertz) and temperature of the VWP gauges were measured and the data recorded. A total of 21 of the 25 individual VWP gauges were still readable on site. All three gauges in PSM20b and one in PSM04 returned no frequency values. Upon review, a further seven sensors provided erroneous data either by showing negative head pressures or data which was well outside the expected range. Therefore, the total number of functioning sensors is 14 at 11 locations. Appendix A - Table A 1.1 summarises the existing VWP arrays and their status.

Geotech International installed 26 new VWP gauges in five geotechnical drill holes around the planned open-pits between December 2014 and March 2015. The recently drilled VWPs used in this assessment are summarised in Appendix A - Table A 2.1.

Figure 4.1 presents the location of all VWP arrays. As the VWPs are fully grouted completions, they do not allow for collecting water samples. The VWPs measure a frequency at each gauge which is converted into a head pressure and an equivalent groundwater elevation.

A total of 48 groundwater monitoring bores were installed in 2009 to 2011 as part of the Glencore Xstrata PFS (Appendix A – Section A1.2). The bores were drilled for geotechnical purposes in the vicinity of previous project infrastructure on the Ok Binai (i.e. they were not planned as part of the current project). The current status of these sites is unknown, but the data collected from these bores has been used to support this regional groundwater assessment.

Five new holes were drilled during 2014 / 2015 as part of current geotechnical investigations into the current ISF impoundment area (SRK, 2015). Packer and falling head tests were used to estimate hydraulic conductivity and a representative groundwater level measured. Appendix A – Table A 2.2 summarises the drill holes and data collected in this assessment.

In addition to the new monitoring bores and VWPs, water samples were collected from 33 artesian exploration drill holes and 102 surface water samples (Section 4.4). The artesian exploration drill holes were not constructed as monitoring bores and therefore the samples represent composite water from across the open hole interval.

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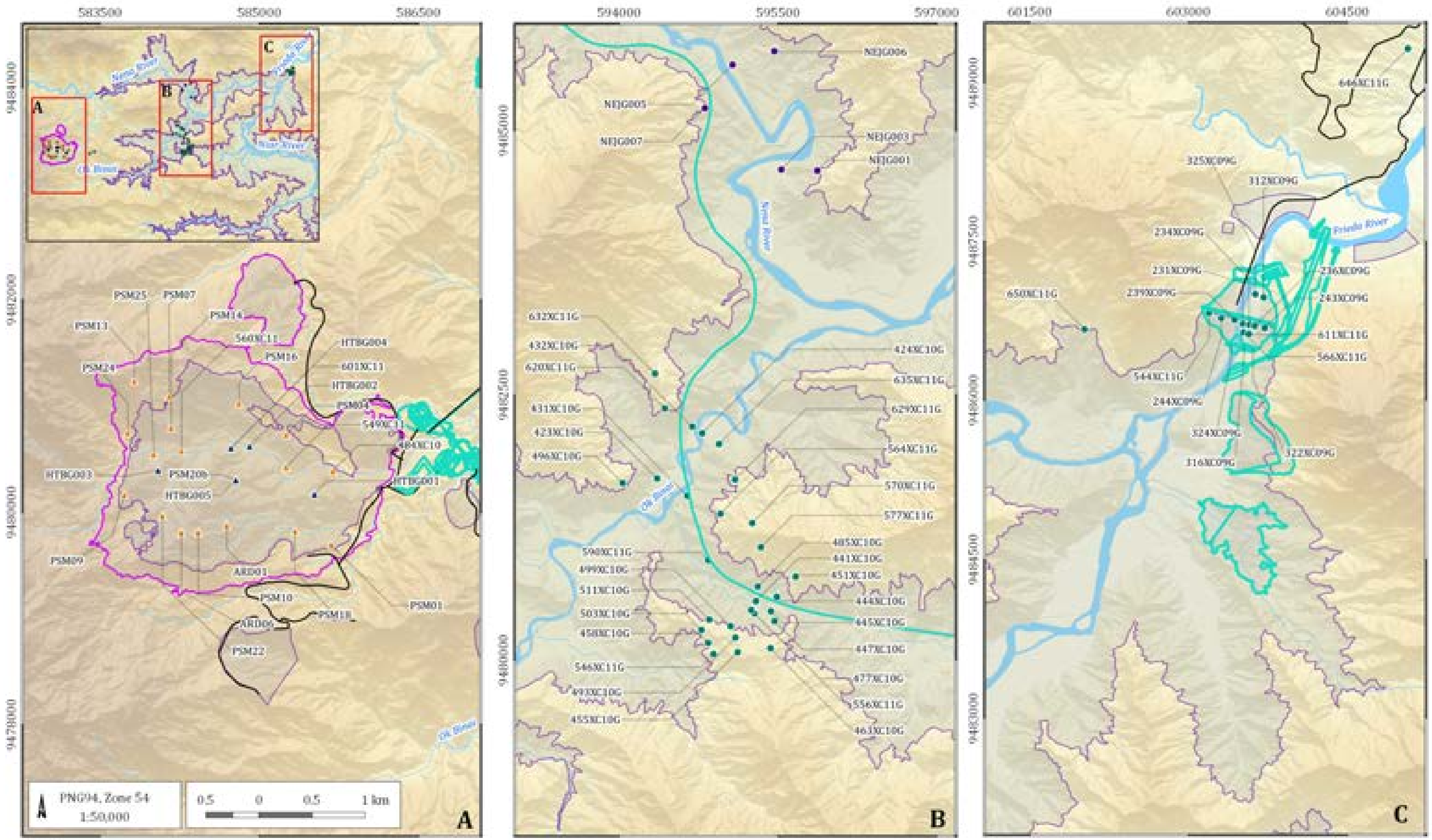
[2] The term VWP array is used to describe when many VWP gauges are installed in one drill hole.

[3] The term VWP gauge describes the individual transducer that is grouted at a set depth within the drill hole.



LEGEND

- Open-pit extent (Year 33)
- FRHEP / ISF extent
- Drainage
- Mining infrastructures
- Road (proposed)

Monitoring network

- ▲ New VWP (2015)
- Existing PSM VWP (2009-2011)
- Geotech hole
- Monitoring bore

Sepik Development Project (I1051A)

AGE

Groundwater monitoring network

DATE 19/07/2018

FIGURE No. **4.1**

4.2 Groundwater levels and gradients

Groundwater level data within the study area has been collected from groundwater monitoring bores and VWPs. Appendix A contains this data and a detailed description of the vertical hydraulic gradients and groundwater flow direction. Groundwater level data has been used as a key component during the conceptualisation of groundwater flow directions, and also as a target for calibrating the numerical model. Nested VWP arrays allowed vertical hydraulic gradients, as wells as spatial distribution of heads to be determined. In addition to this, available transient data allowed for temporal water level changes due to recharge and discharge to be observed.

Analysis of the VWP data has been carried out indicating that 14 historical VWP gauges at 11 locations installed by Glencore Xstrata are reliable. The geotechnical investigations have installed an additional 26 new sensors in five new drill holes. There are a total of 40 VWP gauges providing a robust head pressure dataset within the proposed HIT open-pit. The geology, hydrostratigraphy and structural domains of the Ekwai and Koki open-pits are similar to the HIT open-pit and the existing data is assessed as sufficient to provide a hydrogeological understanding and calibrate the numerical model.

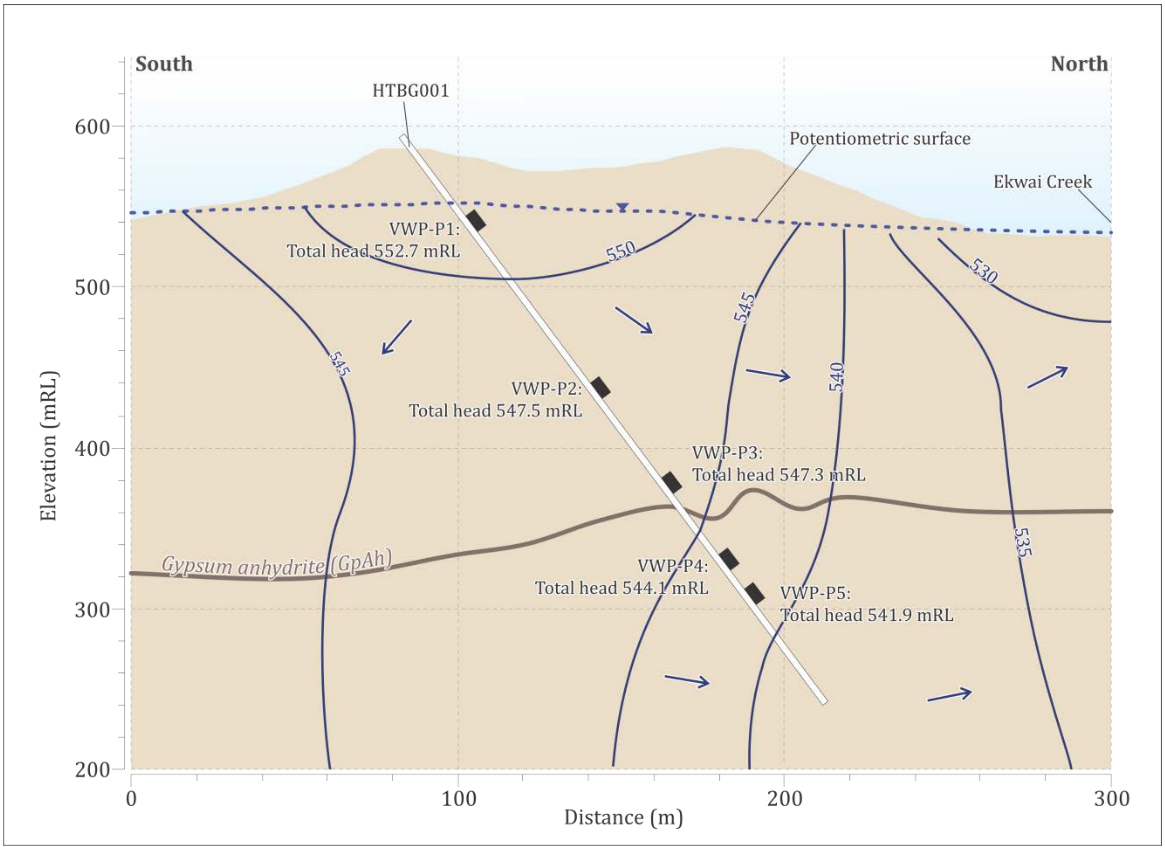
4.2.1 Vertical hydraulic gradients

A total of four sites (HTBG002, PSM24, 484XC10 and 601XC11) show an upward hydraulic gradient (between -0.02 m/m and -0.1 m/m), and the remaining 11 sites show a downward gradient varying between 0.02 m/m and 0.96 m/m. Site PSM13 is situated at RL 1,020 m and records the steepest hydraulic downward gradient, reflecting the elevated terrain at this point.

The head pressures measured at HTBG001, HTBG002, HTBG003, HTBG004 and HTBG005 are presented as cross-sections and include the lines of equal head showing pressure changes with depth (Figure 4.2 to Figure 4.6). The data generally indicates a downward gradient below areas of elevated terrain and an upward gradient in areas of lower elevation. These lower elevations generally coincide with surface water drainage systems such as Ekwai Creek.

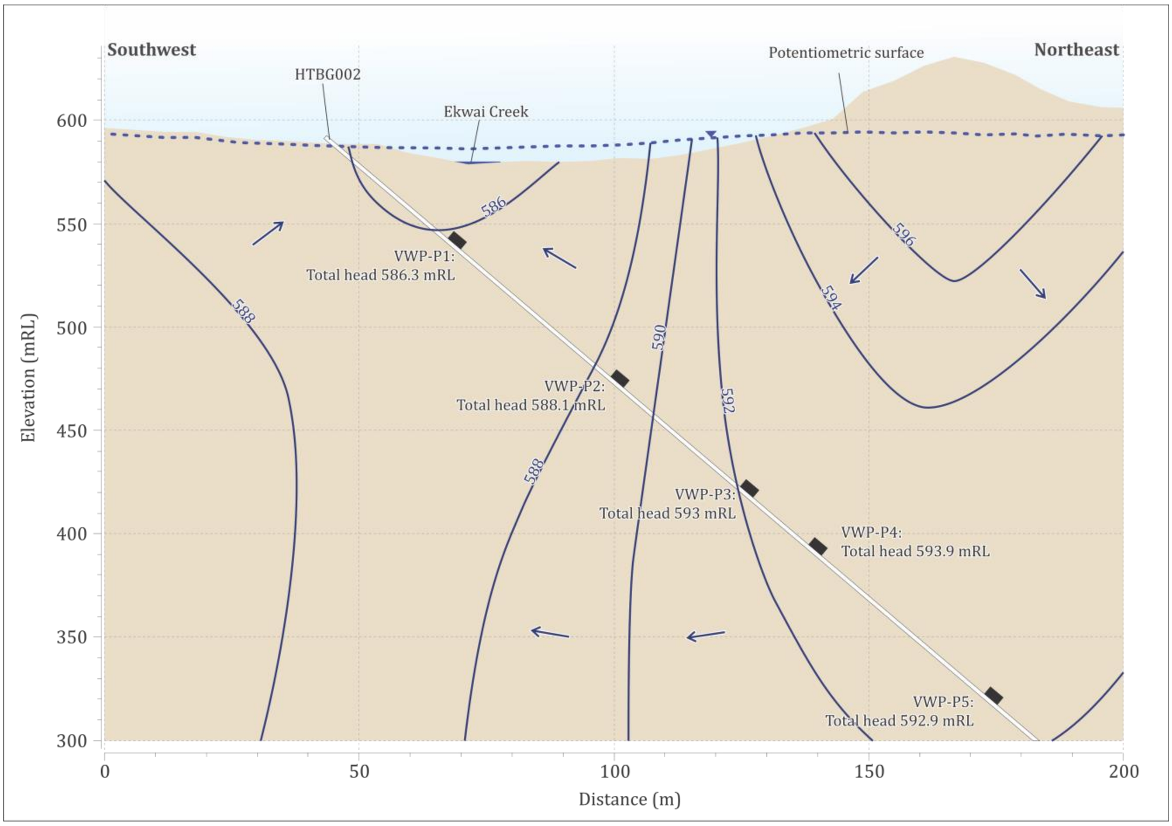
The hydrogeological conditions driving artesian pressures at some of these sites, (eg. HTBG002 – Figure 4.3) occur elsewhere in the study area. The artesian conditions observed at the numerous exploration drill holes occurs when the drill hole collar elevation is below the potentiometric surface of the deeper (confined) aquifer and drilling intersects the aquifer.

Where a downward vertical gradient exists, the VWP gauge in the weathered zone generally shows a greater response to recharge events compared to the deeper VWP gauges. In general, where VWP gauges have been constructed above and below the GAS, the two gauges record similar head pressures suggesting the GAS does not does not act as a confining layer.



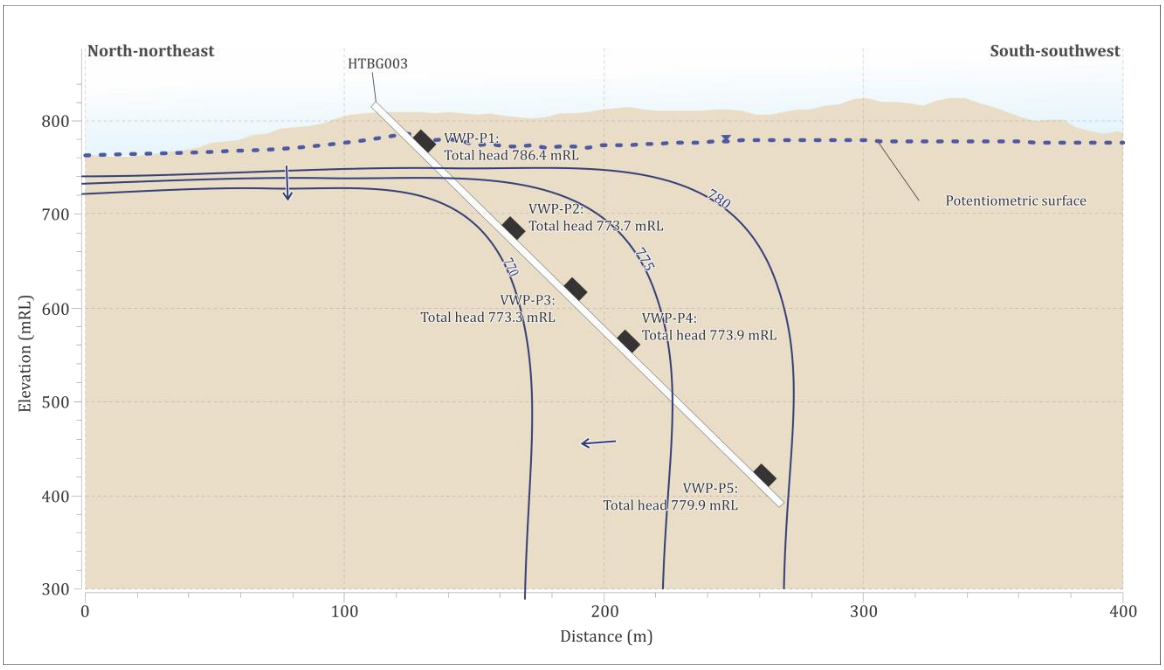
Note: *blue lines represent lines of equal head, the arrow indicate flow direction*

Figure 4.2 HTBG001 schematic of head pressures



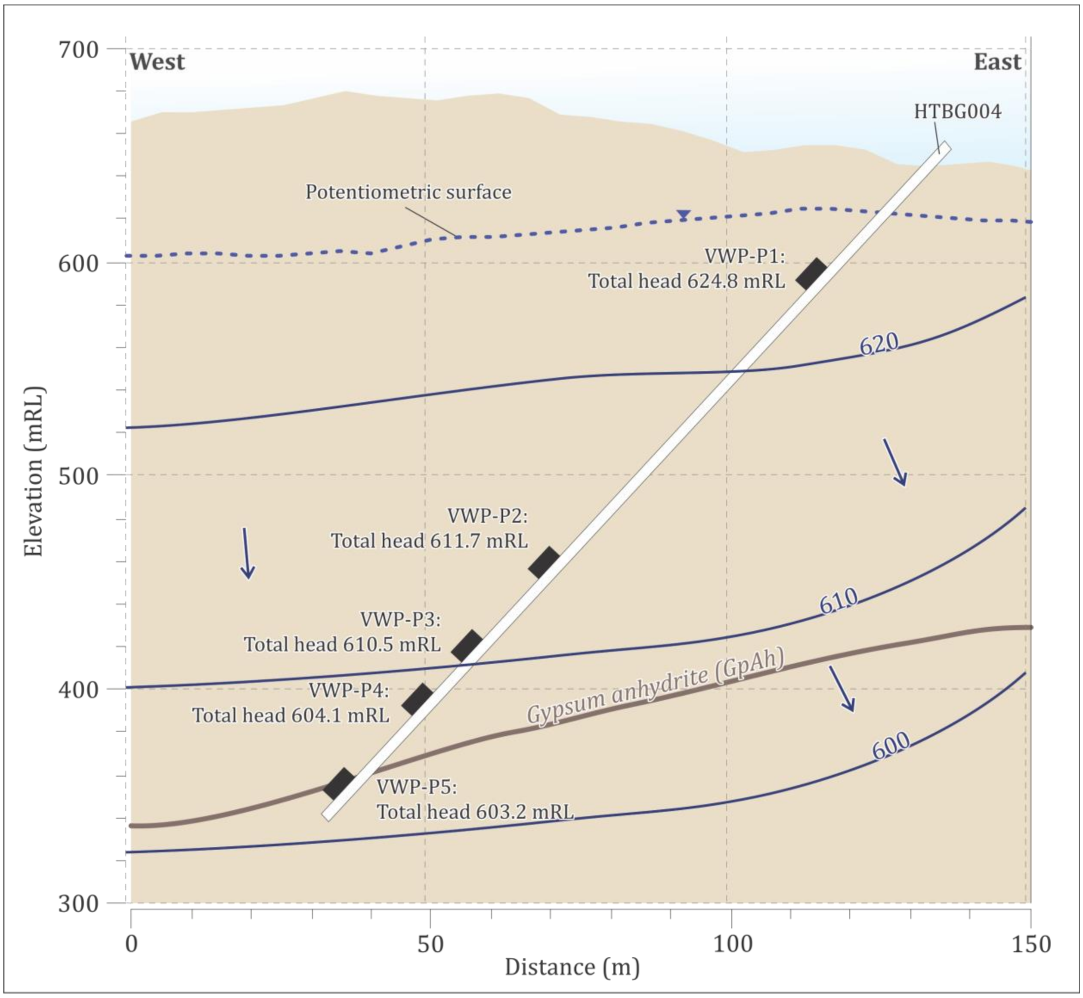
Note: *blue lines represent lines of equal head, the arrow indicate flow direction*

Figure 4.3 HTBG002 schematic of head pressures



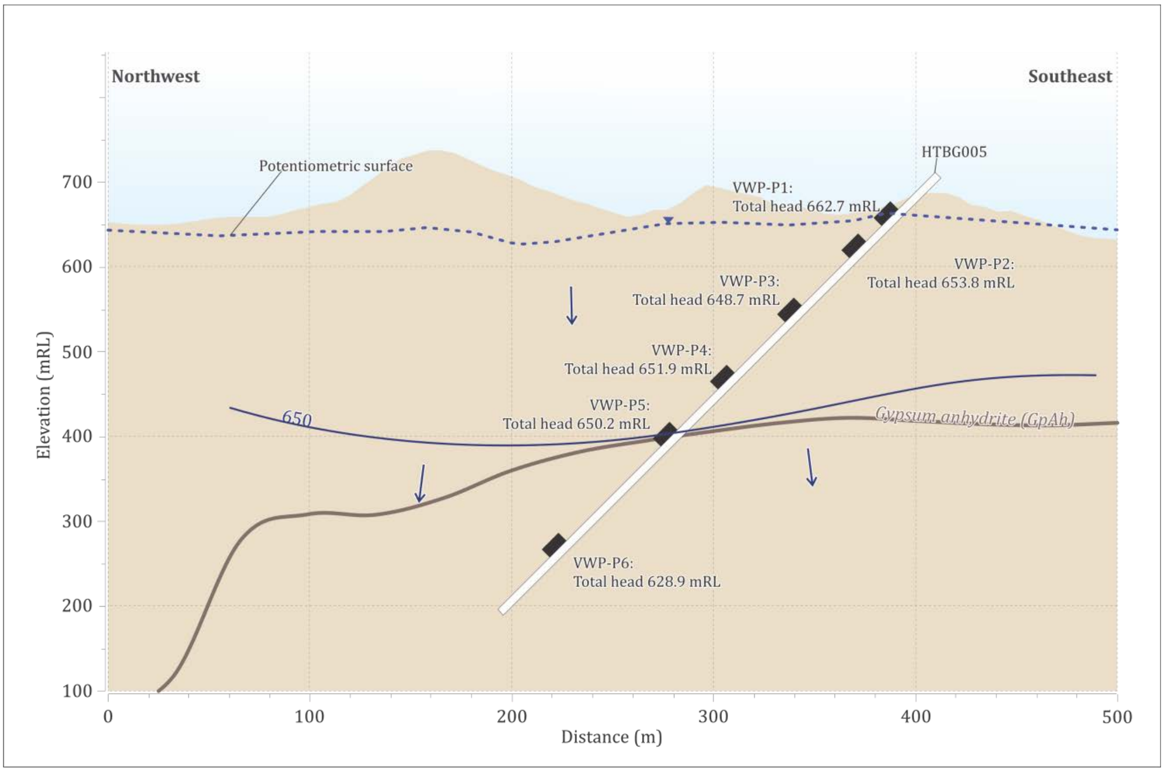
Note: *blue lines represent lines of equal head, the arrow indicate flow direction*

Figure 4.4 HTBG003 schematic of head pressures



Note: *blue lines represent lines of equal head, the arrow indicate flow direction*

Figure 4.5 HTBG004 schematic of head pressures



Note: *blue lines represent lines of equal head, the arrow indicate flow direction*

Figure 4.6 HTBG005 schematic of head pressures

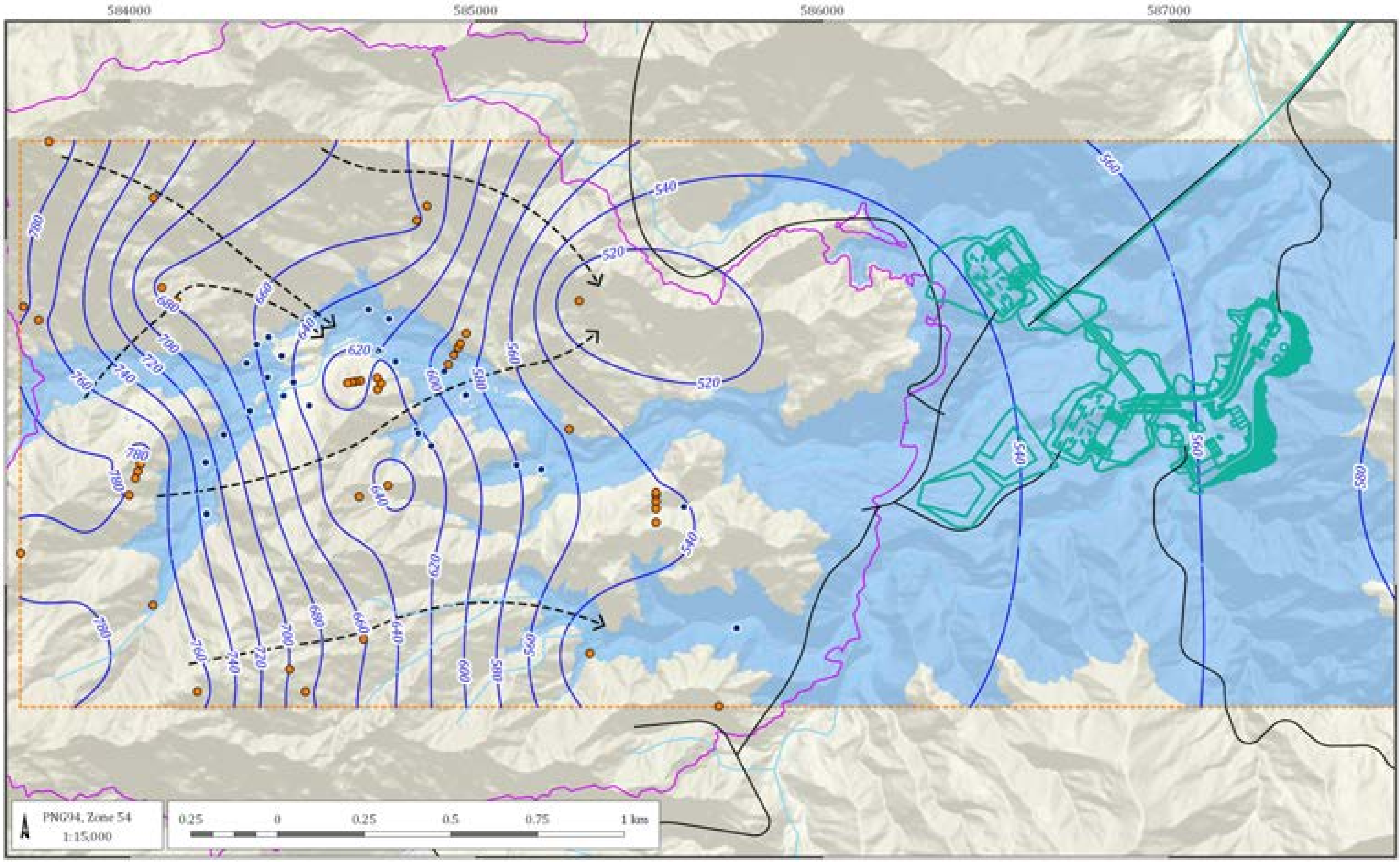
4.2.2 Groundwater levels

Figure 4.7 presents the groundwater level contours and artesian conditions around the open-pits. The contours were generated using data from the VWP monitoring sites (see Figure 4.1, inset B). These VWP monitoring sites are generally installed within inclined holes (Appendix A - Table A 1.1).

The groundwater flow direction is from west to east and approximates the flow direction of the major drainage lines. The groundwater level contours generally reflect the potentiometric surface of the deeper volcanic lithology. However, there is insufficient data (five data points) to generate water table contours for the surface weathered zone. Available data would suggest that shallow perched aquifers occur in the study area and these are presented in Figure 4.2 to Figure 4.6.

Artesian conditions[4] are observed at 30 exploration drill holes. The inferred artesian conditions shown on Figure 4.7 are consistent with observed artesian conditions at exploration drillholes. Artesian conditions are associated with topographic lows within the drainage features. The artesian sampling sites were not used in the contouring process but have been shown to verify the contours against the known artesian conditions.

[4] Artesian conditions occur where the potentiometric surface is above ground surface.



LEGEND

- Open-pit extent (Year 33)
- Interpolation extent
- Drainage
- Mining infrastructures
- Road (proposed)
- Artesian head
- Potentiometric surface contours confined volcanics (RL m)
- Flow direction
- Artesian sites
- 2014 data used for interpolation

Sepik Development Project (I1051A)

AGE

Groundwater flow direction

DATE 19/07/2018

FIGURE No. **4.7**

Some localised and potentially more widespread depressurisation of the volcanics and intrusive lithologies appears to have occurred as a response to the artesian groundwater discharge. An example of the depressurisation is observed within PSM10 (Figure 4.8). The upper gauge (PSM10A) has recorded little response whilst the deeper gauge (PSM10B) has recorded up to 20 m depressurisation over two years.

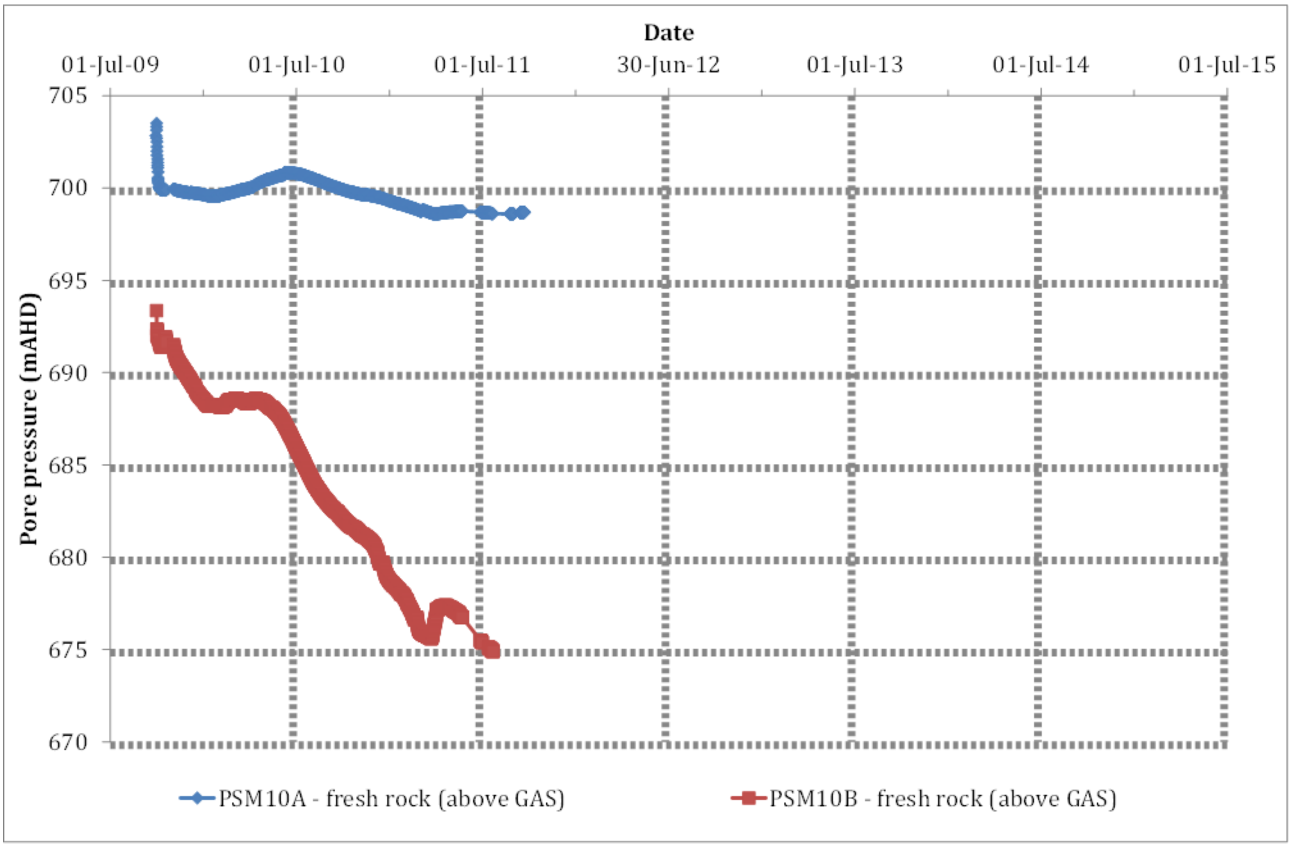


Figure 4.8 VWP hydrograph - PSM10

4.2.3 Transient data

Hydrographs of transient head pressure measured by the existing 19 VWP arrays are provided in Appendix A (Attachment B). The transient data is varied and three typical response types are observed:

- Little or no change in head pressure (that is less than 2 m) over the monitoring record.
- Irregular and sudden increases (2 m to 5 m) in head pressure. These sudden and irregular increases in head pressure are observed within deeper VWP gauges which are likely to monitor confined conditions. This VWP data has been compared against daily rainfall data and shows a reasonable correlation. Where there are rainfall events in excess of 75 mm/day there is typically an increase in head pressure, for example recorded by VWP 549XC11A (Appendix A – Attachment B). Changes in barometric pressure may result in a similar head pressure response. However, it is not clear whether this increase in head pressure is a result of barometric pressure, rainfall recharge, or a hydraulic response from a flooded surface water system. Barometric pressure data is not available to compare against and there is significant variability in rainfall distribution which is problematic in correlating to head pressure trends.
- Gradual and continuing decline in head pressure. Most likely related to the gradual depressurisation of the rock mass in response to discharge from the artesian exploration drill holes (see Figure 4.8 as an example).

The transient data has been used in the calibration of the numerical model.

4.3 Hydraulic parameters

The hydraulic conductivity data collected to date is based upon packer testing on exploration drill holes, and falling head tests in open exploration holes and monitoring bores. Appendix B summarises the hydraulic conductivity data for the project.

The 2015 open-pits area geotechnical investigations completed drilling and packer testing of five holes (as of April 2015) with a total of 108 packer tests completed in these holes. Historical hydraulic data for previous project infrastructure was supplied by SRK and PanAust.

The project has compiled 321 individual hydraulic conductivity test results (current and historical data) for areas located within and outside the proposed open-pits.

Table 4.1 summarises the hydraulic conductivity measurements for the key geologic units represented in the groundwater model. Statistical bounds have been estimated for four layers including alluvium, weathered zone, above the GAS and below the GAS. The geometric mean, 20th percentile, and 80th percentile bounds are presented in Table 4.1 and shown on Figure 4.9.

Table 4.1 Summary of hydraulic conductivity data

Unit	No. of data points	Hydraulic conductivity (m/day)				
		Min.	Max.	20th percentile	80th percentile	Geometric mean
alluvium / colluvium	40	6.0×10^{-2}	24.0	0.3	4.9	1.02
weathered rock	39	5.6×10^{-4}	15.2	2.1×10^{-2}	1.05	0.15
fresh rock (above GAS)	218	4.0×10^{-5}	7.31	2.0×10^{-3}	0.14	1.7×10^{-2}
fresh rock (below GAS)	24	1.0×10^{-5}	0.14	1.0×10^{-4}	0.011	6.9×10^{-4}
Total	**321**					

The in-situ permeability packer testing data in the recent geotechnical drill holes was generally carried out along zones of relatively competent rock. Only a small number of tests were completed on zones containing fault gouge or structural features. As a result, the packer test data is considered representative of the bulk (in-situ) rock mass.

The hydraulic conductivity measurements range significantly within each geologic unit. However, this range is typical of fractured rock and is controlled by the nature of the fracture network. The geometric mean of hydraulic conductivity for each unit indicates a general trend of decreasing hydraulic conductivity with depth (Figure 4.9). A log linear decline in horizontal hydraulic conductivity (Kh) is evident with depth. Although the data for the GAS shows a slight correlation between hydraulic conductivity and depth, tests below the GAS show a larger range than expected. Visual observations of lithology above and below the GAS (Figure 4.10 and Figure 4.11 respectively) suggest that the GAS should have an overall lower hydraulic conductivity.

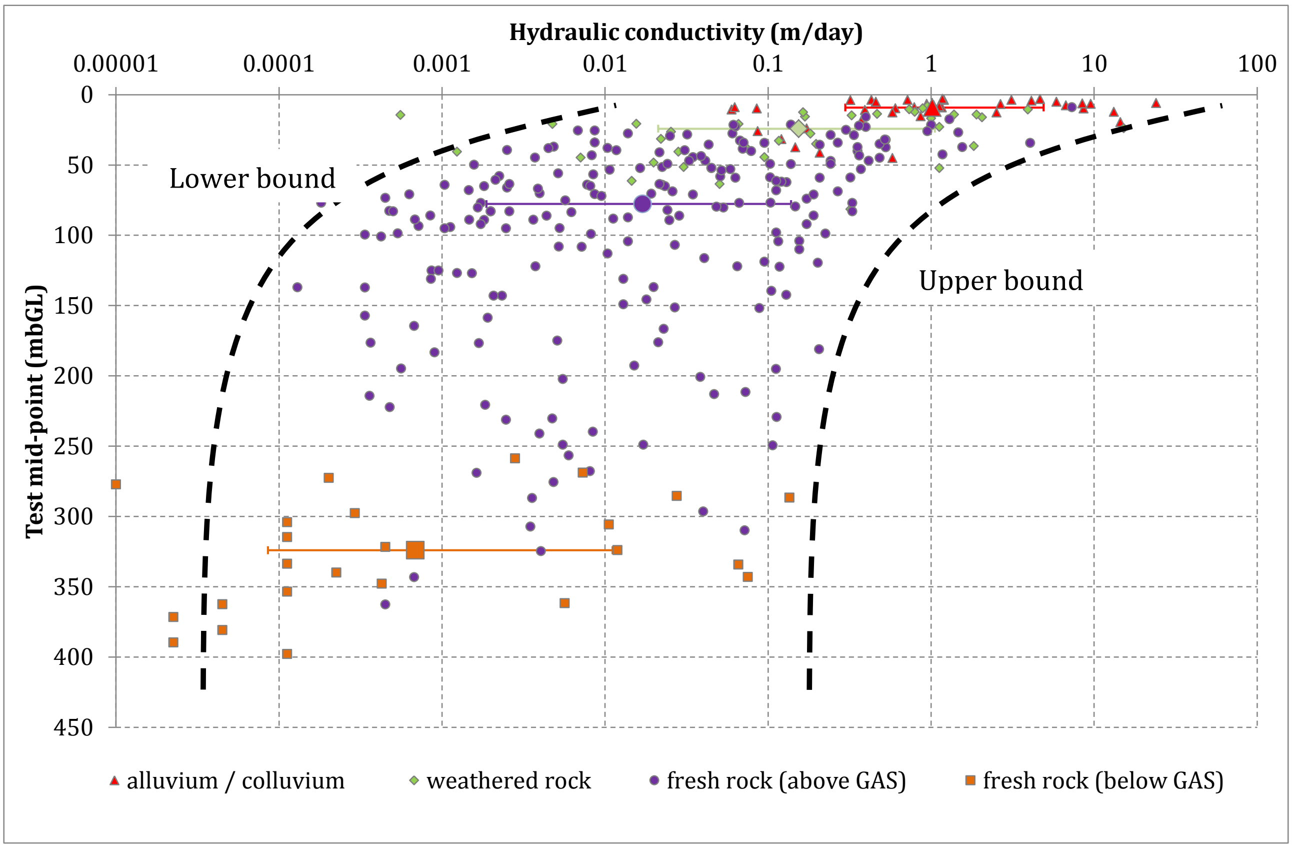


Figure 4.9 Hydraulic conductivity with depth

Figure 4.10 Example of broken core above the GAS

Figure 4.11 Example of competent core below the GAS

To date there have been a limited number of hydraulic conductivity tests completed below the GAS. However, core photos and geotechnical logs suggest that the hydraulic conductivity below the GAS is lower than that above. The limited number of test results below the GAS shows some reduction in hydraulic conductivity but to not the degree expected.

Aquifer storage parameters have not been measured for the study area. For the purposes of the development of the regional groundwater model, these parameters were estimated during calibration of the transient model. These estimates are based on experience, and examples of storage parameters from similar lithology types. Storage within fractured rock domains with limited primary porosity is generally lower compared to equivalent porous media.

4.4 Water quality

During December 2014, AGE collected 136 water samples (Figure 4.12) from the following sources:

- 33 groundwater samples from artesian exploration drill holes;
- 102 surface water samples from various streams; and
- one rainfall sample.

The origin of the surface water (i.e. catchment runoff or groundwater springs) could not be confirmed at the time of sampling with certainty. Therefore, all water samples collected at the ground surface have been grouped together and termed surface water.

Physico-chemical parameters and flow rates were measured from the sampling locations and a total of 42 samples were sent to Australian Laboratory Services Pty Ltd (ALS) in Brisbane (Australia). ALS is a NATA accredited laboratory. The laboratory analysed samples included the following:

- 29 groundwater samples from artesian exploration drill holes;
- 12 surface water samples from various streams; and
- one rainfall sample.

All 42 samples were analysed for the following suite of parameters, using the standard ALS limit of reporting (LOR):

- physical parameters (pH, EC, total dissolved solids [TDS], total hardness, and sodium adsorption ratio);
- alkalinity (CO_3, HCO_3, and total alkalinity);
- major anions (Cl and SO_4);
- major cations (Ca, Mg, Na, and K);
- bromide, silicon as SiO_2, and fluoride; and
- dissolved and total metals (Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe^{2+}, Hg, Mn, Mo, Ni, Pb, Sr, Se, V, and Zn).

A subset of 32 samples were analysed for the following suite of parameters, using the ALS trace LOR:

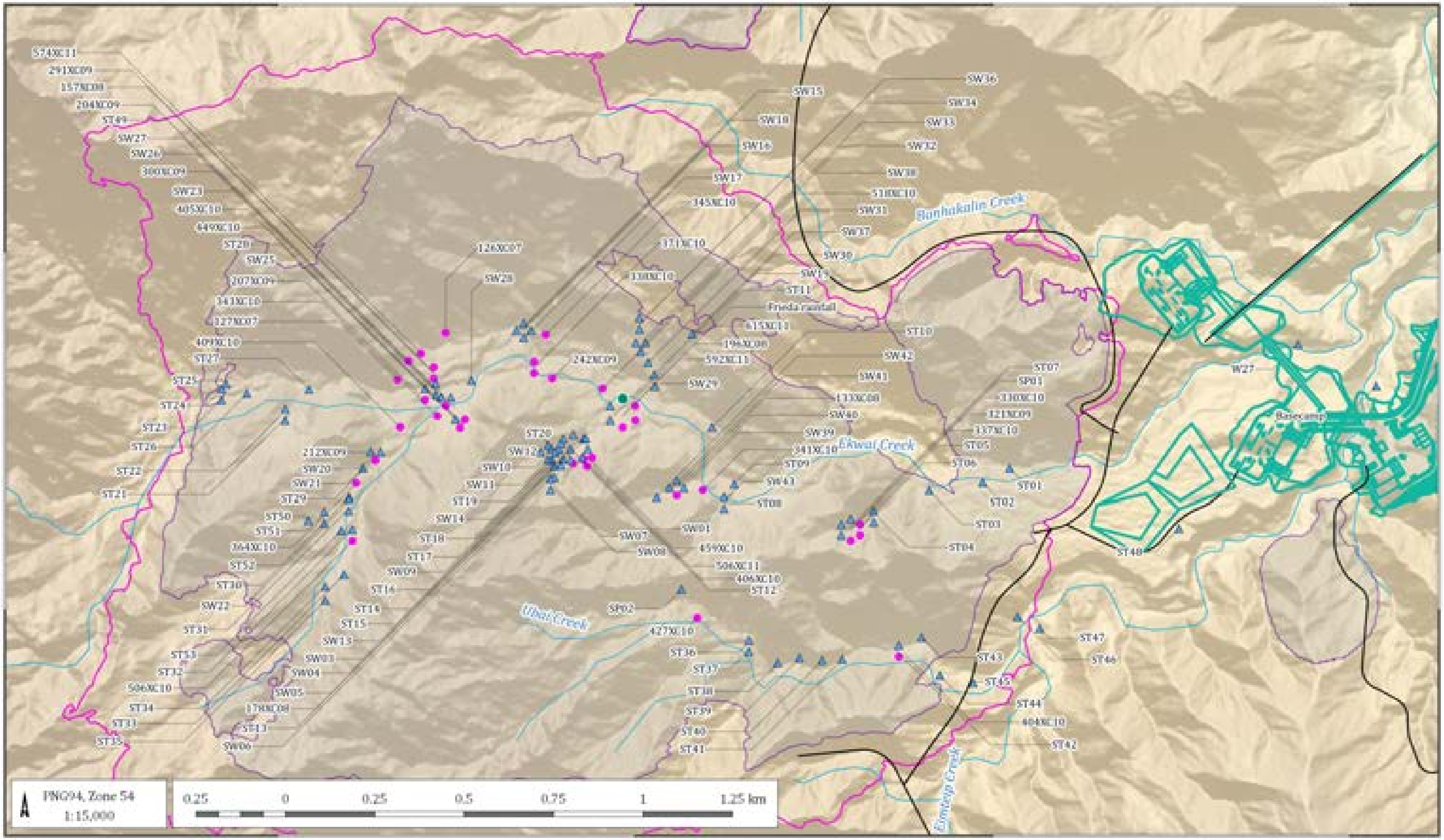
- major anions (Cl and SO_4); and
- major cations (Ca, Mg, Na, and K).

The trace LOR was required because many of the groundwater samples and surface water samples had concentrations of Cl, SO_4, Ca, Mg, Na, and K below the standard LOR.

Water quality data was also provided by SKM (2011) and Hydrobiology (2015). A statistical summary of the laboratory water quality data (compiled from standard LOR and trace LOR analyses) and the data sourced from SKM (2011) and Hydrobiology (2015) is provided in Table 4.2. Appendix C provides further interpretation of the water quality data.

It is noted that there is data available from bores that that were sampled outside the study area. For the purpose of this assessment, data outside of the study area was not considered.

Surface water and rainfall within the study area is predominantly fresh (2 µS/cm to 1,023 µS/cm). Some artesian groundwaters are fresh, but some groundwater also exhibit slightly brackish to brackish quality (126 µS/cm to 2,260 µS/cm). Groundwater within the study area is characterised as weakly acidic to weakly alkaline. Moderately acidic waters (pH < 5) are more predominant in the surface waters.



LEGEND

- Open-pit extent (Year 33)
- FRHEP / ISF extent
- Drainage
- Mining infrastructures
- Road (proposed)

Water sample locations

- Groundwater
- Surface water
- Frieda rainfall

Sepik Development Project (I1051A)

DATE
19/07/2018

AGE

Water sample locations in the vicinity of the open-pits

FIGURE No:
4.12

G:/Projects/I1051A.Frieda River_IESA/3_GIS/Workspaces/001_Deliverable1/04.12_I1051A_Water sample locations in the vicinity of the open-pits.qgs

Table 4.2 Statistical summary of laboratory water quality data

Parameter	Groundwater							Surface water							Rainfall	
	min	20th %ile	average	geomean	80th %ile	max	count	min	20th %ile	average	geomean	80th %ile	max	count	-	count
pH	3.43	4.18	6.32	6.1	7.55	7.77	27	3.69	4.05	5.03	4.9	6.60	7.77	111	6.22	1
EC (µS/cm)	126	282.4	1002	724.53	1706	2260	27	10	47.36	175	104.54	280.20	1023	111	2.0	1
TDS	82	183.2	651	470.62	1110	1470	27	30	35.07	103	66.92	110.0	413	19	1.0	1
Total Hardness	13	99.2	577	328.55	1058	1520	27	0.5	6.60	59	22.16	53.0	326	20	0.5	1
Bromide	0.01	0.01	0.02	0.01	0.03	0.05	27	0.01	0.01	0.01	0.01	0.01	0.01	11	0.01	1
Hydroxide Alkalinity	0.5	0.5	0.5	0.5	0.5	0.5	27	0.5	0.5	0.5	0.5	0.5	0.5	20	0.5	1
Carbonate Alkalinity	0.5	0.5	0.5	0.5	0.5	0.5	27	0.5	0.5	0.5	0.5	0.5	0.5	20	0.5	1
Bicarbonate Alkalinity	0.5	0.5	28.96	10.22	50.0	77.0	27	0.5	0.5	12.71	3.16	25.24	48.0	20	1.0	1
Total Alkalinity	0.5	0.5	28.96	10.22	50.0	77.0	27	0.5	0.5	12.71	3.16	25.24	48.0	20	1.0	1
SO4	24.0	97.2	532.78	313.12	909.0	1460.0	27	2.68	5.57	51.13	17.4	42.40	287.0	20	0.5	1
Chloride	0.1	0.25	1.26	0.67	2.0	5.0	27	0.05	0.05	0.36	0.23	0.5	1.0	20	0.05	1
Calcium	2.0	36.6	225.41	116.49	415.0	599.0	27	0.1	1.80	21.87	6.10	17.18	121.0	20	0.05	1
Magnesium	0.4	1.36	3.27	2.67	5.0	8.0	27	0.1	0.6	1.19	0.97	1.89	3.0	20	0.05	1
Sodium	1.0	2.68	8.01	6.14	12.0	23.0	27	0.1	1.06	1.63	1.29	2.01	5.3	20	0.05	1
Potassium	1.0	1.0	1.75	1.6	2.0	3.0	27	0.1	0.4	0.56	0.48	0.5	2.1	20	0.1	1
Aluminium	0.005	0.005	0.299	0.024	0.476	2.21	27	0.005	0.019	0.319	0.108	0.596	1.1	20	0.005	1
Arsenic	0.0005	0.0005	0.0022	0.001	0.002	0.015	27	0.0005	0.0005	0.0007	0.0007	0.001	0.001	20	0.0005	1
Beryllium	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	27	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	11	0.0005	1

Parameter	Groundwater							Surface water							Rainfall	
	min	20th %ile	average	geomean	80th %ile	max	count	min	20th %ile	average	geomean	80th %ile	max	count	-	count
Barium	0.0005	0.0102	0.0193	0.0151	0.0248	0.065	27	0.002	0.007	0.0155	0.0115	0.023	0.042	11	0.0005	1
Cadmium	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	27	0.00005	0.00005	0.00003	-	0.00005	0.0001	20	0.0001	1
Chromium	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	27	0.0005	0.0005	0.0007	0.0007	0.001	0.001	20	0.0005	1
Cobalt	0.0005	0.0005	0.0016	0.001	0.0028	0.007	27	0.0005	0.001	0.0020	0.0016	0.0022	0.008	20	0.0005	1
Copper	0.0005	0.0005	0.0257	0.0018	0.0058	0.507	27	0.001	0.001	0.1463	0.014	0.0624	1.6	20	0.0005	1
Lead	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	27	0.0005	0.0005	0.0007	0.0007	0.001	0.001	20	0.0005	1
Manganese	0.0005	0.0914	0.2872	0.1706	0.5304	0.944	27	0.001	0.0038	0.0359	0.0164	0.0442	0.232	20	0.0005	1
Molybdenum	0.0005	0.0005	0.0006	0.0005	0.0005	0.002	27	0.0005	0.0005	0.0010	0.0007	0.0005	0.004	11	0.0005	1
Nickel	0.0005	0.0005	0.0018	0.0012	0.003	0.006	27	0.0005	0.001	0.0012	0.0011	0.002	0.003	20	0.0005	1
Selenium	0.005	0.01	0.005	0.01	0.01	0.005	27	0.004	0.01	0.0050	0.005	0.01	0.01	20	0.005	1
Strontium	0.024	0.3952	2.2049	1.1308	4.152	5.56	27	0.002	0.009	0.3171	0.0658	0.808	1.08	11	0.0005	1
Vanadium	0.005	0.005	0.005	0.005	0.005	0.005	27	0.005	0.005	0.005	0.005	0.005	0.005	11	0.005	1
Zinc	0.0025	0.0025	0.0153	0.0077	0.0254	0.063	27	0.0025	0.0029	0.0081	0.0057	0.016	0.023	20	0.0025	1
Boron	0.025	0.025	0.025	0.025	0.025	0.025	27	0.025	0.025	0.025	0.025	0.025	0.025	11	0.025	1
Iron	0.025	0.025	1.246	0.119	1.104	16.7	27	0.025	0.025	0.099	0.066	0.16	0.3	11	0.025	1
Mercury	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	27	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	11	0.00005	1
Silicon as SiO2	13.6	17.14	32.24	29.14	48.7	54.6	27	2.6	8.9	14.23	11.51	21.0	38.1	11	0.05	1
Fluoride	0.05	0.05	0.14	0.11	0.2	0.5	27	0.05	0.05	0.07	0.06	0.10	0.20	11	0.05	1

Notes: *All values in mg/L unless otherwise stated.*

All metals are dissolved.

For laboratory results less than Limit of Reporting (LOR), a concentration of one half of the LOR has been adopted.

Figure 4.13 and Figure 4.14 show the analytical results as plotted on a Piper diagram and Durov plot, respectively. These figures are intended to demonstrate groundwater type groupings based on cation-anion ratios. Figure 4.13 shows that major ion ratios are similar for all artesian exploration drill holes with samples plotting in a similar section of the piper diagram (dominated by Ca and SO_4). The surface waters tend to plot as Ca – HCO_3 type waters.

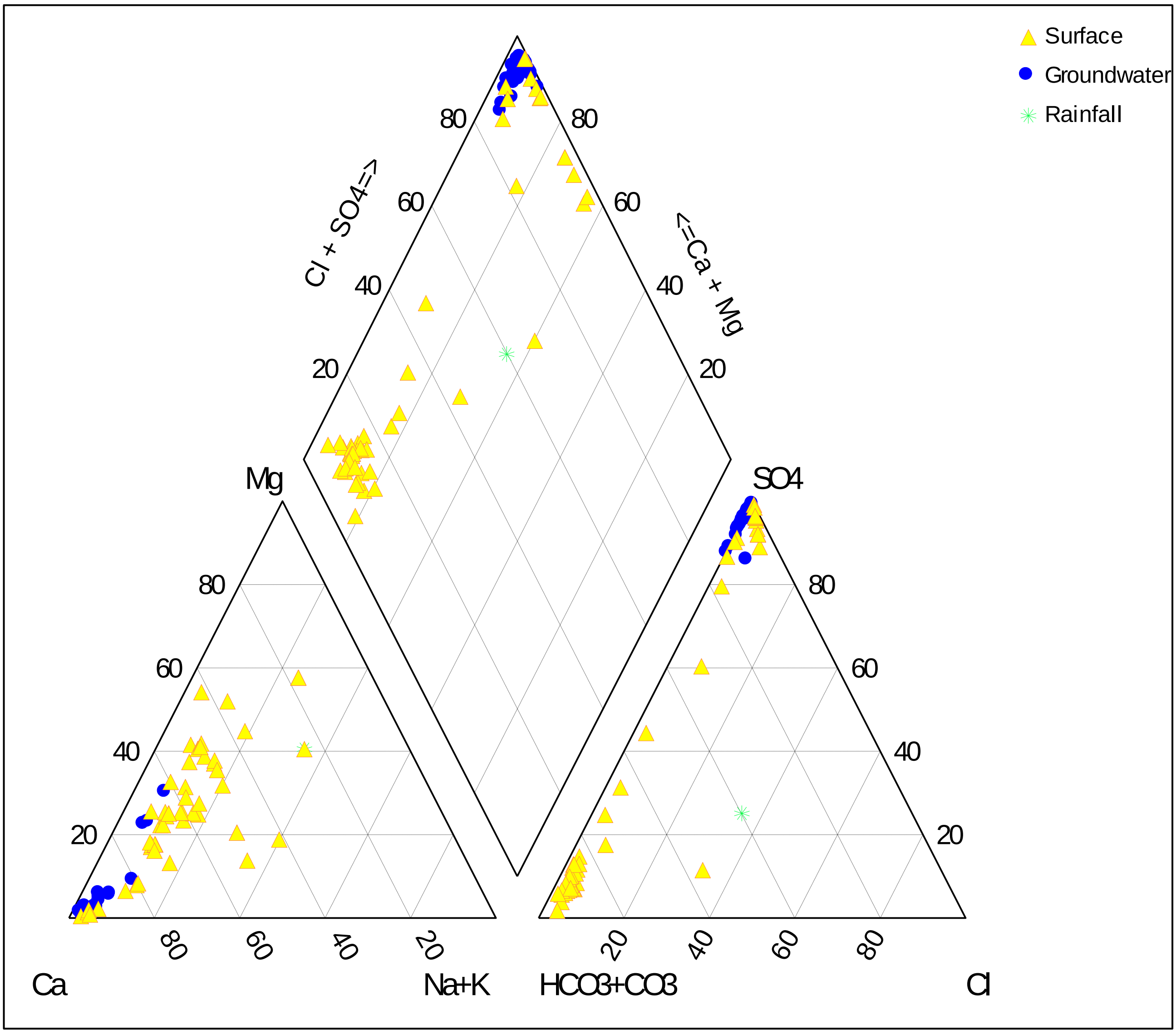


Figure 4.13 Piper diagram

The Durov Plot (Figure 4.14) shows a similar major ion grouping, although the electrical conductivity (EC) variations show that enrichment of some samples over others is occurring. Figure 4.14 also shows a wide range of pH from the groundwater samples. Both graphs show similarity in some surface water samples to the open-pit area groundwater.

The artesian exploration drill holes are not cased or screened and as such, the water sample is considered representative of composite lithology. To infer that groundwaters are representative of a certain geology type cannot be carried out with the available data.

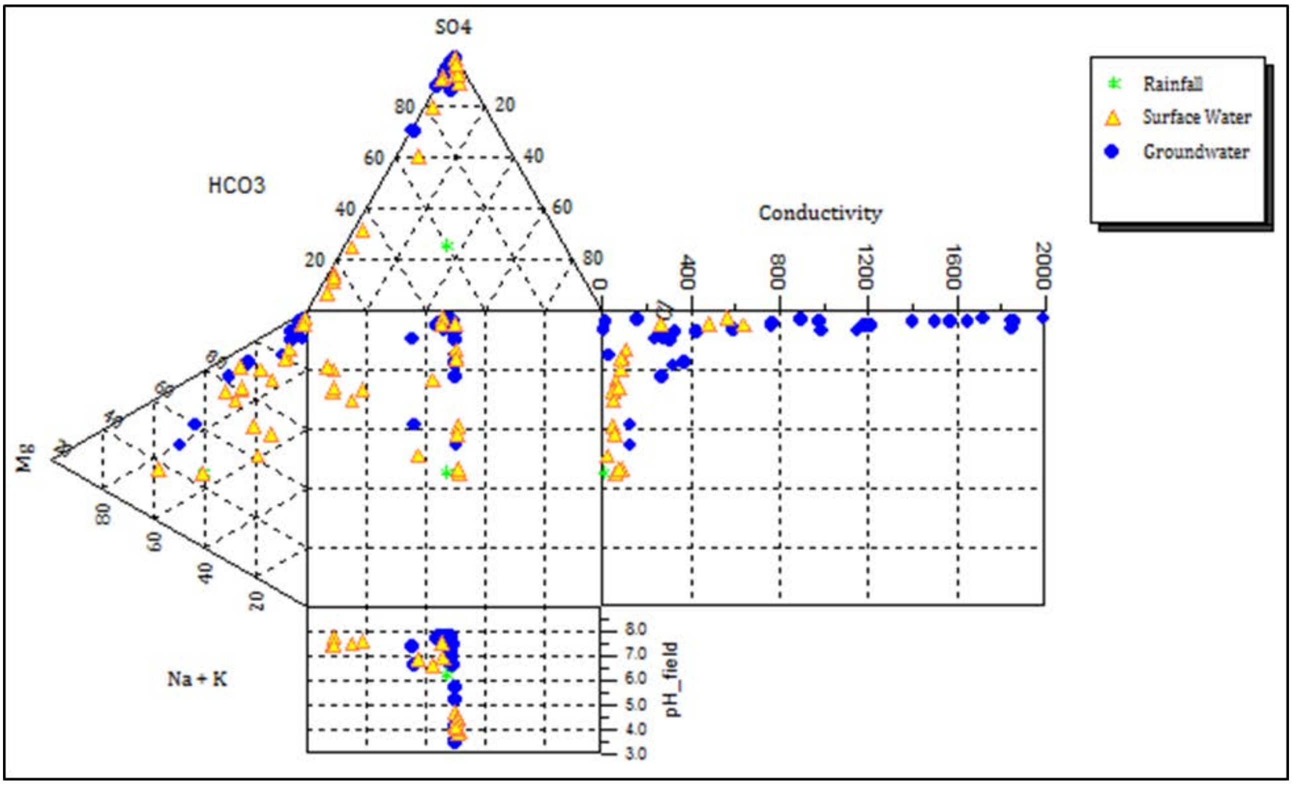


Figure 4.14 Durov diagram

Further assessment of the major ion water quality data would suggest that there are two chemical processes occurring. These are:

- the dissolution of anhydrite ($CaSO_4$) which is occurring within the artesian groundwaters; and
- the oxidation of sulphide, which is evident in a number of surface water samples and a limited number of groundwater samples.

Anhydrite dissolution and pyrite oxidation are the dominant sources of dissolved sulphate in these waters. Distinct trends of mixing between water dominated by anhydrite dissolution and water dominated by pyrite oxidation are inferred from the data and some spatial correlation between these mixed waters is apparent. By plotting the ratio of SO_4 and HCO_3 versus pH (Figure 4.15) the waters being affected by these two processes are visible.

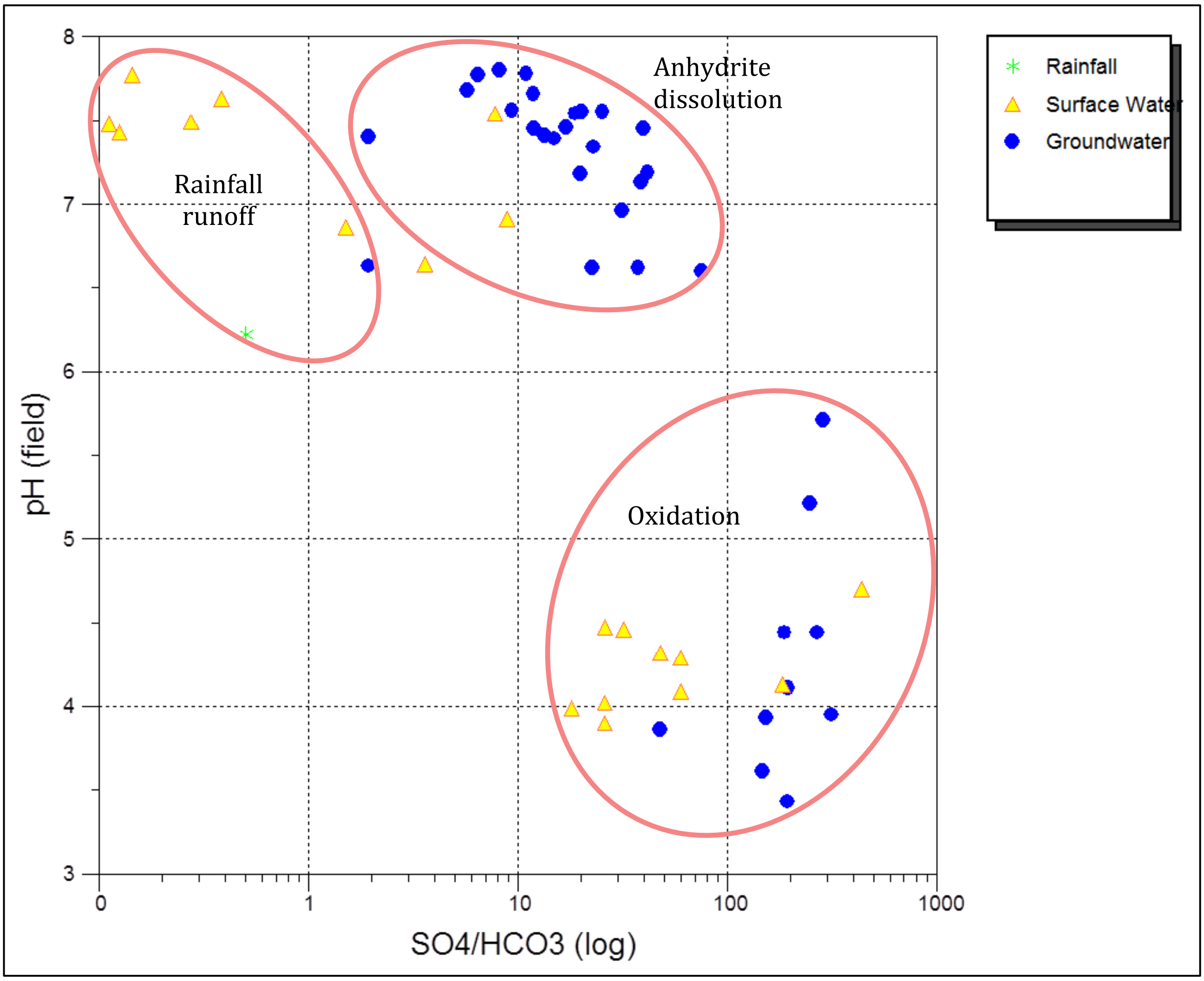


Figure 4.15 SO_4/HCO_3 versus pH

The surface waters with near neutral pH (6 – 8) and a SO_4/HCO_3 ratio less than 1 represent runoff water with a low residence time. The groundwaters from the artesian exploration drill holes typically have near neutral pH (6 - 8) and a SO_4/HCO_3 ratio between 1 and 100, that is enriched in sulphate. Hounslow (1995) states that anhydrite dissolution can be determined if $Ca/(Ca+SO_4) = 0.5$. These waters are also enriched in Ca and satisfy this condition. The deeper groundwater chemistry is therefore dominated by the dissolution of anhydrite ($CaSO_4$) from the country rock.

The remaining water samples (groundwater and surface waters) have more acidic pH (less than 6) and a SO_4/HCO_3 ratio between 10 and 1,000. Hounslow (1995) states that if $Ca/(Ca+SO_4) < 0.5$ and if pH < 5.5, then pyrite oxidation is said to be occurring. Assessment of the data shows that these chemical conditions suggest that oxidation processes are contributing both SO_4 and acidity within surface water and groundwater. The oxidation process would be occurring at shallow depths, and infers local mixing between surface waters, deeper groundwaters, and water in contact with oxidising material in the unsaturated zone.

In general, metals such as Al, Cu, Co, Ni, and Zn were slightly elevated in the samples affected by pyrite oxidation. The groundwater samples affected by anhydrite dissolution do not show the same increased metal concentrations.

4.5 Recharge

Recharge is difficult to measure and is usually estimated by a number of methods to achieve a plausible and reliable range. These methods generally include water balance models, water level fluctuations, chloride mass balance (CMB), and numerical modelling. For the purpose of this assessment, recharge estimates were carried out using a catchment scale water balance (Section 4.5) and the chloride mass balance method. These estimates were then verified with the numerical groundwater model (Appendix D).

The CMB method assumes that the chloride ion behaves conservatively and is not easily affected by reactions through the unsaturated zone through to the saturated zone and is considered applicable in a tropical environment (Mensah *et al*., 2014). Recharge using the CMB method can be estimated using the following:

$$R = \frac{PC_p}{C_g}$$

Where:

R	recharge (mm)
P	rainfall (mm)
Cp	chloride concentration in rainfall (mg/L)
Cg	chloride concentration in groundwater (mg/L)

The concentration of chloride in rainfall was laboratory reported (trace method) as <0.1 mg/L and therefore was assumed to be 0.05 mg/L. The geomean chloride concentration in groundwater is 0.67 mg/L (minimum of 0.1 mg/L and a maximum of 5 mg/L). The results of the CMB method suggest that recharge is in the order of 1% up to 50% of rainfall. However, the geometric mean of the data would suggest that a recharge value of 7.5% is more realistic.

4.6 Discharge

Discharge of groundwater is considered to encompass:

- baseflow to streams;
- seepage at springs;
- evapotranspiration from areas where a shallow perched water table exists; and
- flow from uncapped exploration holes.

4.6.1 Baseflow to streams

Based on available stream flow data and the artesian conditions in the exploration drill holes, significant baseflow to local streams is likely and this was estimated by KP (2015). However, the high, persistent rainfall and subsequent lack of flow recession makes baseflow definition (including a Baseflow Index) problematic. With this in mind, the supplied information from KP has been used to determine an initial estimate of steady state baseflow in the major catchments around the open-pits and ISF.

It is apparent that all surface water gauges have some outlying low flows when the data is sorted. The rainfall record was assessed and periods of little to no rainfall were found to correlate with these low flows. October to November 1997 is one such period of very little rainfall. This data was used as a lower bound for baseflow. The data was further assessed for short periods of no rainfall. The corresponding stream flow data was then used as the upper bound for baseflow. Using this approach, the estimated range of baseflow dominated stream flows are listed below for a number of catchments:

- Nena River 660 megalitres/day (ML/day) to 800 ML/day
- Ekwai Creek 2 ML/day to 4 ML/day
- Ok Binai 240 ML/day to 460 ML/day

Based on the available data, the best estimates of steady state baseflow contributions from the regional groundwater system are:

- Nena River 695 ML/day
- Ekwai Creek 2.5 ML/day
- Ok Binai 295 ML/day

Given the uncertainty of the baseflow estimates, the data provides a general indication for modelling purposes. The estimated baseflow also provides an additional calibration target for the numerical model in addition to the groundwater level data (Appendix D). These additional calibration targets reduce predictive uncertainty.

Based on the available groundwater level and drill log data there is potential that perched groundwater systems are present (e.g. at the base of the weathered zone). While rainfall may infiltrate the soil zone initially, this water may migrate laterally and discharge to local watercourses before it reaches the regional groundwater table, this is described as interflow. For the purposes of this assessment, baseflow and interflow have been treated as the same water balance component.

4.6.2 Seepage at springs

Springs are considered to probably exist within the study area. However, limited site observations were unable to identify them with confidence because of the high rainfall environment and lack of dry periods. Although springs probably exist, their permanency is unknown but they are expected to be persistent given the high amount of rainfall recharge received by the study area.

In the context of a fully saturated hydrogeological system and high rainfall environment, the importance of spring discharge in the overall water balance is considered to be negligible.

4.6.3 Evapotranspiration

Evapotranspiration is likely to occur within the study area where deep rooted vegetation removes water from the water table where it is located near surface (i.e. within the perched aquifer system of the surface weathered zone and the unconfined and unconsolidated alluvium / colluvium where it occurs). The total volume of groundwater removed from the system by evapotranspiration is estimated to be about 435 ML/day. This estimate is discussed further in Section 4.7.

4.6.4 Flow from uncapped exploration holes

Artesian conditions were observed in 30 exploration drill holes. It is understood that these holes have been uncapped and have flowed since drilling commenced in 2008. Assuming an average flow rate of 2 L/s (based upon field observations), discharge from the artesian exploration drill holes is equivalent to about 4 ML/day. The total volume of groundwater removed from the system by artesian flow from drill holes is negligible in the context of the total water balance for the study area.

4.7 Water balance

A steady state 'bucket' water balance for the Nena River catchment (upstream of stream gauge 105310, see Figure 3.5) was developed. The Nena River catchment was selected as it includes the key project component (open-pits) likely to affect the groundwater regime. The water balance was developed to assist in the establishment of the numerical model and to ensure appropriate fluxes were used in the process. The water balance assumes that storage is constant and that groundwater flow in and out of the system is constant.

KP (2015) processed and supplied climate and surface water flow data (Sections 3.2 and 3.3) (KP, 2015). Rainfall data for the site is available from a number of catchments and was supplied as daily and monthly averages. Climate data is generally available for two periods 1995 to 1999, and 2008 to 2015.

Monthly and annual rainfall data is considered most relevant to the groundwater conceptual model. KP report that climate patterns are not spatially variable across the study area and the use of a single, long term, rainfall value is considered appropriate. An average annual rainfall value of 8,509 mm/year was used for the study area.

KP (2015) advise that runoff coefficients of 80% are likely. Using this runoff coefficient allows 20% of available rainfall to be lost to either:

- shallow infiltration and interflow to streams;
- evaporation and transpiration; and
- deep drainage and recharge to the regional groundwater system.

A simple water balance for the Nena River catchment was developed assuming:

- Total annual rainfall of 8,509 mm/yr – based on rainfall data provided by KP (2015). The average monthly rainfall data for all sites was used to calculate the annual average rainfall. Whilst it is acknowledged that this annual rainfall is higher than annual average rainfall provided in Table 2, SRK (2016) state that rainfall across mountainous regions ranges between 7,700 to 8,600 mm/yr and is higher than in valley regions, where the rainfall stations presented in Table 2 are located.
- A catchment area of 1.937 x 10^8 m^2.
- Total rainfall volume of 4,514.3 ML/day.
- Runoff co-efficient of 0.7 (0.8 estimated by KP, 2015). Given the level of uncertainty regarding the stream flow data at the time of reporting, a reduced runoff coefficient was used.
- Total runoff volume of 3,160.0 ML/day.
- An evaporation rate of 934 mm/yr, equivalent to a volume of volume of 369.9 ML/day with a 0.75 pan evaporation factor.
- A transpiration rate of 1,200 m^3/yr/ha (Wang *et al*., 2009), equivalent to a volume of 63.7 ML/day.
- A baseflow (and interflow) component estimated by KP (2015) between 660 ML/day and 800 ML/day.
- Groundwater recharge was estimated by AGE at 5% of annual rainfall (225.7 ML/day). This is consistent with the 7.5% recharge calculation (geometric mean) derived using the CMB method (Section 4.5).

The water balance described above assumes that rainfall and evaporation within the Nena River catchment does not vary spatially. With this in mind, the water balance is highly sensitive to the larger components such as runoff coefficient, baseflow, and evaporation (Table 4.3). The water balance assumes that KP (2015) has addressed the uncertainty within these climatic and surface water variables.

Table 4.3 Nena River catchment water balance components

Water balance component	Rate (ML/day)
Rainfall	4,514.3
Runoff	3,160.0
Evaporation	369.9
Transpiration	63.7
Baseflow / Interflow	695.0
Recharge	225.7

4.8 Conceptual model

A conceptual model describes how the groundwater system operates, and assists in understanding the level of risks posed by the project. The conceptual model describes aquifers, aquitards, recharge mechanisms, discharge areas, and the interaction of groundwater and surface water. A robust conceptual model is an essential starting point upon which a numerical model is developed (Section 5).

The previous PFS groundwater assessments for the project have been reviewed by AGE as part of this assessment. The three key references include water balance modelling (SKM, 2011a), open-pit numerical groundwater modelling (SKM, 2011b), and an open-pit hydrogeology report (SKM, 2011c).

The early PFS work by SKM refers to three general conceptual layers:

- the surface weathered zone;
- rock units located above the GAS transition zone; and
- rock units located below the GAS transition zone.

This simplified approach to define the hydrostratigraphy within the mine area is still considered valid. However, data to date indicates that structure and faults are likely to play a role in the movement of groundwater, particularly within the mine area during development. Data also indicates the presence of colluvial material, which along with the alluvial sediments associated with surface water features, will play an important role in the groundwater regime. Therefore, the current hydrogeological interpretation is based on the following:

- Unconsolidated alluvium and colluvium – the alluvial material is associated with the current surface water systems including major streams and rivers and minor tributaries and creeks. The colluvial material is associated with zones of rock transported by gravity. There is little information on this geology within the open-pits and much of the data has been sourced from ISF studies. There is significant hydraulic conductivity and water level data from this unit. The alluvial / colluvial unit is expected to receive recharge from rainfall events. Local recharge from stream / river interaction is also likely to occur however, this process is not observed near the open-pits area due to the steep terrain. The alluvial / colluvial unit is the discharge zone for groundwater as baseflow to streams and rivers. This discharge occurs locally and is expected to be significant in the catchment water balance.

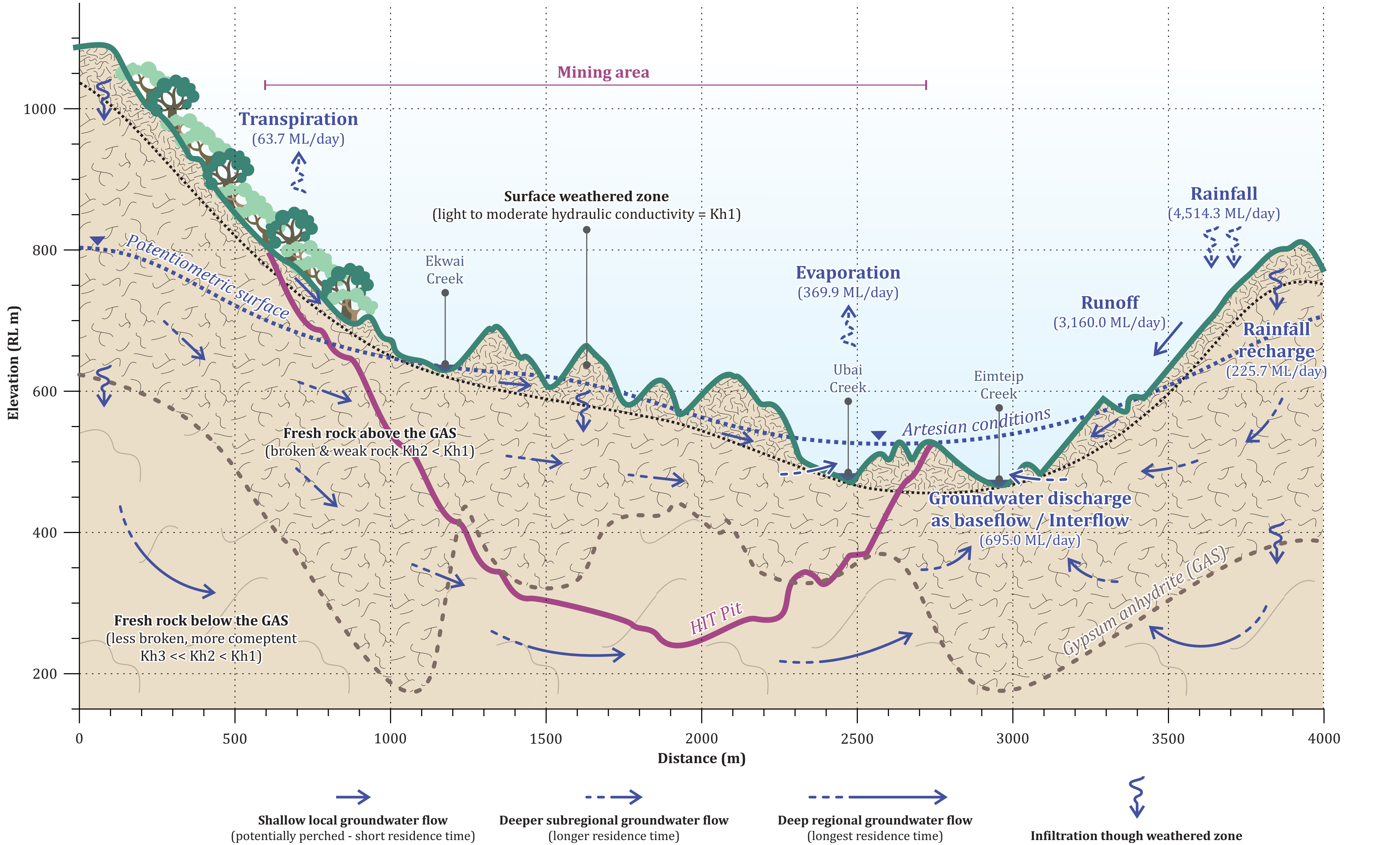
- The surface weathered zone – associated with an extensive surficial layer of rock mass that has been affected by weathering processes (TOX and POX). The weathering process increases the hydraulic conductivity and secondary porosity within the near surface rock mass. There are a number of VWP gauges within this unit for which to characterise hydraulic response. Furthermore, water quality data (both surface water and groundwater) provides information on the chemical processes (i.e. oxidation of sulphides) occurring within this weathered zone. The weathered zone is expected to receive recharge (5% of annual rainfall) from rainfall events. This zone may also operate as a perched aquifer system, which may result in reduced recharge to the regional groundwater system and an increase in interflow.
- Above the GAS – data to date indicates that this rock mass is particularly broken and weak and that the secondary structures within the rock mass will have a significant effect on the control of groundwater movement and flow. There is significant hydraulic testing and groundwater level data for this unit for which to generate a suitable numerical model for impact assessment purposes.
- Below the GAS – below the gypsum layer the rock appears stronger with joints and structures in filled with GAS precipitation. The GAS is expected to coincide with a reduction in hydraulic conductivity compared with the rock mass above the gypsum layer. Groundwater quality data confirms the process of anhydrite dissolution within the rock mass and supports the significance of the GAS layer in the regional groundwater context. There is hydraulic testing and groundwater level data available for this unit to understand the importance of the GAS on the groundwater regime.

Groundwater flow generally follows the topography and drainage and the available data suggests flow from the west or south-west to the east or north east in the open-pits area. However, local and regional scale structural features are expected to influence the direction of local groundwater flow. The structures appear to be a combination of thrust type structures and shear faults which due to their formation behave differently. Thrust type structures tend to be closed and / or tight structures and can behave as barriers to water flow; whereas, shear zones tend to be less tight and can conduct water along the length of the structure. Additionally, alteration around the porphyry deposit (Section 3.1.1) may both influence saturated zone hydraulic conductivity and groundwater flow pathways (e.g. zones of supergene enrichment).

For the purposes of this assessment, the role of geological structure and alteration on the groundwater regime are considered and regional structures are represented in the numerical model. With the exception of the GAS surface, alteration is not explicitly represented in the conceptual groundwater model. Furthermore, because of the relatively broken rock mass at the site, individual geology types have not been represented in the conceptual groundwater model. For example, intrusions such as the Horse Microdiorite in the mineralised domain area intrude several geology types. This geology is then overprinted by local structure and alteration.

For the purpose of this assessment, the rock mass in the study area has been assessed as a relatively homogenous unit and the overprinting structure, alteration and lithology is largely disregarded. The observed field data supports this conceptual understanding of the regional system as a valid assumption.

Figure 4.16 presents a schematic conceptual model cross-section through the HIT open-pit, from north west to south east. The cross section graphically shows the main processes influencing the groundwater system, including recharge, flow directions and discharge.



Schematic section of conceptual hydrogeology - HIT open-pit

Figure 4.16

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5 Numerical modelling

The primary objective of the numerical modelling was to quantify the potential impact of the project on the groundwater system. The design, construction, and calibration of the numerical model were tailored to meet this objective, whilst providing a framework for future iterations during mining. The model was calibrated so that it broadly replicated groundwater flow directions, hydraulic gradients, and fluxes to the rivers and creeks. The model was then used to assess the:

- rate of groundwater inflow to the open-pits as a function of time;
- groundwater heads, hydraulic gradients, and flow vectors around the proposed open-pits and the ISF during operation;
- extent and area of drawdown and depressurisation;
- changes post-closure to groundwater levels and stream baseflow around the open-pits and ISF; and
- areas of potential risk where groundwater impact mitigation / control measures may be necessary.

MODFLOW-USG (Panday *et al.*, 2013) was determined to be the most suitable modelling code to meet the model objectives. MODFLOW-USG simulates unsaturated conditions, which is critical for mining projects where saturated rock units will be progressively dewatered during active mine operations, and then re-wet following the cessation of mining. The distinct advantage MODFLOW-USG has over its predecessors is the ability to discretise the model using an unstructured mesh, meaning that the cells in the model are not restricted to rectangular shapes. Small cells can refine an area of interest and represent geological or mining features, while larger cells are used outside these areas where refinement is not required. This produces an optimal model mesh, aiding numerical stability and limiting the number of cells. In addition, model layering does not need to be continuous over the model area, and layers can "pinch out" where geological units are not present. A new unstructured mesh was generated using Algomesh to accommodate the revised open-pit designs and the new, larger ISF impoundment extent.

The groundwater model was calibrated for the previous regional groundwater assessment (AGE, 2016) in both steady state and transient modes, where the aquifer properties of hydraulic conductivity, recharge, specific yield, and specific storage were adjusted to produce the best match between observed and simulated water levels and streamflow. No new data was employed in this groundwater model, so parameters from the previous model were utilised as the starting point for the model calibration. A transient model was run for verification of the previous parameters and the new unstructured mesh, and the modelled water levels were again compared to historical data. The comparison returned a scaled root mean square (RMS) of 5.2%, which is well within the Australian guidelines of 10% (Barnett *et al.*, 2012). This constituted the model calibration and provides confidence in the ability of the model to be fit-for-purpose for the impact assessment.

The operation and mining of the open-pits and the ISF were simulated in the predictive model. Post-closure predictions for the open-pits and ISF were also simulated. Section 6 details the results of the numerical modelling and provides assessment of changes in the groundwater regime as a result of the project. Appendix D provides detail regarding the numerical model development, calibration sensitivity, and predictions.

6 Results

The project comprises the operation of a series of open-pits and ISF for 33 years. At the completion of operations, the mined voids will remain open. These voids will fill with surface water and groundwater, and will have a spill point elevation of approximately RL 449 m (HIT / Ekwai combined open void) and RL 548 m (Koki open void). The maximum pit lake depths of HIT and Koki will be approximately 257 m and 166 m respectively. During operations, water will drain to the open-pit sump and be pumped from the open-pit. The FRHEP will continue to operate into the future and the ISF will remain as a saturated structure with an average operating water level of around RL 210 m (maximum operating level of RL 227 m).

The following sections describe the results of these model deliverables. Appendix D describes the setup of the numerical model in detail.

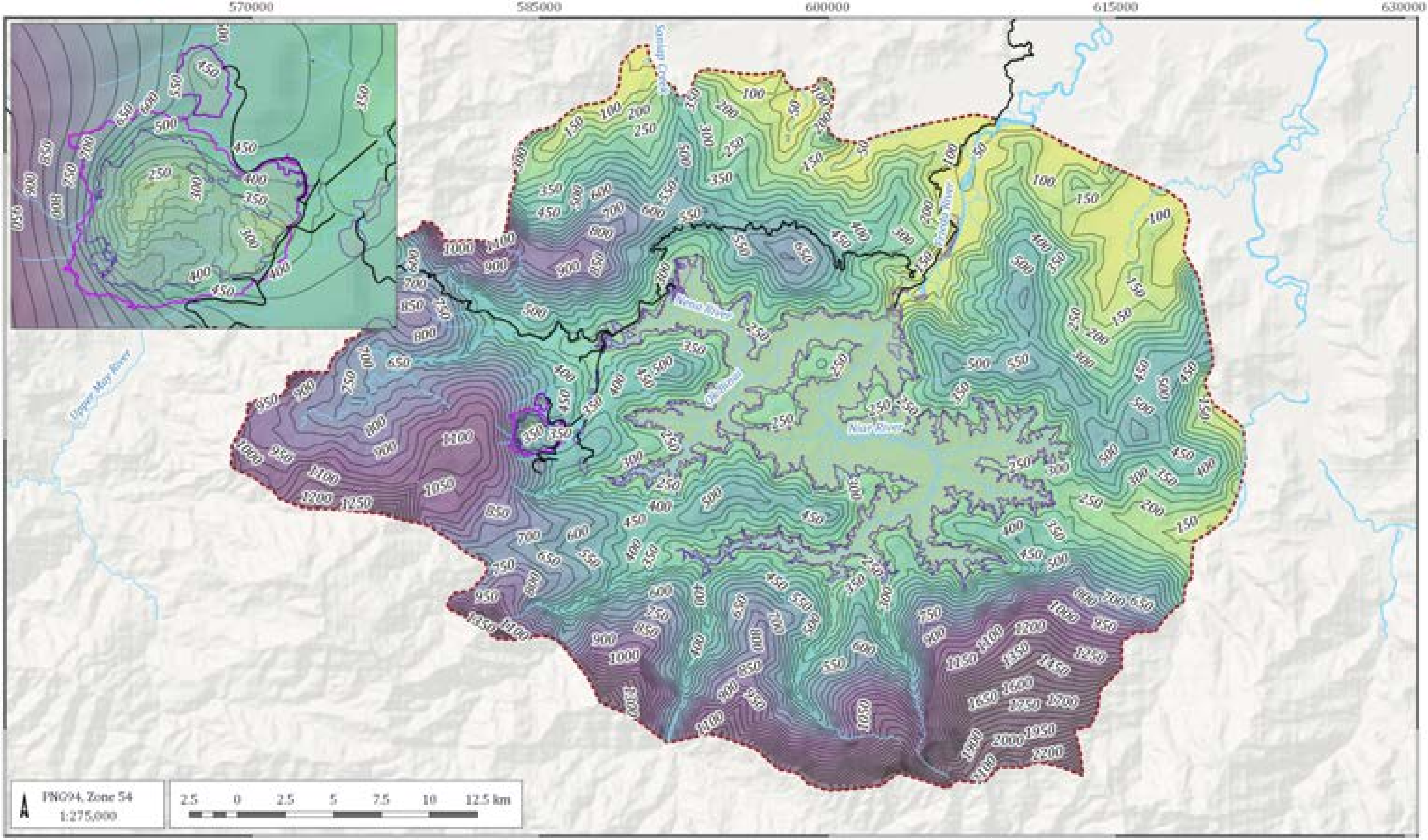
6.1 Groundwater levels and drawdown

Figure 6.1 presents the predicted water table at the end of mining (Year 33). Figure 6.2 presents the drawdown in water table elevation at the end of mining. The maximum extent of drawdown is represented by the 1 m contour, which is assessed as measureable and regarded as a practical magnitude to present groundwater level change.

The greatest magnitude of water table drawdown, up to around 500 m, will occur in the HIT / Ekwai combined open-pit and will be consistent with the depth of the open-pit below the shallowest water table. The greatest drawdown of the water table in the Koki open-pit is predicted to be around 200 m. The drawdown from mining at the end of operations (Year 33) generally extends radially some 5 km to 6 km from the centre of the open-pits. The extent of drawdown remains predominantly within the Nena River and Ok Binai catchments. The minimum groundwater elevation in the open-pits at Year 33 is approximately RL 200 m (HIT / Ekwai combined open-pit) and RL 390 m (Koki open-pit).

During operations, the ISF will create groundwater mounding of up to around 150 m above the current elevation of the Frieda River (Figure 6.2). However, given the steep topography surrounding the ISF, groundwater will flow predominantly toward the containment structure (Figure 6.1). The only significant groundwater movement from the ISF will occur near the ISF embankment.

The groundwater “mounding” that occurs as a result of the ISF extends up to around 3.5 km away from Frieda River. The extent of mounding (1 m contour) is contained within the Frieda River catchment. The magnitude of mounding in the ISF impoundment is up to around 150 m, which occurs directly over Frieda River. The steepest hydraulic gradient around the ISF is predicted to occur through the embankment (Figure 6.1).



LEGEND
- Model boundary
- Open-pit extent (Year 33)
- FRHEP / ISF extent
- Road (proposed)
- Drainage
- Water table contours (RL m)

Water table elevation (RL m)

0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 2000

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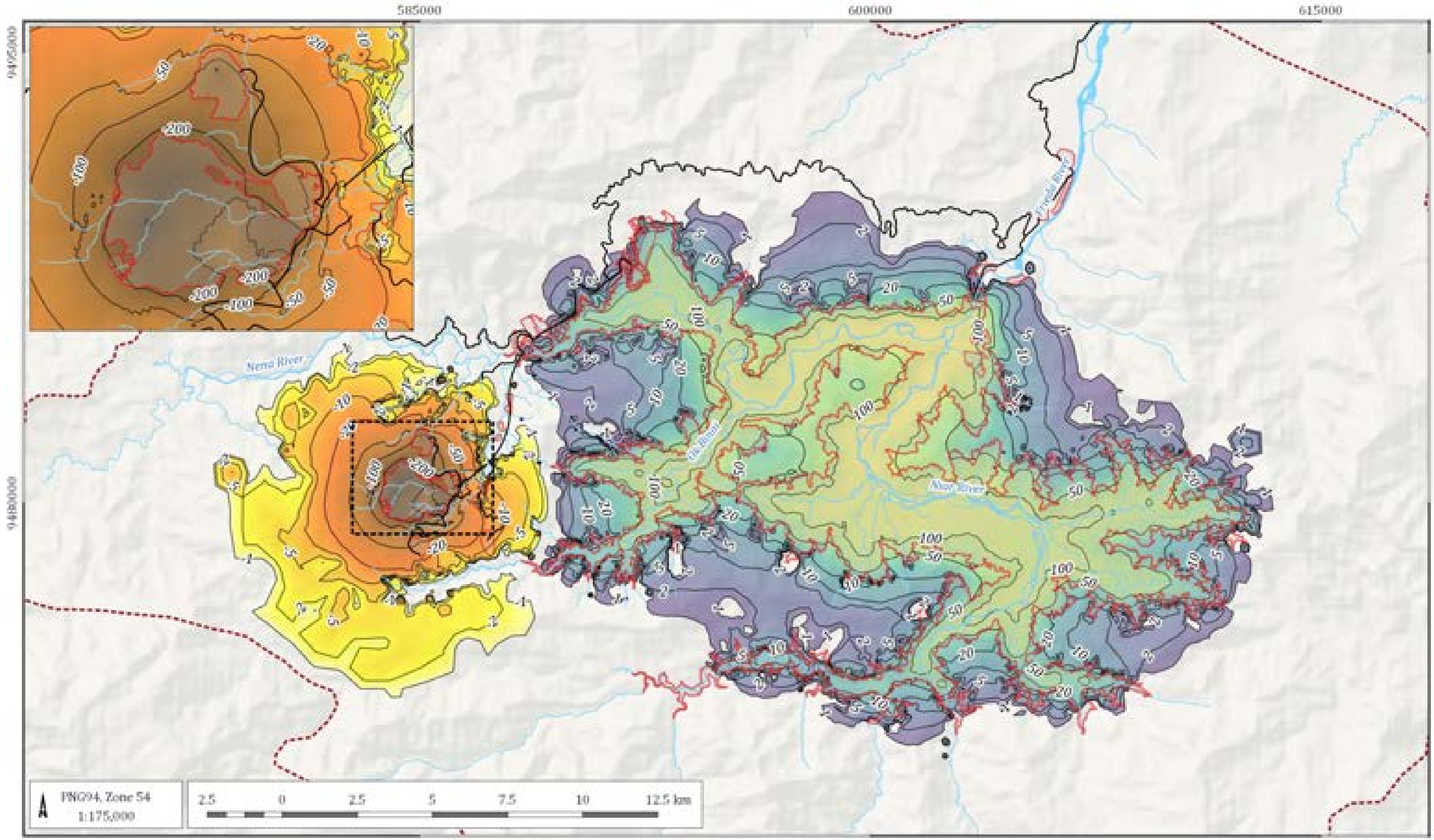
AGE

Water table - End of Mining

DATE
19/07/2018

FIGURE No:
6.1



Sepik Development Project (I1051A)

Drawdown - End of Mining

DATE 19/07/2018

FIGURE No: **6.2**

6.2 Open-pit seepage

The base case model predicts that after Year 2 of mining, the total groundwater seepage into the combined open-pits will increase to around 10 ML/day (116 L/s), shown in Figure 6.3. The total groundwater seepage for the project is predicted to be 28 ML/day.

The highest rates of groundwater seepage are predicted to occur within the HIT open-pit, which is expected given its size and depth. Groundwater seepage to the Koki open-pit and Ekwai open-pit are predicted to be low (less than 3 ML/day per pit), with consistent seepage rates occurring from around Year 6 onwards.

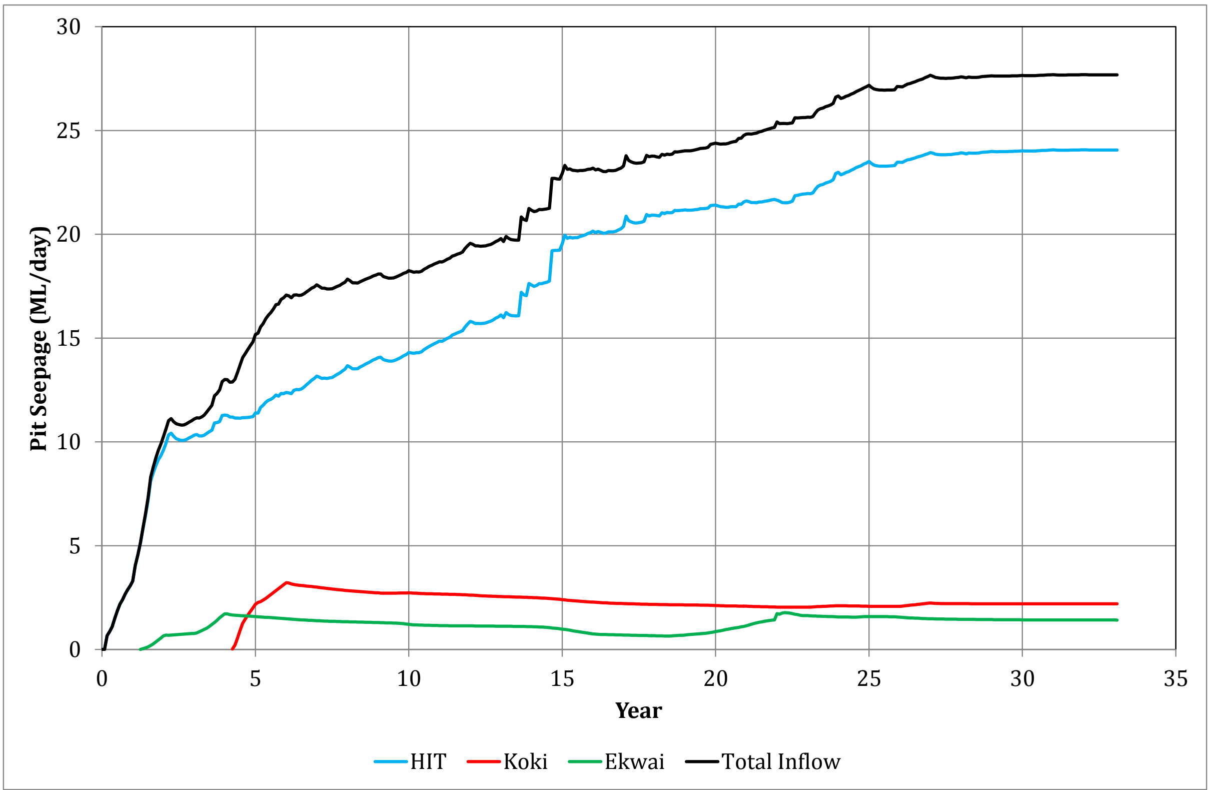


Figure 6.3 Predicted groundwater open-pit seepage

6.3 Change in baseflow

The numerical model simulates baseflow to the major creek and river catchments surrounding the project. The baseflow rates estimated from rainfall / runoff data, and the baseflow determined by the calibrated numerical model, are presented in Appendix D. During operation of the open-pit and the ISF, baseflow in a number of catchments is predicted to decrease as a result of the interception of recharge and groundwater from the open-pit. However, the presence of the ISF is predicted to increase baseflow in the Frieda River catchment.

In order to determine the effect of the open-pit on the baseflow of the various catchments, two separate models were configured as follows:

1. a scenario which did not simulate the open-pits nor the ISF ('no mine' model); and
2. a scenario that simulated the open-pits but not the ISF ('mine only' model).

The change in baseflow attributed to the open-pits can be predicted by comparing these two scenarios.

Figure 6.4 shows the net change in baseflow as a result of the open-pits only (the 'no mine' model minus the 'mine only' model). The Nena River catchment is predicted to experience up to 15.5 ML/day baseflow reduction (19 % of baseflow predicted by the 'no mine' model), whereas the Ekwai Creek catchment is predicted to reduce by 5 ML/day (100 % of modelled baseflow). Ok Binai has a baseflow reduction up to 2.6 ML/day (less than 3 % of modelled baseflow). No change is predicted for Oma Creek.

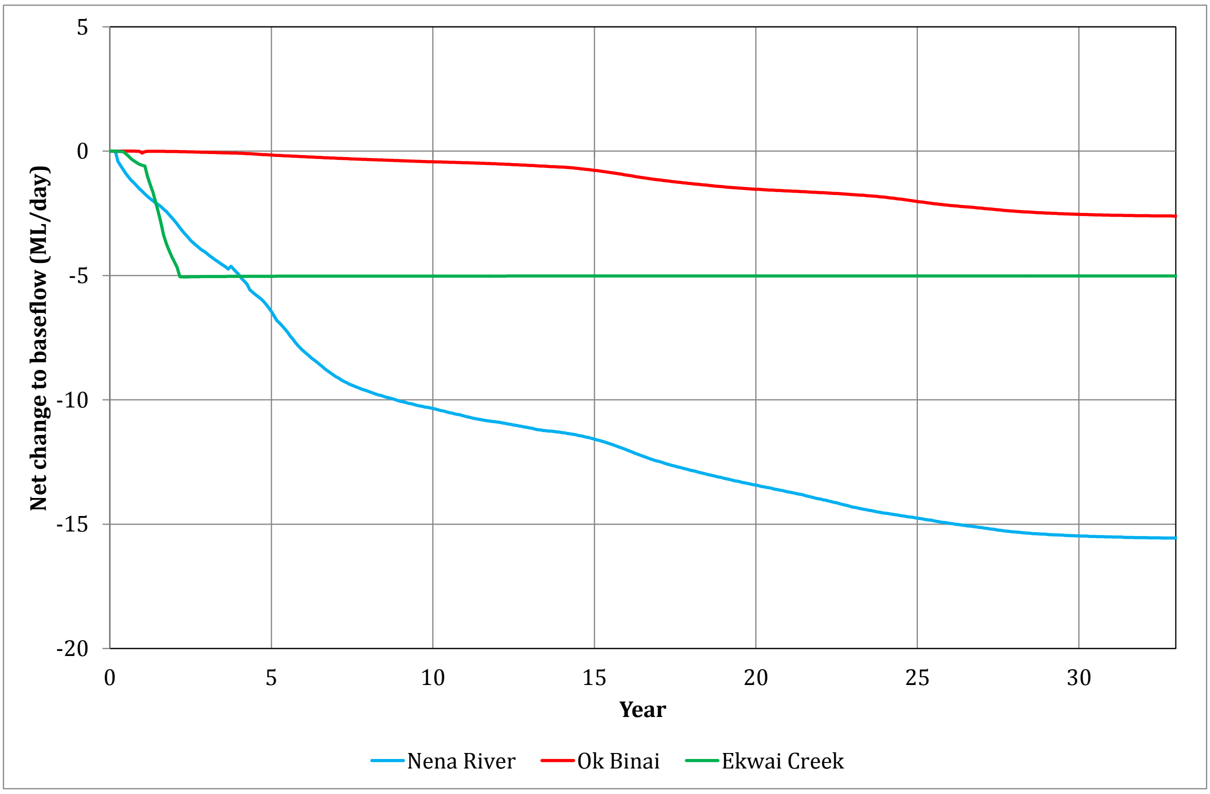


Figure 6.4 Net change in catchment baseflow

6.4 Post closure

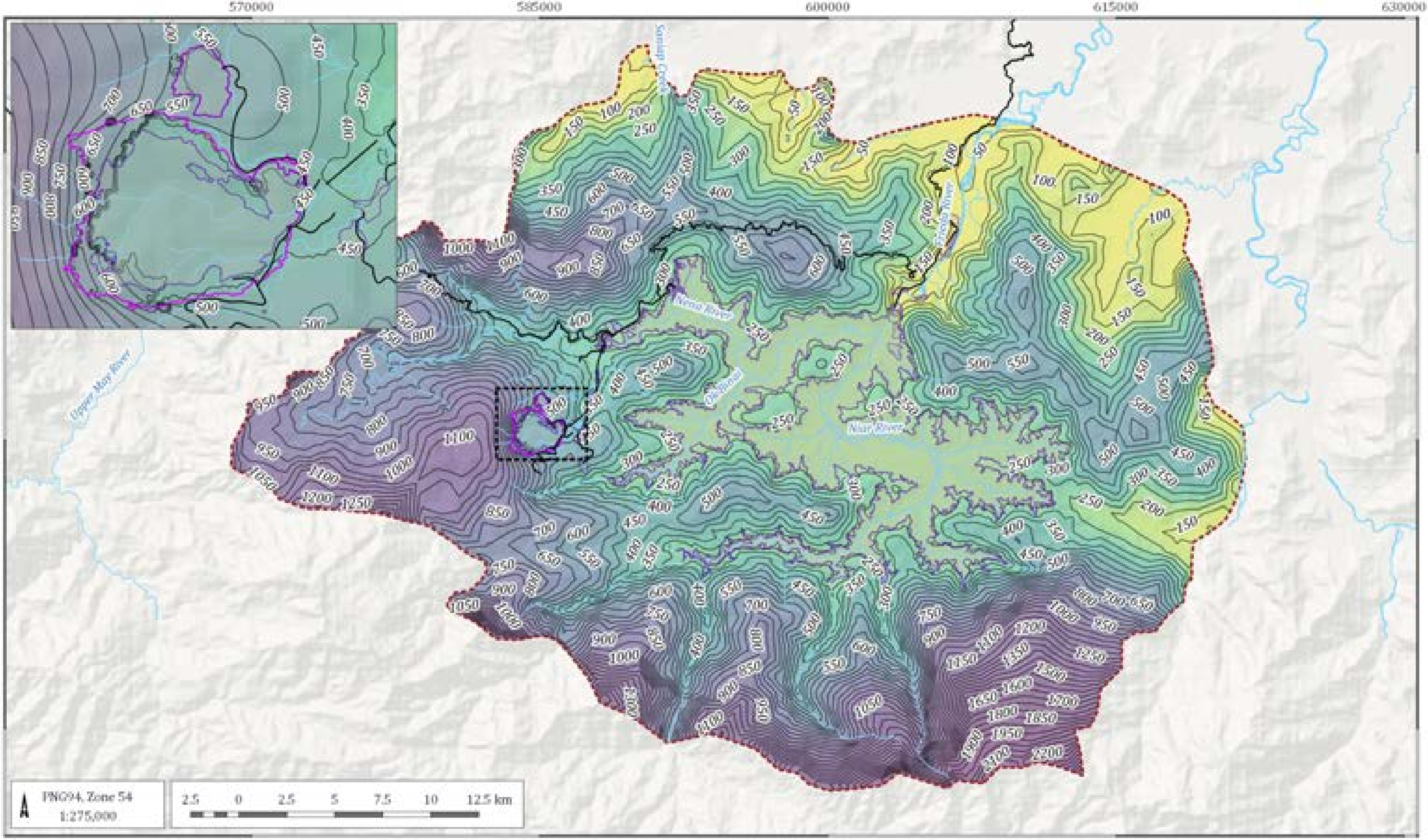
SRK (2018) predict that complete inundation of the open-pit voids will occur 10 years after completion of mining. This will ensure that the walls of the open-pits below the spill point elevations will be saturated after closure.

A 2,000 year transient simulation was undertaken to simulate post-closure of the open-pits and ISF (see Appendix D). Figure 6.5 presents the predicted post-closure water table. Figure 6.6 presents the post-closure water table drawdown and mounding.

The maximum extent of drawdown is represented by a 1 m contour, which is assessed as measureable and is regarded as a practical magnitude to present groundwater level change. The maximum post closure drawdown predicted in the vicinity of the HIT open-pit is approximately 435 m, and 160 m in the Koki open-pit. Particle tracking (up to 2,000 years) was also carried out on the post-closure model to assess the rate of post-closure groundwater seepage from the open-pit voids and ISF. This is presented on Figure 6.6.

The ISF will maintain a groundwater mound post-closure. However, as per the groundwater conditions predicted during operations, the steep topography surrounding the ISF will result in groundwater flow occurring predominantly toward the containment structure. The only groundwater movement from the ISF will occur in the vicinity of the ISF embankment.

Groundwater seepage from the ISF embankment will occur during post-closure.



LEGEND
Model boundary
Open-pit extent (Year 33)
FRHEP / ISF extent
Road (proposed)
Drainage
Water table contour line (RL m)

Water table elevation (RL m)

0	400	800
100	500	900
200	600	1000
300	700	2000

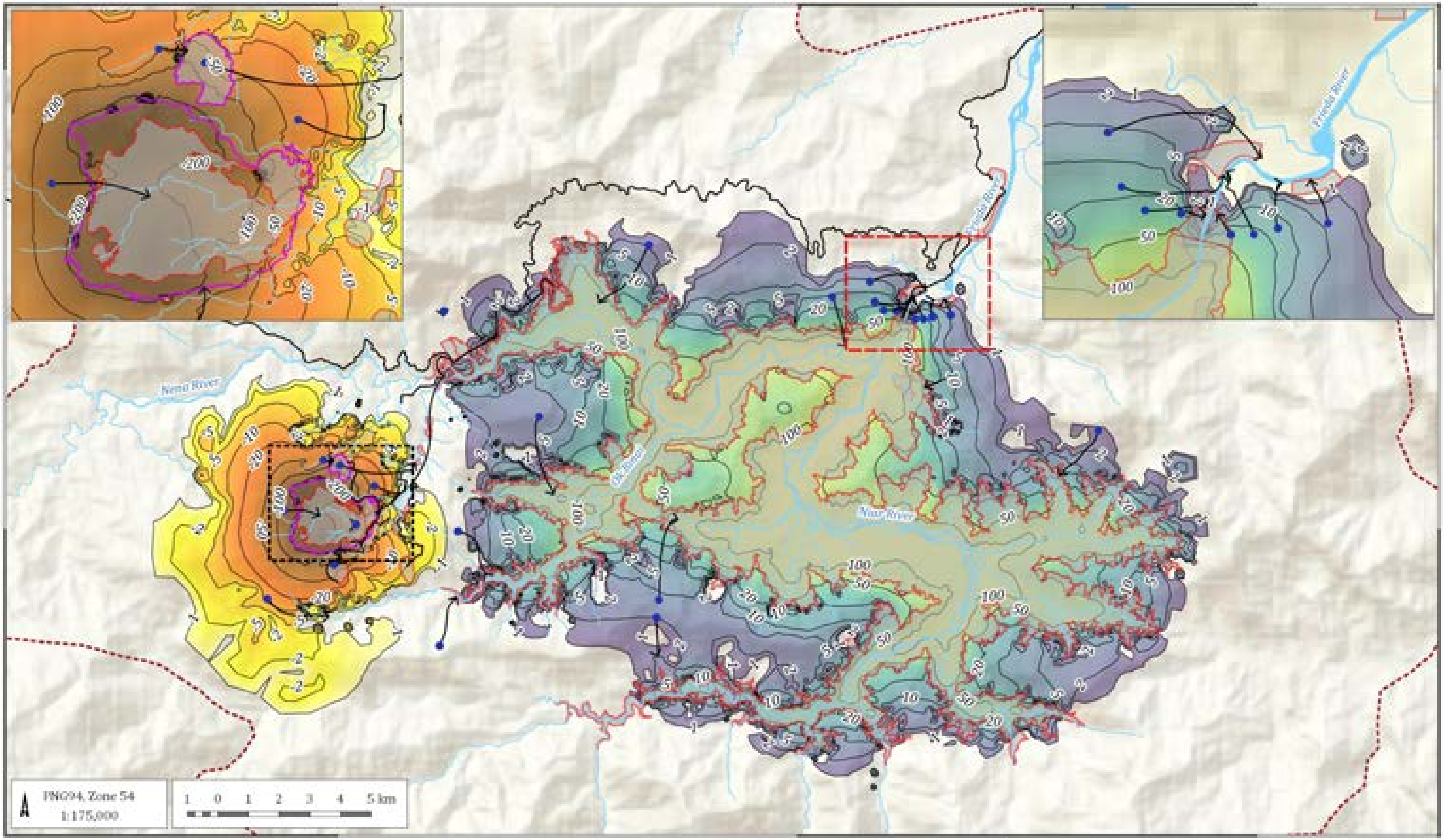
Sepik Development Project (I1051A)

AGE

Water table - Post-closure

DATE
19/07/2018

FIGURE No:
6.5



Sepik Development Project (I1051A)

DATE
19/07/2018

Drawdown - Post-closure

FIGURE No:
6.6

The post-closure groundwater levels show that the open-pit voids will be "flow through systems". That is, groundwater will seep into the voids from areas of higher head pressure (upstream), then seep out of the open voids towards areas with lower head pressure (downstream). As a result, all groundwater that enters the open-pit voids will migrate into the ISF catchment. This groundwater flow will predominantly occur via Ekwai Creek. Modelling predicts that there is no movement of groundwater from the open voids that does not discharge into the ISF. Groundwater flow from the ISF will migrate downstream predominantly through the ISF embankment.

Post closure, baseflow in the Nena River and Ok Binai catchments is predicted to increase slightly from that predicted at the end of mining. However, there is still predicted to be a reduction in baseflow as a result of the long term interception of recharge and groundwater from the open-pit. Post closure, the Nena River catchment is predicted to experience 7.9 ML/day baseflow reduction, whereas the Ok Binai catchment is predicted to experience a 1.5 ML/day reduction in baseflow. The Ekwai Creek catchment is heavily impacted by mining and 100 % reduction in modelled baseflow is predicted post closure. No change is predicted for Oma Creek.

The recovery model predicts that the post-closure drawdown extent will be slightly smaller than the predicted drawdown at the end of mining. However, in general the magnitude of drawdown outside of the open-pits will increase post-mining. This will occur because a permanent groundwater drawdown will remain around the open voids, and the void water levels will always be at an elevation lower than the pre-mining groundwater level. The drawdown extent is predicted to decrease slightly as the groundwater regime adjusts over time towards a new equilibrium. The water level with the final voids is predicted to recover to a level of RL 449 m (HIT / Ekwai combined open void) and RL 548 m (Koki open void).

Predicted particle tracking shows that post-closure groundwater flow from the mine area will discharge as baseflow to Nena River and Ok Binai. These watercourses then flow to the ISF. It is understood that detailed seepage modelling has been carried out by SRK to assess the seepage through the ISF embankment.

6.5 Water quality

The groundwater assessment provides information on typical groundwater quality in the context of the conceptual groundwater model. The numerical model predicts only change in groundwater flow and does not address groundwater quality considerations. It is understood that the water quality predictions for the project being undertaken by SRK will use groundwater chemistry data and rock geochemistry to address open-pit water quality, site water quality considerations, and downstream water quality impacts associated with the ISF.

6.6 Sensitivity

Sensitivity analyses were carried out to assess the response of the model to varying input parameters. This was achieved by changing and assessing the following:

- ±20 % to ±1 order of magnitude change in horizontal hydraulic conductivity (Kh) of all geological units (dependant on field testing upper and lower bounds);
- ±100 % to ±1 order of magnitude change in the specific yield (Sy) of all geological units;
- ±100 % to ±1 order of magnitude change in the specific storage (Ss) of all geological units; and
- ±0.5 order of magnitude change in the rainfall recharge rate across the model domain.

These changes represent the potential parameter bounds of the groundwater regime. The model sensitivity for predicted open-pit inflows is presented in Figure 6.7. Figure 6.8 presents the results of the sensitivity analysis at the end of mining in terms of water table drawdown.

The sensitivity scenario whereby the hydraulic conductivity is increased provides the greatest drawdown and mounding extent. Drawdown from the open-pits extends up to around 8 km away from the void extent. Mounding from the ISF extends up to around 8 km from Frieda River. However, the observed hydraulic data for the project suggests that this sensitivity scenario is highly unlikely.

Upper and lower bound sensitivity analyses were carried out on the model to assess the influence on predicted open-pit seepage rates (Figure 6.7). The analyses show that the open-pit seepage rates are most sensitive to hydraulic conductivity and recharge. The open-pit seepage rates appear relatively insensitive to changes in storage. Using the upper prediction of seepage resulting from increased recharge, seepage rates are up to 45 ML/day (521 L/s). Using the lower prediction of inflows resulting from decreased recharge, inflows are up to 17 ML/day (197 L/s).

It is important to note that the model has been calibrated to a set of hydraulic parameters and water balance assumptions. During the sensitivity analyses, the model deviates from these inputs and is essentially un-calibrated. There is greater confidence in the base case inflow predictions than the extreme sensitivities, as the model is constrained to the observed field data.

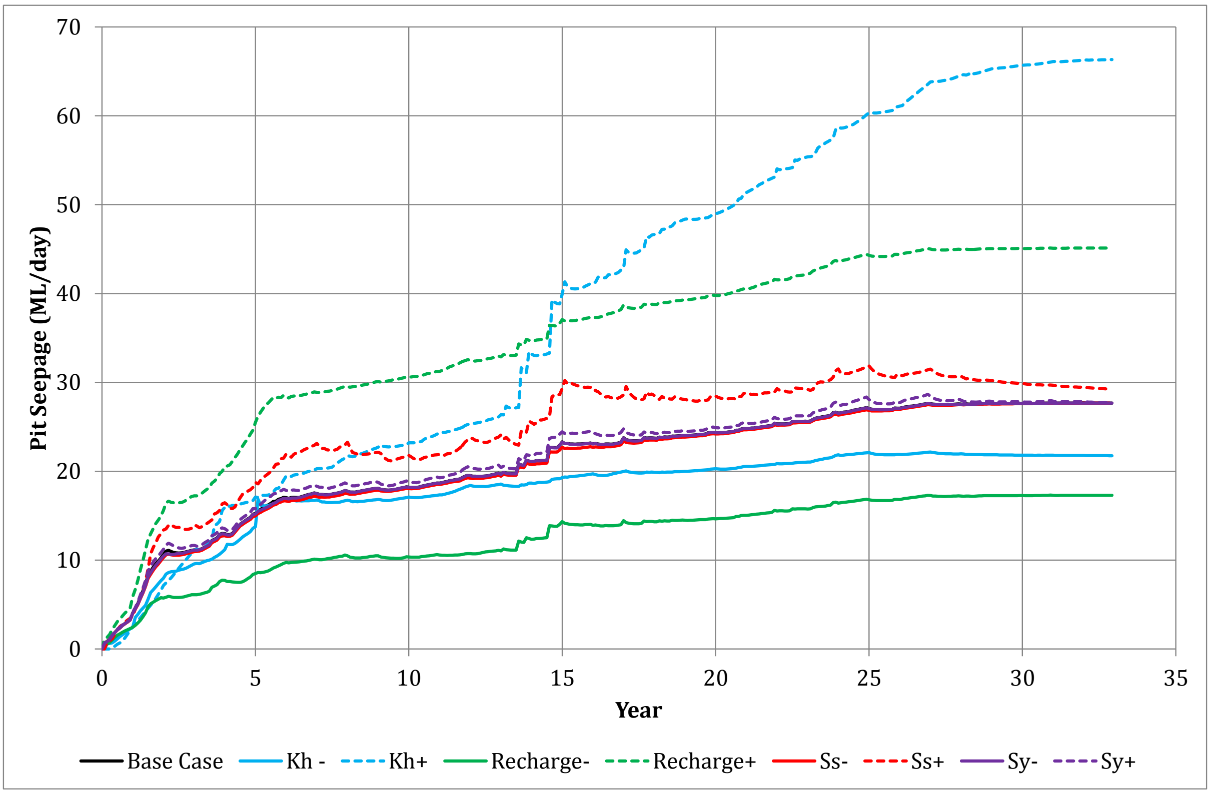
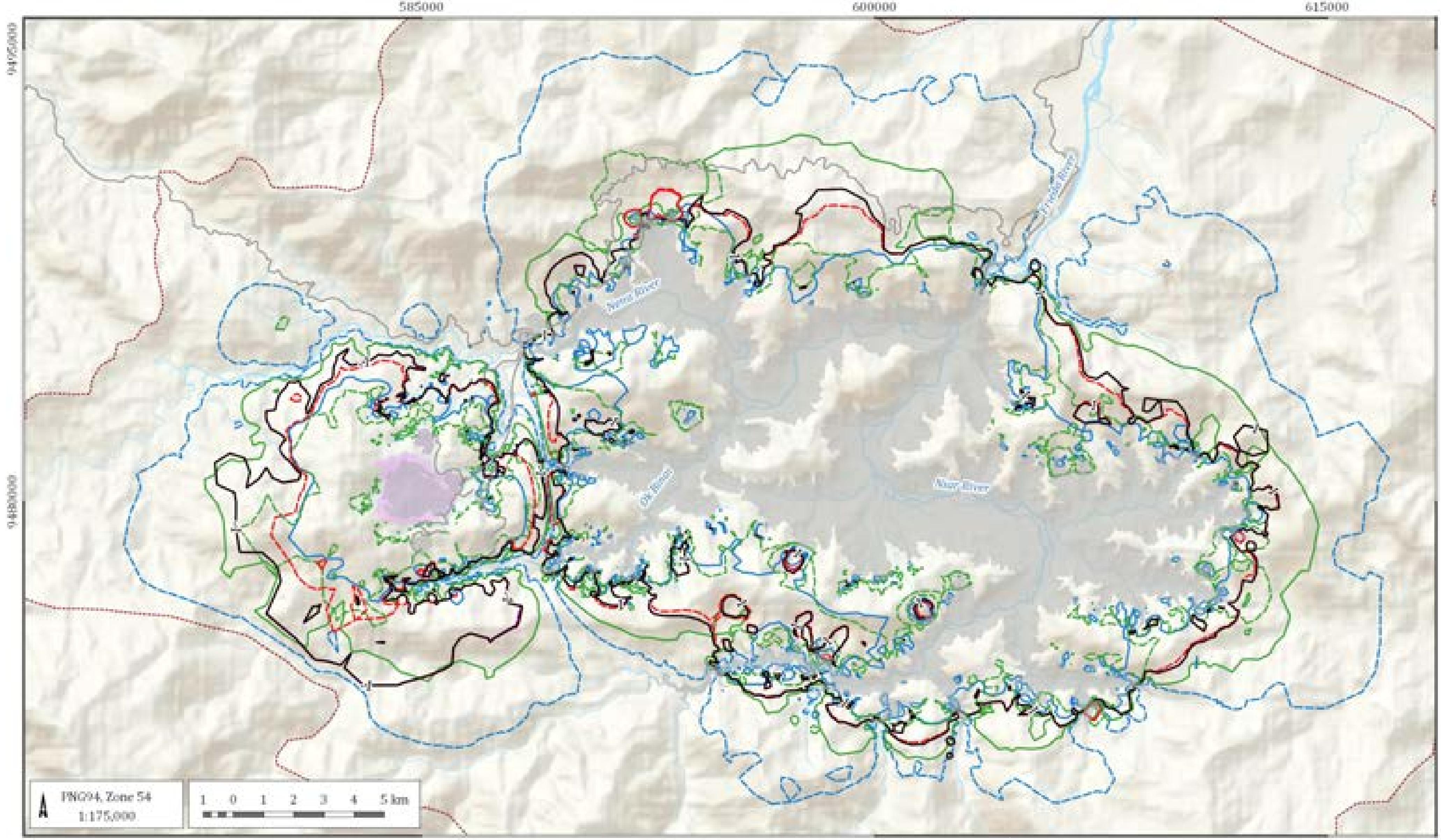


Figure 6.7 Sensitivity – Predicted open-pit groundwater seepage



LEGEND

- Model boundary
- Open-pit extent (Year 33)
- FRHEP / ISF extent
- Road (proposed)
- Drainage

Drawdown/mounding sensitivity (1 m contour)

- Base case
- Hydraulic conductivity+
- Hydraulic conductivity-
- Recharge+
- Recharge-
- Specific storage+
- Specific storage-
- Specific yield+
- Specific yield-

Sepik Development Project (I1051A)

AGE

Drawdown / mounding sensitivity - Year 33

DATE
19/07/2018

FIGURE No:
6.8

7 Groundwater management

7.1 Monitoring

The groundwater monitoring program established as part of EIS groundwater investigations will be continued throughout the life of the project. Some monitoring bores or VWPs will be destroyed as the open-pit develops. If required, monitoring bores and / or VWPs will be installed progressively throughout the mine life to monitor impacts.

The recording of head pressures from the open-pits VWP arrays will continue from pre- to post-mining to monitor fluctuations in groundwater levels. The volume or rate of dewatering and groundwater inflow should also be measured where / when practical.

Following completion of the initial 12 to 24 months of mining operations, the monitoring data should be reviewed and the numerical model updated where necessary with this new data to validate the model assumptions and parameterisation, and to verify the predictions presented in this report.

In-situ groundwater quality monitoring around the open-pits is not considered necessary for this project. Groundwater within 3 km of the open-pits will migrate towards the open-pits as the groundwater level drawdown occurs during the mine operation and post closure. However, groundwater seepage into the open-pits has the ability to be of poor quality and this should be monitored as part of the surface water management strategy.

The Environmental Management and Monitoring Plan (EMMP) for the project (Attachment 3 of the EIS) outlines specific requirements for groundwater and provides a Water Management Sub-plan. The Water Management Sub-plan addresses activities associated with the project that have the potential to impact on water quality, surface water flow regimes and groundwater systems. One of the objectives of the Water Management Sub-plan is to limit the contamination of groundwater resources.

7.2 Dewatering and depressurisation

The dewatering and depressurisation strategy for the open-pits is ongoing and has not yet been finalised. However, the strategy is likely to include some or all of the following components:

- Active dewatering using a number of vertical dewatering bores around the perimeter of the open-pits. These bores would be operated to intercept groundwater flow that would otherwise discharge to the slopes of the open-pits.
- Dewatering bores may be required in the open-pits prior to mining (advance dewatering) and during early stages of mining. These bores would be designed to remove groundwater in storage and depressurise rock mass prior to mining. Minor residual water would be managed using in-pit horizontal drains and sumps.
- Depressurisation as required, largely using horizontal drain holes drilled from benches of the open-pits. The depressurisation strategy would be developed based upon geotechnical requirements of the open-pits.
- Installation of surface water diversions or berms at the crests of open-pits, as required, to prevent or minimise surface water inflow to the open-pits. The surface water management strategy would consider civil design requirements and geochemical concerns.
- Management of incident rainfall to the open-pits using sumps and mobile and primary transfer pumping stations.

The groundwater monitoring program outlined above in Section 7 would provide a measure of dewatering and depressurisation performance and would assist with the optimisation and efficiency of the dewatering system.

8 Conclusions

A calibrated numerical groundwater model was developed to predict drawdown, open-pit seepage rates, groundwater mounding, change in baseflow, and post closure groundwater recovery. The following conclusions are presented as part of the groundwater assessment.

- The geology in the study area is complex however, for the purpose of the EIS, the rock mass has been assessed as a relatively homogenous unit and the overprinting structure, alteration and lithology is not represented in the modelling. The available data indicates this approach is valid.
- The numerical model was developed on the current conceptual understanding and used observed hydraulic parameters and measurements to constrain acceptable steady state and transient calibrations.
- Mining of the open-pit and the operation of the ISF was simulated by the model throughout operations and post closure.
- Open-pit seepage rates (10 ML/day to 28 ML/day for the combined open-pits) are supported by monitoring data and support the concept of lower groundwater recharge and hence lower groundwater inflow to the open-pits.
- Operation of the open-pits will induce changes in baseflow to the surface water systems. The Nena River catchment is predicted to experience between 15.5 ML/day baseflow reduction (19% of modelled baseflow), whereas the Ekwai Creek catchment is predicted to reduce by 5 ML/day (100% of modelled baseflow). The Ok Binai has a baseflow reduction of up to 2.6 ML/day (less than 3% of modelled baseflow). No change is predicted for Oma Creek.
- Groundwater drawdown and depressurisation from the open-pits will extend some 5 km to 6 km from the centre of the HIT open-pit. The extent of drawdown predominantly remains within the Nena River and Ok Binai catchments, encroaching marginally into the Anai River catchment to the south.
- Groundwater flow will report to the open-pits and it will form a temporary sink during operations.
- The open voids will rapidly fill post closure to the spill point elevation of approximately RL 449 m (HIT / Ekwai open void), and RL 548 m (Koki open void).
- The open-pit void will behave as a flow through window in the water table and will remain a sink for all upstream groundwater flow. All downstream flow will report to the ISF catchment.
- The ISF will create mounding during operations and post closure, however, with the steep topography surrounding the ISF, groundwater movement will predominantly be toward the ISF. The only groundwater movement away from the ISF will occur via the ISF embankment. Modelling has been carried by others to predict seepage through the embankment.
- Particle tracking indicates that the rate of movement of any potential contaminant is highly likely to be slow with the maximum rate of movement predicted to be in the order of 2,500 m after 2,000 years.

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10 Glossary

Alluvium – Sediment (gravel, sand, silt, clay) transported by water (i.e. deposits in a stream channel or floodplain).

Aquifer – Rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

***Aquifer* - Confined** – An aquifer that is overlain by a confining bed. The confining bed has a significantly lower hydraulic conductivity than the aquifer. The water level in a bore that penetrates a confined aquifer will rise to a level that is higher than the top of the aquifer.

***Aquifer* - Perched** – A region in the unsaturated zone where the soil may be locally saturated because it overlies a low-permeability unit.

***Aquifer* - Unconfined** – An aquifer in which there are no confining beds between the zone of saturation and the surface. There will be a water table in an unconfined aquifer. Water-table aquifer is a synonym.

Aquitard – A low-permeability unit than can store ground water and also transmit it slowly from one aquifer to another.

Artesian conditions – *an aquifer is said to be artesian if the hydraulic head is so high that the water level rises above the elevation of the land surface.*

Barrier Boundary – An aquifer-system boundary represented by a rock mass that is not a source of water.

Baseflow – That part of stream flow that originates from ground water seeping into the stream.

Colluvium – Sediment (gravel, sand, silt, clay) transported by gravity (i.e. deposits at the base of a slope).

Depressurisation – A lowering of the potentiometric surface of a confined aquifer caused by pumping of ground water from wells or excavations.

Discharge – The volume of water flowing in a stream or through an aquifer past a specific point in a given period of time.

Discharge Area – An area in which there are upward components of hydraulic head in the aquifer. Groundwater is flowing toward the surface in a discharge area and may escape as a spring, seep, or baseflow or by evaporation and transpiration.

Drawdown – A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping of ground water from wells or excavations.

Evaporation – The process by which water passes from the liquid to the vapour state.

Evapotranspiration – The sum of evaporation plus transpiration.

Falling / Rising Head (Slug) Test – A test made by the instantaneous addition, or removal, of a known volume of water to or from a well. The subsequent well recovery is measured and analysed to provide a permeability value.

Groundwater – The water contained in interconnected pores located below the water table in an unconfined aquifer or located in a confined aquifer.

Groundwater Flow – The movement of water through openings in sediment and rock; occurs in the zone of saturation.

Groundwater, Perched – The water in an isolated, saturated zone located in the zone of aeration. It is the result of the presence of a layer of material of low hydraulic conductivity, called a perching bed. Perched ground water will have a perched water table.

Hornfels – A metamorphic rock produced by contact metamorphism and characterised by equi-dimensional grains without preferred orientation.

Hydraulic Conductivity – A measure of the rate at which water moves through a soil / rock mass. It is the volume of water that moves within a unit of time under a unit hydraulic gradient through a unit cross-sectional area that is perpendicular to the direction of flow.

Hydraulic Gradient – The change in total head with a change in distance in a given direction. The direction is that which yields a maximum rate of decrease in head.

Hydrogeology – The study of the interrelationships of geologic materials and processes with water, especially ground water.

Infiltration – The flow of water downward from the land surface into and through the upper soil layers.

Limit of Reporting – *the lowest concentration (or amount) of analyte, that can be reported by a laboratory*

Model Calibration – The process by which the independent variables of a digital computer model are varied in order to calibrate a dependent variable such as a head against a known value such as a water-table map.

Monitoring Bore – A non-pumping well (bore), generally of small diameter that is used to measure the elevation of the water table or potentiometric surface. A monitoring bore generally has a short well screen through which water can enter.

Packer Test – An aquifer test performed in an open borehole to determine rock permeability; the segment of the borehole to be tested is sealed off from the rest of the borehole by inflating seals, called packers, both above and below the segment.

Porosity – The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment.

Potentiometric Surface – A surface that represents the level to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The water table is a particular potentiometric surface for an unconfined aquifer.

Recharge – The addition of water to the zone of saturation; also the amount of water added.

Recovery – The rate at which the water level in a well rises after the pump has been shut off. It is the inverse of drawdown.

Rock, Volcanic – An igneous rock formed when molten rock called lava cools on the earth's surface.

Specific Yield – The ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of the rock or soil. Gravity drainage may take many months to occur.

Storage and Storativity – The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. It is equal to the product of specific storage and aquifer thickness. In an unconfined aquifer, the storativity is equivalent to the specific yield. Also called storage coefficient.

Subduction zone – Region where portions of tectonic plates are diving beneath other plates.

Transpiration – The process by which plants give off water vapour through their leaves.

Unsaturated Zone – The zone between the land surface and the water table. It includes the root zone, intermediate zone, and capillary fringe. The pore spaces contain water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched ground water, may exist in the unsaturated zone. Also called zone of aeration and vadose zone.

Water Budget – An evaluation of all the sources of supply and the corresponding discharges with respect to an aquifer or a drainage basin.

11 Abbreviations

AGE	Australasian Groundwater and Environmental Consultants Pty Ltd
ALS	ALS Environmental Laboratories (ALS)
DEM	Digital elevation model
EC	Electrical conductivity
EIS	Environmental Impact Assessment
FRHEP	Frieda River Hydroelectric Project
FRIC	Frieda River Igneous Complex
FRL	Frieda River Limited
GAS	Gypsum-anhydrite (dissolution) surface
ha	Hectare
HIT	Horse-Ivaal-Trukai open-pit
HITEK	Horse-Ivaal-Trukai, Ekwai, and Koki porphyry copper-gold deposit
ISF	Integrated Storage Facility
L/s	litres per second
LIDAR	Light detection and ranging
LOR	Limit of reporting
MW	Megawatts of electrical power
m	Metres
m/day	Metres per day
Mt/year	Million tons per year
mE	Easting
mN	Northing
µS/cm	Micro Siemens per centimetre
mg/L	Milligram per litre
ML	Megalitres
ML/yr	Megalitres per annum
ML/day	Megalitres per day
NATA	National Association of Testing Authorities
No.	Number
PNG	Papua New Guinea
POX	Zone of partial oxidation
RMS	Root mean square
RQD	Rock quality designation
Ss	Specific storage
Sy	Specific yield
SRTM	Shuttle Radar Topography Mission
TDS	Total dissolved solids
TOX	Zone of total oxidation
USG	Un-structured grid
VWP	Vibrating Wire Piezometer
%	percentage

Appendix A Groundwater levels and pressures

Attachments: A - Summary of VWP and bore details

B - Existing VWP hydrographs

A1 Existing groundwater monitoring network

A1.1 Vibrating wire piezometer network

Glencore Xstrata installed a network of 39 vibrating wire piezometers (VWP) within 19 holes around their proposed open-pit between May 2009 and May 2011. The VWPs were part of the pre-feasibility geotechnical investigations for open-pit slope design.

Head pressures at each of the VWP sensors were recorded electronically by data loggers. Glencore Xstrata removed the data loggers from all the VWP sites in 2011. The VWP gauges were left in-situ allowing for all VWPs to be reconnected to data loggers in the future. During December 2014, an AGE visited the VWP sites to assess functionality and to measure head pressures. No dataloggers were re-connected during the site visit.

Of the 19 VWP arrays[1] around the open-pits, 12 were located during the December 2014 field program. Eleven of the arrays consisted of two VWP gauges[2], one site (PSM20b) consisted of three VWP gauges. Once located, the frequency (hertz) and temperature of the VWP gauges were measured and the data recorded. A total of 21 of the 25 individual VWP gauges were still readable on site. All three gauges in PSM20b and one in PSM04 returned no frequency values. Upon review, a further seven sensors provided erroneous data either by showing negative head pressures or data which was well outside the expected range. Therefore, the total number of functioning sensors is 14 at 11 locations.

Table A 1.1 summarises of the existing VWPs and their status determined from the site visit. Figure A 1.1 presents the location of all existing VWPs and Attachment A contains a summary table of their location and construction details.

Hydrographs of transient head pressure measured by the existing 19 VWP arrays are provided in Attachment B. The transient data is varied and three typical response types are observed:

1. Little or no change in head pressure (that is less than 2 m) over the monitoring record.
2. Irregular and sudden increases (2 m to 5 m) in head pressure that are assessed to be related to recharge events. These sudden increases are often followed by sharp declines suggesting a rapid hydraulic response to recharge.
3. Gradual and continuing decline in head pressure. Most likely related to the gradual depressurisation of the rock mass in response to discharge from the artesian exploration drill holes (i.e. VWP hydrograph for PSM10).

The transient data has been used in the calibration of the numerical model.

[1] The term VWP array is used to describe when many VWP gauges are installed in one drill hole.

[2] The term VWP gauge describes the individual transducer that is grouted at a set depth within the drill hole.

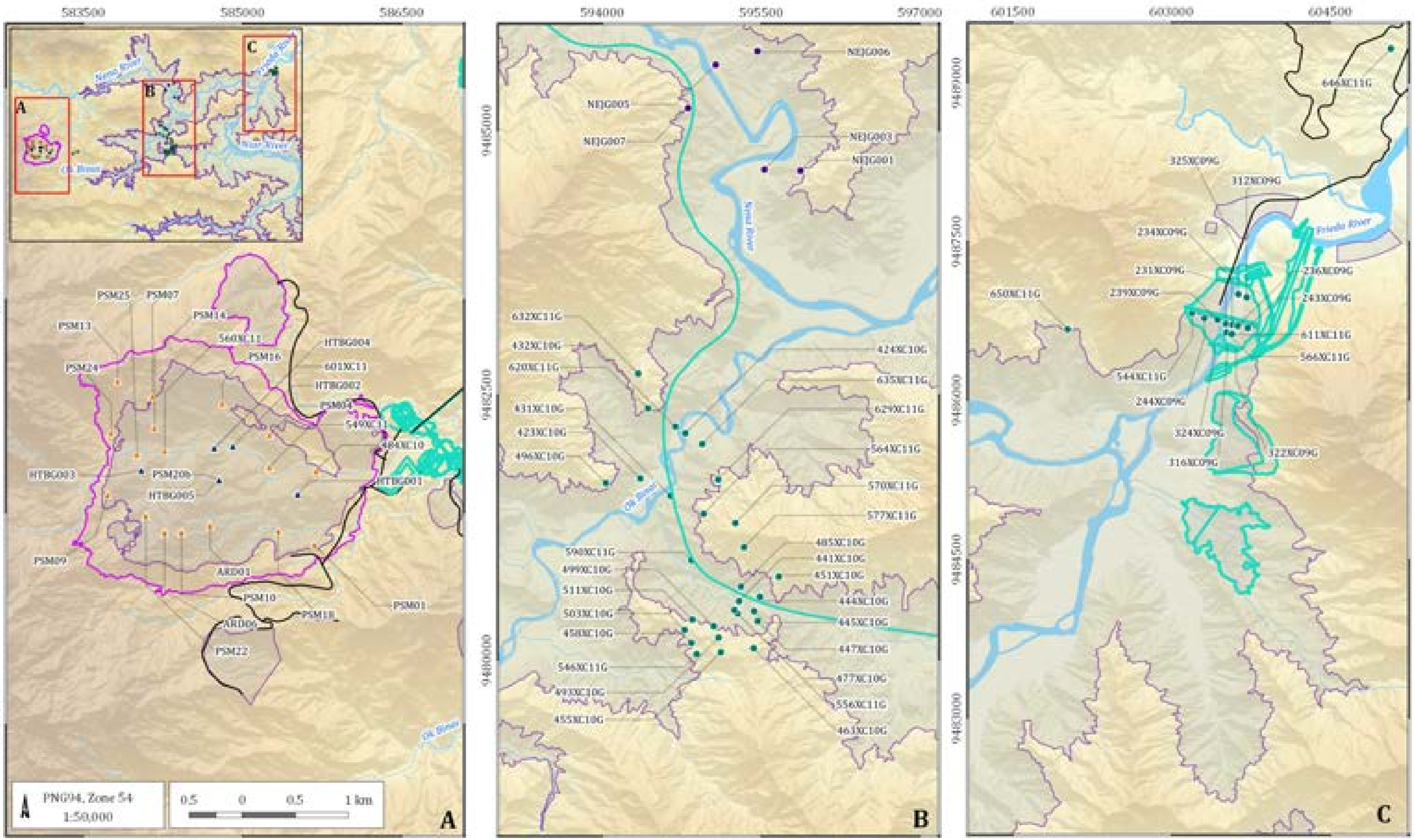
Table A 1.1 Existing VWP summary table

VWP ID (Hole ID)	VWP reference	VWP serial no.	Gauge depth (mDH)	True gauge depth (mbGL)	Total head (RL m)[3]	Unit	Data collected during December 2014			Comments
							Frequency (hertz)	Temp	Date	
ARD01 (516XC10)	ARD01A	10-5691	200	196.5	662	fresh rock (above GAS)[1]	not visited during field program			
	ARD01B	10-5697	350	343.9	464.7	fresh rock (below GAS)[1]				no confidence in data
ARD06 (639XC11)	ARD06A	10-5694	80	73.1	866.7	fresh rock (above GAS)[1]	2789.6	20.9	22-Dec-14	
	ARD06B	10-5695	335	306	769.6	fresh rock (above GAS)[1]	2418	22.3	22-Dec-14	
PSM01 (278XC09)	PSM01A	99407	175	166.7	525.3	fresh rock (above GAS)[1]	2464.5	23.4	18-Dec-14	
	PSM01B	99410	345	328.7	294.5		2727.8	26.3	18-Dec-14	no confidence in data
PSM04 (302XC09)	PSM04A	99406	190	181.1	n/a		1.00E+09	22.3	19-Dec-14	gauge not functional (1e+9)
	PSM04B	99409	356	339.3	498.3		2563.6	25	19-Dec-14	
PSM07 (299XC09)	PSM07A	99412	225	207.9	722.3	fresh rock (above GAS)[1]	not visited during field program			
	PSM07B	09-5075	440	406.5	669.3	fresh rock (above GAS)[1]				
PSM09 (279XC09)	PSM09A	99411	245	232.3	774.2	fresh rock (above GAS)[1]	2677.5	21.4	15-Dec-14	
	PSM09B	09-5074	480	455.2	879.4	fresh rock (above GAS)[1]	5683.4	23.4	15-Dec-14	raw data fluctuates between 2300 to 6100 Hz, gauge is no longer working
PSM10 (286XC09)	PSM10A	99405	180	166.7	699.7	fresh rock (above GAS)[1]	not visited during field program			

VWP ID (Hole ID)	VWP reference	VWP serial no.	Gauge depth (mDH)	True gauge depth (mbGL)	Total head (RL m)[3]	Unit	Data collected during December 2014			Comments
							Frequency (hertz)	Temp	Date	
	PSM10B	99408	390	361.1	683.7	fresh rock (above GAS)[1]				
PSM13 (623XC11)	PSM13A	10-5693	195	188.4	873.6	fresh rock (above GAS)[1]	not visited during field program			
	PSM13B	10-4283	280	270.5	794.9	fresh rock (above GAS)[1]				
PSM14 (627XC11)	PSM14A	10-4285	400	386.4	672.2	fresh rock (above GAS)[1]	not visited during field program			
	PSM14B	10-4251	180	173.9	677.1	fresh rock (above GAS)[1]				
PSM16 (492XC10)	PSM16A	10-4929	380	369.7	653.3	fresh rock (above GAS)[1]	not visited during field program			
	PSM16B	10-4906	160	155.6	664.2	fresh rock (above GAS)[1]				
PSM18 (473XC10)	PSM18A	10-4904	80	76.5	520.8	fresh rock (above GAS)[1]	2440.5	23.4	18-Dec-14	
	PSM18B	10-4933	230	219.8	300.4	fresh rock (above GAS)[1]	2775.9	26.5	18-Dec-14	Data erroneous, very little pressure head above gauge.
PSM20b (558XC11)	PSM20b1	10-4249	75	65.4	658		1.00E+09	22.7	14-Dec-14	all gauges not functional (1e+9) Site has been decommissioned
	PSM20b2	10-5696	256.5	223.7	615.25		1.00E+09	24.6	14-Dec-14	
	PSM20b3	10-4331	505	440.4	n/a		1.00E+09	90	14-Dec-14	
PSM22 (539XC11)	PSM22A	10-4905	125	120.6	772.5	fresh rock (above GAS)[1]	2383.3	21.9	17-Dec-14	
	PSM22B	10-4930	350	337.8	426.9	fresh rock (above GAS)[1]	2807.3	24.6	17-Dec-14	negative pressure at gauge

VWP ID (Hole ID)	VWP reference	VWP serial no.	Gauge depth (mDH)	True gauge depth (mbGL)	Total head (RL m)[3]	Unit	Data collected during December 2014			Comments
							Frequency (hertz)	Temp	Date	
PSM24 (626XC11)	PSM24A	10-4286	260	244.3	786.7	fresh rock (above GAS)[1]	2253.4	22.5	15-Dec-14	
	PSM24B	10-4256	90	84.6	763.9	fresh rock (above GAS)[1]	2156.8	21	15-Dec-14	
PSM25 (625XC11)	PSM25A	10-4254	330	310.1	594	fresh rock (above GAS)[1]	2257.8	22.2	15-Dec-14	
	PSM25B	10-4287	195	183.2	542.9	fresh rock (above GAS)[1]	2892.4	23.4	15-Dec-14	negative pressure at gauge, significant difference between ABC and Ti factors suggests gauge maybe incorrect calibration factors
484XC10	484XC10A	10-4907	220	196.4	475.2	fresh rock (above GAS)[1]	2203.8	24.9	14-Dec-14	
	484XC10B	10-4931	350	312.4	478.6	fresh rock (above GAS)[1]	2174.3	23.5	14-Dec-14	
549XC11	549XC11A	10-4252	130	125.6	556.8	fresh rock (above GAS)[1]	2253.7	24.4	14-Dec-14	
	549XC11B	10-4282	290	280.1	268.4	fresh rock (above GAS)[1]	2819	26.8	14-Dec-14	negative pressure at gauge
560XC11	560XC11A	10-4255	240	225.5	603.2	fresh rock (above GAS)[1]	2227.5	23.4	15-Dec-14	
	560XC11B	10-5698	320	300.7	512.9	fresh rock (above GAS)[1]	2482.9	21.8	15-Dec-14	temperature gauge damaged, no confidence in data
601XC11	601XC11A	10-4257	40	34.6	626.3	fresh rock (above GAS)[1]	not located during field program, situated at site HTGB004 but covered by new pad			
	601XC11B	10-5692	80	69.3	627.8	fresh rock (above GAS)[1]				

Note: *[1]Gypsum anhydrite surface (GAS)*



LEGEND

- Open-pit extent (Year 33)
- FRHEP / ISF extent
- Drainage
- Mining infrastructures
- Road (proposed)

Monitoring network

- New VWP (2015)
- Existing PSM VWP (2009-2011)
- Geotech hole
- Monitoring bore

Sepik Development Project (J1051A)

DATE 19/07/2018

AGE

Groundwater monitoring network

FIGURE No.

A - 1.1

A1.2 Monitoring bore network

Glencore Xstrata installed a total of 48 standpipe monitoring bores within 20 km of their proposed open-pit between April 2009 and June 2011. All the bores are associated with the previous project Integrated Storage Facility (ISF), the proposed Frieda Bend site, and Frieda Airstrip. Of the 48 bores, three were excluded due to erroneous data, no water level data, unknown construction details, or are located outside the Project area. Table A 1.2 presents details for each monitoring bore within the Project area. Figure A 1.1 presents the location of all existing monitoring bores and Attachment A contains a summary table of their location and construction details.

Table A 1.2 Standpipe monitoring water levels

Location	Hole ID	Elevation (RL m)	Average water level (RL m)	Unit	Comments
Frieda Bend Site	312XC09G	66.46	60.78	alluvium / colluvium	
Frieda Bend Site	243XC09G	116.35	96.79	weathered rock	
Frieda Bend Site	244XC09G	155.49	150.44	weathered rock	
Frieda Bend Site	231XC09G	66.62	53.41	fresh rock (above GAS)	
Frieda Bend Site	234XC09G	67.54	58.91	fresh rock (above GAS)	
Frieda Bend Site	236XC09G	68.37	60.42	fresh rock (above GAS)	
Frieda Bend Site	239XC09G	68.15	62.86	fresh rock (above GAS)	
Frieda Bend Site	316XC09G	73.51	55.26	fresh rock (above GAS)	
Frieda Bend Site	322XC09G	77.95	63.6	fresh rock (above GAS)	
Frieda Bend Site	324XC09G	73.4	55.78	fresh rock (above GAS)	
Frieda Bend Site	325XC09G	63.24	57.1	fresh rock (above GAS)	
Frieda Bend Site	544XC11G	220.83	197.89	fresh rock (above GAS)	
Frieda Bend Site	566XC11G	69.78	56.42	fresh rock (above GAS)	
Frieda Bend Site	611XC11G	70.7	60.93	fresh rock (above GAS)	
Frieda Strip	646XC11G	119.97	-	-	outside the model domain
North East Nina	642XC11G	257.64	252.29	weathered rock	
North East Nina	650XC11G	228.49	193.78	fresh rock (above GAS)	
Ok Binai (North West Ridge)	564XC11G	242.91	224.83	fresh rock (above GAS)	
Ok Binai (North West Ridge)	570XC11G	355.52	321.16	fresh rock (above GAS)	
Ok Binai (North West Ridge)	577XC11G	318.27	294.43	fresh rock (above GAS)	
Ok Binai (North West Ridge)	590XC11G	156.26	136.17	fresh rock (above GAS)	
Ok Binai (North West Ridge)	635XC11G	158.05	128.99	fresh rock (above GAS)	
Ok Binai 2	496XC10G	246.55	217.4	weathered rock	
Ok Binai 2	620XC11G	234.03	197.23	weathered rock	
Ok Binai 2	632XC11G	303.29	262.19	weathered rock	
Ok Binai 2	423XC10G	103.37	102.89	fresh rock (above GAS)	
Ok Binai 2	424XC10G	96.97	96.22	fresh rock (above GAS)	

Location	Hole ID	Elevation (RL m)	Average water level (RL m)	Unit	Comments
Ok Binai 2	431XC10G	122.9	108.65	fresh rock (above GAS)	
Ok Binai 2	432XC10G	98.29	97.14	fresh rock (above GAS)	
Ok Binai 2	629XC11G	242.23	217.99	fresh rock (above GAS)	
Ok Binai 3 (Guria Ridge)	514XC10G	514.67	475.38	fresh rock (above GAS)	
Ok Binai 3 (Guria Ridge)	655XC11G	601.73	588.9	fresh rock (above GAS)	
Ok Binai 3 (Pineapple Ridge)	503XC10G	262.38	231.72	weathered rock	
Ok Binai 3 (Pineapple Ridge)	455XC10G	331.33	288.12	fresh rock (above GAS)	
Ok Binai 3 (Pineapple Ridge)	458XC10G	248.54	-	fresh rock (above GAS)	dry bore
Ok Binai 3 (Pineapple Ridge)	463XC10G	305.97	280.87	fresh rock (above GAS)	
Ok Binai 3 (Pineapple Ridge)	493XC10G	282.28	262.94	fresh rock (above GAS)	
Ok Binai 3 (Pineapple Ridge)	499XC10G	247.07	236.11	fresh rock (above GAS)	
Ok Binai 3 (Pineapple Ridge)	511XC10G	226.68	192.57	fresh rock (above GAS)	
Ok Binai 3 (Pineapple Ridge)	546XC11G	269.3	256.78	fresh rock (above GAS)	
Ok Binai 3 Camp	485XC10G	184.28	163.04	weathered rock	
Ok Binai 3 Camp	556XC11G	185.98	145.93	weathered rock	
Ok Binai 3 Camp	441XC10G	145.64	131.82	fresh rock (above GAS)	
Ok Binai 3 Camp	444XC10G	162.01	158.09	fresh rock (above GAS)	
Ok Binai 3 Camp	445XC10G	161.37	142.63	fresh rock (above GAS)	
Ok Binai 3 Camp	447XC10G	162.76	155.39	fresh rock (above GAS)	
Ok Binai 3 Camp	451XC10G	267.73	247.82	fresh rock (above GAS)	
Ok Binai 3 Camp	477XC10G	177.91	-	fresh rock (above GAS)	erroneous data

A2 New vibrating wire piezometers

A2.1 Open-pits

Geotech International installed 26 new VWP gauges in five geotechnical drill holes around the planned open-pits between December 2014 and March 2015. Geotech International provided summary lithology logs and core photos to AGE on completion of each drill hole. The placement of each VWP gauge was selected by an AGE hydrogeologist in consultation with PSM. All VWPs were installed by QED Drilling under supervision from Geotech International.

Table A 2.1 summarises the new VWPs. Figure A 1.1 presents the location of all VWPs and Attachment A contains the VWP details.

Table A 2.1 VWP summary table

Hole ID	VWP reference	VWP serial no.	Gauge depth (mDH)	True gauge depth (m below collar)	True gauge depth (mbGL)	True gauge depth (mRL)	Total head (mRL)	Unit	Comments on gauge placement
HTBG001	VWP-P1	1403939	50	47	41.8	539.39	552.7	weathered rock	located at the base of the weathered zone in a strong potassic alteration zone
	VWP-P2	1403952	160	150.4	137.5	436.02	547.5	fresh rock (above GAS)	located at the base of the PQ in a Hornblende Monzonite
	VWP-P3	1403965	222	208.6	200.3	377.76	547.3	fresh rock (above GAS)	located near the proposed HIT open-pit shell boundary
	VWP-P4	1403988	275	258.4	257.7	327.95	544.1	fresh rock (above GAS)	located within crush zone above the GAS
	VWP-P5	1403989	297	279.1	279.4	307.28	541.9	fresh rock (below GAS)	located below the GAS at the max depth of gauge
HTBG002	VWP-P1	1403937	53.6	48.6	38.6	540.17	586.3	weathered rock	higher permeability zone representing the phreatic surface
	VWP-P2	1403955	127.6	115.6	108.7	473.11	588.1	fresh rock (above GAS)	located just below the base of more fractured zone, core photos suggest potential water flow.
	VWP-P3	1403997	186.6	169.1	172.9	419.63	593	fresh rock (above GAS)	located within a fault zone
	VWP-P4	1403964	217.6	197.2	209.1	391.54	593.9	fresh rock (above GAS)	located within a fault zone
	VWP-P5	1403987	297.6	269.7	308.7	319.03	592.9	fresh rock (above GAS)	fault modelled in the available structural data, lower VWP above GAS
HTBG003	VWP-P1	1403943	28.8	27.1	27.5	781.59	786.4	weathered rock	iron staining consistent with groundwater flow near surface
	VWP-P2	1403958	130.8	122.9	119.1	685.74	773.7	fresh rock (above GAS)	more competent rock mass zone below a fault zone @116 m depth
	VWP-P3	1403996	198.8	186.8	186.1	629.36	773.3	fresh rock (above GAS)	clay gouge section
	VWP-P4	1403986	259.8	244.1	248.1	564.52	773.9	fresh rock (above GAS)	weak altered zone with higher permeability than surrounding rock mass
	VWP-P5	1500441	411.8	387	384.5	421.68	779.9	fresh rock (above GAS)	located at the base of the hole

Hole ID	VWP reference	VWP serial no.	Gauge depth (mDH)	True gauge depth (m below collar)	True gauge depth (mbGL)	True gauge depth (mRL)	Total head (mRL)	Unit	Comments on gauge placement
HTBG004	VWP-P1	1403938	54	50.7	59.7	594.29	624.8	weathered rock	located at the base of the weathered zone and above a mapped fault at 56 m
	VWP-P2	1403963	197	185.1	216.9	459.91	611.7	fresh rock (above GAS)	more competent rock mass section above a fault zone at 232 m depth, max cable length 200 m
	VWP-P3	1403962	240	225.5	255.9	419.5	610.5	fresh rock (above GAS)	located within a major fault zone from 232 - 245.8 m
	VWP-P4	1403984	265	249.0	281.8	396.01	604.1	fresh rock (above GAS)	located above the GAS and below a major fault zone
	VWP-P5	1500442	307	288.5	316.9	356.54	603.2	fresh rock (below GAS)	located below the GAS
HTBG005	VWP-P1	1403945	25	22.7	22.7	664.6	662.7	weathered rock	located at the base of weathering
	VWP-P2	1403936	63	57.1	57.1	630.2	653.8	fresh rock (above GAS)	located within higher rock mass section, in HMD, above fault gouge zone between 74.2 - 75 m
	VWP-P3	1403959	138	125.1	125.1	562.2	648.7	fresh rock (above GAS)	Located within higher rock mass section between logged fault at 75 m and 182 m
	VWP-P4	1403966	218	197.6	197.6	489.7	651.9	fresh rock (above GAS)	located within broken rock mass below logged fault at 202 m
	VWP-P5	1403985	285	258.3	258.3	429.0	650.2	fresh rock (above GAS)	located 7 m above the GAS
	VWP-P6	1500440	416	377.0	377.0	310.3	628.9	fresh rock (below GAS)	located below the GAS (292 m) in a higher fractured zone

A2.2 Nena Integrated Storage Facility

SRK completed a geotechnical investigation for the then proposed ISF between December 2014 and May 2015. The ISF was proposed to be located within the Nena Creek catchment approximately 11 km northeast of the open-pits. The program ran concurrently with the AGE/PSM investigation and included geotechnical drilling, hydraulic tests and VWP installations. The SRK field program was on going at the time of writing this report, and whilst no VWP data was available, water level data was collected from five holes during the hydraulic testing. Table A 2.2 contains this data.

Table A 2.2 Nena ISF water level data

Hole ID	Elevation (RL m)	Water level (mDH)	Water Level (RL m)	Comments
NEJG001	228.92	19	214.07	
NEJG003	121.68	8.7	114.53	
NEJG005	112.89	-1	113.89	water level not measured due to artesian head
NEJG006	195.91	8.5	189.21	
NEJG007	237.46	31.5	207.50	

A3 Hydraulic gradients

A3.1 Open-pits

The hydrographs presented in Attachment B and for the new VWP gauges (shown Section A3.1.1 to Section A3.1.5 below) generally show that the vertical hydraulic gradient is downward and the difference in head varies between 5 m up to 100 m. The data also shows that head pressures have generally been stable since the VWPs were commissioned in 2011. Table A 3.1 presents the vertical hydraulic gradients for all sites with two or more functional gauges.

Table A 3.1 Vertical hydraulic gradient

Hole ID	Ground level (RL m)[1]	Difference in vertical head gradient between upper and lower gauge	Comment
HTBG001	586.4	0.05	downward gradient
HTBG002	588.8	-0.03	upward gradient
HTBG003	808.7	0.02	downward gradient
HTBG004	645	0.09	downward gradient
HTBG005	687.3	0.1	downward gradient
ARD06	911.4	0.4	downward gradient
PSM07	831.1	0.3	downward gradient
PSM10	861.3	0.08	downward gradient
PSM13	1021.5	0.96	downward gradient
PSM14	800.6	0.02	downward gradient

Hole ID	Ground level (RL m)[1]	Difference in vertical head gradient between upper and lower gauge	Comment
PSM16	719.5	0.05	downward gradient
PSM20b	687.3	0.3	downward gradient
PSM24	786.3	-0.1	upward gradient
484XC10	543.2	-0.03	upward gradient
601XC11	648.8	-0.04	upward gradient

Note: [1]*elevation data based on Lidar*

A total of four sites (HTBG002, PSM24, 484XC10, and 601XC11) show an upward hydraulic gradient, the remaining 11 sites show a downward gradient varying between 0.02 and 0.96. Site PSM13 shows the highest hydraulic gradient and is situated at RL 1,020 m, the steep gradient reflects the elevated terrain at this point.

Figure A 3.1 compares the measured head pressures against gauge depth for the five recently installed VWP arrays. It represents changes in vertical hydraulic gradients within each hole. Sites with a downward hydraulic gradient have data points progressively moving to the left or head pressures reducing with depth (e.g. HTBG004). An upward hydraulic gradient is represented by data points progressively moving to the right at depth, or pressures increasing with depth (e.g. HTBG002). Where there is no change in head pressure with depth, the data will plot vertically indicating the system is in quasi-equilibrium.

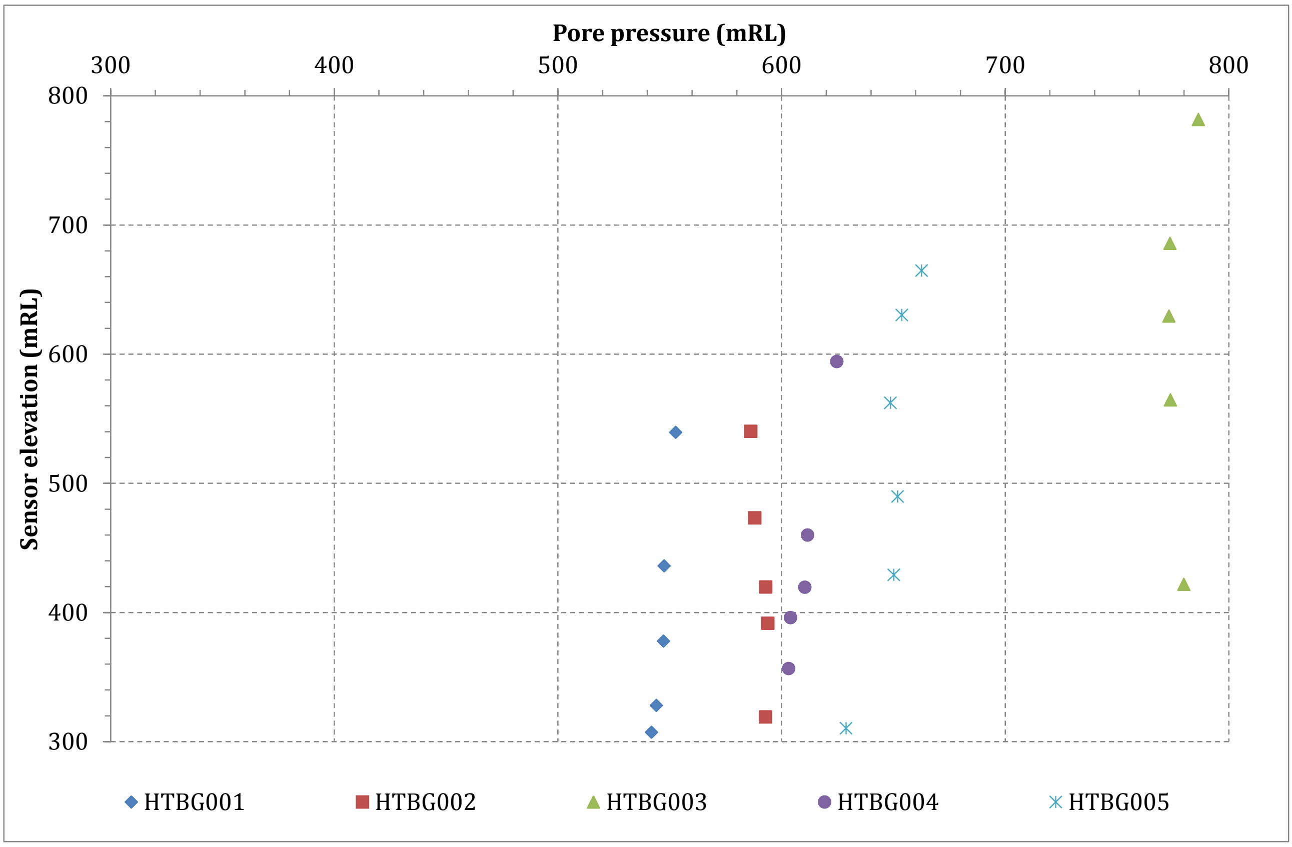


Figure A 3.1 Vertical hydraulic gradients

The hydraulic gradients observed at these sites are discussed further in Section A3.1.1 to Section A3.1.3.

A3.1.1 HTBG001

Head pressures measured at HTBG001 (Figure A 3.2) show a downward hydraulic gradient with a relatively steep vertical gradient of 0.05 between VWP-P1 and VWP-P5 (10 m / 232 m). All five gauges show similar subtle head pressure fluctuations, which are potentially responses to groundwater recharge events.

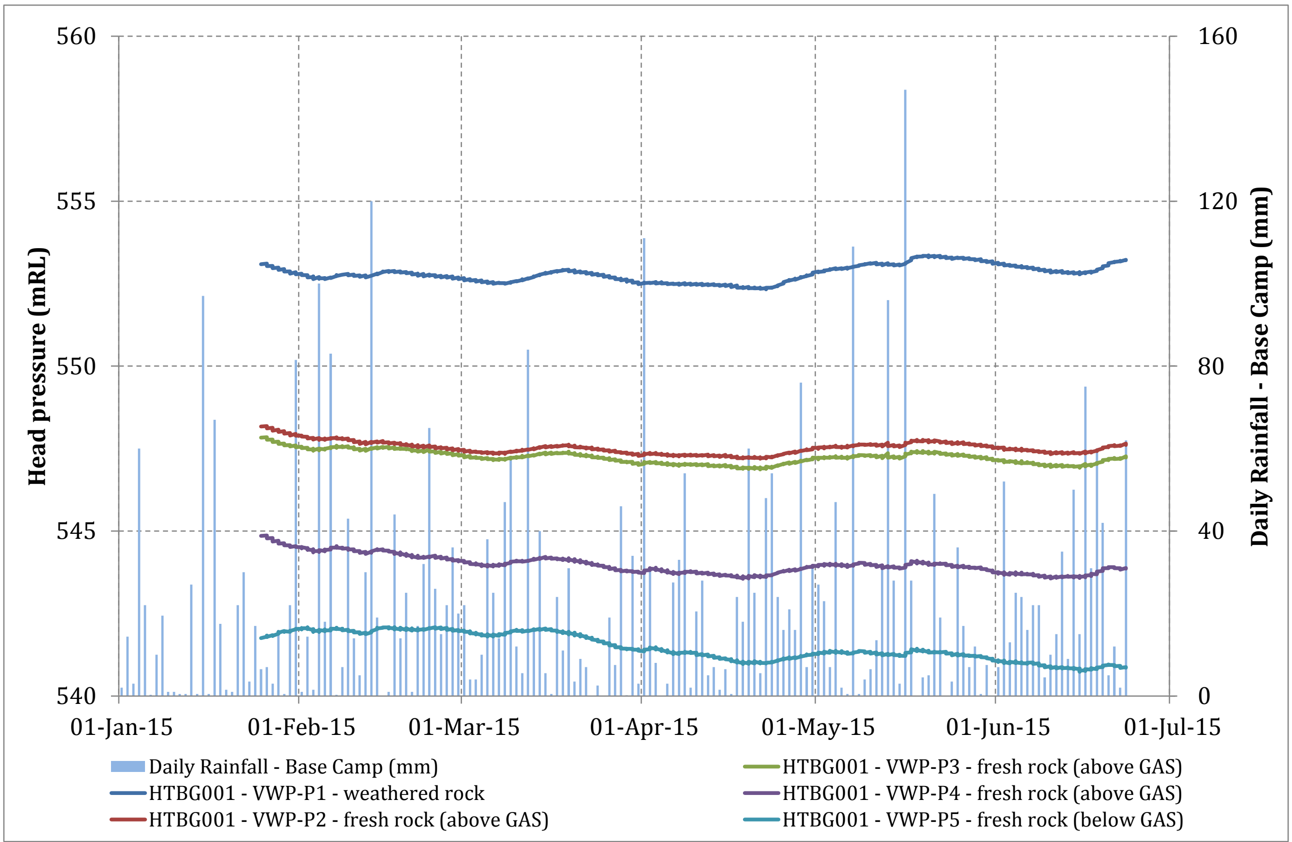
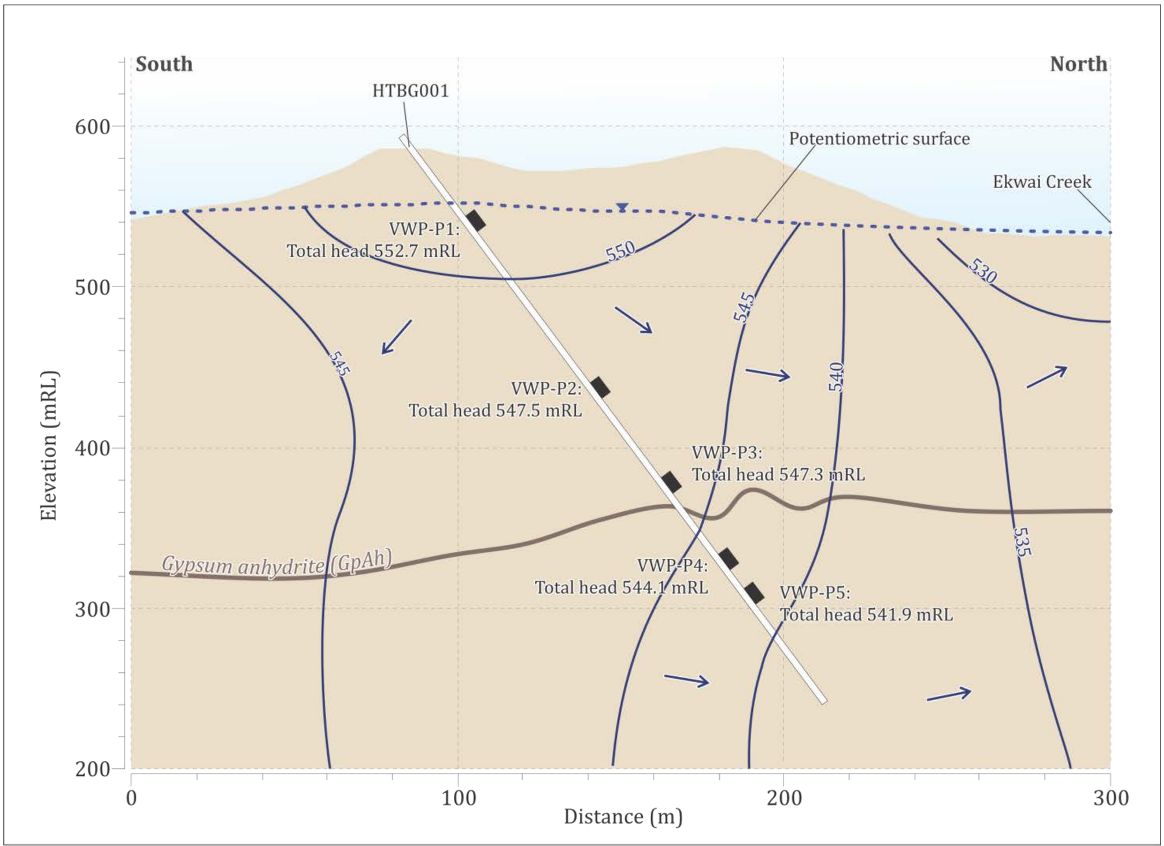


Figure A 3.2 HTBG001 hydrograph

Figure A 3.3 presents a schematic cross-section of HTBG001 and includes interpolated contours of equal head pressure to illustrate pressure changes with depth and geology. Figure A 3.3 indicates a downward hydraulic gradient exists below areas of elevated terrain and an upward hydraulic gradient exists towards the Ekwai Creek valley. This pattern of hydraulic gradients is commonly observed in mountainous / hilly terrain where groundwater preferentially recharges in upland areas and discharges in low land / creek drainages.

HTBG001 intersected a mixture of the Horse Microdiorite, Flimtem Trachyandesite and Hornblende Monzonite from surface to 278 m (downhole). The Debom Volcanics were intersected between 278 m and 319 m. At 319 m the gypsum anhydrite surface was identified within the Horse Microdiorite and was intersected to total downhole depth. The geology described in the drill log is inconsistent with the 3D geology model. The equipotential contours (Figure A 3.3) show that below the gypsum anhydrite surface, the contours are closer together which usually indicates a reduction in hydraulic conductivity in this zone.



Note: *blue lines represent lines of equal head, the arrow indicate flow direction*

Figure A 3.3 HTBG001 schematic of head pressures

A3.1.2 HTBG002

HTBG002 intersected predominantly Horse Microdiorite from surface to total depth downhole. The hole also intersected minor (less than 5 m thick intersects) Frieda Diorite Porphyry. The gypsum anhydrite surface was intersected at approximately 331 m (downhole), well below the lowermost VWP gauge in this hole.

During drilling, HTBG002 became artesian at approximately 199 m depth. Geotechnical engineers on-site noted a crush zone immediately above 199 m which may act as a confining layer. Artesian conditions are observed at the three deeper gauges (Figure A 3.4) and the site shows an upward hydraulic gradient of 0.03 between VWP-P1 and VWP-P5 (7 m / 220 m). The shallow VWP gauge at this site shows minor fluctuation in response to rainfall events.

The terrain elevation increases along the azimuth of HTBG002 from RL 581 m above VWP-P1 up to RL 627 m above VWP-P5. These two gauges are separated by a horizontal distance of 100 m (Figure A 3.5). The interpreted pattern of hydraulic gradients observed for HTBG002 is similar to that interpreted for HTBG001, where a downward hydraulic gradient exists below areas of elevated terrain and an upward hydraulic gradient exists towards the Ekwai Creek valley.

The pattern of hydraulic gradients driving artesian pressures at HTBG002 are also likely to occur elsewhere in the Project area. This assumption is supported by observed artesian conditions at numerous exploration drill holes. (see Section A3.2).

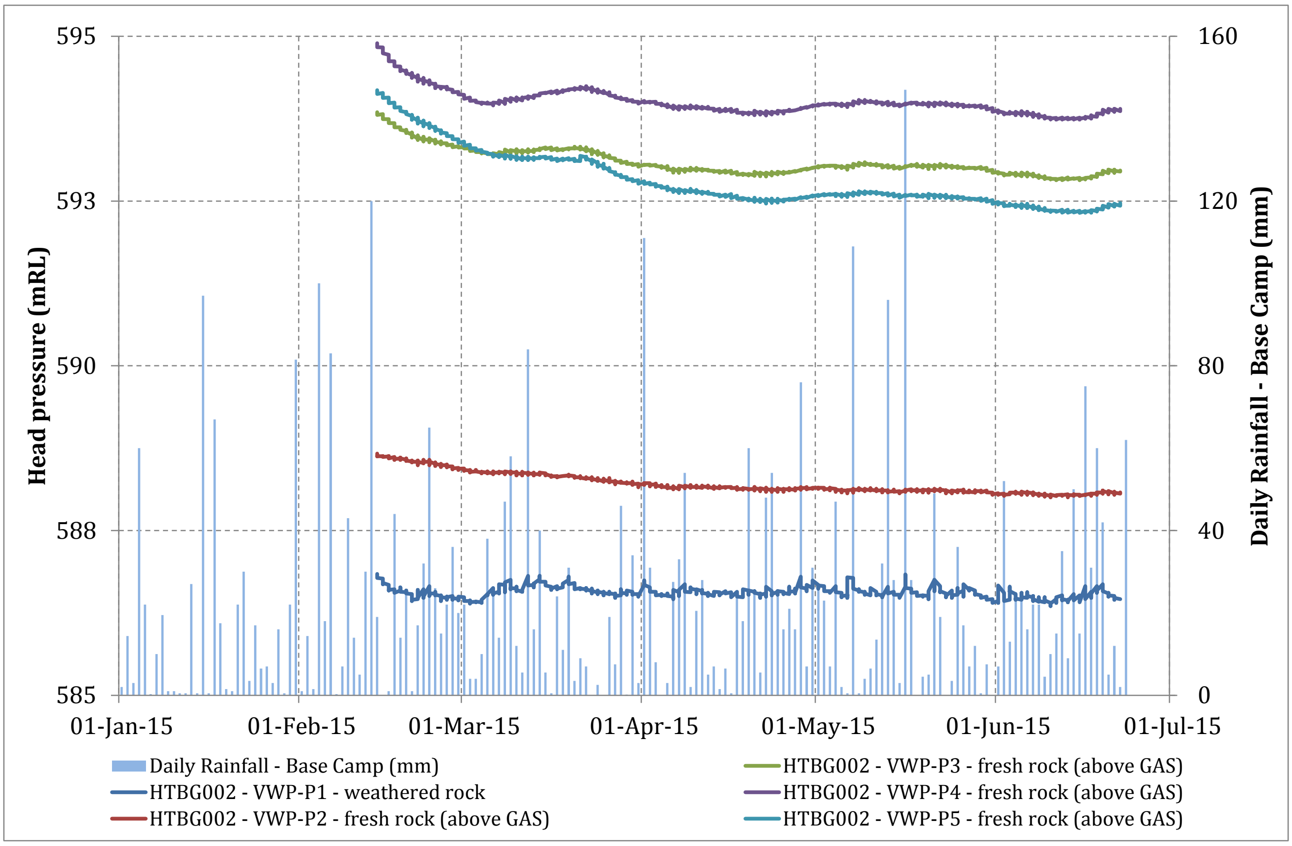
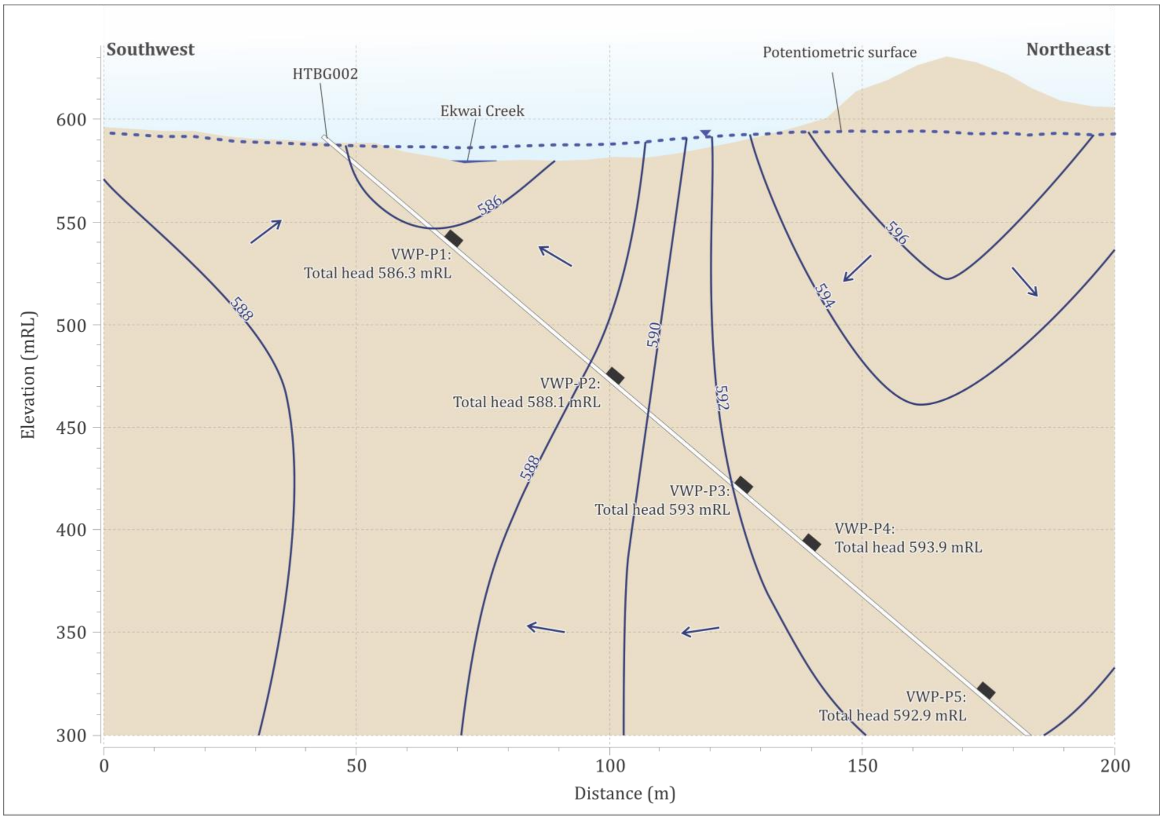


Figure A 3.4 HTBG002 hydrograph



Note: *blue lines represent lines of equal head, the arrow indicate flow direction*

Figure A 3.5 HTBG002 schematic of head pressures

A3.1.3 HTBG003

HTBG003 intersected predominantly Horse Microdiorite with minor Frieda Diorite Porphyry within the initial 35 m (downhole) from surface. The gypsum anhydrite surface was not intersected in this hole.

Head pressures measured at HTBG003 (Figure A 3.6) show a downward vertical gradient of 0.13 between the VWP-P1 and VWP-P2 suggesting a possible perched aquifer in the shallow lithology. HTBG003 is located on a topographic high where the terrain elevation declines at a gradient matching the decline in head pressure between the upper two gauges (0.13). VWP-P1 is situated in the weathered zone and the early time data shows a greater response to short-term recharge events compared to the four deeper VWP gauges. However, since May 2015 the gauge in the weathered zone has shown a continued reduction in head pressure which is counter to the rise in head pressure recorded by the reminder of gauges. The cause of the continued head pressure decline is not readily apparent.

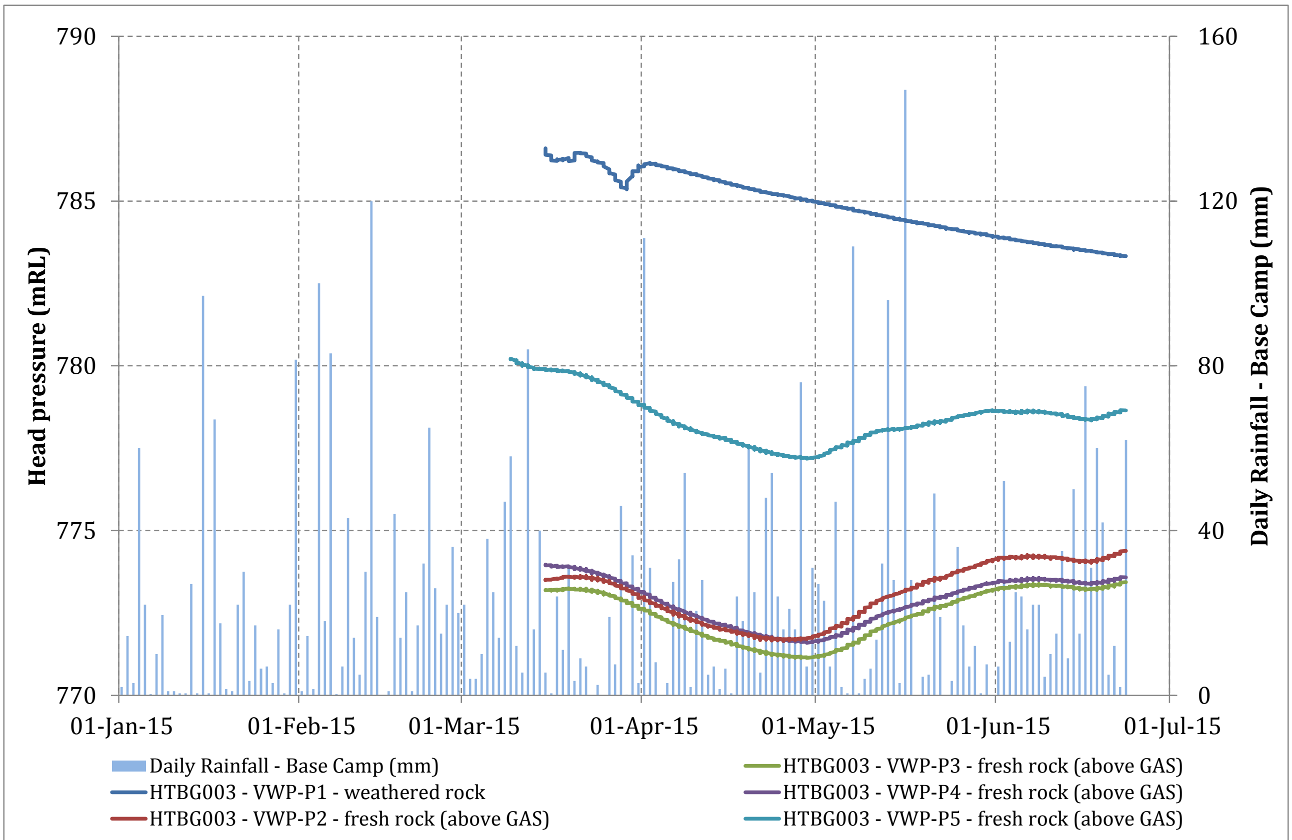
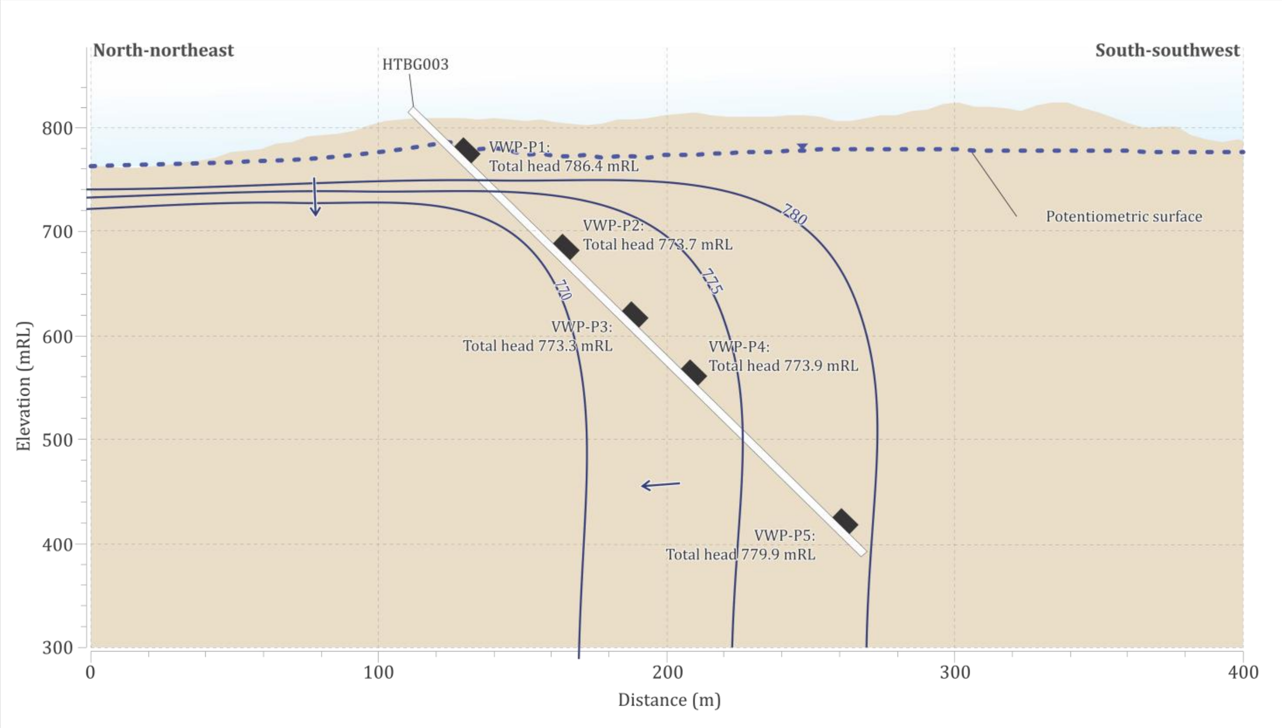


Figure A 3.6 HTBG003 hydrograph

Figure A 3.7 presents a schematic cross-section of HTBG003 and includes contours of equal head pressure to illustrate pressure changes with depth. Figure A 3.7 shows the downward vertical gradient in the shallow profile where changes in terrain strongly influence the hydraulic gradient. The deeper groundwater flow direction is toward the north east. The data at this site indicates a shallow perched aquifer.



Note: *blue lines represent lines of equal head, the arrow indicate flow direction*

Figure A 3.7 HTBG003 schematic of head pressures

A3.1.4 HTBG004

HTBG004 intersected predominantly Horse Microdiorite from the surface. The gypsum anhydrite surface was intersected at approximately 272 m (downhole) in this hole.

Head pressures measured at HTBG004 (Figure A 3.8) show a downward hydraulic gradient of 0.09 between VWP-P2 and VWP-P5. The early time head pressure in the weathered zone (VWP-P1) is approximately 13 m above the head pressure in the fresh rock mass above the GAS (VWP-P4 and VWP-P5) suggesting a perched shallow aquifer. VWP-P4 is located 7 m above the GAS and VWP-P5 is 35 m below the GAS. The two gauges initially record similar head pressures with a downward gradient of 0.02 suggesting the GAS does not does not act as a confining layer. However, since installation, HTBG004-P5 has failed and no longer provides head pressure data. VWP-P4 shows a gradual 10 m drop in pressure from May 2015 to June 2015. Further discussion regarding this reduction in pressure is discussed below for HTBG005.

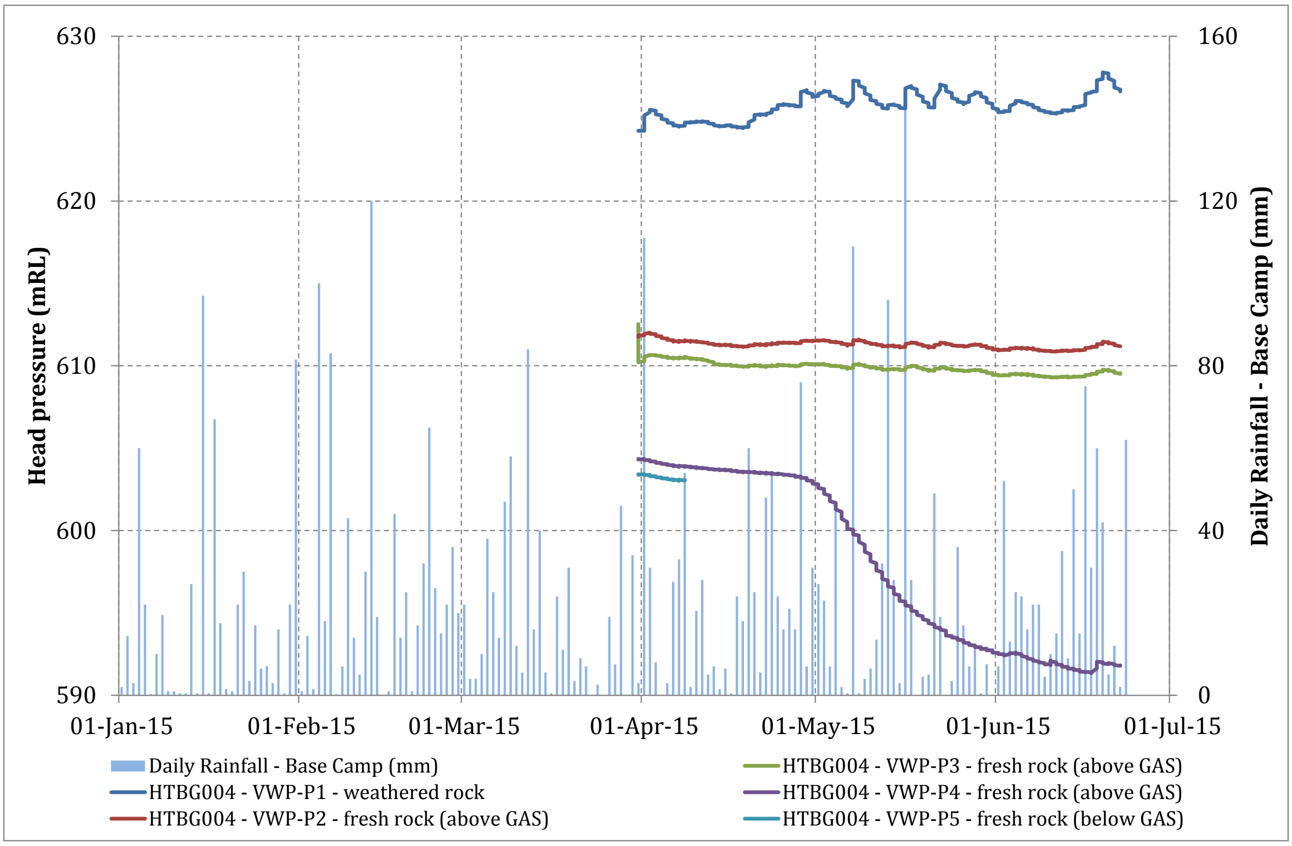
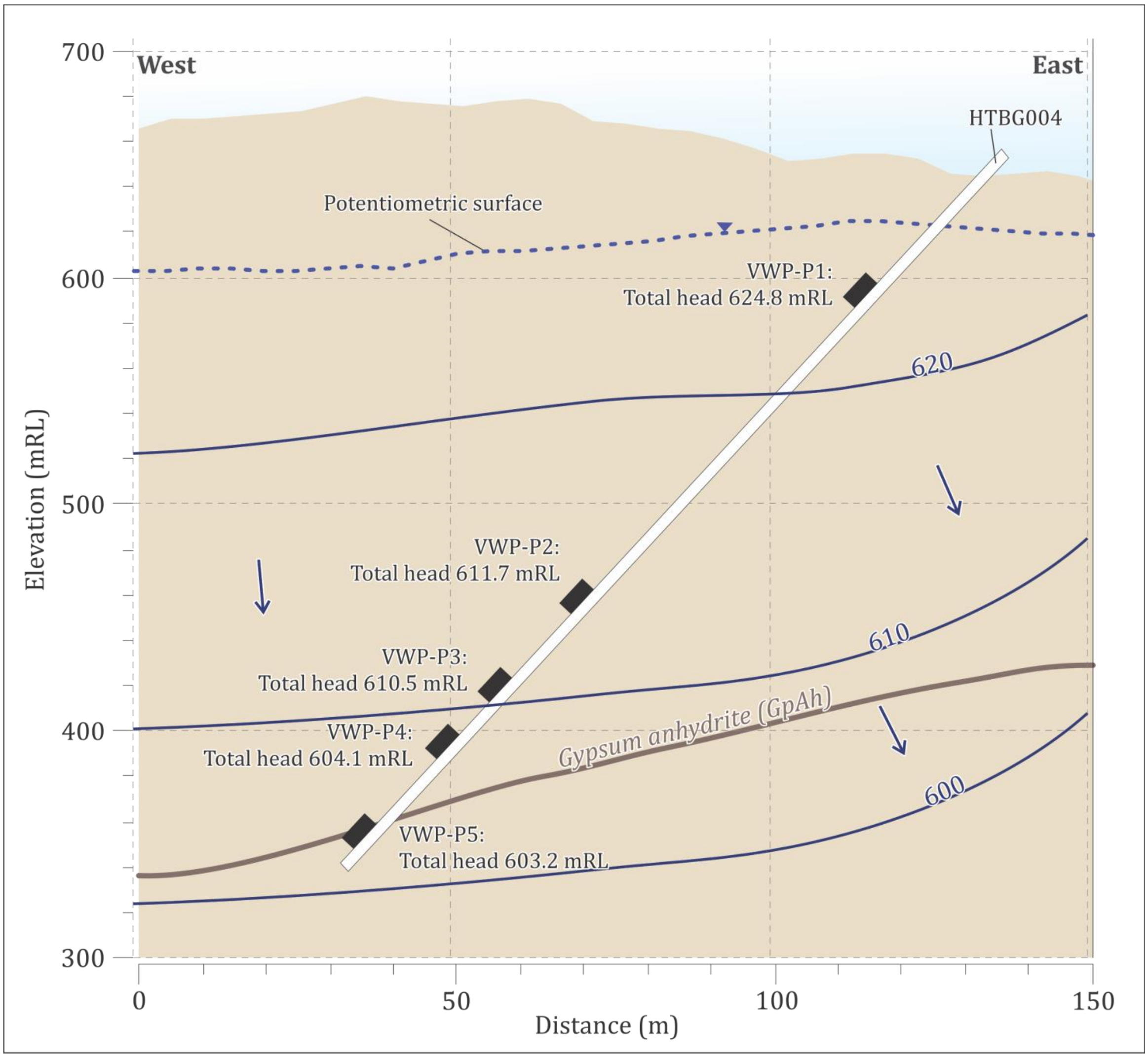


Figure A 3.8 HTBG004 hydrograph

Figure A 3.9 shows the two dimensional aspect of the head pressures at HTBG004. HTBG004 is located along the side of a topographic high which is reflected in the steep downward hydraulic gradient. Northeast of HTBG004, Ekwai Creek is at approximately RL 600 m elevation, to which groundwater flows. The equipotential contours appear closer together below the gypsum anhydrite surface (272 m from surface), indicating a reduction in hydraulic conductivity in this zone.



Note: *blue lines represent lines of equal head, the arrow indicate flow direction*

Figure A 3.9 HTBG004 schematic of head pressures

A3.1.5 HTBG005

HTBG005 intersected predominantly Horse Microdiorite from surface down to a depth of 80 m (downhole). The Frieda Diorite Porphyry was intersected from 80 m to total depth (downhole), with the gypsum anhydrite surface intersected at approximately 292 m (downhole) in this hole. Head pressures measured at HTBG005 (Figure A 3.1111) show a downward hydraulic gradient of 0.09 between VWP-P1 and VWP-P5. The head pressure in the weathered zone (VWP-P1) is approximately 13 m above the head pressure in the fresh rock mass above the GAS (VWP-P2 to VWP-P5).

VWP-P6 shows a 20 m decline in head pressure from May 2015 to June 2015. The timing of this pressure reduction coincides with a 10 m pressure reduction at HTBG004-P4. This coincident timing would suggest that the drilling and completion of the VWP hole at HTBG005 is responsible for the pressure reduction at both HTBG004-P4 and HTBG005-P6.

The mechanism for this depressurisation is explained as follows; it is likely that HTBG005 has locally intersected two structures that were otherwise hydraulically disconnected. It is important to note that the hole was designed to target a modelled fault (Ivall_03) between 436 m and 476 m (249 mRL and 209 mRL). Fault zone defects were described in the lithology log for HTBG005 at 240 m, 264 m, 290 m and 481 m. The downhole gauge depth of HTBG005-P6 was set at 416 m, below the GAS (292 m) in a highly fractured zone.

A vertical hydraulic gradient existed between the two structures which after completion, allowed groundwater to locally flow from one structure to the other. The structure that was locally depressurised is represented by the head pressure at HTBG005-P6 which depressurised from 645 mRL to 625 mRL (~20 m pressure reduction). It is assumed that the fault being depressurised is continuous and hydraulically connected to a fault intersected near HTBG004-P4, which depressurised from 604 mRL to 592 mRL (~12 m head pressure reduction). Fault zone defects were described in the lithology log for HTBG004 at 260 m and 270 m. The downhole gauge depth of HTBG004-P4 was 265 m, above the GAS and below a major fault zone.

Whilst the exact mechanism and pathway for depressurisation between the two gauges is unknown, it is highly likely to be fault related given the large distance between the gauges (174 m) and short response time to drilling (1 week to 1 month). The response observed at both HTBG004 and HTBG005 is important in the context of open-pit depressurisation as it shows that drainage will occur via structures and faults within the open-pit area. The data does also show that the influence of structures will only assist depressurisation where there is a direct hydraulic connection.

Head pressures observed at VWP gauges above the response zone show no influence of enhanced vertical drainage.

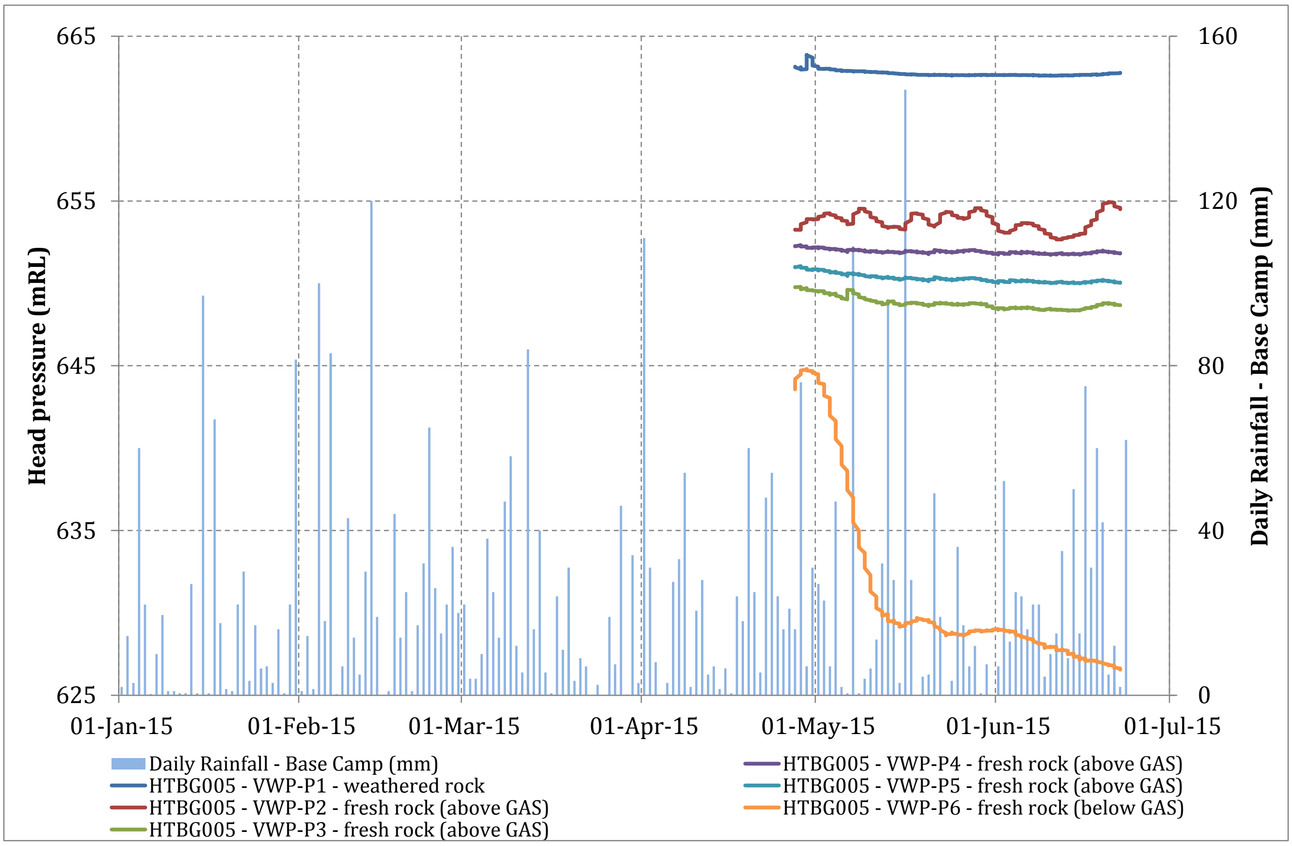
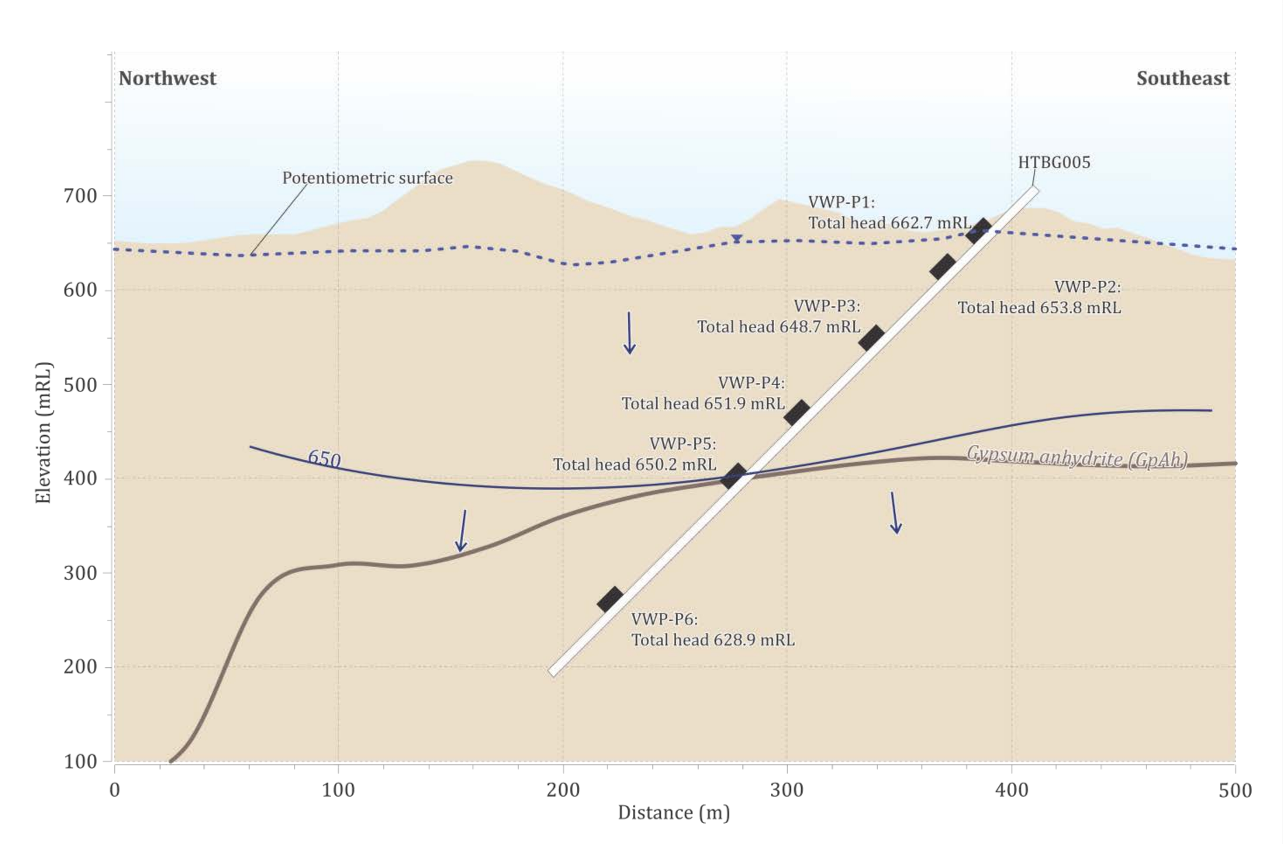


Figure A 3.10 HTBG005 hydrograph

Figure A 3.11 shows the two dimensional aspect of the head pressures at HTBG005. HTBG005 is located on a steep slope perpendicular to the orientation of the hole and shows a steep downward hydraulic gradient.



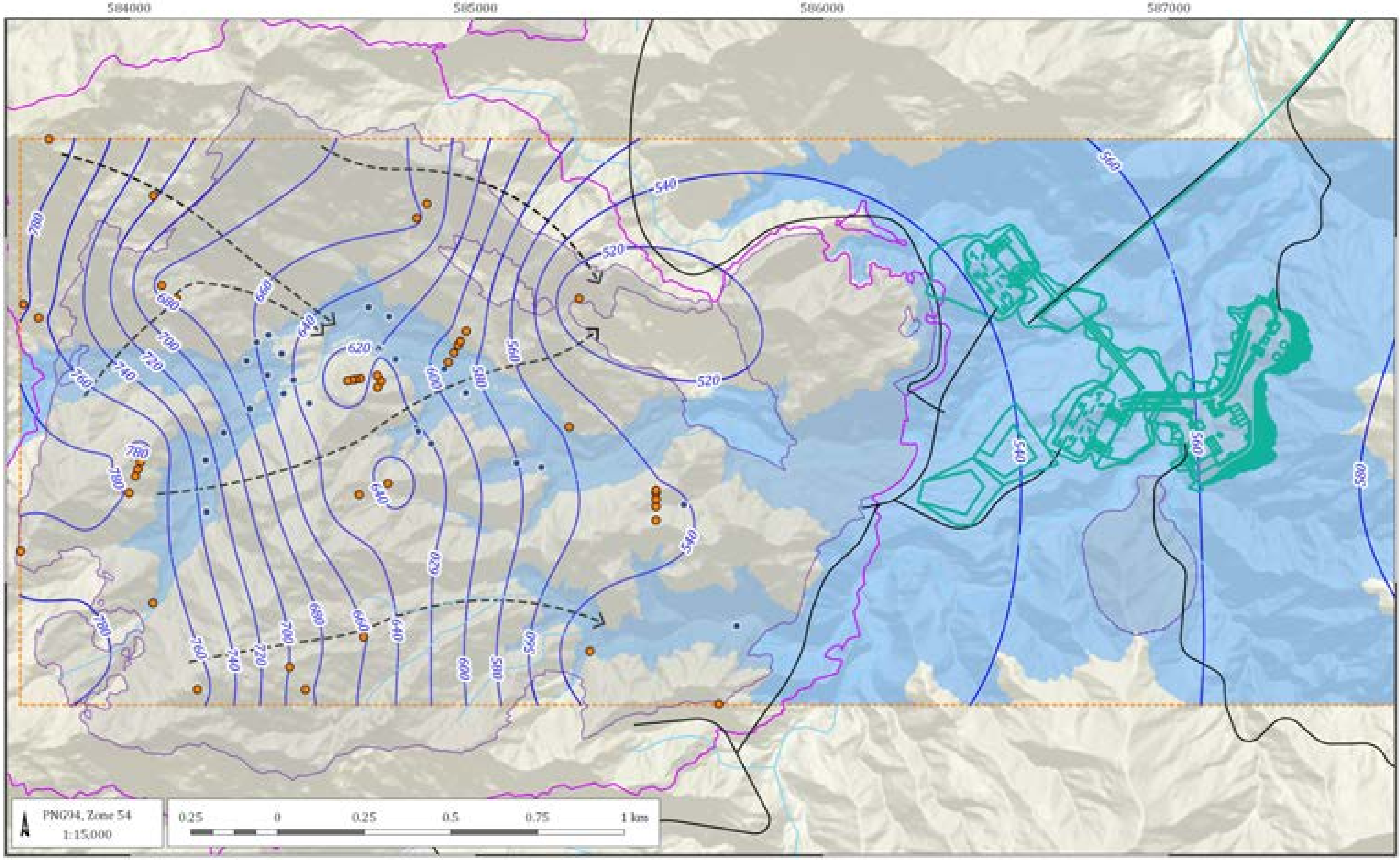
Note: *blue lines represent lines of equal head, the arrow indicate flow direction*

Figure A 3.11 HTBG005 schematic of head pressures

A3.2 Groundwater flow

Figure A 3.12 presents the groundwater level contours and artesian conditions around the open-pits. The groundwater flow direction is from west to east and approximately follows the drainage lines.

Artesian conditions are observed at a number of exploration drill holes. The inferred artesian conditions shown on Figure A 3.12 are consistent with observed artesian conditions at exploration drillholes. Artesian conditions are associated with topographic lows within the drainage features. The artesian sampling sites were not used in the contouring process but have been shown to verify the contours against the known artesian conditions.



LEGEND

- Open-pit extent (Year 33)
- FRHEP / ISF extent
- Interpolation extent
- Mining infrastructures
- Road (proposed)
- Artesian head
- Potentiometric surface contours confined volcanics (RL m)
- Flow direction
- Drainage
- Artesian sites
- 2014 data used for interpolation

Sepik Development Project (I1051A)

AGE

Groundwater flow direction

DATE
19/07/2018

FIGURE No:
A - 3.12

Attachment A Summary of VWP and bore details

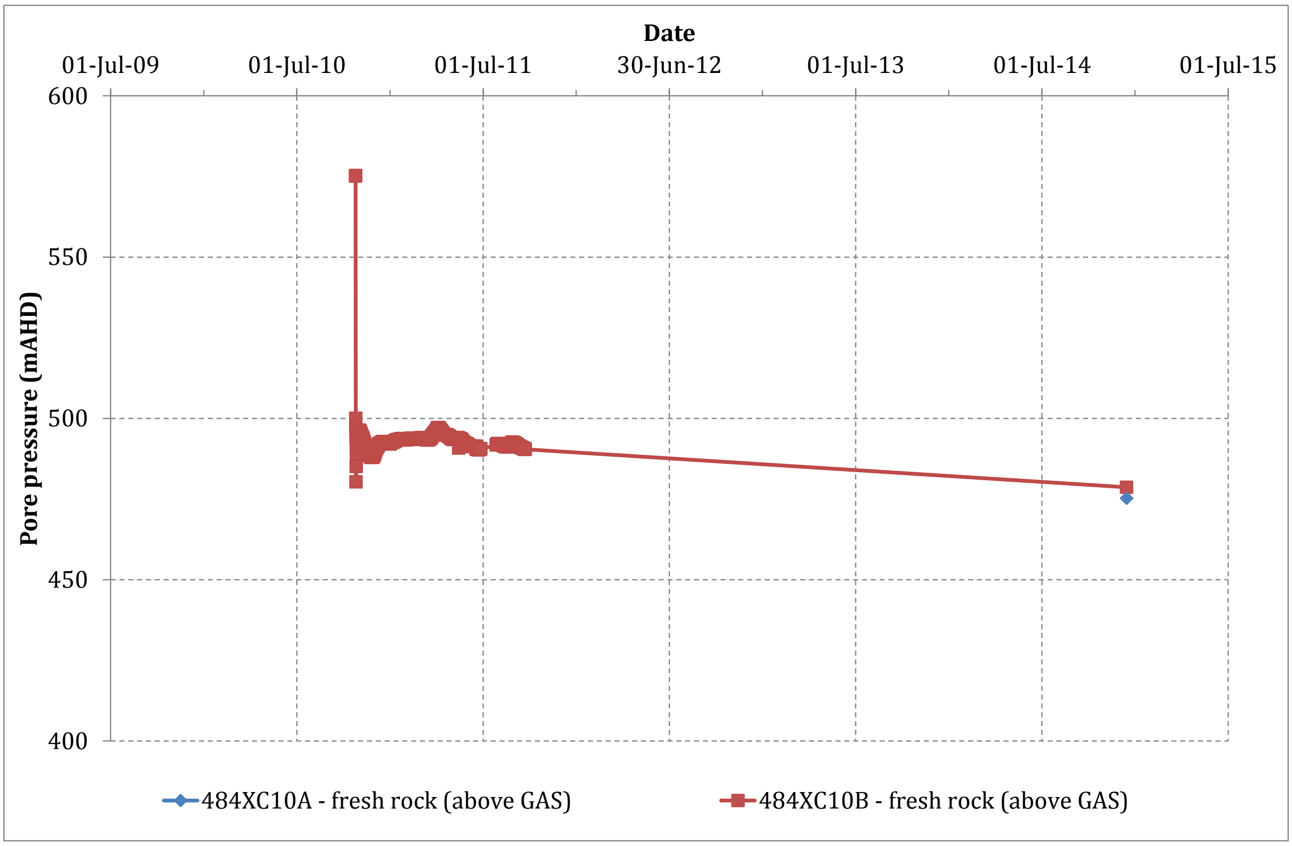
Location	Hole ID	Easting	Northing	Elevation (RL m)	Dip	Stick up (maGL)	Screen interval			Gravel pack / open hole			Standing water level		Unit
							top (mbGL)	base (mbGL)	length (m)	top (mbGL)	base (mbGL)	length (m)	mbGL	RL m	
Frieda Bend Site	312XC09G	603710	9486970	66.46	90	0.6	construction details unknown						5.68	60.78	alluvium / colluvium
	243XC09G	603719	9486680	116.35	60	0.28	construction details unknown						19.56	96.79	weathered rock
	244XC09G	603309	9486775	155.49	60	0.67	construction details unknown						5.05	150.44	weathered rock
	231XC09G	603514	9486720	66.62	90	0.7	construction details unknown						13.21	53.41	fresh rock (above GAS)
	234XC09G	603574	9486710	67.54	90	0.52	construction details unknown						8.63	58.91	fresh rock (above GAS)
	236XC09G	603624	9486700	68.37	90	0.27	construction details unknown						7.95	60.42	fresh rock (above GAS)
	239XC09G	603433	9486759	68.15	90	0.4	construction details unknown						5.29	62.86	fresh rock (above GAS)
	316XC09G	603525	9486514	73.51	90	0.7	construction details unknown						18.25	55.26	fresh rock (above GAS)
	322XC09G	603610	9486487	77.95	90	0.7	construction details unknown						14.35	63.6	fresh rock (above GAS)
	324XC09G	603400	9486529	73.4	90	0.68	construction details unknown						17.62	55.78	fresh rock (above GAS)
	325XC09G	603630	9487000	63.24	90	0.45	construction details unknown						6.14	57.1	fresh rock (above GAS)
	544XC11G	603194	9486824	220.83	90	0.96	construction details unknown						22.94	197.89	fresh rock (above GAS)
	566XC11G	603520	9486640	69.78	90	0.45	60	77.4	17.4	60	80	20	13.36	56.42	fresh rock (above GAS)

Location	Hole ID	Easting	Northing	Elevation (RL m)	Dip	Stick up (maGL)	Screen interval			Gravel pack / open hole			Standing water level		Unit
							top (mbGL)	base (mbGL)	length (m)	top (mbGL)	base (mbGL)	length (m)	mbGL	RL m	
	611XC11G	603570	9486625	70.7	90	0.53	60	77.4	17.4	60	80	20	9.77	60.93	fresh rock (above GAS)
Frieda Strip	646XC11G	605072	9489324	119.97	90	0.4	21.8	39.2	17.4	21.8	61.8	40			
North East Nina	642XC11G	598909	9486624	257.64	90	0.22	construction details unknown						5.35	252.29	weathered rock
	650XC11G	602018	9486668	228.49	90	0.8	33.5	50.9	17.4	33.5	50.9	17.4	34.71	193.78	fresh rock (above GAS)
Ok Binai (North West Ridge)	564XC11G	594955	9481383	242.91	90	0.53	11.9	35.1	23.2	11.9	49.9	38	18.08	224.83	fresh rock (above GAS)
	570XC11G	595255	9481295	355.52	90	0.6	17	40.2	23.2	17	55	38	34.36	321.16	fresh rock (above GAS)
	577XC11G	595337	9481067	318.27	90	0.5	construction details unknown						23.84	294.43	fresh rock (above GAS)
	590XC11G	594841	9480944	156.26	90	0.5	construction details unknown						20.09	136.17	fresh rock (above GAS)
	635XC11G	594942	9482035	158.05	90	0.5	construction details unknown						29.06	128.99	fresh rock (above GAS)
Ok Binai 2	496XC10G	594033	9481666	246.55	90	0.49	2.2	8	5.8	2.2	35.1	32.9	29.15	217.4	weathered rock
	620XC11G	594431	9482372	234.03	90		construction details unknown						36.8	197.23	weathered rock
	632XC11G	594338	9482701	303.29	90	0.47	27.5	50.7	23.2	27.5	50.7	23.2	41.1	262.19	weathered rock
	423XC10G	594359	9481708	103.37	90	0.85	2.2	8	5.8	2.2	100.3	98.1	0.48	102.89	fresh rock (above GAS)
	424XC10G	594783	9482136	96.97	90	0.96	2.2	8	5.8	2.2	103.3	101.1	0.75	96.22	fresh rock (above GAS)

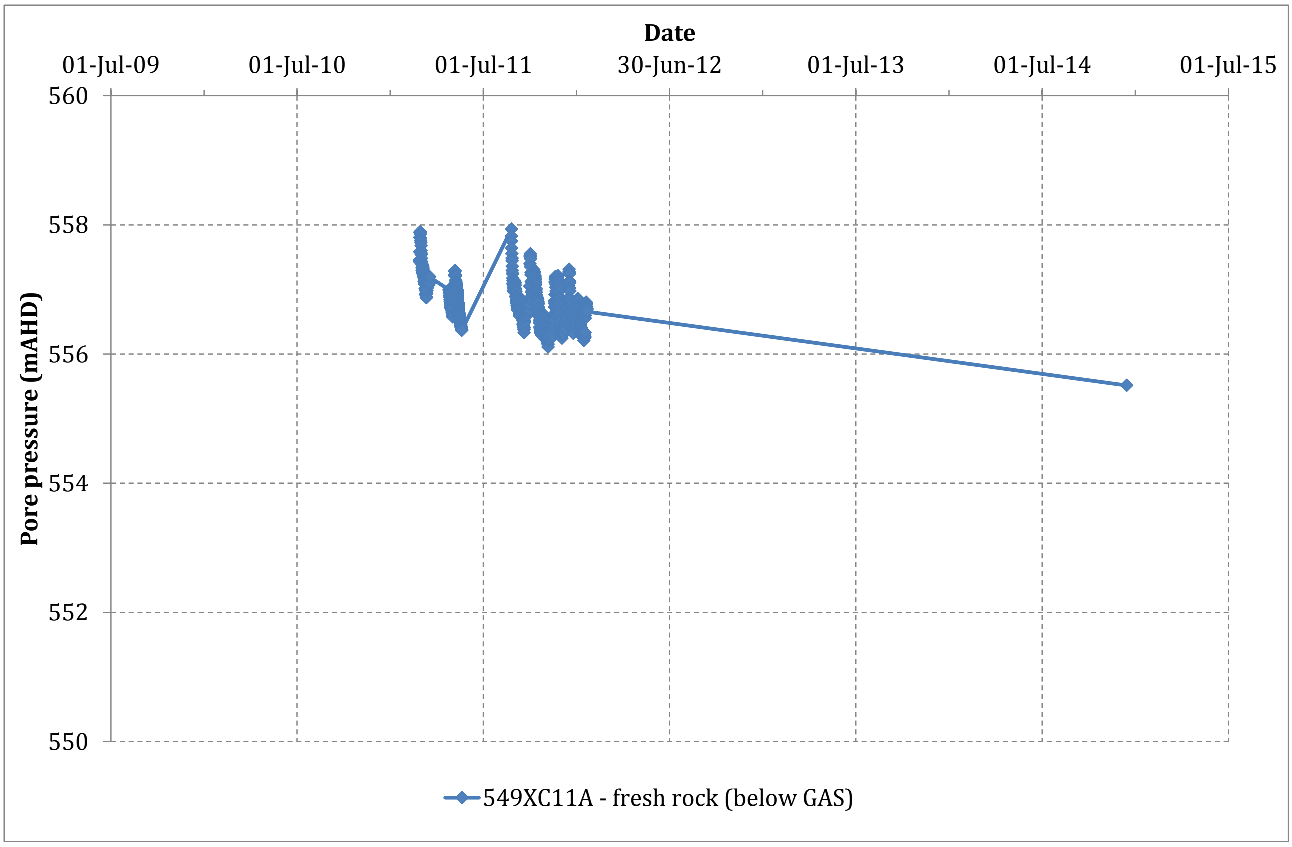
Location	Hole ID	Easting	Northing	Elevation (RL m)	Dip	Stick up (maGL)	Screen interval			Gravel pack / open hole			Standing water level		Unit
							top (mbGL)	base (mbGL)	length (m)	top (mbGL)	base (mbGL)	length (m)	mbGL	RL m	
	431XC10G	594642	9481545	122.9	90	0.7	2.2	8	5.8	2.2	100	97.8	14.25	108.65	fresh rock (above GAS)
	432XC10G	594690	9482199	98.29	90	0.95	2.2	8	5.8	2.2	100.3	98.1	1.15	97.14	fresh rock (above GAS)
	629XC11G	595094	9481698	242.23	90	0.5	62.7	68	5.3	50	68.5	18.5	24.24	217.99	fresh rock (above GAS)
Ok Binai 3 (Guria Ridge)	514XC10G	587404	9480119	514.67	90	0.56	2.2	8	5.8	2.2	50	47.8	39.29	475.38	fresh rock (above GAS)
	655XC11G	587749	9480260	601.73	90	0.3	40	57.31	17.31	40	70	30	12.83	588.9	fresh rock (above GAS)
Ok Binai 3 (Pineapple Ridge)	503XC10G	594777	9480285	262.38	90	0.57	11.9	35.1	23.2	11.9	49.9	38	30.66	231.72	weathered rock
	455XC10G	595117	9480075	331.33	90	1.22	2.2	8	5.8	2.2	150	147.8	43.21	288.12	fresh rock (above GAS)
	458XC10G	594841	9480161	248.54	90		11.9	35.1	23.2	11.9	49.9	38	dry hole		fresh rock (above GAS)
	463XC10G	595428	9480112	305.97	90	0.9	11.9	35.1	23.2	11.9	49.9	38	25.1	280.87	fresh rock (above GAS)
	493XC10G	595098	9480212	282.28	90	0.73	11.9	35.1	23.2	11.9	49.9	38	19.34	262.94	fresh rock (above GAS)
	499XC10G	595051	9480320	247.07	90	0.49	11.9	35.1	23.2	11.9	49.9	38	10.96	236.11	fresh rock (above GAS)
	511XC10G	594850	9480382	226.68	90	0.49	11.9	35.1	23.2	11.9	49.9	38	34.11	192.57	fresh rock (above GAS)
	546XC11G	594891	9480057	269.3	90	1	60	83.2	23.2	60	150.5	90.5	12.52	256.78	fresh rock (above GAS)

Location	Hole ID	Easting	Northing	Elevation (RL m)	Dip	Stick up (maGL)	Screen interval			Gravel pack / open hole			Standing water level		Unit
							top (mbGL)	base (mbGL)	length (m)	top (mbGL)	base (mbGL)	length (m)	mbGL	RL m	
Ok Binai 3 Camp	485XC10G	595309.	9480694	184.28	90	0.71	2.2	8	5.8	2.2	103.4	101.2	21.24	163.04	weathered rock
	556XC11G	595274	9480442	185.98	90	0.56	2.2	8	5.8	2.2	100	97.8	40.05	145.93	weathered rock
	441XC10G	595290	9480557	145.64	90	0.62	2.2	8	5.8	2.2	80	77.8	13.82	131.82	fresh rock (above GAS)
	444XC10G	595487	9480598	162.01	90	0.95	2.2	8	5.8	2.2	100	97.8	3.92	158.09	fresh rock (above GAS)
	445XC10G	595431	9480462	161.37	90	0.68	2.2	8	5.8	2.2	100	97.8	18.74	142.63	fresh rock (above GAS)
	447XC10G	595466	9480368	162.76	90	0.79	2.2	8	5.8	2.2	100	97.8	7.37	155.39	fresh rock (above GAS)
	451XC10G	595666	9480788	267.73	90	0.76	2.2	8	5.8	2.2	100	97.8	19.91	247.82	fresh rock (above GAS)
	477XC10G	595246	9480473	177.91	90	1.14	2.2	8	5.8	2.2	100	97.8			fresh rock (above GAS)

Attachment B Existing VWP hydrographs



Date
01-Jul-09
01-Jul-10
01-Jul-11
30-Jun-12
01-Jul-13
01-Jul-14
01-Jul-15
600
550
500
450
400
Pore pressure (mAHD)
484XC10A - fresh rock (above GAS)
484XC10B - fresh rock (above GAS)



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01-Jul-09
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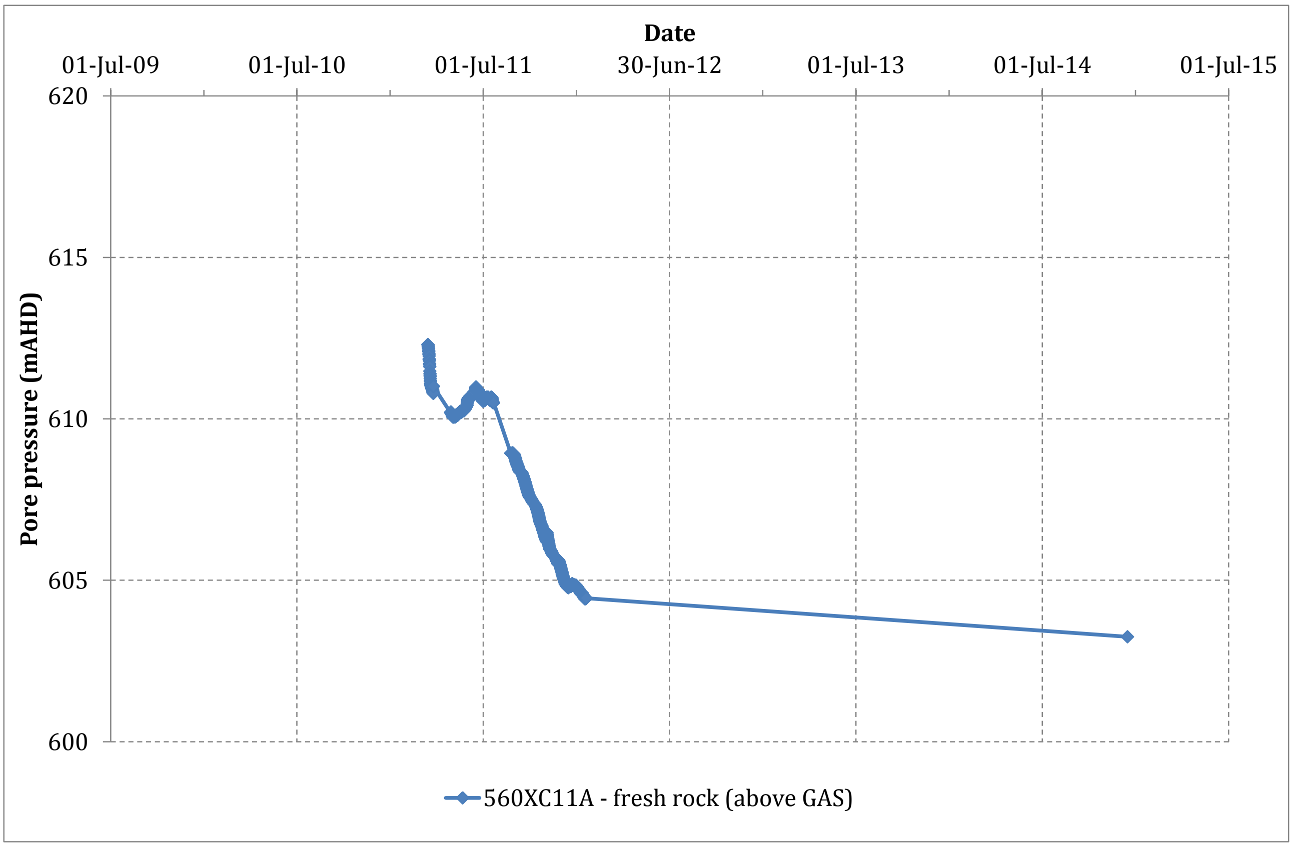
01-Jul-11
30-Jun-12
01-Jul-13
01-Jul-14
01-Jul-15
560
558
556
554
552
550
Pore pressure (mAHD)
549XC11A - fresh rock (below GAS)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30-Jun-12
01-Jul-13
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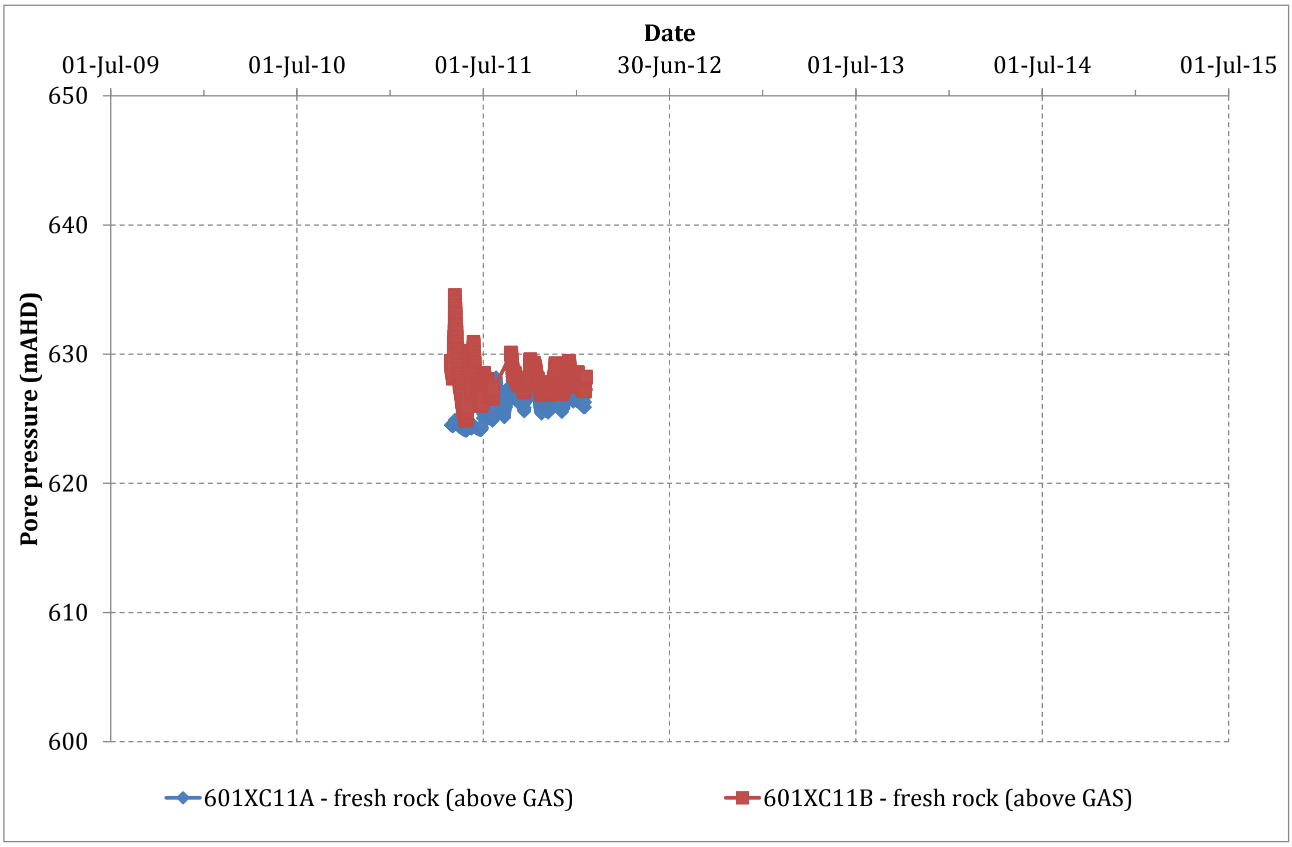
01-Jul-15
Pore pressure (mAHD)
620
615
610
605
600
560XC11A - fresh rock (above GAS)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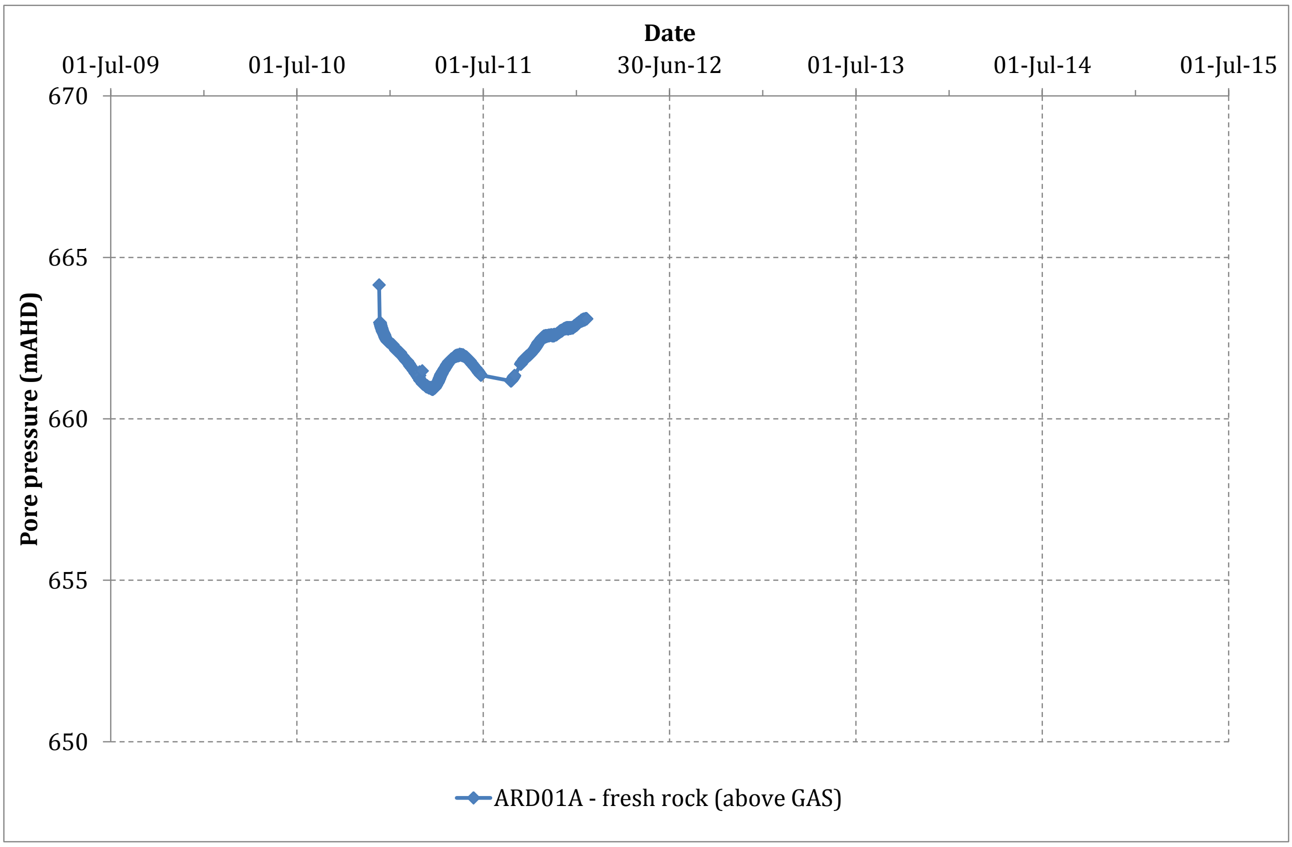
01-Jul-15
Pore pressure (mAHD)
650
640
630
620
610
600
601XC11A - fresh rock (above GAS)
601XC11B - fresh rock (above GAS)



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01-Jul-11
30-Jun-12
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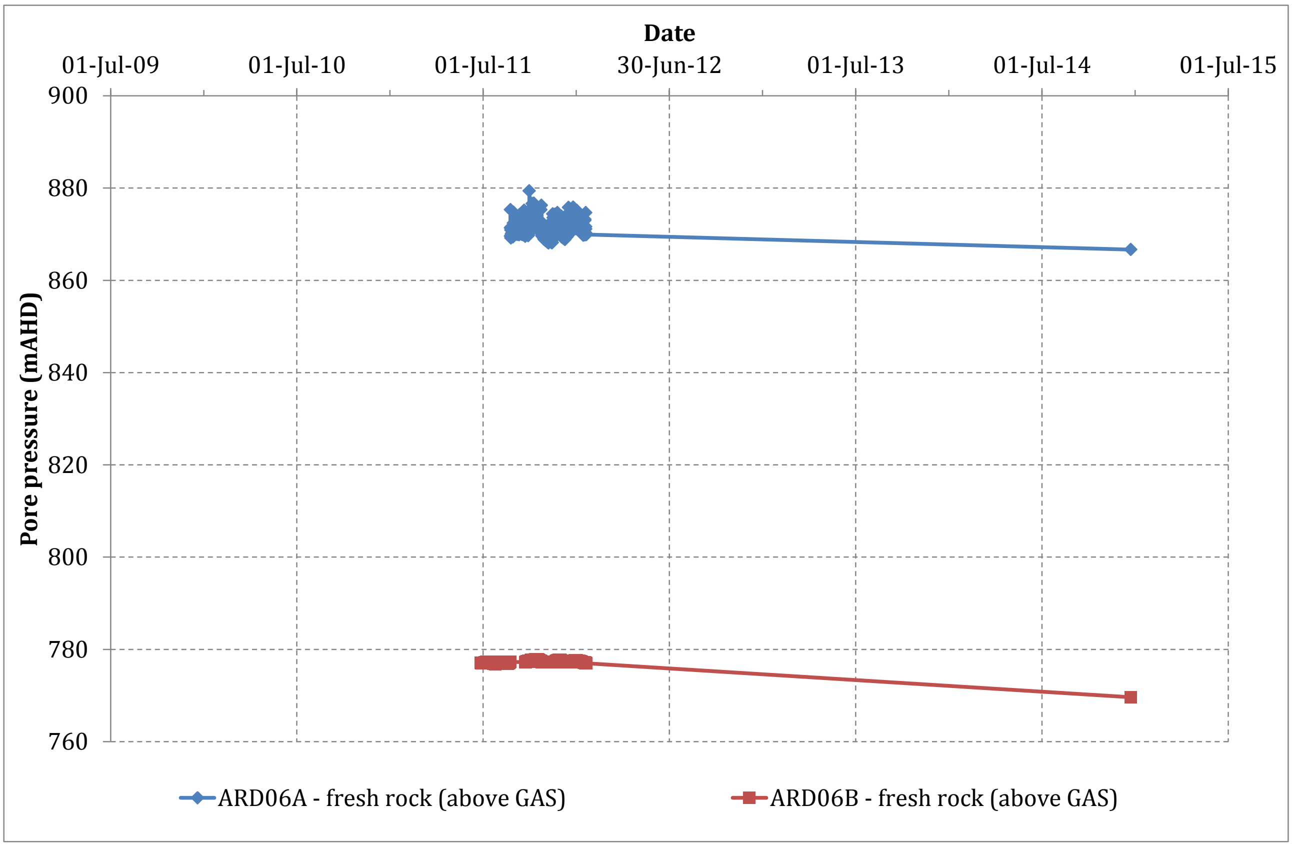
01-Jul-14
01-Jul-15
670
665
660
655
650
Pore pressure (mAHD)
ARD01A - fresh rock (above GAS)



Date
01-Jul-09
01-Jul-10
01-Jul-11
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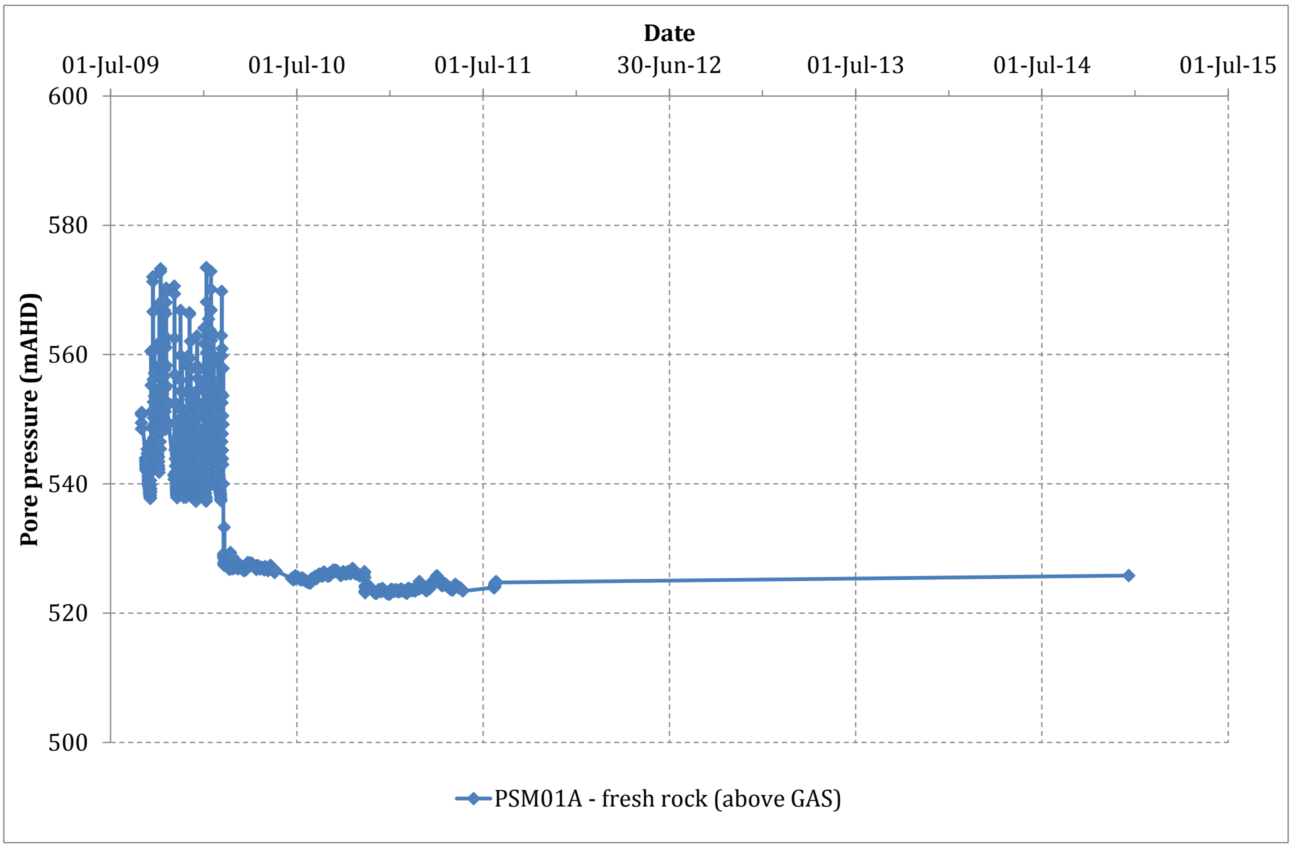
01-Jul-13
01-Jul-14
01-Jul-15
900
880
860
840
820
800
780
760
Pore pressure (mAHD)
ARD06A - fresh rock (above GAS)
ARD06B - fresh rock (above GAS)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01-Jul-14
01-Jul-15
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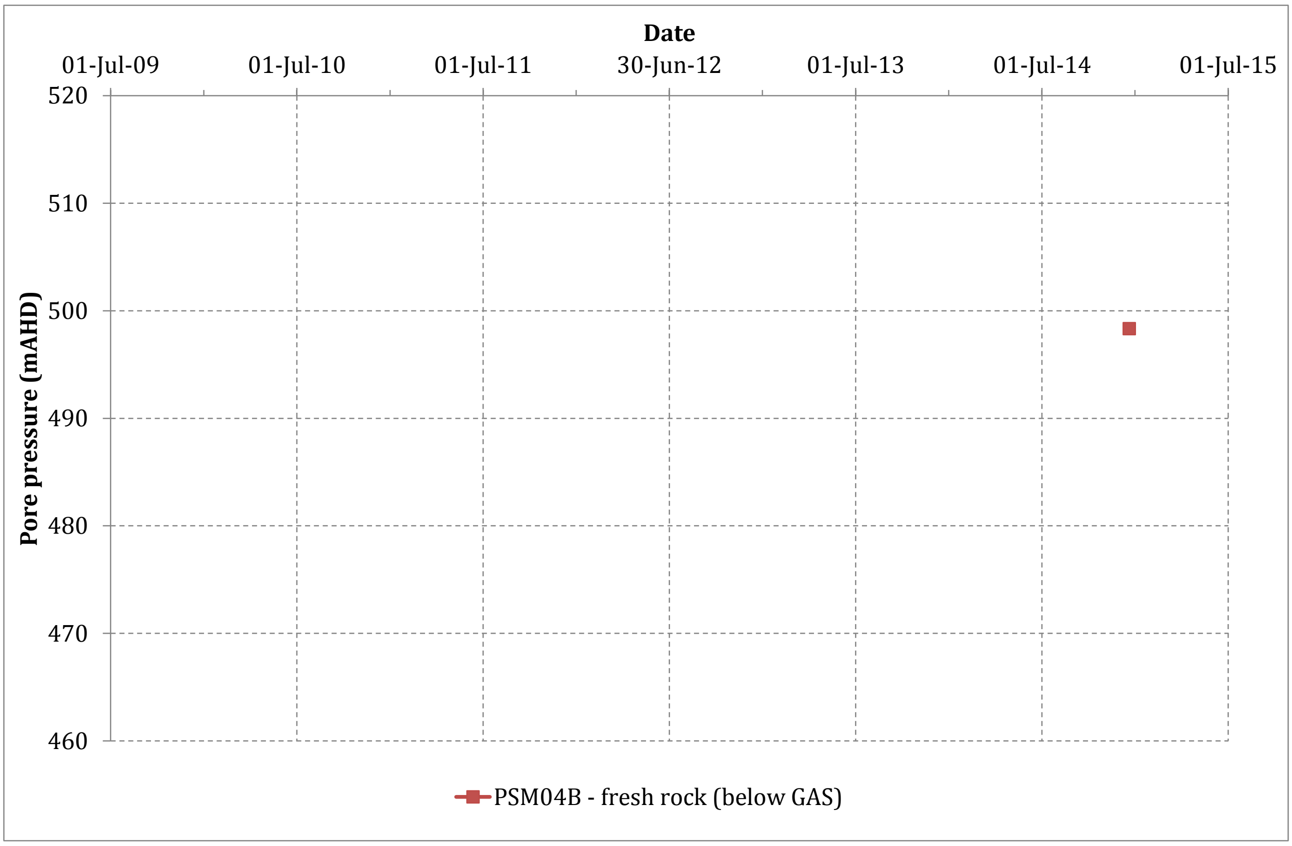
580
560
540
520
500
Pore pressure (mAHD)
PSM01A - fresh rock (above GAS)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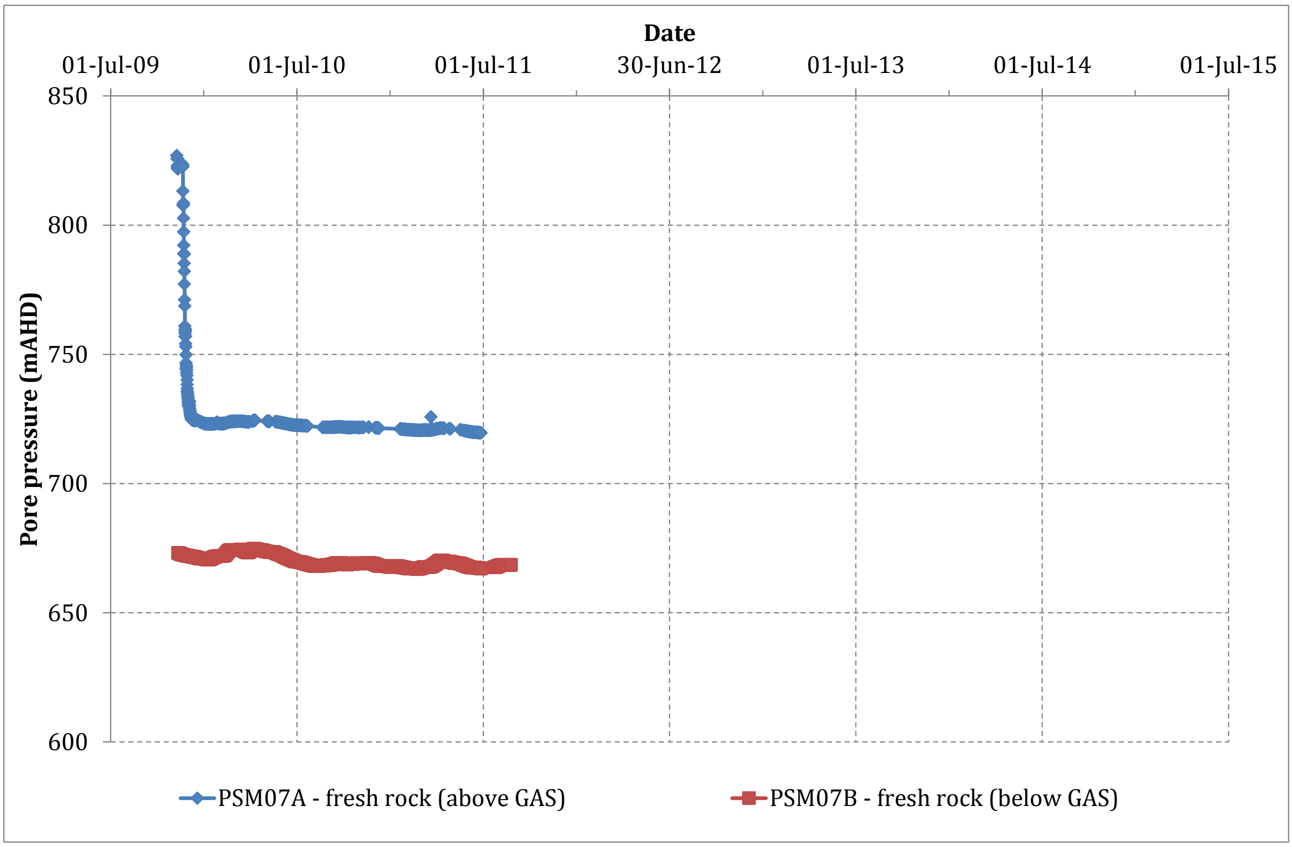
520
510
500
490
480
470
460
Pore pressure (mAHD)
PSM04B - fresh rock (below GAS)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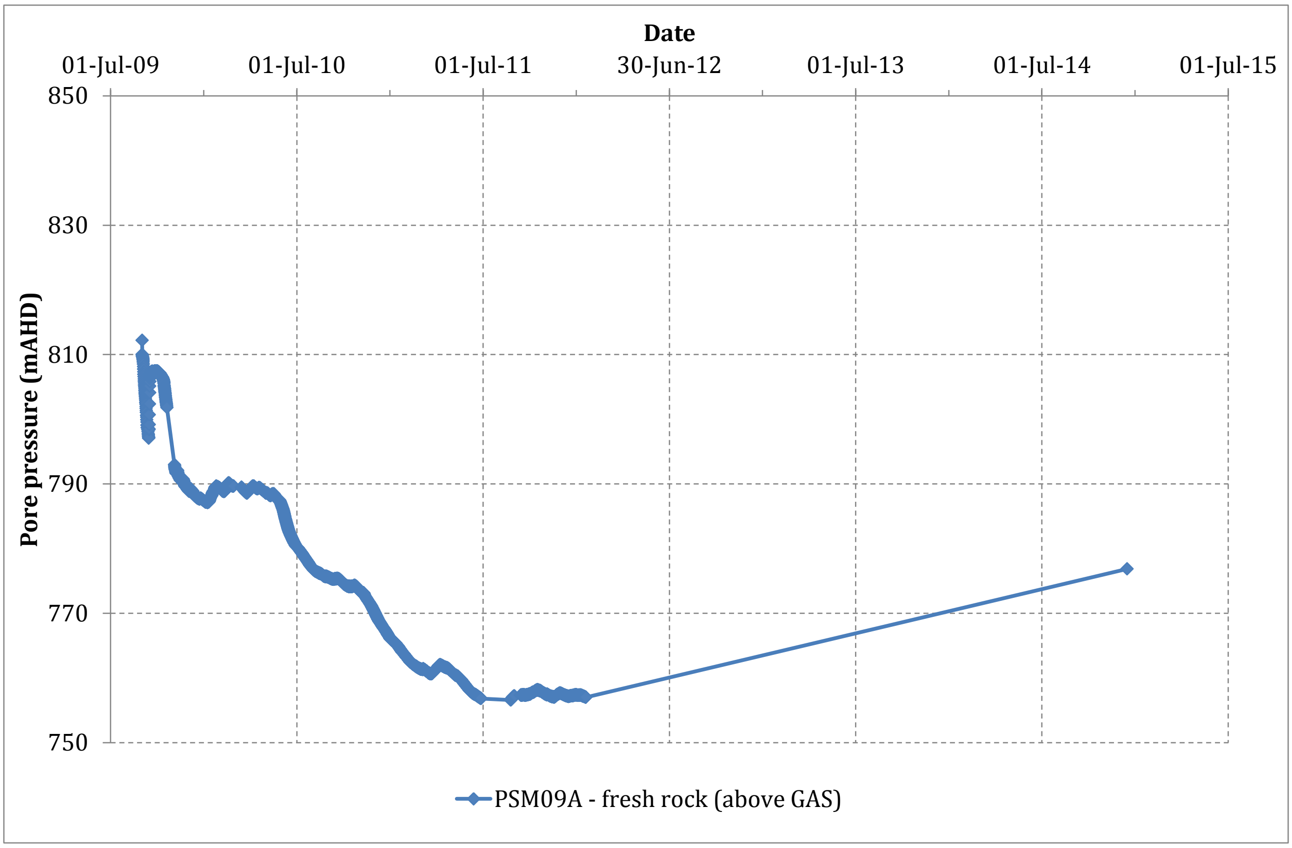
01-Jul-14
01-Jul-15
850
800
750
700
650
600
Pore pressure (mAHD)
PSM07A - fresh rock (above GAS)
PSM07B - fresh rock (below GAS)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01-Jul-15
850
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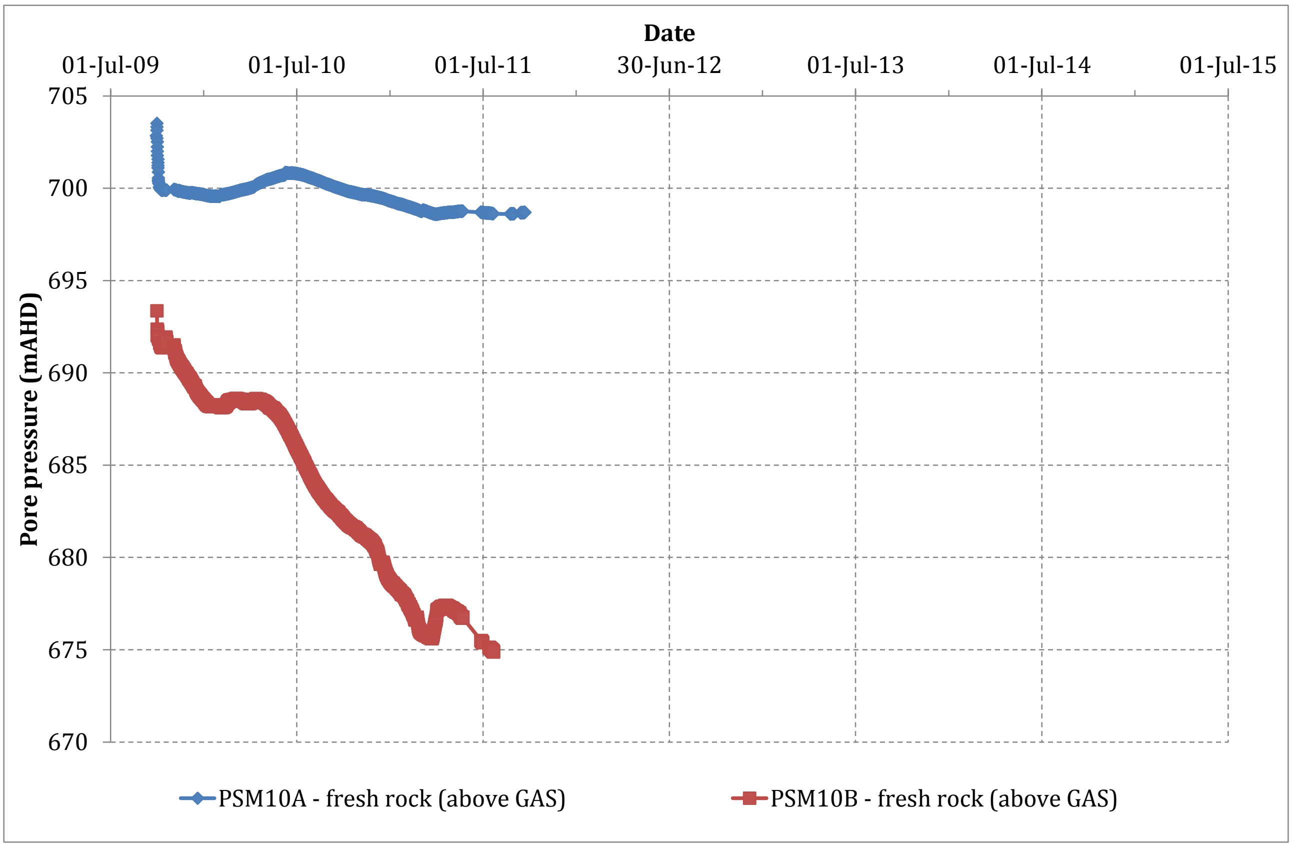
810
790
770
750
Pore pressure (mAHD)
PSM09A - fresh rock (above GAS)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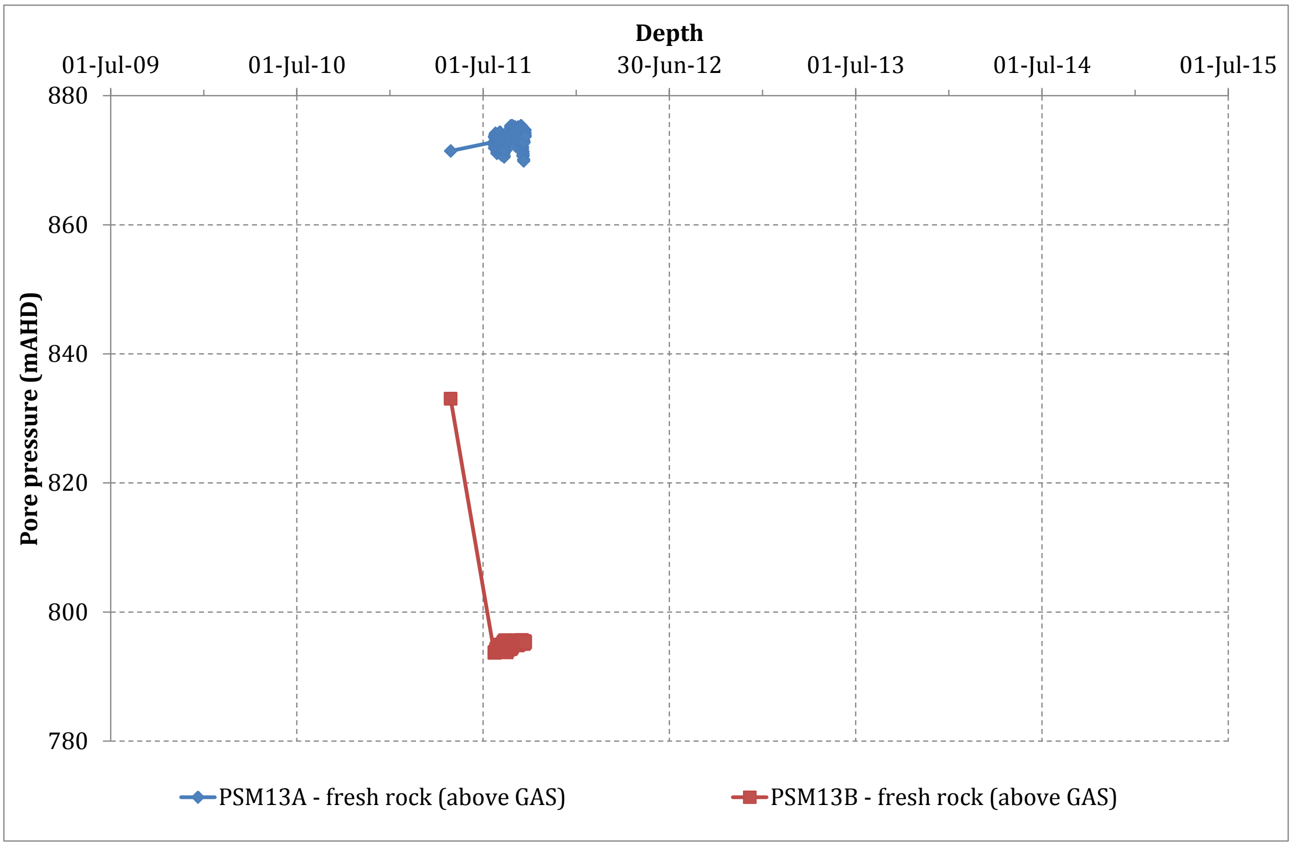
01-Jul-13
01-Jul-14
01-Jul-15
705
700
695
690
685
680
675
670
Pore pressure (mAHD)
PSM10A - fresh rock (above GAS)
PSM10B - fresh rock (above GAS)


Depth
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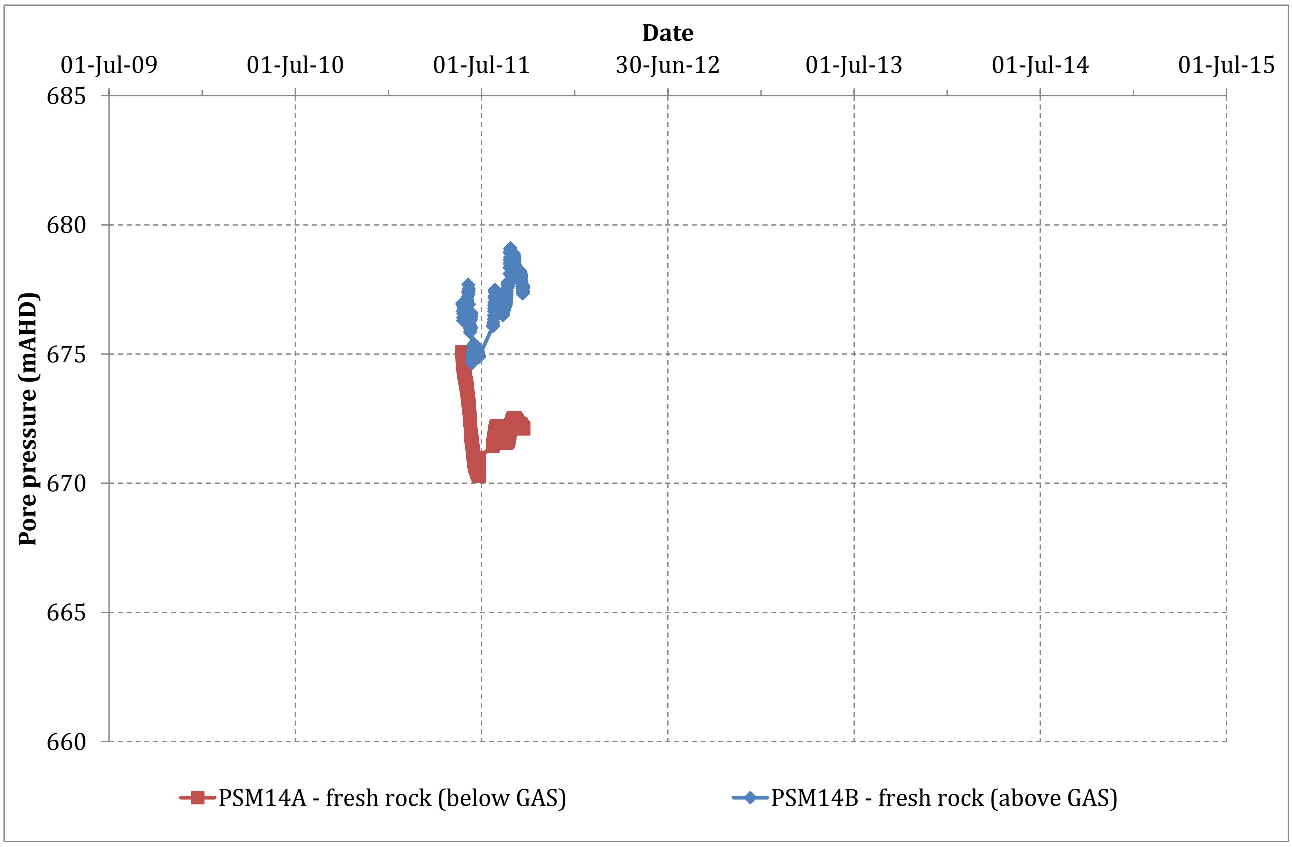
01-Jul-10
01-Jul-11
30-Jun-12
01-Jul-13
01-Jul-14
01-Jul-15
880
860
840
820
800
780
Pore pressure (mAHD)
PSM13A - fresh rock (above GAS)
PSM13B - fresh rock (above GAS)


Date
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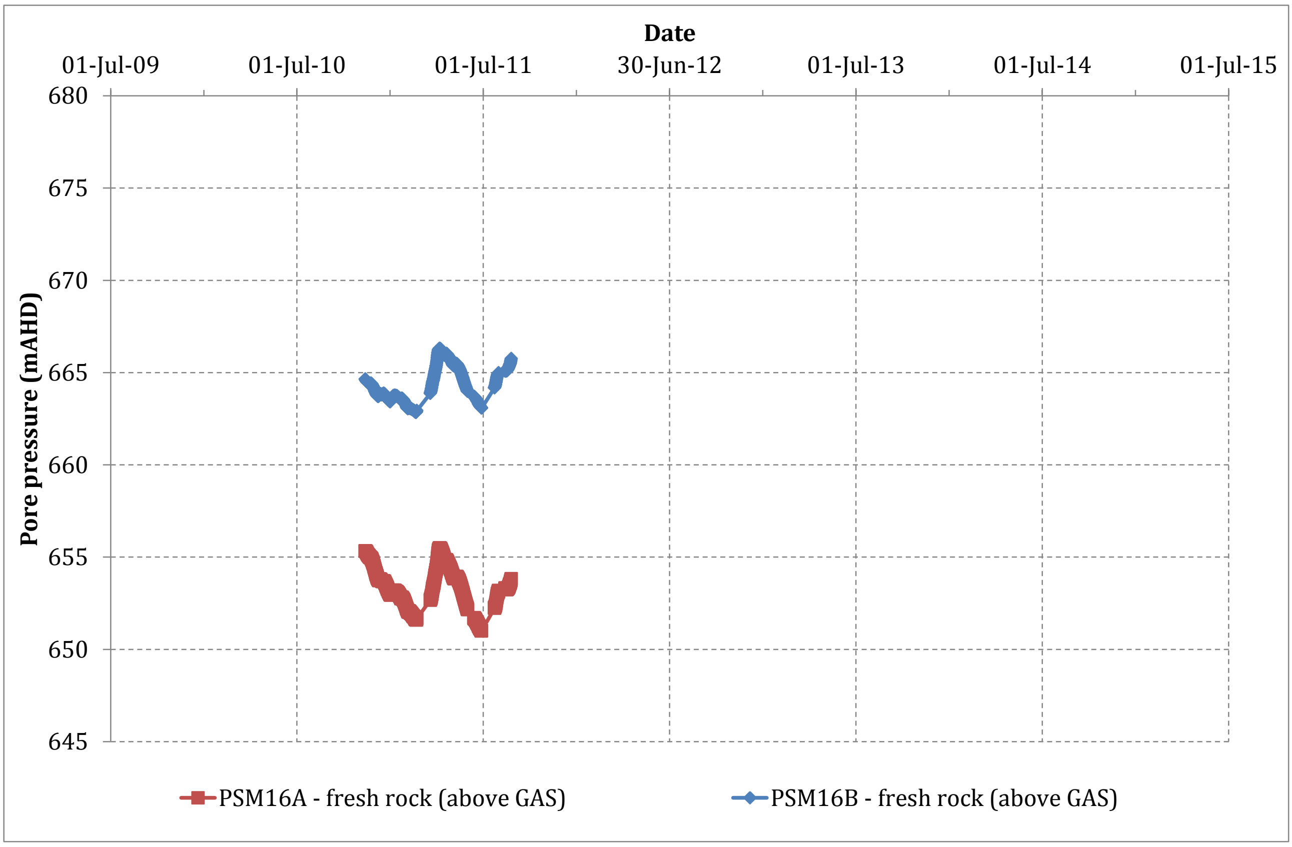
01-Jul-14
01-Jul-15
Pore pressure (mAHD)
685
680
675
670
665
660
PSM14A - fresh rock (below GAS)
PSM14B - fresh rock (above GAS)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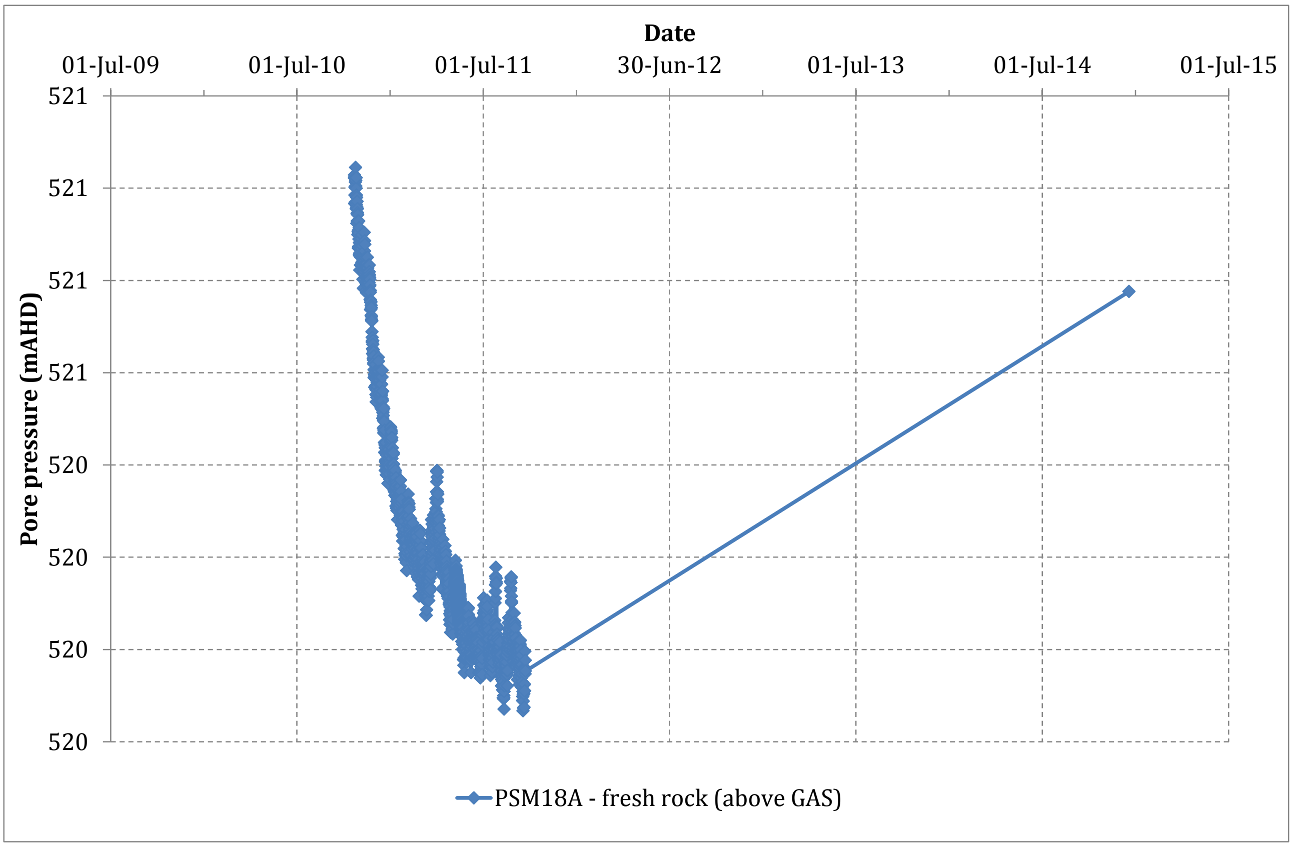
01-Jul-15
Pore pressure (mAHD)
680
675
670
665
660
655
650
645
PSM16A - fresh rock (above GAS)
PSM16B - fresh rock (above GAS)


Date
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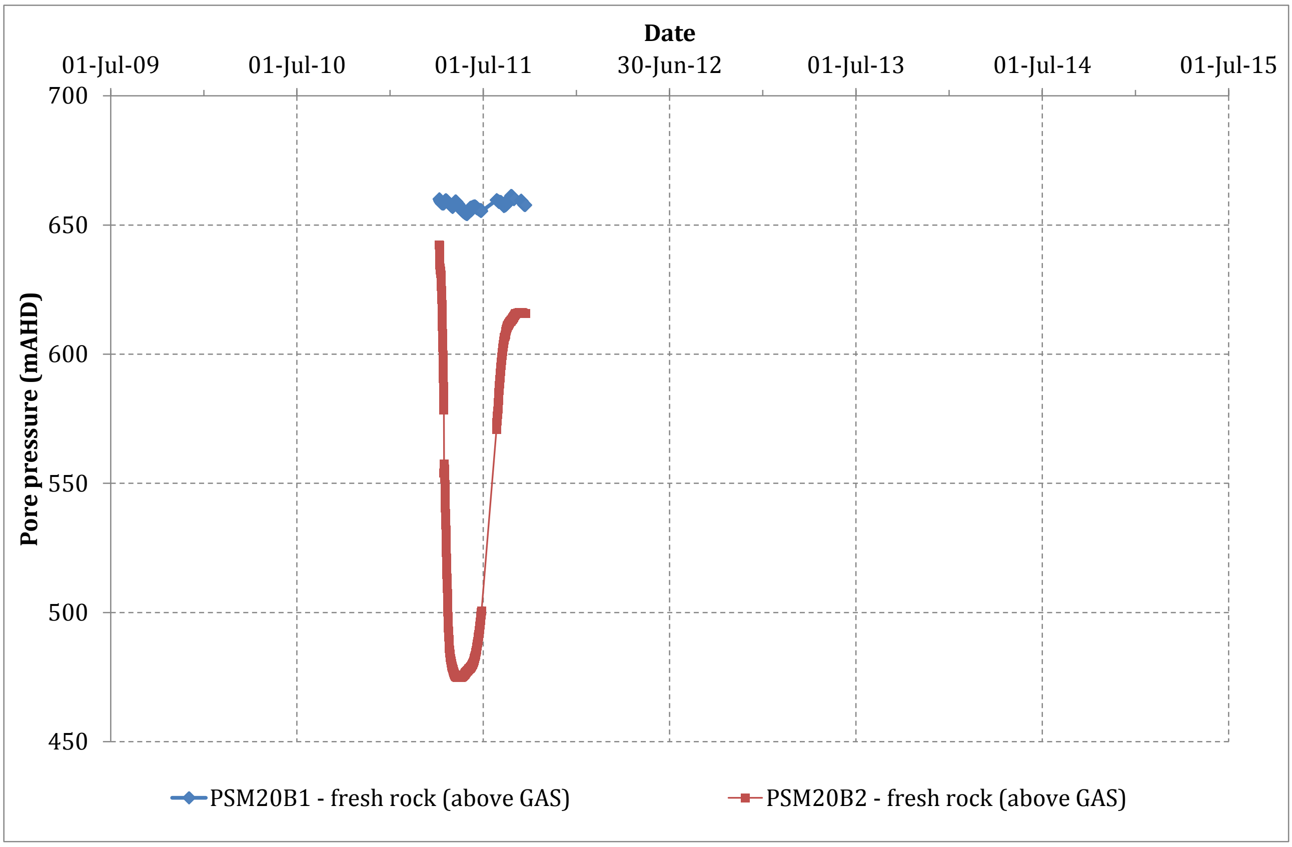
01-Jul-13
01-Jul-14
01-Jul-15
Pore pressure (mAHD)
521
521
521
521
520
520
520
520
PSM18A - fresh rock (above GAS)


Date
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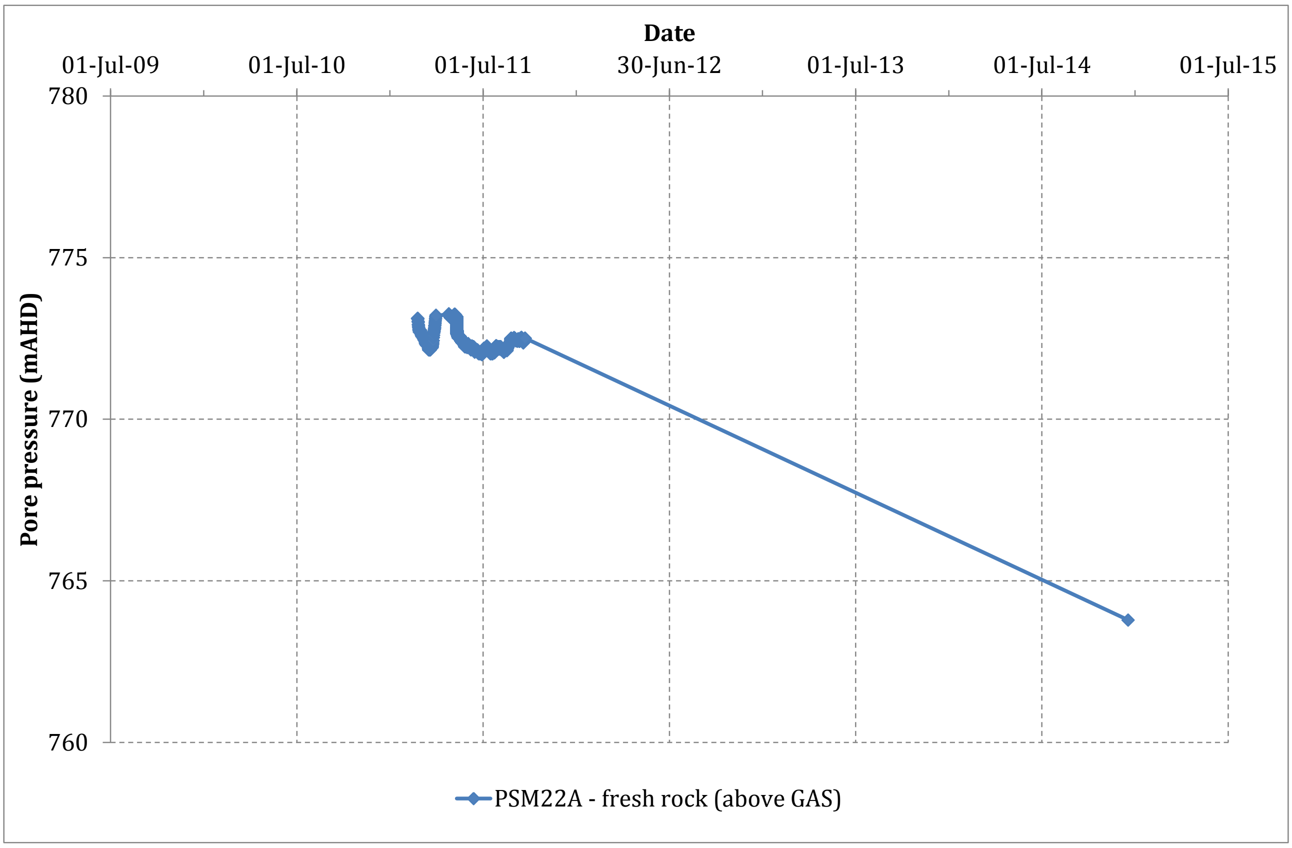
01-Jul-14
01-Jul-15
Pore pressure (mAHD)
700
650
600
550
500
450
PSM20B1 - fresh rock (above GAS)
PSM20B2 - fresh rock (above GAS)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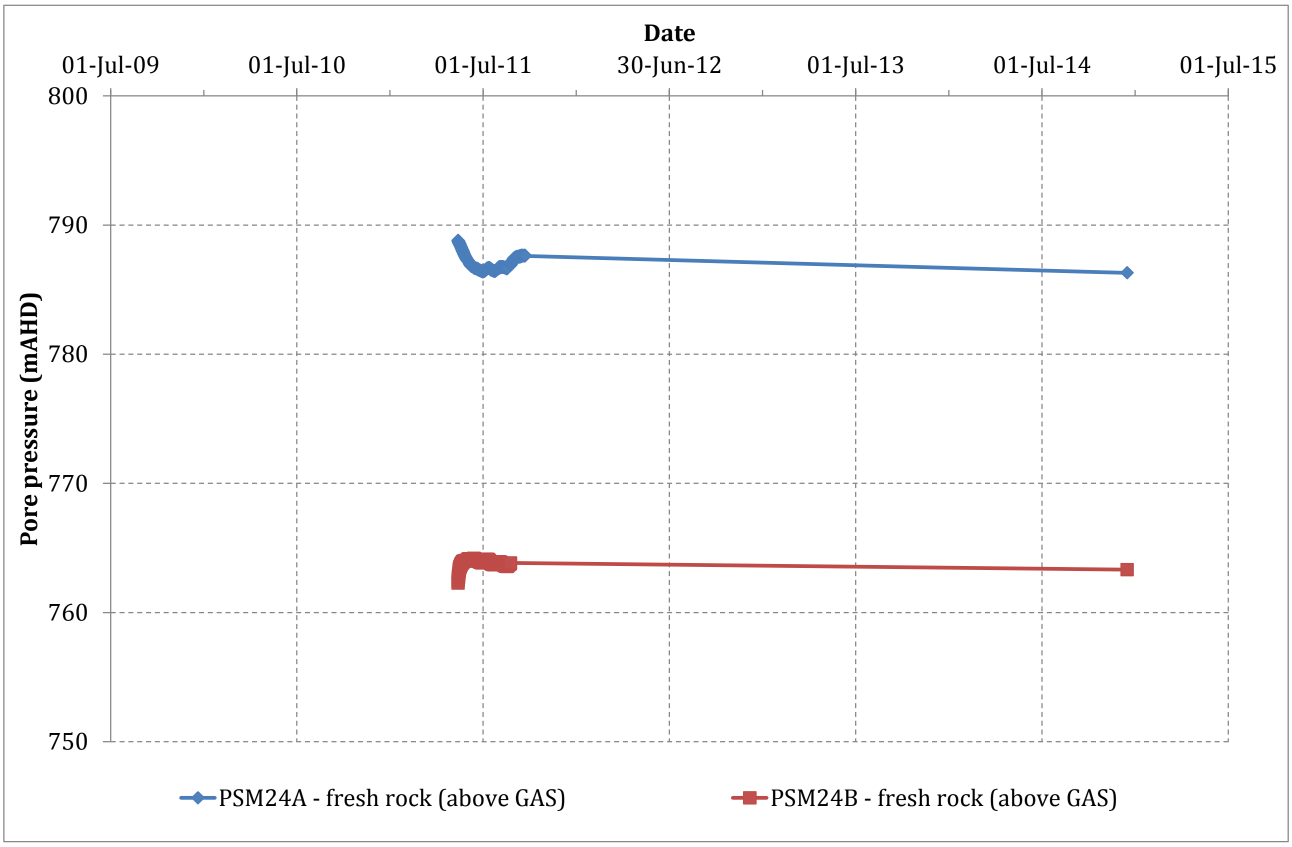
01-Jul-15
780
775
770
765
760
Pore pressure (mAHD)
PSM22A - fresh rock (above GAS)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01-Jul-14
01-Jul-15
800
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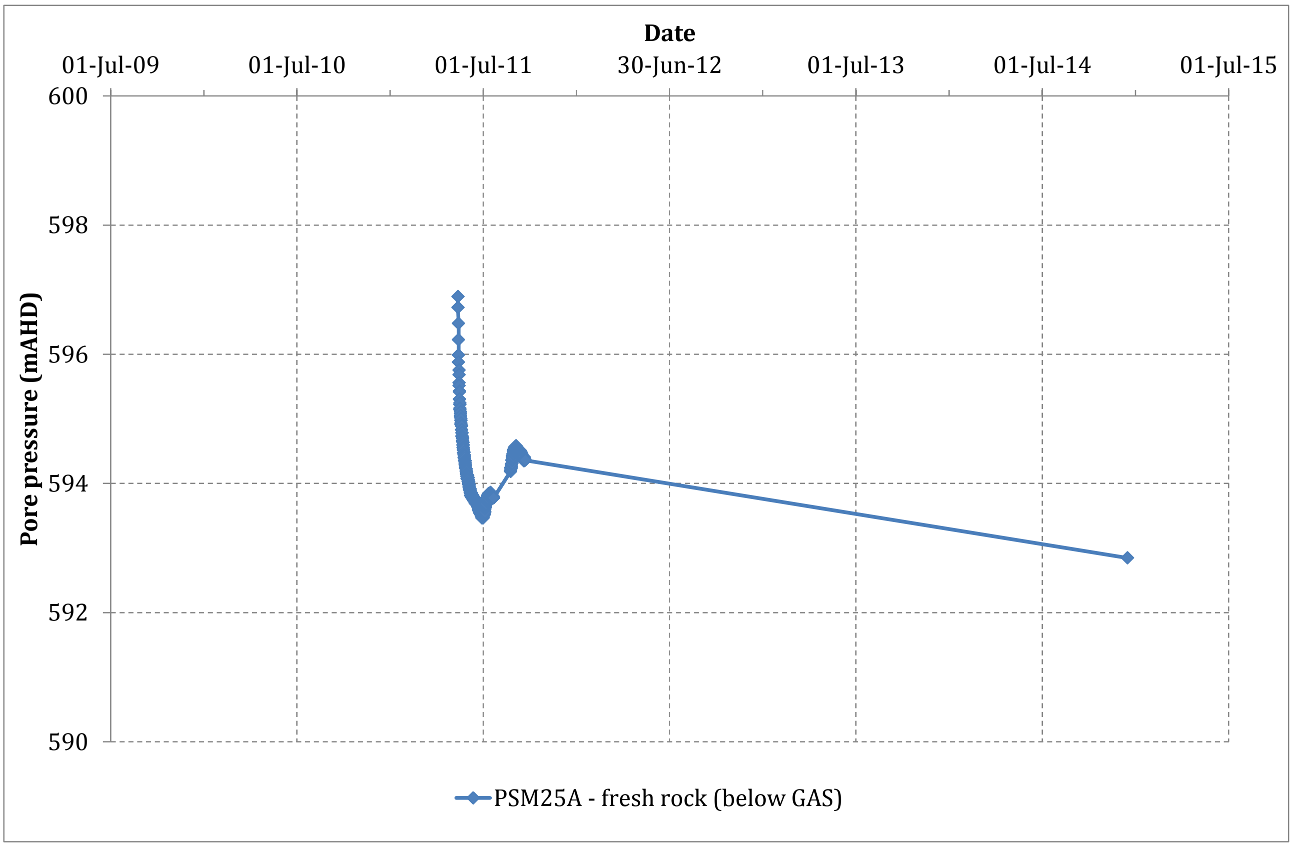
780
770
760
750
Pore pressure (mAHD)
PSM24A - fresh rock (above GAS)
PSM24B - fresh rock (above GAS)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01-Jul-14
01-Jul-15
600
598
596
594
592
590
Pore pressure (mAHD)
PSM25A - fresh rock (below GAS)

Appendix B Hydraulic testing

Attachments: A - Hydraulic conductivity data

B - Hydraulic conductivity test analysis sheets

B1 Methodology

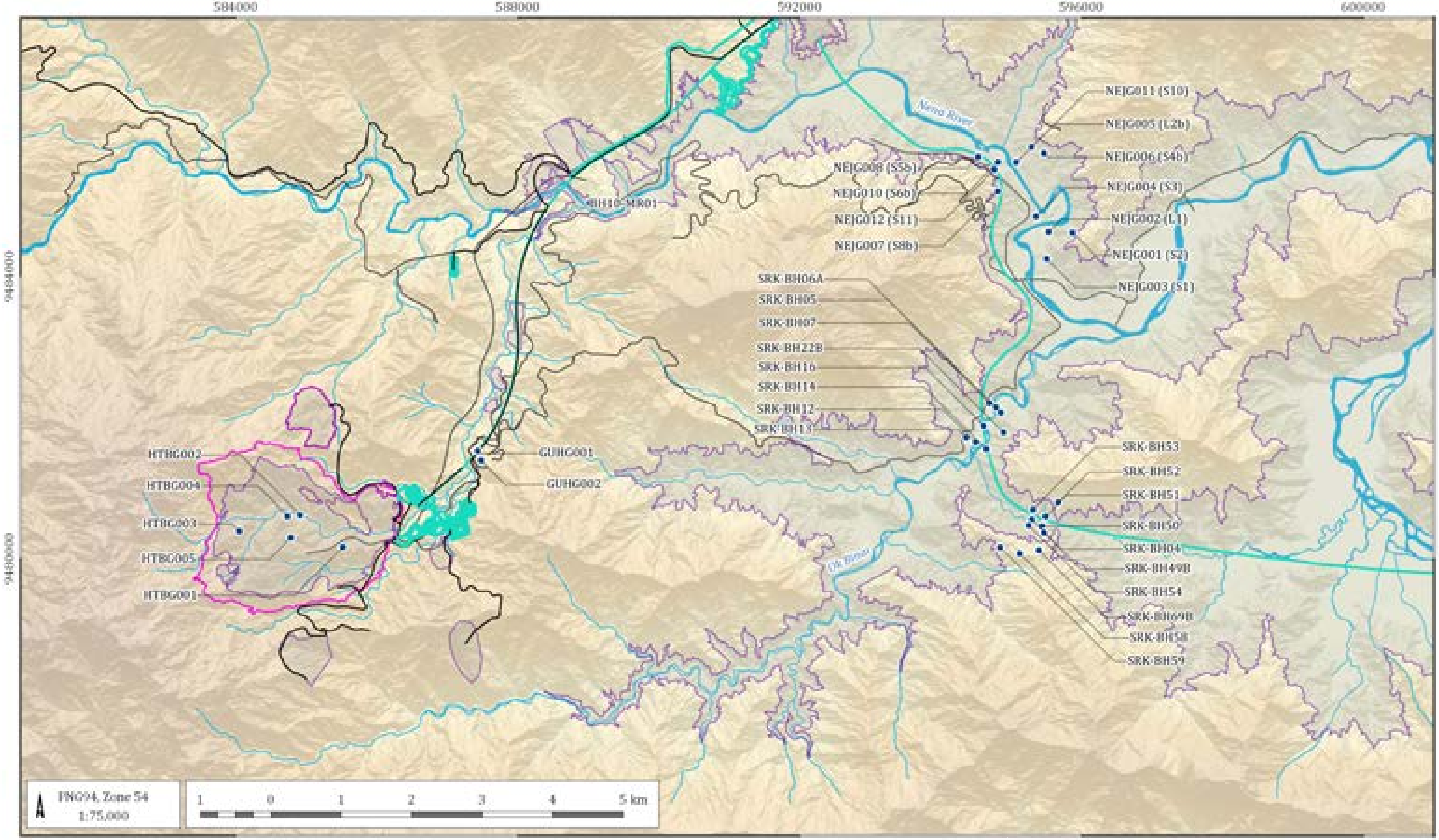
Geotech International conducted 108 in-situ hydraulic tests in five core holes between December 2014 and April 2015. Test methods used included packer tests and falling head tests, which are described in further detail below.

Table B 1.1 summarises the in-situ hydraulic testing conducted in each hole. Attachment A presents the test details for each zone and the calculated hydraulic conductivity. Attachment B contains the raw data for each packer test zone. Figure B 1.1 presents the location of all holes where hydraulic data was collected.

Table B 1.1 Summary of EIS hydraulic testing program

Hole ID	Total no. of tests	No. of successful tests	falling head tests	packer tests	No. of tests per unit				Comments
					alluvium / colluvium	weathered rock	fresh rock (above GpAh)	fresh rock (below GpAh)	
HTBG001	20	19	7	12	2	4	9	4	upper 130 m was unsuitable for packer testing due to ground conditions.
HTBG002	21	20	2	18	1	2	14	3	a falling head test and packer test were completed across one interval
HTBG003	23	23	4	19	1	5	17	0	falling head tests and packer tests were completed across three intervals
HTBG004	19	19	0	19	0	3	10	6	no falling head tests completed
HTBG004	25	25	0	25	0	1	13	11	no falling head tests completed
Total	**108**	**106**	**13**	**93**	**4**	**15**	**63**	**24**	

***Notes**: GpAh - gypsum anhydrite zone*



LEGEND

- Open pit
- FRHEP / ISF extent
- Drainage
- Mining infrastructures
- Road (proposed)
- • Hydraulic test location

Sepik Development Project (I1051A)

AGE

Hydraulic test locations

DATE
19/07/2018

FIGURE No:
B - 1.1

B1.1 Packer tests

The packer tests were completed using the following methodology:

- each test was completed with a GeoPro wireline single packer in a HQ hole;
- packer tests were completed concurrently with drilling - when a suitable test interval was identified, drilling was suspended, the hole was flushed with fresh water, and the water level allowed to stabilise;
- the specific test interval was selected by on-site personnel and AGE provided feedback throughout the drilling program on the number and location of test intervals;
- packer inflation pressures were calculated by Geotech International depending on the hydrostatic pressure for each test; and
- each test was conducted in five stages, with the water pressure changing during each step.

The pressure for each step was calculated as a percentage of the maximum test pressure (Pmax). Table B 1.2 presents the pressure step relative to the maximum pressure for a given test depth (Pmax).

Table B 1.2 Pressure steps for packer tests

Test stage	Pressure step
1	0.5 x Pmax
2	0.75 x Pmax
3	Maximum pressure (Pmax)
4	0.75 x Pmax
5	0.5 x Pmax

Note: *Pmax is defined as the maximum pressure which does not exceed the in-situ confinement stress.*

The raw data was analysed by Geotech International to calculate an averaged Lugeon value. Each test was then reviewed by AGE using the interpretation procedure detailed by Houlsby (1976). Lugeon values were converted to a hydraulic conductivity value by AGE. Under ideal homogeneous and isotropic conditions, one lugeon is equivalent to a hydraulic conductivity value of 1.3 x 10^{-5} cm/sec (Fell *et al*., 2005).

B1.2 Falling head tests

Falling head tests were completed using the following methodology:

- where the ground conditions were not suitable to adequately seat the packer assembly, a falling head test was carried out;
- the HQ steel casing was pulled back above the selected test interval and the hole flushed with fresh water - the test intervals ranged from 2.2 m to 12.3 m;
- before each test the water level was allowed to stabilise and the initial standing water level was recorded;
- water was gravity fed from a large tank at each site for up to 10 seconds or until the hole was filled; and
- the water level during the test was recorded using a pressure transducer.

The falling head test data was analysed by AGE using Aquifer Test 2011.1 software (Schlumberger Water Services, 2011) to calculate the hydraulic conductivity of the test interval. Two methods were used to analyse the data depending on the aquifer type and the response from the test. The Bouwer and Rice (1976) method was used for unconfined conditions, and the Hvorslev method (1953) was used for confined systems. Attachment B contains the raw data and analysis of each falling head test.

Both falling head tests and packer tests were completed across four intervals in holes HTBG002 and HTBG003 to compare the estimated hydraulic conductivity. Section B3.1 discusses the results of this testing further.

B2 Other hydraulic testing data

To supplement the hydraulic testing data collected during the current field program, hydraulic conductivity data was collated from previous geotechnical investigations at the former integrated storage facility (ISF), along with the proposed ISF in the Nena Creek catchment. This data was collected by SRK. Table B 2.1 summarises the tests completed at each site. Figure B 1.1 presents the location of the SRK holes, and Attachment A presents the details and hydraulic conductivity data for each test.

Table B 2.1 ISF hydraulic conductivity data (after SRK)

Site	Date	No. of holes	Unit	Total no. of tests
Former Ok Binai ISF	2010 - 2011	20	alluvium / colluvium	36
			weathered rock	20
			fresh rock (above GpAh)	140
			fresh rock (below GpAh)	0
Nena ISF	2015	13	alluvium / colluvium	0
			weathered rock	3
			fresh rock (above GpAh)	15
			fresh rock (below GpAh)	0
Total		**33**		**214**

B2.1 Nena ISF data

SRK completed a geotechnical investigation for the proposed ISF located within the Nena Creek catchment approximately 11 km northeast of the proposed open-pits. The program ran concurrently with the AGE/PSM investigation and test methods included falling head, single packer and shut-in tests. The SRK field program was on going at the time of writing this report. A total of 18 tests from 13 holes were used in this assessment.

B2.2 Former Ok Binai ISF data

Geotechnical investigations at the site of the former Ok Binai ISF included 196 packer tests in 20 holes. The holes were tested between July 2010 and April 2011 on the completion of drilling each hole.

B3 Hydraulic conductivity data

Table B 3.1 summarises the hydraulic conductivity results for each geological unit. Whilst the results vary significantly within each unit, there is a general trend of hydraulic conductivity decreasing with depth. Statistical bounds of hydraulic conductivity have been calculated for four units including alluvium, weathered zone, above the GpAh, and below the GpAh. The geometric mean, 20th percentile, and 80th percentile bounds are presented in Table B 3.1.

Figure B 3.1 shows the hydraulic conductivity data versus depth grouped into four basic geological units and highlights how results can vary several orders of magnitude.

Table B 3.1 Summary of hydraulic conductivity data

Unit	No. of data points	Hydraulic conductivity (m/day)				
		Min.	Max.	20th percentile	80th percentile	Geomean
alluvium / colluvium	40	6.0×10^{-2}	24.0	0.3	4.9	1.02
weathered rock	39	6.0×10^{-4}	15.2	2.0×10^{-2}	1.1	0.15
fresh rock (above GpAh)	218	4.0×10^{-5}	7.31	2.0×10^{-3}	0.14	1.7×10^{-2}
fresh rock (below GpAh)	24	1.0×10^{-5}	0.14	1.0×10^{-4}	0.01	6.9×10^{-4}
Total	**321**					

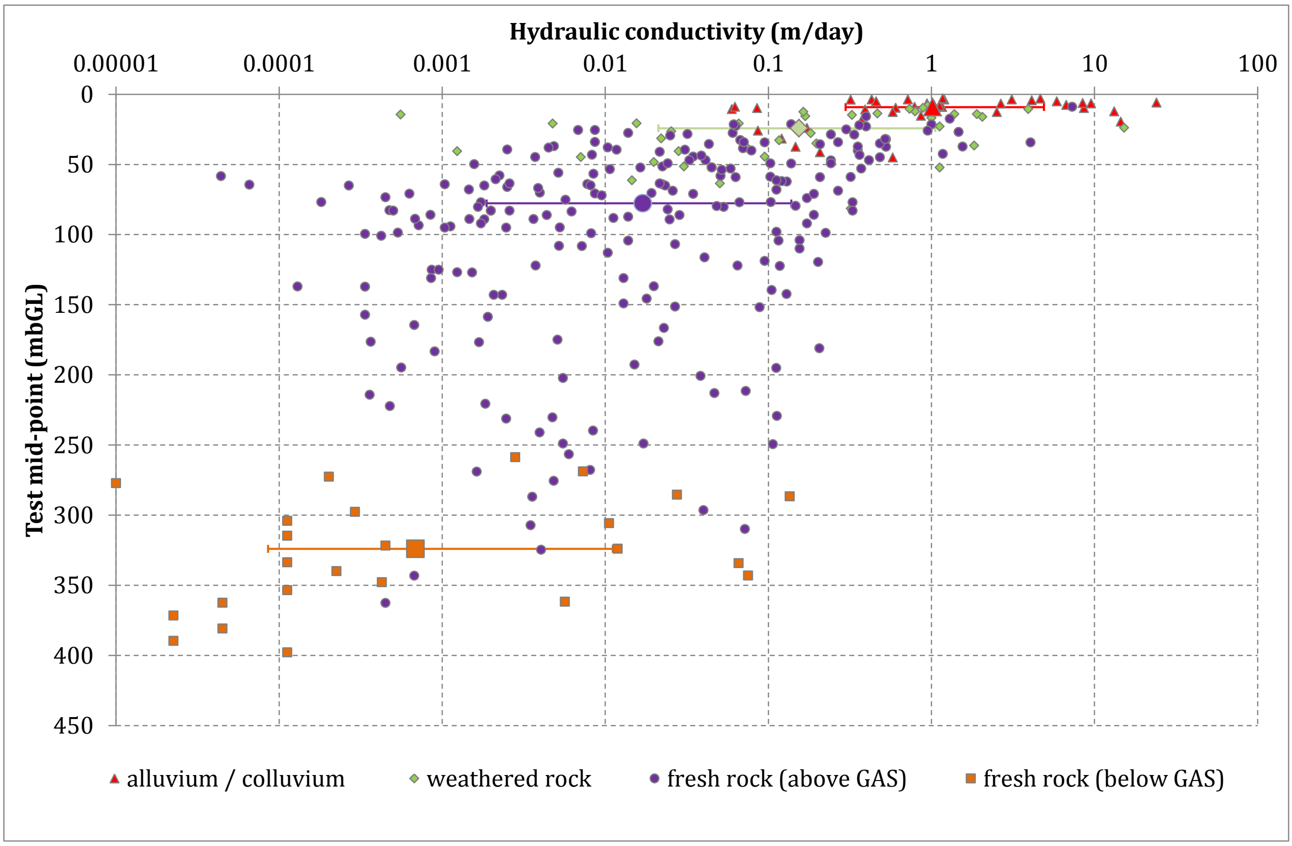


Figure B 3.1 Hydraulic conductivity of each unit

An attempt was made to correlate the results of the packer test data with RQD data from the geotechnical logging, however, the correlation was poor. Comments provided by PSM suggest that the RQD data is generally not representative of the in-situ rock mass. As the core is brought to the surface the confining stress on the rock mass is released and core tends to break apart. Therefore the use of RQD index to correlate against hydraulic conductivity was not suitable for this investigation.

B3.1 Comparison of falling head and packer test results

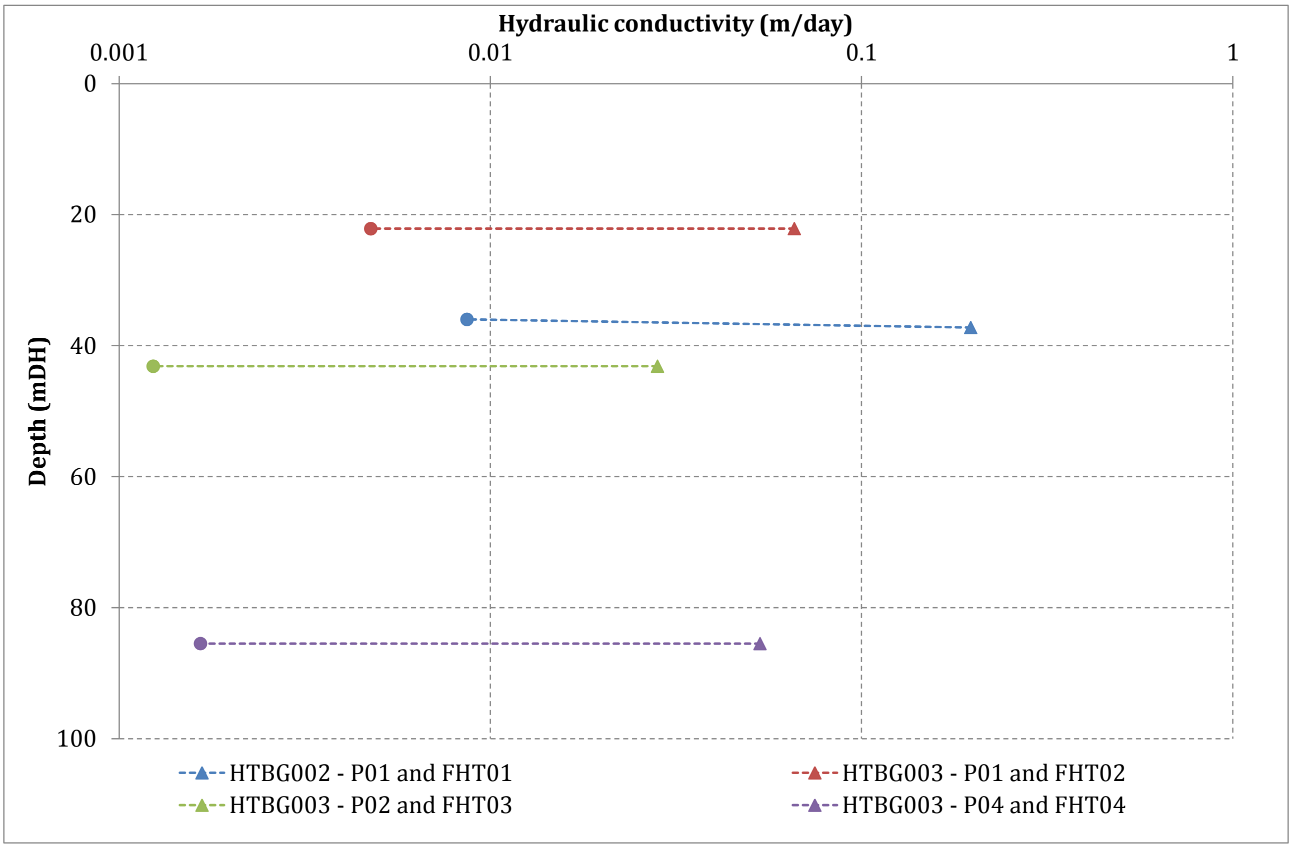
Table B 3.2 compares the hydraulic conductivity values calculated from the falling head test and packer tests conducted across the same zone.

Table B 3.2 Packer and falling head test results

Hole ID / test no.	Test type	Test interval (mDH)			Hydraulic conductivity (m/day)	Analysis method	Lithology[1]
		Top	Base	Interval (m)			
HTBG002 - P01 / FHT01	Packer	31.5	40.5	9.0	0.009	-	HMD
	FHT	34	40.5	6.5	0.2	Hvorslev	HMD
HTBG003 - P01 / FH02	Packer	17.4	26.9	9.5	0.005	-	HMD / FDM
	FHT	17.4	26.9	9.5	0.07	Bouwer & Rice	HMD / FDM
HTBG003 - P02 / FHT03	Packer	37	49.3	12.3	0.001	-	HMD
	FHT	37	49.3	12.3	0.03	Hvorslev	HMD
HTBG003 - P04 / FHT04	Packer	81.3	89.7	8.4	0.002	-	HMD
	FHT	81.3	89.7	8.4	0.05	Hvorslev	HMD

Notes: *[1]Horse Microdiorite (HMD), Frieda diorite porphyry (FDM)*
mDH – metres down hole
FHT – falling head test

Figure B 3.2 presents the difference between the packer test (circle) and falling head test (triangle) data for each interval. The packer test results are consistently an order of magnitude lower than the equivalent falling head test data. This trend is likely related to the larger zone influenced by the packer tests, and therefore the hydraulic conductivity value estimated by this method is considered more representative of the rock mass.



Note: *circles represent packer test data and triangles represent falling head data*

Figure B 3.2 Comparison between falling head and packer test data

B4 References

Bouwer, H., and Rice, R.C., (1976) "*A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells*", Water Resources Research, vol. 12, no. 3, pp. 423-428.

Fell R., MacGregor P., Stapledon D. and Bell G, (2005) "*Geotechnical Engineering of Dams*" A.A. Balkema Publishers.

Houlsby, A.C., (1976) "*Routine interpretation of the lugeon water test*", Quarterly Journal of Engineering Geology, Vol. 9, pp. 303 - 313.

Hvorslev, M.J., (1951). "*Time lag and soil permeability in groundwater observations: Vicksberg, Miss*"., U.S. Army Corps of Engineers, Waterways Experiment Station, Bulletin 36, 50 p. TIC#238956.

Schlumberger Water Services (2011), "*Aquifer Test 2011.1*".

Attachment A Hydraulic conductivity data

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
HTBG001	585519	9480165	586.387	0	70	FHT0	FHT	3 - 5.2	2.8 - 4.9	0.32	0.32	-	alluvium / colluvium
HTBG001	585519	9480165	586.387	0	70	FHT1	FHT	6.5 - 12.5	6.1 - 11.7	0.06	0.08	-	alluvium / colluvium
HTBG001	585519	9480165	586.387	0	70	FHT2	FHT	25.1 - 31.1	23.6 - 29.2	0.19	0.25	-	weathered rock
HTBG001	585519	9480165	586.387	0	70	FHT3	FHT	44.3 - 50.4	41.6 - 47.4	0.07	0.09	-	weathered rock
HTBG001	585519	9480165	586.387	0	70	FHT4	FHT	64.7 - 70.7	60.8 - 66.4	0.04	0.05	-	weathered rock
HTBG001	585519	9480165	586.387	0	70	FHT5	FHT	83.6 - 89.7	78.6 - 84.3		0.32		fresh rock (above GAS)
HTBG001	585519	9480165	586.387	0	70	FHT6	FHT	104.4 - 110.4	98.1 - 103.7	Data inconclusive			fresh rock (above GAS)
HTBG001	585519	9480165	586.387	0	70	FHT7	FHT	124.3 - 130.3	116.8 - 122.4	0.16	0.20	-	fresh rock (above GAS)
HTBG001	585519	9480165	586.387	0	70	P1	PT	146 - 151	137.2 - 141.9			0.002	fresh rock (above GAS)
HTBG001	585519	9480165	586.387	0	70	P2	PT	157 - 166.1	147.5 - 156.1			0.0009	fresh rock (above GAS)
HTBG001	585519	9480165	586.387	0	70	P3	PT	183 - 192	172 - 180.4			0.0002	fresh rock (above GAS)
HTBG001	585519	9480165	586.387	0	70	P4	PT	200 - 210.1	187.9 - 197.4			0.0002	fresh rock (above GAS)
HTBG001	585519	9480165	586.387	0	70	P5	PT	220 - 230.1	206.7 - 216.2			0.0007	fresh rock (above GAS)
HTBG001	585519	9480165	586.387	0	70	P6	PT	238 - 250	223.6 - 234.9			0.001	fresh rock (above GAS)
HTBG001	585519	9480165	586.387	0	70	P7	PT	260 - 270	244.3 - 253.7			0.0004	fresh rock (above GAS)
HTBG001	585519	9480165	586.387	0	70	P8	PT	280 - 290	263.1 - 272.5			0.0004	fresh rock (above GAS)
HTBG001	585519	9480165	586.387	0	70	P9	PT	300 - 310	281.9 - 291.3			0.001	fresh rock (below GAS)
HTBG001	585519	9480165	586.387	0	70	P10	PT	320 - 330.6	300.7 - 310.7			0.0003	fresh rock (below GAS)
HTBG001	585519	9480165	586.387	0	70	P11	PT	340 - 349.5	319.5 - 328.4			0.0002	fresh rock (below GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
HTBG001	585519	9480165	586.387	0	70	P12	PT	360 - 370	338.3 - 347.7			0.0008	fresh rock (below GAS)
HTBG002	584909	9480617	588.75	30	65	FHT1	FHT	4.5 - 9.3	4.2 - 8.7	9.55	12.40	-	alluvium / colluvium
HTBG002	584909	9480617	588.75	30	65	P1	PT	31.5 - 40.5	29.6 - 38.1			0.00009	weathered rock
HTBG002	584909	9480617	588.75	30	65	FHT2	FHT	34 - 40.5	31.9 - 38.1	0.15	0.20	-	weathered rock
HTBG002	584909	9480617	588.75	30	65	P2	PT	50 - 63.8	47 - 60			0.0001	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P3	PT	73 - 83.3	68.6 - 78.3			0.00002	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P4	PT	96.2 - 106.2	90.4 - 99.8			0.0001	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P5	PT	109 - 121.2	102.4 - 113.9			0.00007	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P6	PT	127 - 143.3	119.3 - 134.7			0.00001	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P7	PT	150 - 161.3	141 - 151.6	Test failed - no flow			fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P8	PT	172.3 - 182.3	161.9 - 171.3			0.0001	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P9	PT	185 - 200.3	173.8 - 188.2			0.002	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P10	PT	207 - 220.2	194.5 - 206.9			0.0004	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P11	PT	230.6 - 242.6	216.7 - 228			0.000007	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P12	PT	251 - 262.2	235.9 - 246.4			0.0001	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P13	PT	266 - 280.2	250 - 263.3			0.0001	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P14	PT	285.8 - 300.8	268.6 - 282.7			0.00009	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P15	PT	310.5 - 320.5	291.8 - 301.2			0.0004	fresh rock (above GAS)
HTBG002	584909	9480617	588.75	30	65	P16	PT	322.3 - 337.3	302.9 - 317			0.0007	fresh rock (above GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
HTBG002	584909	9480617	588.75	30	65	P17	PT	350.2 - 361.2	329.1 - 339.4			0.0007	fresh rock (below GAS)
HTBG002	584909	9480617	588.75	30	65	P18	PT	364.2 - 376.2	342.2 - 353.5			0.000003	fresh rock (below GAS)
HTBG002	584909	9480617	588.75	30	65	P19	PT	376.8 - 392.9	354.1 - 369.2			0.00006	fresh rock (below GAS)
HTBG003	584047	9480391	808.65	200	70	FHT1	FHT	7.5 - 13.4	7 - 12.6	0.09	0.11	-	alluvium / colluvium
HTBG003	584047	9480391	808.65	200	70	P1	PT	17.4 - 26.9	16.4 - 25.3			0.00005	weathered rock
HTBG003	584047	9480391	808.65	200	70	FHT2	FHT	17.4 - 26.9	16.4 - 25.3	0.07	0.14	-	weathered rock
HTBG003	584047	9480391	808.65	200	70	P2	PT	37 - 49.3	34.8 - 46.3			0.00003	weathered rock
HTBG003	584047	9480391	808.65	200	70	FHT3	FHT	37 - 49.3	34.8 - 46.3	0.02	0.03	-	weathered rock
HTBG003	584047	9480391	808.65	200	70	P3	PT	60 - 70.4	56.4 - 66.2			0.0001	weathered rock
HTBG003	584047	9480391	808.65	200	70	FHT4	FHT	81.3 - 89.7	76.4 - 84.3	0.04	0.05	-	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P4	PT	81.3 - 89.7	76.4 - 84.3			0.00003	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P5	PT	100.7 - 111.1	94.6 - 104.4			0.00005	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P6	PT	125 - 134.8	117.5 - 126.7			0.0002	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P7	PT	141.5 - 150.6	133 - 141.5			0.000008	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P8	PT	162.5 - 171.9	152.7 - 161.5			0.00002	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P9	PT	182.6 - 193	171.6 - 181.4			0.000008	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P10	PT	203 - 211.7	190.8 - 198.9			0.00002	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P11	PT	223.8 - 232	210.3 - 218			0.000003	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P12	PT	240 - 250.1	225.5 - 235			0.00009	fresh rock (above GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
HTBG003	584047	9480391	808.65	200	70	P13	PT	258.5 - 271.5	242.9 - 255.1			0.0003	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P14	PT	281 - 291.5	264.1 - 273.9			0.00003	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P15	PT	300 - 310.5	281.9 - 291.8			0.00005	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P16	PT	322.5 - 331.5	303.1 - 311.5			0.00005	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P17	PT	340.5 - 350.5	320 - 329.4			0.00004	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P18	PT	360 - 370.4	338.3 - 348.1			0.000007	fresh rock (above GAS)
HTBG003	584047	9480391	808.65	200	70	P19	PT	381.4 - 390.4	358.4 - 366.9			0.00005	fresh rock (above GAS)
HTBG004	584733	9480601	645.03	260	70	P1	PT	11 - 20.5	10.3 - 19.3			0.003	weathered rock
HTBG004	584733	9480601	645.03	260	70	P2	PT	30 - 40	28.2 - 37.6			0.001	weathered rock
HTBG004	584733	9480601	645.03	260	70	P3	PT	49.3 - 60.3	46.3 - 56.7			0.0003	weathered rock
HTBG004	584733	9480601	645.03	260	70	P4	PT	70 - 80	65.8 - 75.2			0.0002	fresh rock (above GAS)
HTBG004	584733	9480601	645.03	260	70	P5	PT	90 - 100	84.6 - 94			0.0002	fresh rock (above GAS)
HTBG004	584733	9480601	645.03	260	70	P6	PT	110 - 120	103.4 - 112.8			0.00003	fresh rock (above GAS)
HTBG004	584733	9480601	645.03	260	70	P7	PT	130 - 140	122.2 - 131.6			0.00003	fresh rock (above GAS)
HTBG004	584733	9480601	645.03	260	70	P8	PT	150 - 160	141 - 150.4			0.0002	fresh rock (above GAS)
HTBG004	584733	9480601	645.03	260	70	P9	PT	170 - 180.2	159.7 - 169.3			0.00001	fresh rock (above GAS)
HTBG004	584733	9480601	645.03	260	70	P10	PT	190 - 200	178.5 - 187.9			0.00001	fresh rock (above GAS)
HTBG004	584733	9480601	645.03	260	70	P11	PT	210 - 220.6	197.3 - 207.3			0.00006	fresh rock (above GAS)
HTBG004	584733	9480601	645.03	260	70	P12	PT	230 - 239.5	216.1 - 225.1			0.00002	fresh rock (above GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
HTBG004	584733	9480601	645.03	260	70	P13	PT	250 - 260.3	234.9 - 244.6			0.0002	fresh rock (above GAS)
HTBG004	584733	9480601	645.03	260	70	P14	PT	270 - 280.6	253.7 - 263.7			0.00003	fresh rock (below GAS)
HTBG004	584733	9480601	645.03	260	70	P15	PT	290 - 300	272.5 - 281.9	Test failed - no flow			fresh rock (below GAS)
HTBG004	584733	9480601	645.03	260	70	P16	PT	280 - 300	263.1 - 281.9			0.000002	fresh rock (below GAS)
HTBG004	584733	9480601	645.03	260	70	P17	PT	311.7 - 321.7	292.9 - 302.3			0.0003	fresh rock (below GAS)
HTBG004	584733	9480601	645.03	260	70	P18	PT	330 - 339	310.1 - 319.4			0.0001	fresh rock (below GAS)
HTBG004	584733	9480601	645.03	260	70	P19	PT	350 - 360.1	328.9 - 338.4			0.0001	fresh rock (below GAS)
HTBG005	584780	9480298	687.30	310	65	P1	PT	10 - 20.3	9.1 - 18.4			0.5	weathered rock
HTBG005	584780	9480298	687.30	310	65	P2	PT	30 - 40.4	27.2 - 36.6			0.5	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P3	PT	50 - 60.1	45.3 - 54.5			0.0003	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P4	PT	70 - 80	63.4 - 72.5			0.001	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P5	PT	90 - 100	81.6 - 90.6			0.03	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P6	PT	110 - 120.4	99.7 - 109.1			0.1	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P7	PT	130 - 140	117.8 - 126.9			0.1	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P8	PT	152 - 162.1	137.8 - 146.9-			0.1	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P9	PT	170 - 180	154.1 - 163.1			0.002	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P10	PT	190 - 200.1	172.2 - 181.4			0.004	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P11	PT	210 - 220.4	190.3 - 199.8			0.1	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P12	PT	230 - 240.2	208.5 - 217.7			0.05	fresh rock (above GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
HTBG005	584780	9480298	687.30	310	65	P13	PT	250 - 260.1	226.6 - 235.7			0.003	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P14	PT	270 - 280.3	244.7 - 254.0			0.1	fresh rock (above GAS)
HTBG005	584780	9480298	687.30	310	65	P15	PT	292 - 301.4	264.6 - 273.2			0.001	fresh rock (below GAS)
HTBG005	584780	9480298	687.30	310	65	P16	PT	310 - 320	281 - 290.0			0.005	fresh rock (below GAS)
HTBG005	584780	9480298	687.30	310	65	P17	PT	331 - 340.1	300 - 308.2			0.002	fresh rock (below GAS)
HTBG005	584780	9480298	687.30	310	65	P18	PT	350 - 359.9	317.2 - 326.2			0.0004	fresh rock (below GAS)
HTBG005	584780	9480298	687.30	310	65	P19	PT	370 - 380.2	335.3 - 344.6			0.0003	fresh rock (below GAS)
HTBG005	584780	9480298	687.30	310	65	P20	PT	380 - 400	344.4 - 362.5			0.0001	fresh rock (below GAS)
HTBG005	584780	9480298	687.30	310	65	P21	PT	380 - 419.9	344.4 - 380.6			0.00005	fresh rock (below GAS)
HTBG005	584780	9480298	687.30	310	65	P22	PT	380 - 439.9	344.4 - 398.7			0.00003	fresh rock (below GAS)
HTBG005	584780	9480298	687.30	310	65	P23	PT	380 - 460.4	344.4 - 417.3			0.00002	fresh rock (below GAS)
HTBG005	584780	9480298	687.30	310	65	P24	PT	380 - 479.9	344.4 - 434.9			0.00001	fresh rock (below GAS)
HTBG005	584780	9480298	687.30	310	65	P25	PT	380 - 498	344.4 - 451.3			0.00002	fresh rock (below GAS)
NEJG001 (S2)	595870	9484620	228.9	137	70	1	PT	30 - 51.4	28.2 - 48.3			0.07	weathered rock
NEJG002 (L1)	595530	9484630	128.7	58	60.5	1	PT	34 - 55	29.6 - 47.9				n/a
NEJG002 (L1)	595530	9484630	128.7	58	60.5	2	PT	55 - 92	47.9 - 80.1			0.02	fresh rock (above GAS)
NEJG002 (L1)	595530	9484630	128.7	58	60.5	3	PT	91 - 150	79.2 - 130.6			0.01	fresh rock (above GAS)
NEJG002 (L1)	595530	9484630	128.7	58	60.5	4	PT	150 - 199.4	130.6 - 173.5			0.03	fresh rock (above GAS)
NEJG003 (S1)	595500	9484250	121.7	53	89	1	FHT	17.8 - 23.8	17.8 - 23.8			0.02	weathered rock

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
NEJG003 (S1)	595500	9484250	121.7	53	89	2	FHT	46.4 - 50.3	46.4 - 50.3			0.02	weathered rock
NEJG004 (S3)	595350	9484850	125.7	87	61	1	FHT	37.5 - 49.5	32.8 - 43.3			0.002	fresh
NEJG005 (L2b)	595070	9485622	115.8	236	52	1	PT	51.5 - 62.6	40.6 - 49.3				fresh rock (above GAS)
NEJG005 (L2b)	595070	9485622	115.8	236	52	2	PT	66 - 94.1	52 - 74.2			0.1	fresh rock (above GAS)
NEJG005 (L2b)	595070	9485622	115.8	236	52	3	PT	112 - 146.7	88.3 - 115.6			0.008	fresh rock (above GAS)
NEJG005 (L2b)	595070	9485622	115.8	236	52	4	PT	164 - 204.5	129.2 - 161.1			1.04	fresh rock (above GAS)
NEJG005 (L2b)	595070	9485622	115.8	236	52	5	SIT	206 - 250.9	162.3 - 197.7			0.005	fresh rock (above GAS)
NEJG005 (L2b)	595070	9485622	115.8	236	52	6	PT	52.5 - 250.9	41.4 - 197.7			0.04	fresh rock (above GAS)
NEJG006 (S4b)	595465	9485750	195.9	2	70	1	FHT	43.1 - 52.1	40.5 - 49			0.007	weathered rock
NEJG007 (S8b)	594809	9485212	236.8	347	89	1	FHT	52 - 66	52 - 66			0.005	fresh rock (above GAS)
NEJG007 (S8b)	594809	9485212	236.8	347	89	2	PT	51 - 72	51 - 72			0.005	fresh rock (above GAS)
NEJG008 (S5b)	594533	9485701	188.3	n/a	90	1	PT	36.1 - 51.3	36.1 - 51.3			0.04	fresh rock (above GAS)
NEJG010 (S6b)	594810	9485625	151	318	72	1	PT	29.9 - 49.3	28.4 - 46.9			0.03	fresh rock (above GAS)
NEJG011 (S10)	595285	9485840	157	n/a	90	1	PT	41.6 - 70.4	41.6 - 70.4			0.005	fresh rock (above GAS)
NEJG011 (S10)	595285	9485840	157	n/a	90	2	PT	71.7 - 100.5	71.7 - 100.5			0.004	fresh rock (above GAS)
NEJG012 (S11)	594760	9485520	193	n/a	90	1	PT	31.2 - 58.3	31.2 - 58.3			0.004	fresh rock (above GAS)
NEJG012 (S11)	594760	9485520	193	n/a	90	2	PT	59.2 - 100.3	59.2 - 100.3			0.05	fresh rock (above GAS)
GUHG001	587430	9481520	394.2	315	75	1	PT	33.2 - 40.4	32.1 - 39			0.04	fresh rock (above GAS)
GUHG002	587480	9481380	444.3	120	65	1	FHT	45.2 - 54.3	41 - 49.2				weathered rock

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
GUHG002	587480	9481380	444.3	120	65	2	PT	56.3 - 91.1	51 - 82.6			0.004	fresh rock (above GAS)
SRK-BH12 (414XC10G)	594493	9481643	100.3		90	-	PT	3 - 5.7	3 - 5.7			4.1	alluvium / colluvium
SRK-BH12 (414XC10G)	594493	9481643	100.3		90	-	PT	6.3 - 8.9	6.3 - 8.9			1.1	alluvium / colluvium
SRK-BH12 (414XC10G)	594493	9481643	100.3		90	-	PT	8.85 - 12.3	8.85 - 12.3			3.9	weathered rock
SRK-BH12 (414XC10G)	594493	9481643	100.3		90	-	PT	13.5 - 15.3	13.5 - 15.3			0.0006	weathered rock
SRK-BH12 (414XC10G)	594493	9481643	100.3		90	-	PT	20.6 - 25.3	20.6 - 25.3			0.4	fresh rock (above GAS)
SRK-BH12 (414XC10G)	594493	9481643	100.3		90	-	PT	25.3 - 29.8	25.3 - 29.8			0.06	fresh rock (above GAS)
SRK-BH12 (414XC10G)	594493	9481643	100.3		90	-	PT	29.6 - 35.8	29.6 - 35.8			0.07	fresh rock (above GAS)
SRK-BH12 (414XC10G)	594493	9481643	100.3		90	-	PT	35.4 - 41.7	35.4 - 41.7			0.07	fresh rock (above GAS)
SRK-BH12 (414XC10G)	594493	9481643	100.3		90	-	PT	41.3 - 47.5	41.3 - 47.5			0.03	fresh rock (above GAS)
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	20.3 - 25	20.3 - 25			0.06	fresh rock (above GAS)
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	26.3 - 31.3	26.3 - 31.3			0.3	fresh rock (above GAS)
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	31.2 - 37.3	31.2 - 37.3			0.1	fresh rock (above GAS)
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	35.6 - 23.3	35.6 - 23.3			0.03	fresh rock (above GAS)
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	44.6 - 29.3	44.6 - 29.3			0.005	fresh rock (above GAS)
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	49.3 - 55.3	49.3 - 55.3			0.02	fresh rock (above GAS)
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	55 - 61.3	55 - 61.3			0.05	fresh rock (above GAS)
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	63.8 - 68.5	63.8 - 68.5			0.003	fresh rock (above GAS)
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	74.6 - 79.3	74.6 - 79.3			0.002	fresh rock (above GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	80.6 - 85.3	80.6 - 85.3			0.002	fresh rock (above GAS)
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	86.6 - 91.3	86.6 - 91.3			0.004	fresh rock (above GAS)
SRK-BH13 (423XC10G)	594360	9481708	103.4		90	-	PT	92.6 - 97.3	92.6 - 97.3			0.005	fresh rock (above GAS)
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	3 - 4.3	3 - 4.3			1.2	alluvium / colluvium
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	8 - 10.3	8 - 10.3			1.2	alluvium / colluvium
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	9.3 - 10.3	9.3 - 10.3			8.6	alluvium / colluvium
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	32.3 - 36	32.3 - 36			0.07	fresh rock (above GAS)
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	49.3 - 55.3	49.3 - 55.3			0.04	fresh rock (above GAS)
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	54.8 - 61	54.8 - 61			0.002	fresh rock (above GAS)
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	61 - 67	61 - 67			0.008	fresh rock (above GAS)
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	62.8 - 67	62.8 - 67			0.008	fresh rock (above GAS)
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	68.2 - 73.3	68.2 - 73.3			0.009	fresh rock (above GAS)
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	71.15 - 79.3	71.15 - 79.3			0.006	fresh rock (above GAS)
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	78.9 - 85.3	78.9 - 85.3			0.02	fresh rock (above GAS)
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	83.4 - 91.3	83.4 - 91.3			0.01	fresh rock (above GAS)
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	89.6 - 97.3	89.6 - 97.3			0.0007	fresh rock (above GAS)
SRK-BH05 (424XC10G)	594784	9482136	97		90	-	PT	94.1 - 103.3	94.1 - 103.3			0.0005	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	14 - 17.6	14 - 17.6			4.7	alluvium / colluvium
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	19.1 - 23.8	19.1 - 23.8			24	alluvium / colluvium

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	25.2 - 29.9	25.2 - 29.9			7.3	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	32.1 - 35.9	32.1 - 35.9			0.4	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	37.1 - 41.8	37.1 - 41.8			0.06	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	44.2 - 48.3	44.2 - 48.3			0.01	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	48.4 - 54.6	48.4 - 54.6			0.009	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	56.3 - 60.5	56.3 - 60.5			0.003	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	62.4 - 66.6	62.4 - 66.6			0.02	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	68.2 - 72.7	68.2 - 72.7			0.00004	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	74.4 - 79.4	74.4 - 79.4			0.00007	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	79.8 - 85.5	79.8 - 85.5			0.0009	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	86.2 - 91.4	86.2 - 91.4			0.0005	fresh rock (above GAS)
SRK-BH14 (431XC10G)	594643	9481545	122		90	-	PT	95.3 - 100	95.3 - 100			0.0007	fresh rock (above GAS)
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	7.1 - 8.1	7.1 - 8.1			6.7	alluvium / colluvium
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	12 - 13.3	12 - 13.3			2.5	alluvium / colluvium
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	15 - 16.3	15 - 16.3			0.2	weathered rock
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	20.6 - 25.3	20.6 - 25.3			1.1	weathered rock
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	35.4 - 40.3	35.4 - 40.3			0.01	fresh rock (above GAS)
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	40 - 46.3	40 - 46.3			0.008	fresh rock (above GAS)
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	46.1 - 52.3	46.1 - 52.3			0.02	fresh rock (above GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	52.1 - 61.3	52.1 - 61.3			0.008	fresh rock (above GAS)
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	61.1 - 67.3	61.1 - 67.3			0.001	fresh rock (above GAS)
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	67 - 73.3	67 - 73.3			0.004	fresh rock (above GAS)
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	81.9 - 85.3	81.9 - 85.3			0.006	fresh rock (above GAS)
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	85 - 91.3	85 - 91.3			0.01	fresh rock (above GAS)
SRK-BH07 (432XC10G)	594690	9482199	98.3		90	-	PT	91 - 97.3	91 - 97.3			0.001	fresh rock (above GAS)
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	1.34 - 4.5	1.34 - 4.5			1.2	alluvium / colluvium
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	7.39 - 9.5	7.39 - 9.5			1.1	alluvium / colluvium
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	10.4 - 14	10.4 - 14			13.2	alluvium / colluvium
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	17.9 - 21.1	17.9 - 21.1			14.5	alluvium / colluvium
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	22.4 - 25.4	22.4 - 25.4			15.2	weathered rock
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	25.6 - 30	25.6 - 30			0.2	weathered rock
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	28.6 - 34.4	28.6 - 34.4			0.02	weathered rock
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	34.6 - 38.6	34.6 - 38.6			1.8	weathered rock
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	40.5 - 44.7	40.5 - 44.7			1.2	fresh rock (above GAS)
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	47.4 - 51.5	47.4 - 51.5			0.1	fresh rock (above GAS)
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	52.3 - 55.4	52.3 - 55.4			0.05	fresh rock (above GAS)
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	62.6 - 65.8	62.6 - 65.8			0.02	fresh rock (above GAS)
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	67.1 - 70.4	67.1 - 70.4			0.03	fresh rock (above GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
SRK-BH06A (438XC10G)	594854	9482063	128.6		90	-	PT	71.6 - 76.4	71.6 - 76.4			0.2	fresh rock (above GAS)
SRK-BH04 (441XC10G)	595290	9480557	145.6		90	-	PT	5.9 - 6.6	5.9 - 6.6			8.5	alluvium / colluvium
SRK-BH04 (441XC10G)	595290	9480557	145.6		90	-	PT	8.8 - 9	8.8 - 9			0.8	alluvium / colluvium
SRK-BH04 (441XC10G)	595290	9480557	145.6		90	-	PT	14.6 - 14.8	14.6 - 14.8			1	weathered rock
SRK-BH04 (441XC10G)	595290	9480557	145.6		90	-	PT	20.6 - 23.6	20.6 - 23.6			0.4	fresh rock (above GAS)
SRK-BH04 (441XC10G)	595290	9480557	145.6		90	-	PT	26.2 - 53	26.2 - 53			0.01	fresh rock (above GAS)
SRK-BH04 (441XC10G)	595290	9480557	145.6		90	-	PT	51.3 - 53	51.3 - 53			0.04	fresh rock (above GAS)
SRK-BH51 (444XC10G)	595488	9480598	162		90	-	PT	3 - 4.3	3 - 4.3			0.4	alluvium / colluvium
SRK-BH51 (444XC10G)	595488	9480598	162		90	-	PT	5.8 - 7.3	5.8 - 7.3			0.9	alluvium / colluvium
SRK-BH51 (444XC10G)	595488	9480598	162		90	-	PT	8.8 - 13	8.8 - 13			0.4	alluvium / colluvium
SRK-BH51 (444XC10G)	595488	9480598	162		90	-	PT	11.5 - 13	11.5 - 13			0.8	weathered rock
SRK-BH51 (444XC10G)	595488	9480598	162		90	-	PT	15.8 - 16.3	15.8 - 16.3			2	weathered rock
SRK-BH51 (444XC10G)	595488	9480598	162		90	-	PT	20.8 - 22.3	20.8 - 22.3			1	weathered rock
SRK-BH51 (444XC10G)	595488	9480598	162		90	-	PT	22.5 - 28.4	22.5 - 28.4			0.007	fresh rock (above GAS)
SRK-BH51 (444XC10G)	595488	9480598	162		90	-	PT	31.1 - 37.3	31.1 - 37.3			0.3	fresh rock (above GAS)
SRK-BH51 (444XC10G)	595488	9480598	162		90	-	PT	37.1 - 43.3	37.1 - 43.3			0.4	fresh rock (above GAS)
SRK-BH51 (444XC10G)	595488	9480598	162		90	-	PT	44.1 - 50.3	44.1 - 50.3			0.2	fresh rock (above GAS)
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	4.5 - 5.6	4.5 - 5.6			5.9	alluvium / colluvium
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	7.4 - 9	7.4 - 9			1	weathered rock

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	9 - 12	9 - 12			0.7	weathered rock
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	13.6 - 14.8	13.6 - 14.8			1.4	weathered rock
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	22.7 - 25.4	22.7 - 25.4			0.2	alluvium / colluvium
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	24.2 - 27.6	24.2 - 27.6			0.09	alluvium / colluvium
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	30.1 - 33.1	30.1 - 33.1			0.1	alluvium / colluvium
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	36.11 - 38.8	36.11 - 38.8			0.1	alluvium / colluvium
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	40.7 - 42	40.7 - 42			0.2	alluvium / colluvium
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	43.7 - 46.4	43.7 - 46.4			0.6	alluvium / colluvium
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	52 - 52.4	52 - 52.4			1.1	weathered rock
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	59.9 - 64.6	59.9 - 64.6			0.1	fresh rock (above GAS)
SRK-BH50 (445XC10G)	595432	9480462	161.4		80	-	PT	67.3 - 70.4	67.3 - 70.4			0.3	fresh rock (above GAS)
SRK-BH49B (447XC10G)	595466	9480368	162.8		90	-	PT	3 - 4.3	3 - 4.3			3.1	alluvium / colluvium
SRK-BH49B (447XC10G)	595466	9480368	162.8		90	-	PT	5.9 - 7.4	5.9 - 7.4			2.7	alluvium / colluvium
SRK-BH49B (447XC10G)	595466	9480368	162.8		90	-	PT	9 - 10.4	9 - 10.4			0.9	weathered rock
SRK-BH49B (447XC10G)	595466	9480368	162.8		90	-	PT	11.6 - 13.4	11.6 - 13.4			0.2	weathered rock
SRK-BH49B (447XC10G)	595466	9480368	162.8		90	-	PT	16.1 - 17.6	16.1 - 17.6			1.002	weathered rock
SRK-BH49B (447XC10G)	595466	9480368	162.8		90	-	PT	20.6 - 22.3	20.6 - 22.3			1.002	fresh rock (above GAS)
SRK-BH49B (447XC10G)	595466	9480368	162.8		90	-	PT	22.5 - 28.4	22.5 - 28.4			0.009	fresh rock (above GAS)
SRK-BH49B (447XC10G)	595466	9480368	162.8		90	-	PT	29.7 - 34.4	29.7 - 34.4			0.5	fresh rock (above GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
SRK-BH49B (447XC10G)	595466	9480368	162.8		90	-	PT	34.2 - 40.4	34.2 - 40.4			0.4	fresh rock (above GAS)
SRK-BH49B (447XC10G)	595466	9480368	162.8		90	-	PT	40.2 - 46.4	40.2 - 46.4			0.4	fresh rock (above GAS)
SRK-BH52 (451XC10G)	595666	9480788	267.7		90	-	PT	34.3 - 40.6	34.3 - 40.6			0.5	fresh rock (above GAS)
SRK-BH52 (451XC10G)	595666	9480788	267.7		90	-	PT	43.4 - 46.4	43.4 - 46.4			0.5	fresh rock (above GAS)
SRK-BH52 (451XC10G)	595666	9480788	267.7		90	-	PT	46.2 - 52.4	46.2 - 52.4			0.2	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	59.6 - 64.4	59.6 - 64.4			0.1	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	65.6 - 70.4	65.6 - 70.4			0.1	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	76.6 - 82.4	76.6 - 82.4			0.1	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	83.6 - 88.4	83.6 - 88.4			0.2	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	89.7 - 94.4	89.7 - 94.4			0.2	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	95.6 - 100.4	95.6 - 100.4			0.1	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	101.6 - 106.4	101.6 - 106.4			0.2	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	107.6 - 112.4	107.6 - 112.4			0.2	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	119.7 - 124.4	119.7 - 124.4			0.06	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	122.7 - 127.4	122.7 - 127.4			0.0008	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	128.6 - 133.4	128.6 - 133.4			0.0009	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	134.6 - 139.4	134.6 - 139.4			0.0001	fresh rock (above GAS)
SRK-BH58 (455XC10G)	595118	9480075	331.3		-	-	PT	140.6 - 145.4	140.6 - 145.4			0.002	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	2.9 - 4.4	2.9 - 4.4			0.7	alluvium / colluvium

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	7.8 - 8.9	7.8 - 8.9			1.1	alluvium / colluvium
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	13.4 - 14.9	13.4 - 14.9			1.9	weathered rock
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	16.8 - 18.1	16.8 - 18.1			1.3	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	21.4 - 21.4	21.4 - 21.4			0.1	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	25.4 - 26.6	25.4 - 26.6			1	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	28.1 - 29.2	28.1 - 29.2			0.2	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	34 - 37.4	34 - 37.4			0.2	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	44.7 - 49.4	44.7 - 49.4			0.4	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	50.7 - 55.4	50.7 - 55.4			0.4	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	56.7 - 61.4	56.7 - 61.4			0.06	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	62.7 - 67.4	62.7 - 67.4			0.0003	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	68.7 - 73.4	68.7 - 73.4			0.2	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	74.7 - 79.4	74.7 - 79.4			0.3	fresh rock (above GAS)
SRK-BH59 (458XC10G)	594841	9480161	248.5	0	90	-	PT	80.7 - 85.4	80.7 - 85.4			0.3	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	6.7 - 8.2	6.7 - 8.2			1.04	alluvium / colluvium
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	8.9 - 10.4	8.9 - 10.4			0.6	alluvium / colluvium
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	11.9 - 13.4	11.9 - 13.4			0.6	alluvium / colluvium
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	14.3 - 16.4	14.3 - 16.4			0.9	alluvium / colluvium
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	26.6 - 27.2	26.6 - 27.2			15	fresh rock (above GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	32.7 - 37.4	32.7 - 37.4			0.5	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	34.1 - 34.4	34.1 - 34.4			4.1	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	37.1 - 37.4	37.1 - 37.4			1.6	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	38.7 - 43.4	38.7 - 43.4			0.02	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	44.7 - 49.3	44.7 - 49.3			0.03	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	50.5 - 55.4	50.5 - 55.4			0.06	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	56.4 - 61.4	56.4 - 61.4			0.3	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	62.7 - 67.4	62.7 - 67.4			0.002	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	68.4 - 73.4	68.4 - 73.4			0.0006	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	74.4 - 79.4	74.4 - 79.4			0.1	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	80.7 - 85.3	80.7 - 85.3			0.002	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	86.4 - 91.4	86.4 - 91.4			0.001	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	92.7 - 97.4	92.7 - 97.4			0.001	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	98.4 - 103.4	98.4 - 103.4			0.0004	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	104.4 - 109.4	104.4 - 109.4			0.03	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	110.7 - 115.4	110.7 - 115.4			0.01	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	116.4 - 121.1	116.4 - 121.1			0.1	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	122.7 - 127.4	122.7 - 127.4			0.0010	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	128.7 - 133.4	128.7 - 133.4			0.01	fresh rock (above GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	134.4 - 139.4	134.4 - 139.4			0.02	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	140.7 - 145.4	140.7 - 145.4			0.002	fresh rock (above GAS)
SRK-BH69B (463XC10G)	595391	9480119	315.4	0	90	-	PT	146.7 - 151.4	146.7 - 151.4			0.01	fresh rock (above GAS)
SRK-BH54 (477XC10G)	595246	9480473	177.9	0	90	-	PT	35.7 - 40.4	35.7 - 40.4			0.004	fresh rock (above GAS)
SRK-BH54 (477XC10G)	595246	9480473	177.9	0	90	-	PT	56.7 - 61.4	56.7 - 61.4			0.2	fresh rock (above GAS)
SRK-BH54 (477XC10G)	595246	9480473	177.9	0	90	-	PT	62.7 - 67.4	62.7 - 67.4			0.02	fresh rock (above GAS)
SRK-BH54 (477XC10G)	595246	9480473	177.9	0	90	-	PT	68.7 - 73.4	68.7 - 73.4			0.03	fresh rock (above GAS)
SRK-BH54 (477XC10G)	595246	9480473	177.9	0	90	-	PT	74.6 - 79.3	74.6 - 79.3			0.07	fresh rock (above GAS)
SRK-BH54 (477XC10G)	595246	9480473	177.9	0	90	-	PT	80.7 - 85.4	80.7 - 85.4			0.0005	fresh rock (above GAS)
SRK-BH54 (477XC10G)	595246	9480473	177.9	0	90	-	PT	86.7 - 91.4	86.7 - 91.4			0.002	fresh rock (above GAS)
SRK-BH54 (477XC10G)	595246	9480473	177.9	0	90	-	PT	97.1 - 100.4	97.1 - 100.4			0.2	fresh rock (above GAS)
SRK-BH53 (485XC10G)	595309	9480694	184.3	0	90	-	PT	4.3 - 5.8	4.3 - 5.8			0.5	alluvium / colluvium
SRK-BH53 (485XC10G)	595309	9480694	184.3	0	90	-	PT	9.15 - 12.1	9.15 - 12.1			0.06	alluvium / colluvium
SRK-BH53 (485XC10G)	595309	9480694	184.3	0	90	-	PT	18 - 19.4	18 - 19.4			0.4	alluvium / colluvium
SRK-BH53 (485XC10G)	595309	9480694	184.3	0	90	-	PT	24.8 - 25.4	24.8 - 25.4			0.3	fresh rock (above GAS)
SRK-BH53 (485XC10G)	595309	9480694	184.3	0	90	-	PT	39.8 - 40.4	39.8 - 40.4			0.08	fresh rock (above GAS)
SRK-BH53 (485XC10G)	595309	9480694	184.3	0	90	-	PT	49.1 - 49.4	49.1 - 49.4			0.1	fresh rock (above GAS)
SRK-BH53 (485XC10G)	595309	9480694	184.3	0	90	-	PT	59.1 - 58.4	59.1 - 58.4			0.1	fresh rock (above GAS)
SRK-BH53 (485XC10G)	595309	9480694	184.3	0	90	-	PT	80.6 - 85.3	80.6 - 85.3			0.003	fresh rock (above GAS)

Hole ID	Easting[1]	Northing[1]	Elevation (RL m)	Azimuth	Dip	Test ID	Test type[2]	Test interval (mDH)	Test interval (mbGL)	Hydraulic conductivity (m/day)			Unit[3]
										Bouwer & Rice	Hvorslev	Converted from Lugeon	
SRK-BH53 (485XC10G)	595309	9480694	184.3	0	90	-	PT	83.4 - 88.4	83.4 - 88.4			0.0008	fresh rock (above GAS)
SRK-BH53 (485XC10G)	595309	9480694	184.3	0	90	-	PT	89.7 - 94.41	89.7 - 94.41			0.002	fresh rock (above GAS)
SRK-BH16 (602XC11G)	594610	9481875	98.5	120	90	-	PT	26.7 - 29.9	26.7 - 29.9			0.03	fresh rock (above GAS)
SRK-BH22B (635XC11G)	594890	9481780	163.8	135	60	-	PT	53.7 - 67.4	53.7 - 67.4			0.002	fresh rock (above GAS)
SRK-BH22B (635XC11G)	594890	9481780	163.8	135	60	-	PT	59.7 - 67.4	59.7 - 67.4			0.003	fresh rock (above GAS)
SRK-BH22B (635XC11G)	594890	9481780	163.8	135	60	-	PT	69 - 75.2	69 - 75.2			0.01	fresh rock (above GAS)
BH10-MR01 (633XC11G)	589015	9485044	217.6	0	90	-	PT	43.2 - 50.7	43.2 - 50.7			0.04	fresh rock (above GAS)

Note: [1]*Coordinate system PNG 94, Zone 54*

[2]*Test type: PT - Packer test FHT - Falling head test SIT - Shut-in test*

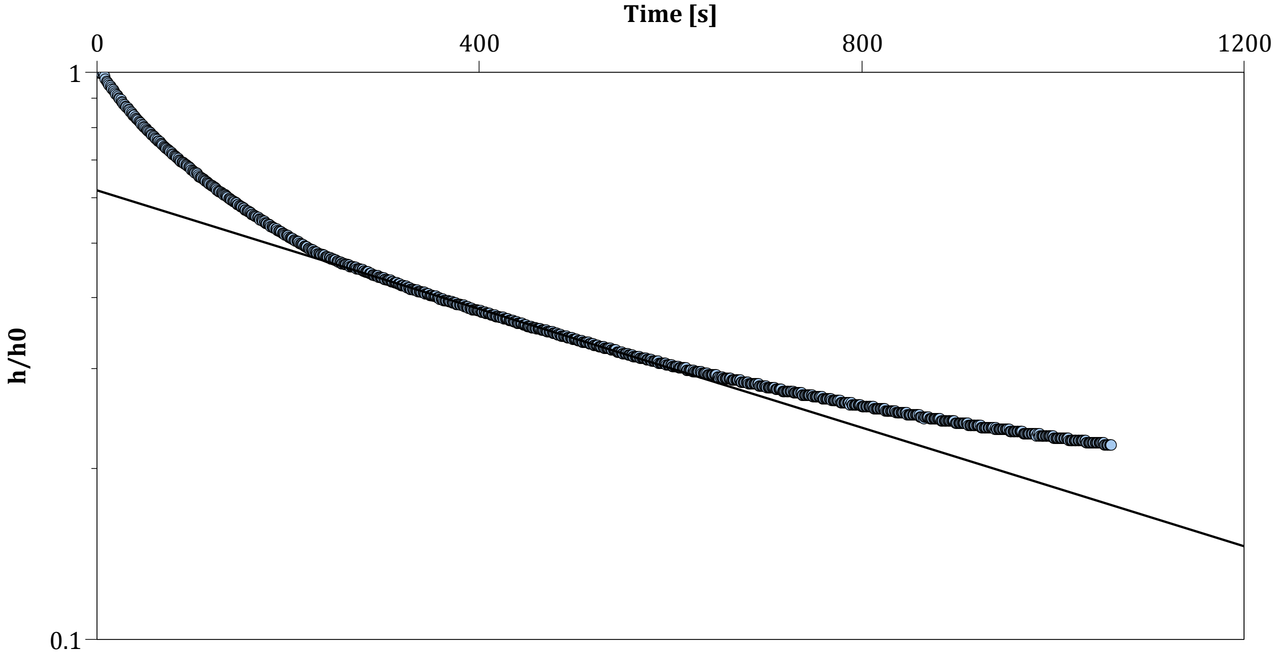
[3]*Gypsum and anhydrite surface (GAS)*

Attachment B Hydraulic conductivity test analyses sheets

AGE Consultants
Level 2/15 Mallon St
Bowen Hills, QLD, 4006

Slug Test Analysis Report
Project: Frieda River
Number: I1049
Client: PanAust

Location: Frieda River, PNG	Slug Test: 3 - 5.2 m	Test Well: HTBG001: Test 00
Test Conducted by: Geotech International		Test Date: 22/12/2014
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 14/01/2015
Aquifer Thickness: 2.20 m		

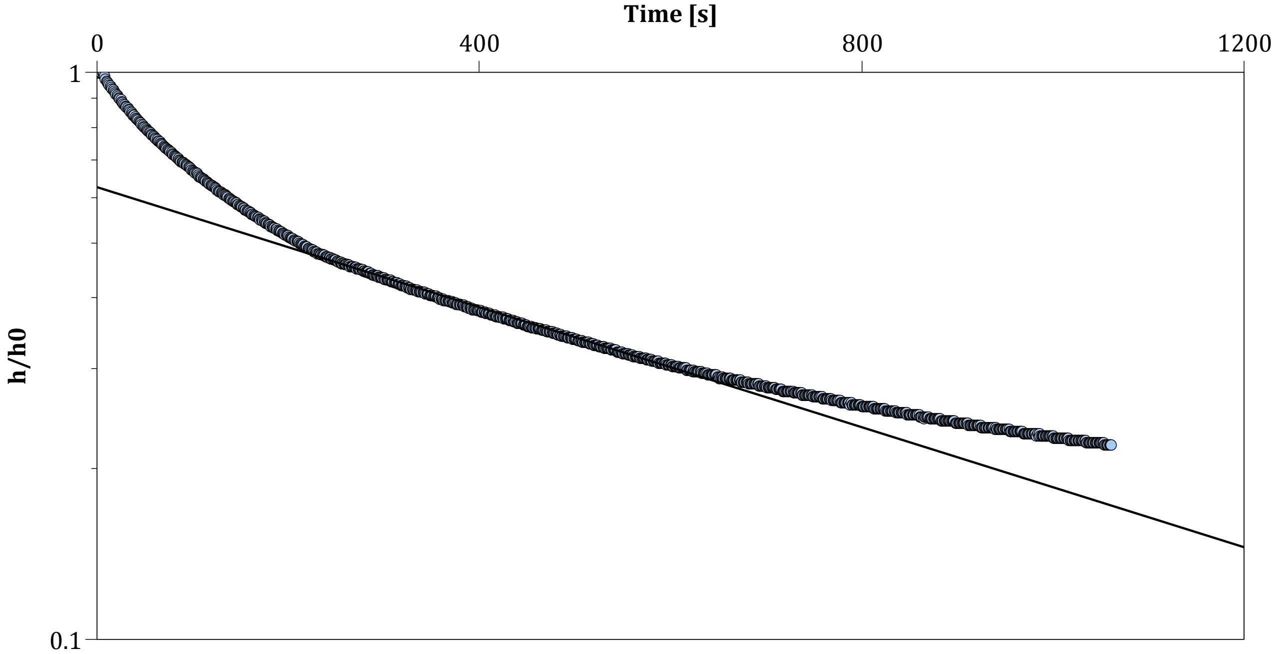


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]
HTBG001: Test 00	3.20×10^{-1}

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report**
	Project: Frieda River
	Number: I1049
	Client: PanAust

Location: Frieda River, PNG	Slug Test: 3 - 5.2 m	Test Well: HTBG001: Test 00
Test Conducted by: Geotech International		Test Date: 22/12/2014
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 14/01/2015
Aquifer Thickness: 2.20 m		



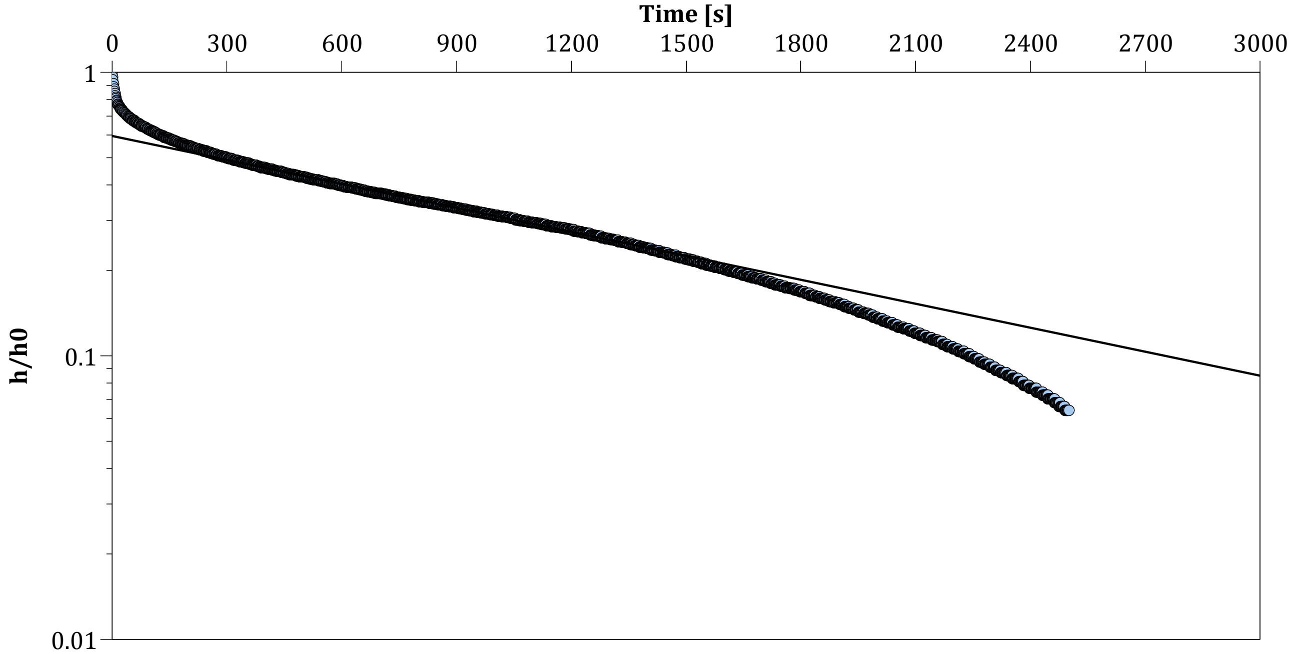
Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
HTBG001: Test 00	3.24×10^{-1}	

AGE Consultants
Level 2/15 Mallon St
Bowen Hills, QLD, 4006

Slug Test Analysis Report
Project: Frieda River
Number: I1049
Client: PanAust

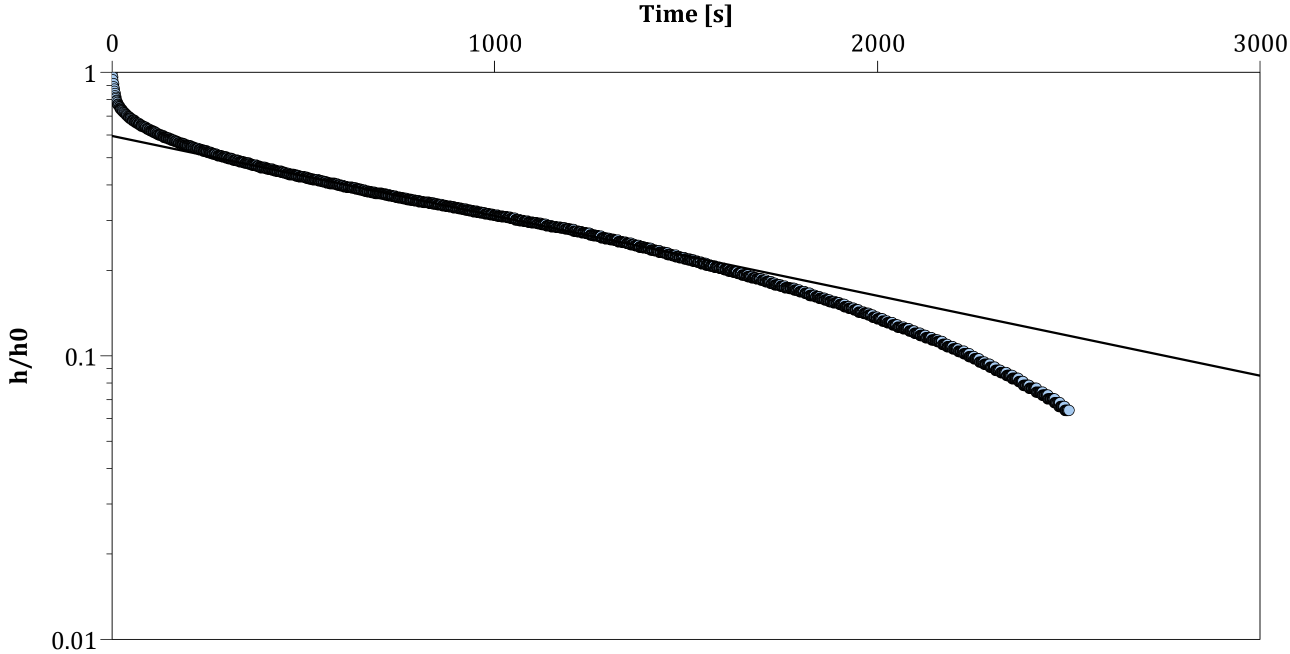
Location: Frieda River, PNG	Slug Test: 6.5 - 12.5 m	Test Well: HTBG001: Test 01
Test Conducted by: Geotech International		Test Date: 27/12/2014
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 26/03/2015
Aquifer Thickness: 6.00 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
HTBG001: Test 01	6.25×10^{-2}	

AGE Consultants **Level 2/15 Mallon St** **Bowen Hills, QLD, 4006**	**Slug Test Analysis Report**	
	Project: Frieda River	
	Number: I1049	
	Client: PanAust	
Location: Frieda River, PNG	Slug Test: 6.5 - 12.5 m	Test Well: HTBG001: Test 01
Test Conducted by: Geotech International		Test Date: 27/12/2014
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 14/01/2015
Aquifer Thickness: 6.00 m		



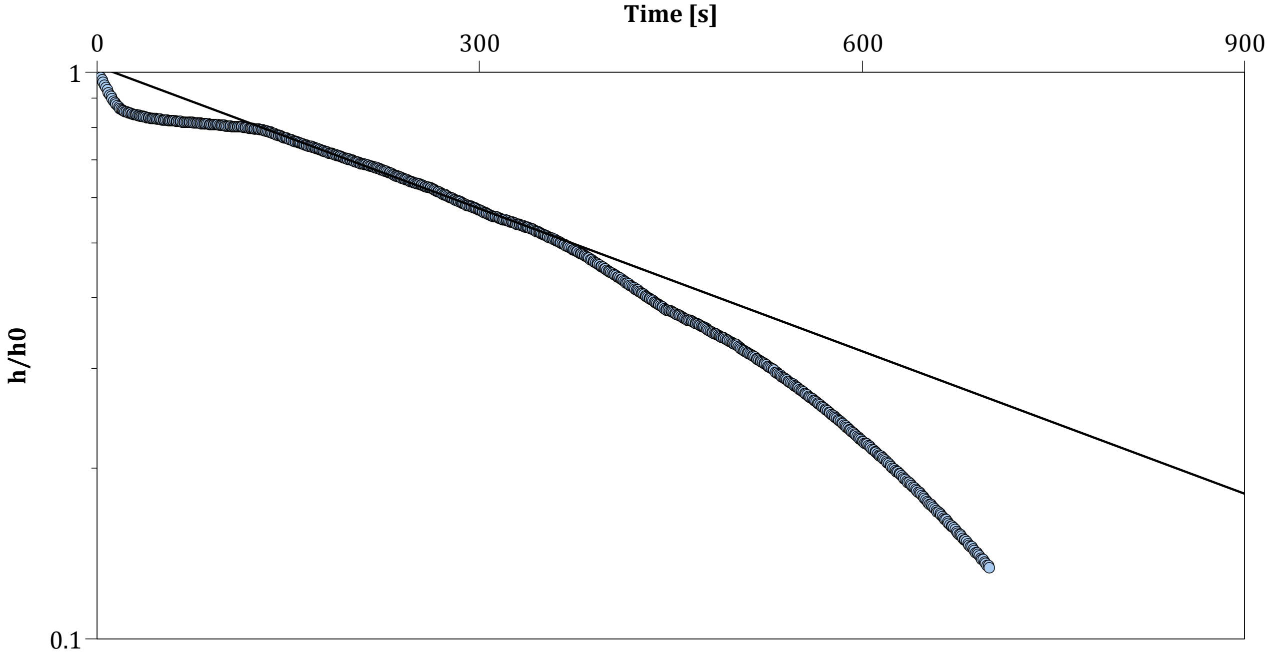
Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
HTBG001: Test 01	8.11×10^{-2}	

AGE Consultants
Level 2/15 Mallon St
Bowen Hills, QLD, 4006

Slug Test Analysis Report

Project: Frieda River		
Number: I1049		
Client: PanAust		
Location: Frieda River, PNG	Slug Test: 25.1 - 31.1 m	Test Well: HTBG001: Test 02
Test Conducted by: Geotech International		Test Date: 28/12/2014
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 26/03/2015
Aquifer Thickness: 6.00 m		

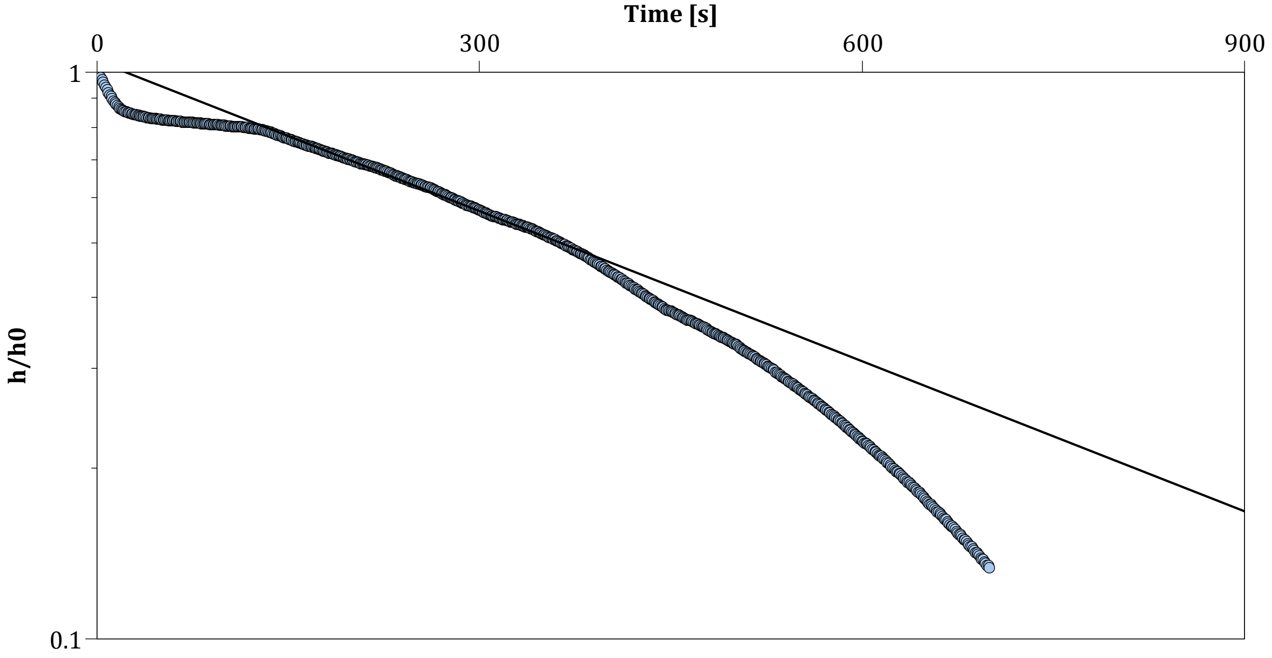


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
HTBG001: Test 02	1.86×10^{-1}	

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report**
	Project: Frieda River
	Number: I1049
	Client: PanAust

Location: Frieda River, PNG	Slug Test: 25.1 - 31.1 m	Test Well: HTBG001: Test 02
Test Conducted by: Geotech International		Test Date: 28/12/2014
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 14/01/2015
Aquifer Thickness: 6.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
HTBG001: Test 02	2.54×10^{-1}	

AGE Consultants
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Bowen Hills, QLD, 4006

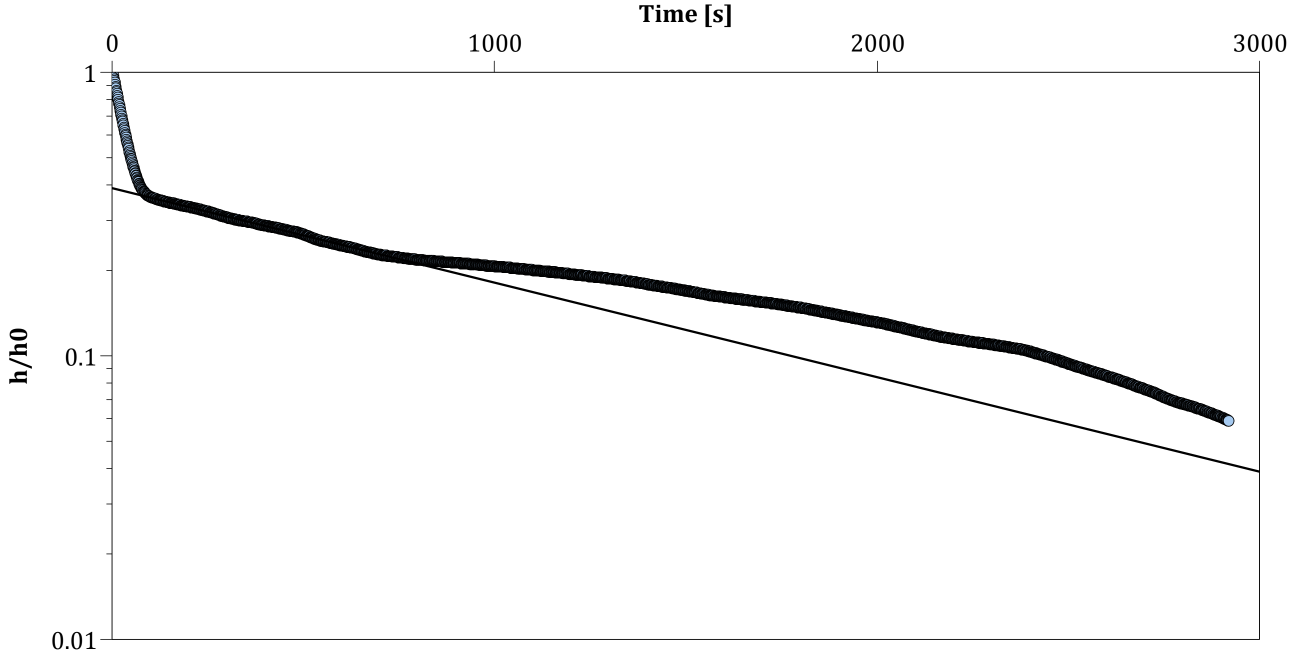
Slug Test Analysis Report

Project: Frieda River

Number: I1049

Client: PanAust

Location: Frieda River, PNG	Slug Test: 44.3 - 50.4 m	Test Well: HTBG001: Test 03
Test Conducted by: Geotech International		Test Date: 30/12/2014
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 26/03/2015
Aquifer Thickness: 6.00 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
HTBG001: Test 03	7.28×10^{-2}	

AGE Consultants
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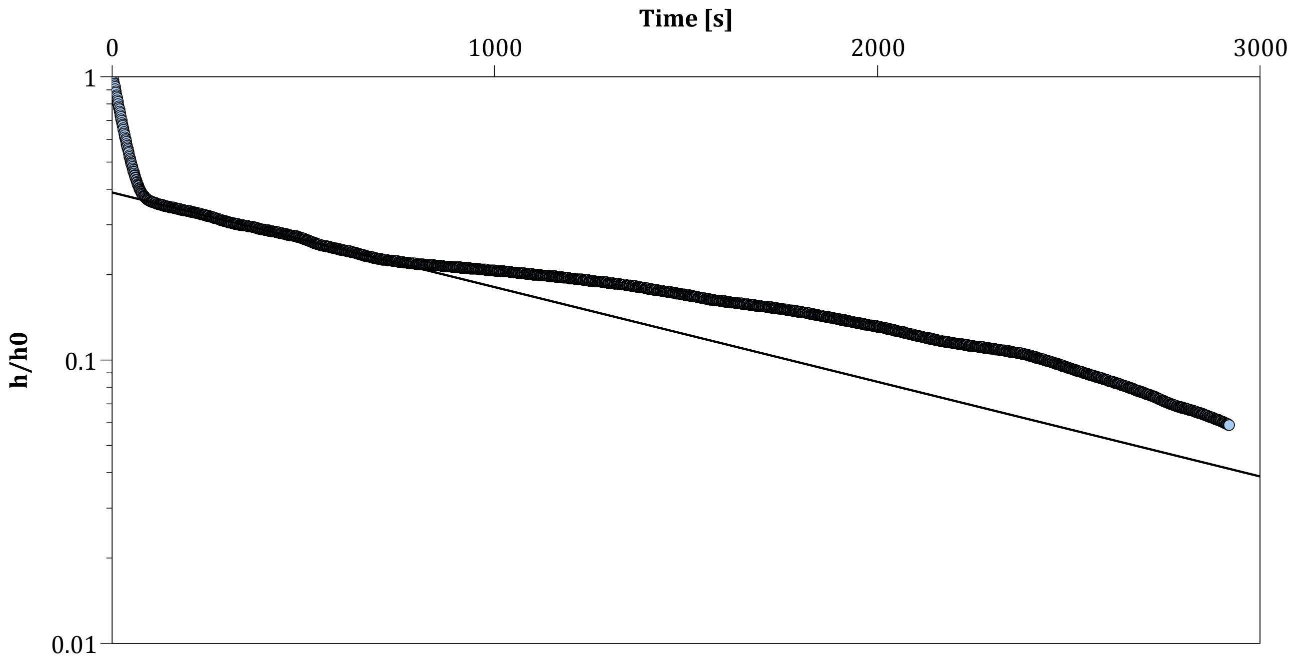
Bowen Hills, QLD, 4006

Slug Test Analysis Report
Project: Frieda River
Number: I1049
Client: PanAust

Location: Frieda River, PNG	Slug Test: 44.3 - 50.4 m	Test Well: HTBG001: Test 03
Test Conducted by: Geotech International		Test Date: 30/12/2014
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 14/01/2015
Aquifer Thickness: 6.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
HTBG001: Test 03	9.49×10^{-2}	

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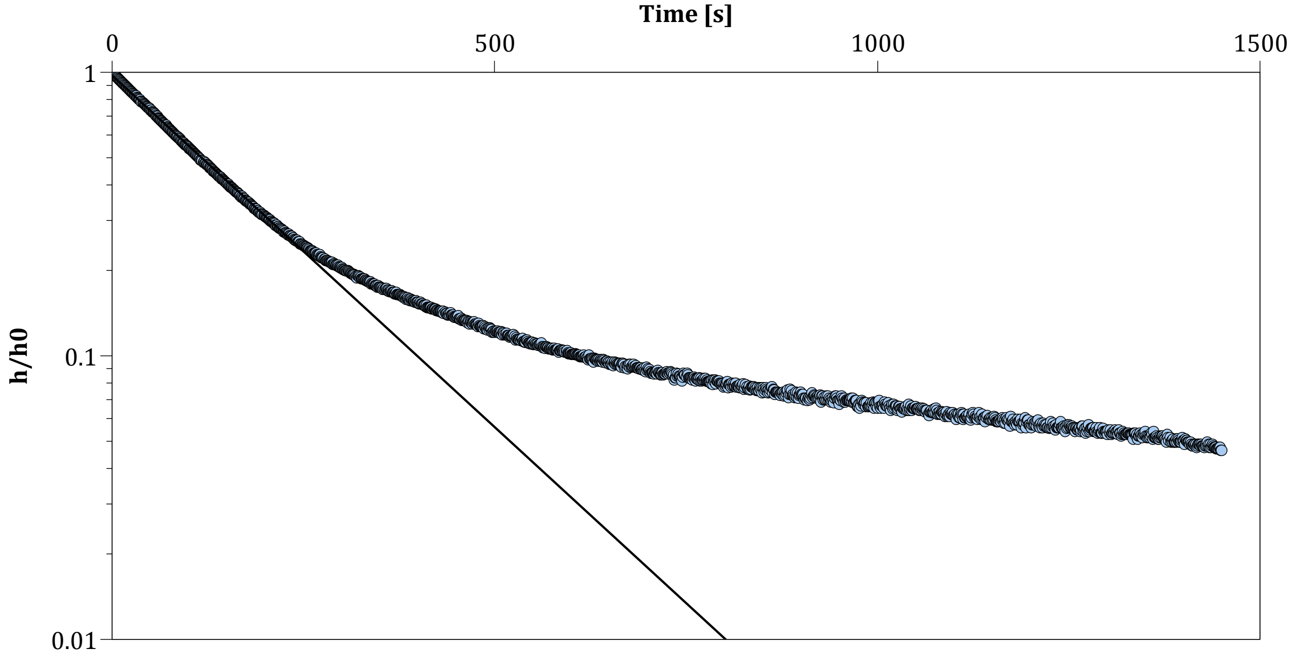
Bowen Hills, QLD, 4006

Slug Test Analysis Report

Project: Frieda River		
Number: I1049		
Client: PanAust		
Location: Frieda River, PNG	Slug Test: 64.7 - 70.7 m	Test Well: HTBG001: Test 04
Test Conducted by: Geotech International		Test Date: 31/12/2014
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 26/03/2015
Aquifer Thickness: 6.00 m		

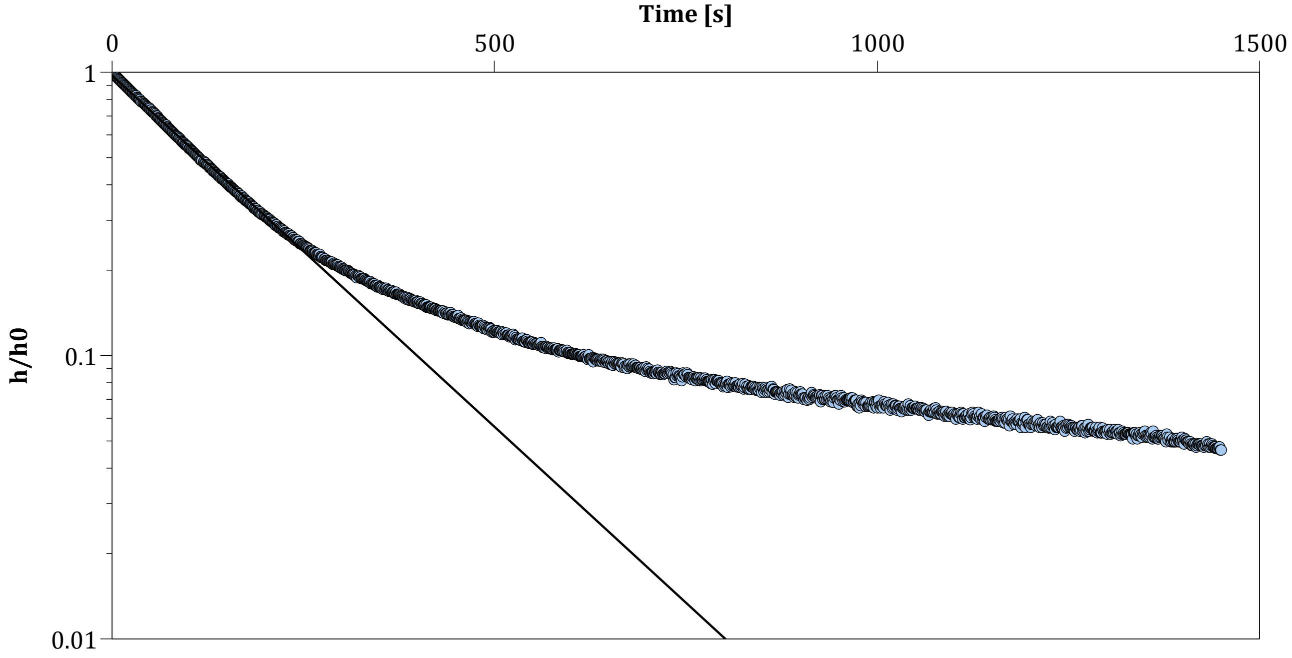


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]
HTBG001: Test 04	3.89×10^{-2}

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report**
	Project: Frieda River
	Number: I1049
	Client: PanAust

Location: Frieda River, PNG	Slug Test: 64.7 - 70.7 m	Test Well: HTBG001: Test 04
Test Conducted by: Geotech International		Test Date: 31/12/2014
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 14/01/2015
Aquifer Thickness: 6.00 m		

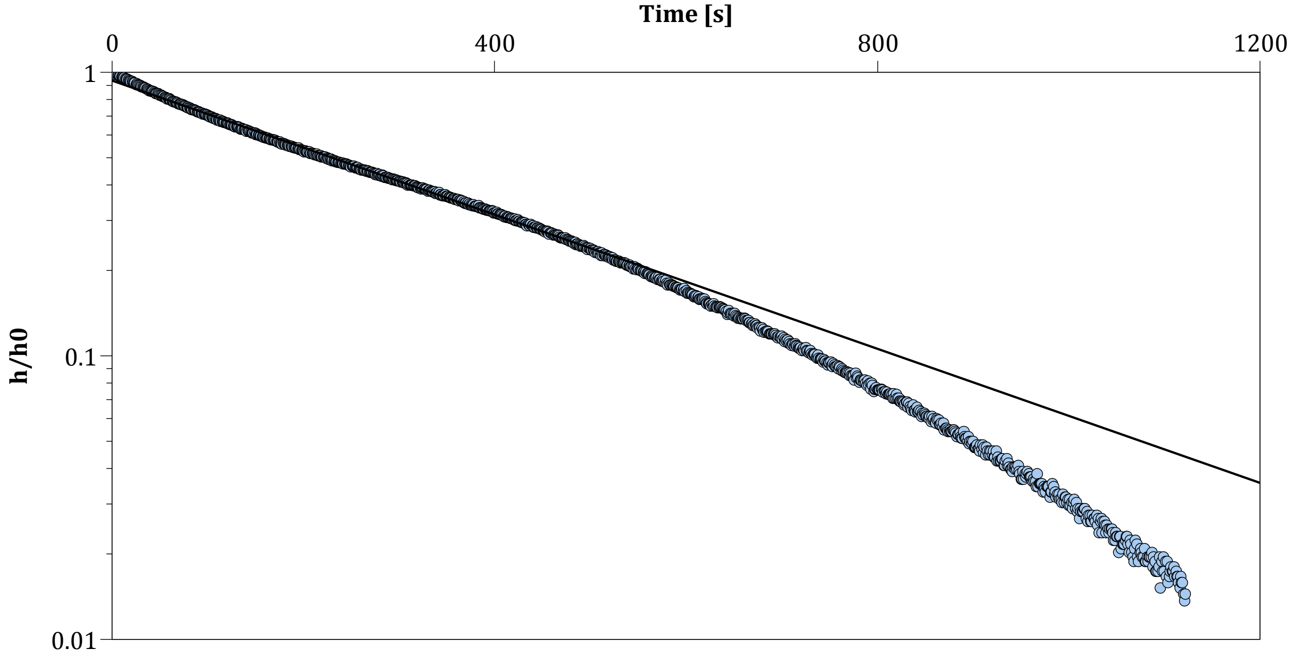


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]
HTBG001: Test 04	5.04×10^{-2}

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report**
	Project: Frieda River
	Number: I1049
	Client: PanAust

Location: Frieda River, PNG	Slug Test: 83.6 - 89.7 m	Test Well: HTBG001: Test 05
Test Conducted by: Geotech International		Test Date: 31/12/2014
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 8/04/2015
Aquifer Thickness: 6.10 m		

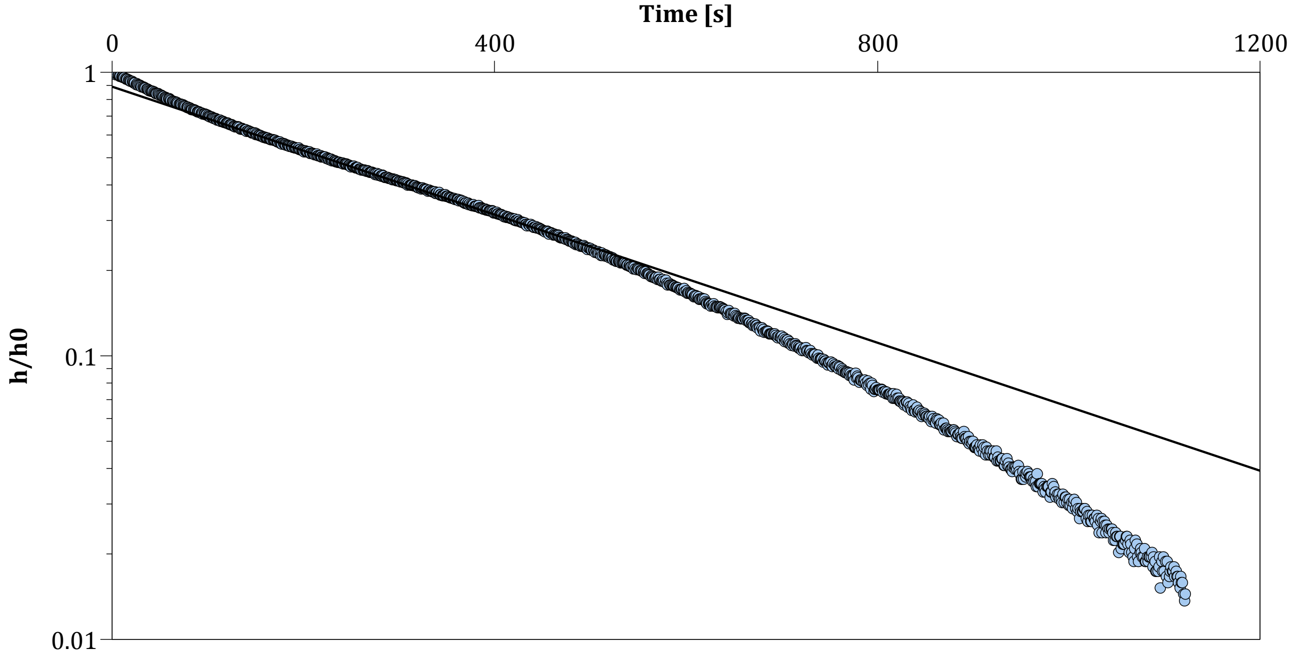


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
HTBG001: Test 05	2.59×10^{-1}	

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report**
	Project: Frieda River
	Number: I1049
	Client: PanAust

Location: Frieda River, PNG	Slug Test: 83.6 - 89.7 m	Test Well: HTBG001: Test 05
Test Conducted by: Geotech International		Test Date: 31/12/2014
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 14/01/2015
Aquifer Thickness: 6.10 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
HTBG001: Test 05	3.20×10^{-1}	

AGE Consultants
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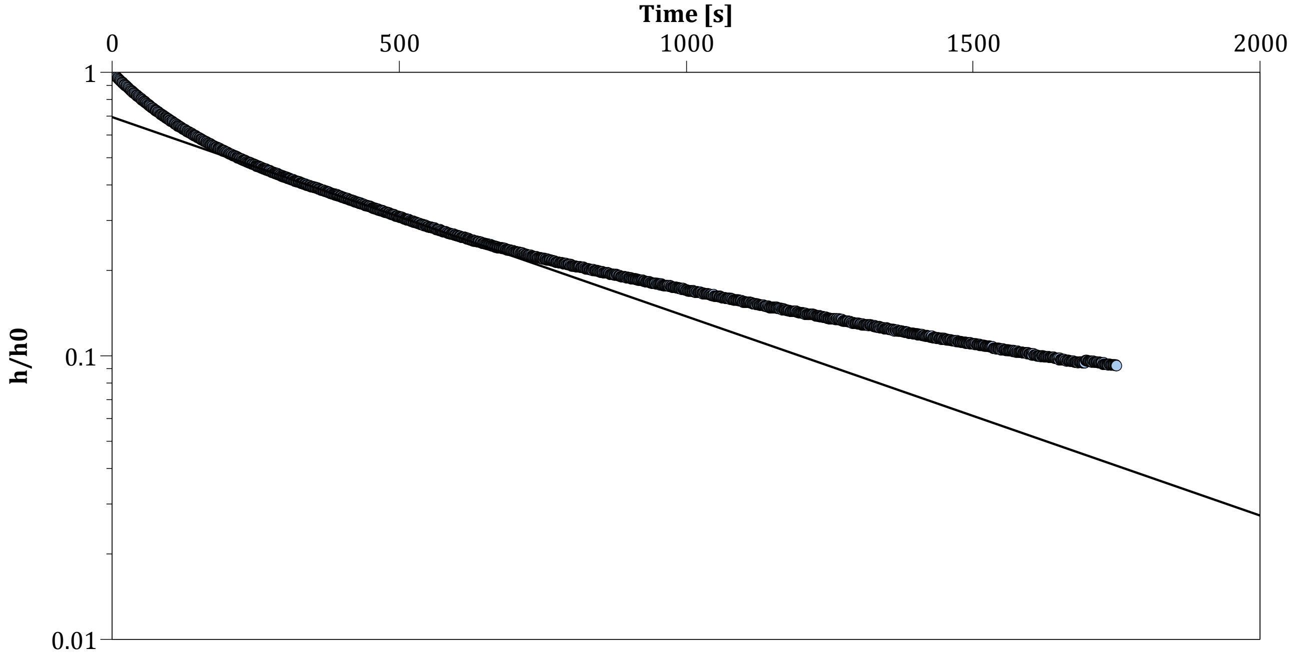
Bowen Hills, QLD, 4006

Slug Test Analysis Report
Project: Frieda River
Number: I1049
Client: PanAust

Location: Frieda River, PNG	Slug Test: 124.3 - 130.3 m	Test Well: HTBG001: Test 07
Test Conducted by: Geotech International		Test Date: 2/01/2015
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 26/03/2015
Aquifer Thickness: 6.00 m		

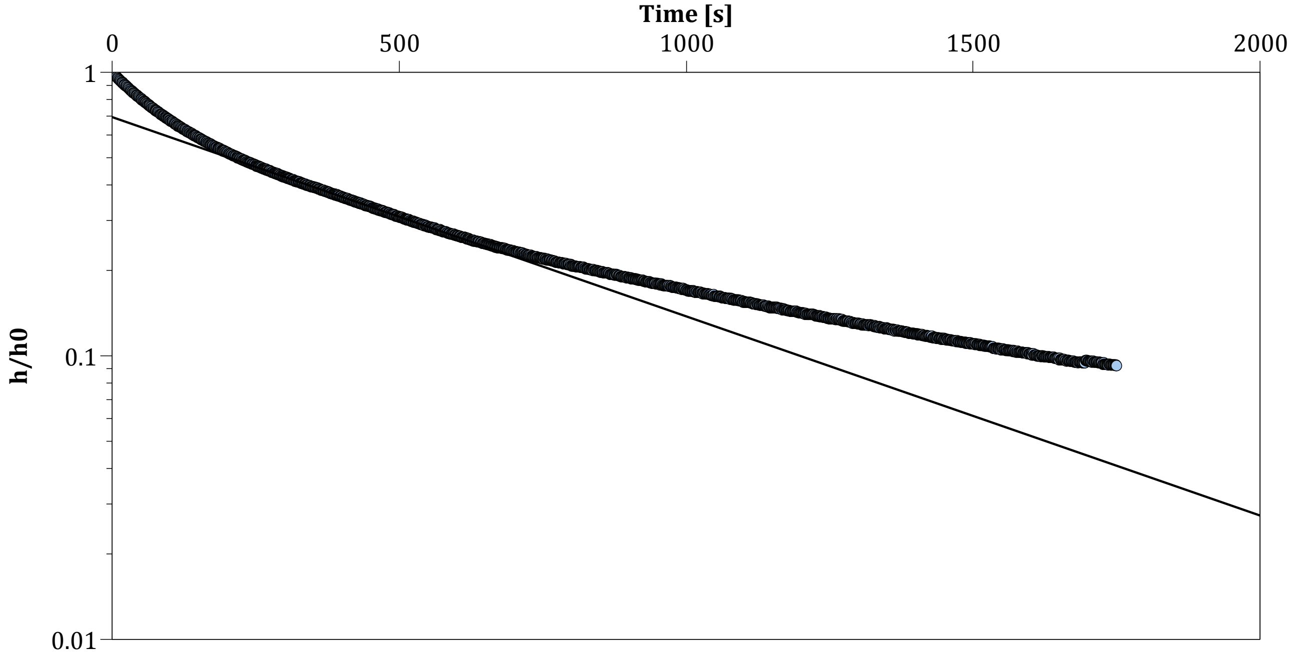


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]
HTBG001: Test 07	1.56×10^{-1}

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report**
	Project: Frieda River
	Number: I1049
	Client: PanAust

Location: Frieda River, PNG	Slug Test: 124.3 - 130.3 m	Test Well: HTBG001: Test 07
Test Conducted by: Geotech International		Test Date: 2/01/2015
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 14/01/2015
Aquifer Thickness: 6.00 m		



Calculation using Hvorslev

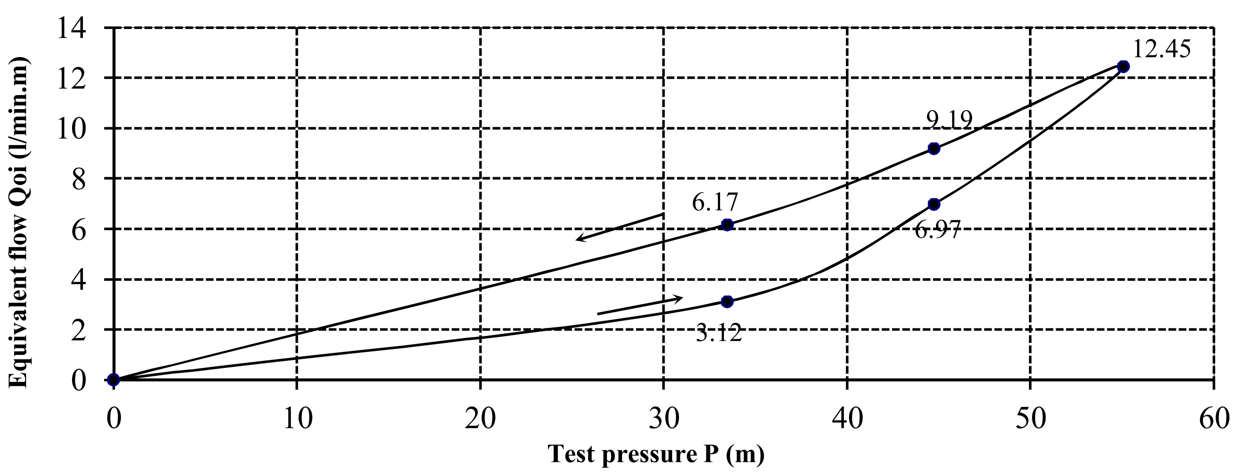
Observation Well	Hydraulic Conductivity [m/d]	
HTBG001: Test 07	2.02×10^{-1}	

	RECORD & CALCULATION LUGEON TEST	BOREHOLE:	HTBG001
		Test No.:	P1

PROJECT: Frieda River Project	Depth of borehole at the time of test: 151 m
	Test section: from (H_2) 146.0 to 151 Length 5 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 18.61 (kG/cm²) — Date of test: 0:30 4/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 147 — Initial groudwater level (H_3) 12.6 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm²)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	2.20	22.0	790	1024	234	15.60	- Test conducted in: Flimtem Trachyandesite - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	3.40	34.0	1066	1589	523	34.87	
15	4.50	45.0	1620	2554	934	62.27	
15	3.40	34.0	2587	3276	689	45.93	
15	2.20	22.0	3317	3780	463	30.87	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** — **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
3.12	0	33.5	0.093	9.33	q= 0.1806 (l/min.m)
6.97	0	44.7	0.156	15.59	
12.45	0	55.1	0.226	22.62	
9.19	0	44.7	0.205	20.54	uL= 18.06
6.17	0	33.5	0.185	18.45	



Recorded by: Thanh	Checked by: Quang

RECORD & CALCULATION LUGEON TEST

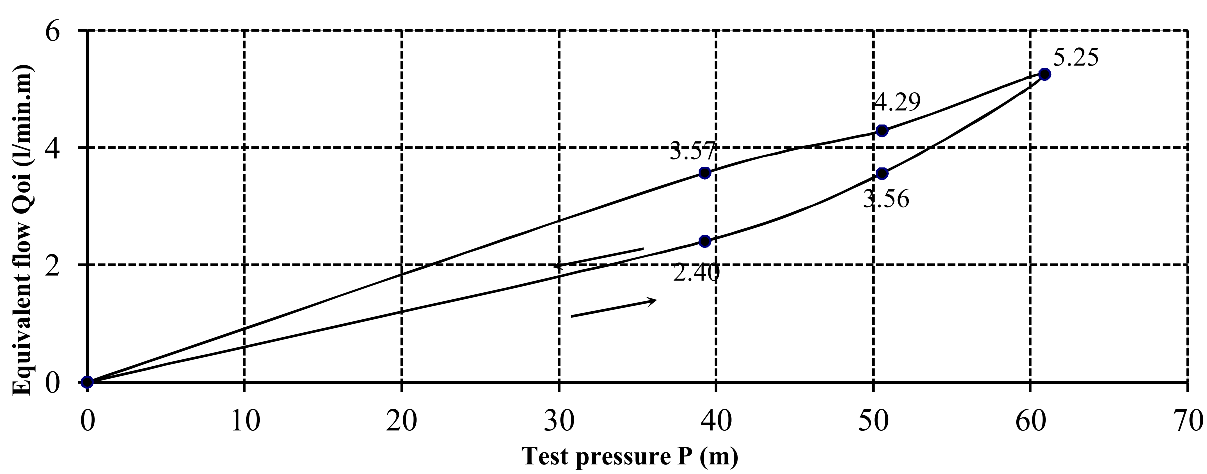
GeoTech

BOREHOLE:	HTBG001
Test No.:	P2

PROJECT: Frieda River Project	Depth of borehole at the time of test: 166.1 m
	Test section: from (H_2) 157.0 to 166.1 Length 9.1 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 20.271 (kG/cm²) — Date of test: 19:15 4/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 158 — Initial groudwater level (H_3) 18.8 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm²)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
							- Test conducted in: Flimtem Trachyandesite from 157.0m to 160.0 m and Horse Microdiorite from 160.0 - 166.0 m. - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	2.20	22.0	2940	3268	328	21.87	
15	3.40	34.0	3310	3796	486	32.40	
15	4.50	45.0	3837	4553	716	47.73	
15	3.40	34.0	4651	5236	585	39.00	
15	2.20	22.0	5260	5747	487	32.47	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
2.40	0	39.3	0.061	6.12	q= 0.0787 (l/min.m)
3.56	0	50.6	0.070	7.04	
5.25	0	60.9	0.086	8.61	
4.29	0	50.6	0.085	8.48	
3.57	0	39.3	0.091	9.08	uL= 7.87



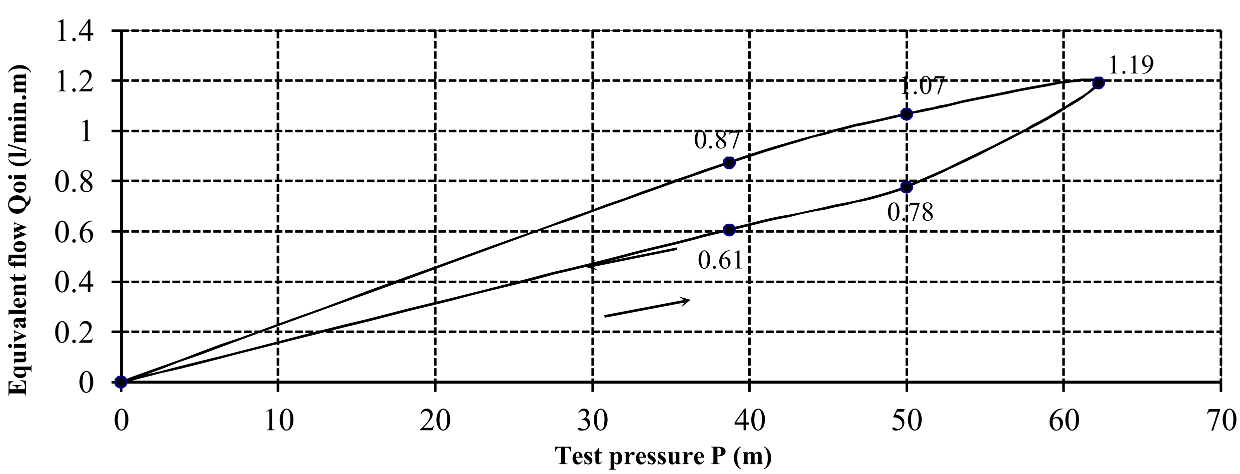
Recorded by: Thanh | Checked by: Quang

GeoTech	RECORD & CALCULATION LUGEON TEST	BOREHOLE:	HTBG001
		Test No.:	P3

PROJECT: Frieda River Project	Depth of borehole at the time of test: 192 m
	Test section: from (H_2) 183.0 to 192 Length 9 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 23.12 (kG/cm^2) — Date of test: 23:15 5/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 184 — Initial groudwater level (H_3) 15.2 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	Flowmeter reading (liter) After	Flowmeter reading (liter) Take	Average flow Qi (l/min)	Remark
15	2.50	25.0	5859	5941	82	5.47	- Test conducted in: HORSE MICRODIORITE
15	3.70	37.0	5947	6052	105	7.00	- No seepage from top of borehole.
15	5.00	50.0	6063	6224	161	10.73	- Parker pressure is constant throughout the test
15	3.70	37.0	6230	6374	144	9.60	
15	2.50	25.0	6381	6499	118	7.87	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.61	0	38.7	0.016	1.57	q= 0.0189 (l/min.m)
0.78	0	50.0	0.016	1.56	
1.19	0	62.2	0.019	1.92	
1.07	0	50.0	0.021	2.13	
0.87	0	38.7	0.023	2.26	uL= 1.89



Recorded by: Thanh | Checked by: Quang

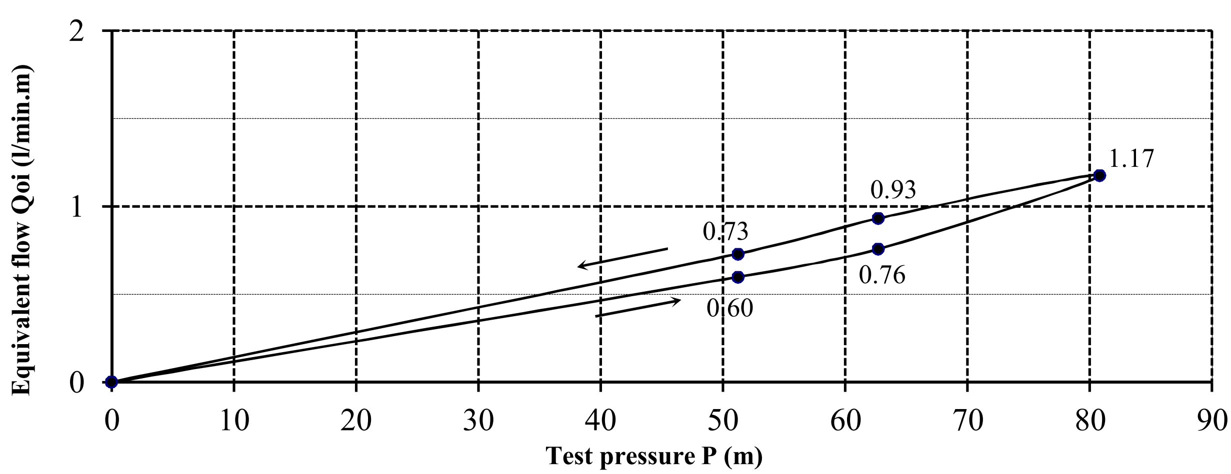
RECORD & CALCULATION
LUGEON TEST

BOREHOLE: HTBG001
Test No.: P4

PROJECT: Frieda River Project	Depth of borehole at the time of test: 210.1 m
	Test section: from (H_2) 200.0 to 210.1 Length 10.1 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 25.111 (kG/cm^2) — Date of test: 19:30 6/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 201 — Initial groudwater level (H_3) 22.0 m

Reading time	Pressure gauge reading (Poi)		Flowmeter reading (liter)			Average flow	Remark
(minute)	(kG/cm^2)	(m)	Before	After	Take	Qi (l/min)	
15	3.15	31.5	6867	6957.5	90.5	6.03	- Test conducted in: HORNBLENDE MONZONITE
15	4.37	43.7	6970	7084.5	114.5	7.63	- No seepage from top of borehole.
15	6.30	63.0	7097	7275	178	11.87	- Parker pressure is constant throughout the test
15	4.37	43.7	7290	7431	141	9.40	
15	3.15	31.5	7436	7546.5	110.5	7.37	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $P_i=(P_{oi}+H_1+H_2-H_f)*\sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.60	0	51.2	0.012	1.17	q= 0.0135 (l/min.m)
0.76	0	62.7	0.012	1.21	
1.17	0	80.8	0.015	1.45	
0.93	0	62.7	0.015	1.48	
0.73	0	51.2	0.014	1.42	uL= 1.35



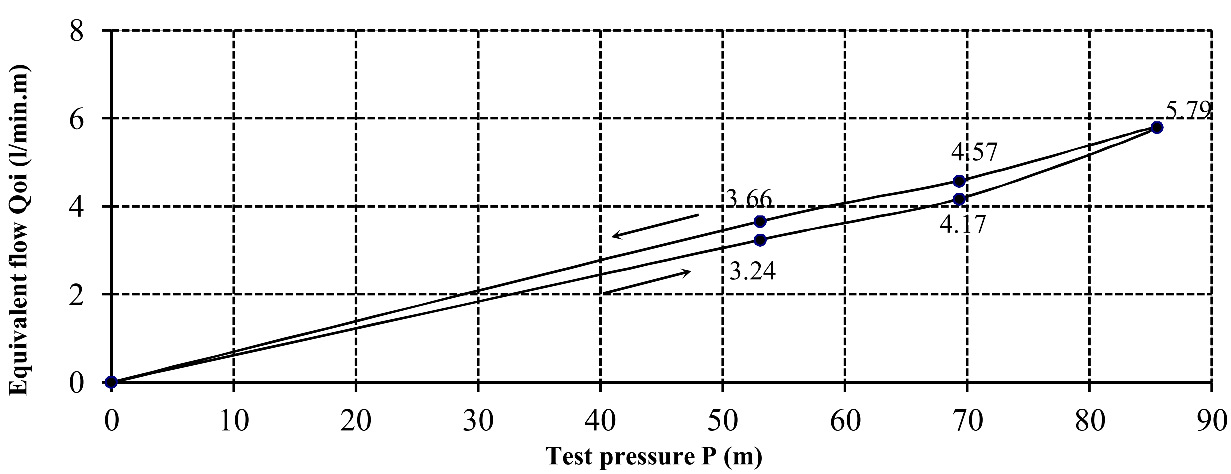
Recorded by: Thanh	Checked by: Quang

GeoTech	**RECORD & CALCULATION** **LUGEON TEST**	**BOREHOLE:**	HTBG001
		Test No.:	P5

PROJECT: Frieda River Project	Depth of borehole at the time of test: 230.1 m
	Test section: from (H_2) 220.0 to 230.1 Length 10.1 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 11 (kG/cm^2) — Date of test: 14:00 7/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 221 — Initial groudwater level (H_3) 21.0 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	3.45	34.5	2398.6	2889	490.4	32.69	- Test conducted in: HORNBLENDE MONZONITE
15	5.18	51.8	2916	3547	631	42.07	- No seepage from top of borehole.
15	6.90	69.0	3657	4534	877	58.47	- Parker pressure is constant throughout the test
15	5.18	51.8	4592	5285	693	46.20	
15	3.45	34.5	5370	5924	554	36.93	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
3.24	0	53.1	0.061	6.10	q= 0.0647 (l/min.m)
4.17	0	69.3	0.060	6.01	
5.79	0	85.5	0.068	6.77	
4.57	0	69.3	0.066	6.60	uL= 6.47
3.66	0	53.1	0.069	6.89	



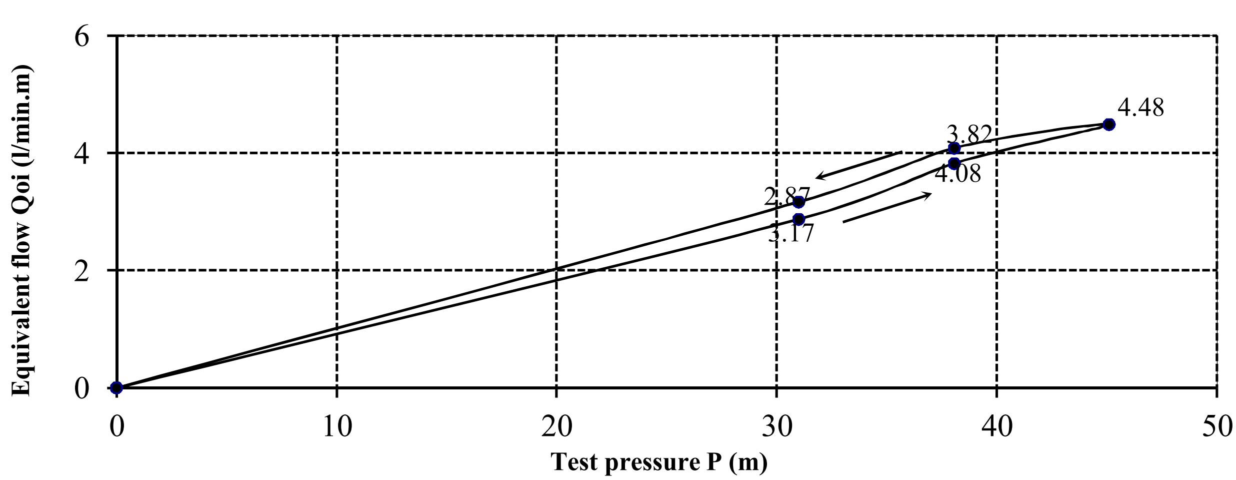
Recorded by: Hanh	Checked by: Quang

	RECORD & CALCULATION LUGEON TEST	**BOREHOLE:**	HTBG001
GeoTech		**Test No.:**	P6

PROJECT: Frieda River Project	Depth of borehole at the time of test: 250 m
	Test section: from (H_2) 238.0 to 250 Length 12.0 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 29.5 (kG/cm^2) Date of test: 12:25 8/01/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 239.0 Initial groudwater level (H_3) 17.0 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	1.50	15.0	6408	6978	570	38.00	- Test conducted in: Horse Microdiorite. - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	2.25	22.5	7036	7771	735	49.00	
15	3.00	30.0	7838	8645	807	53.80	
15	2.25	22.5	8692	9380	688	45.87	
15	1.50	15.0	9450	9967	517	34.47	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
3.17	0	31.0	0.102	10.21	q= 0.1004 (l/min.m)
4.08	0	38.1	0.107	10.73	
4.48	0	45.1	0.099	9.94	
3.82	0	38.1	0.100	10.04	uL= 10.04
2.87	0	31.0	0.093	9.26	



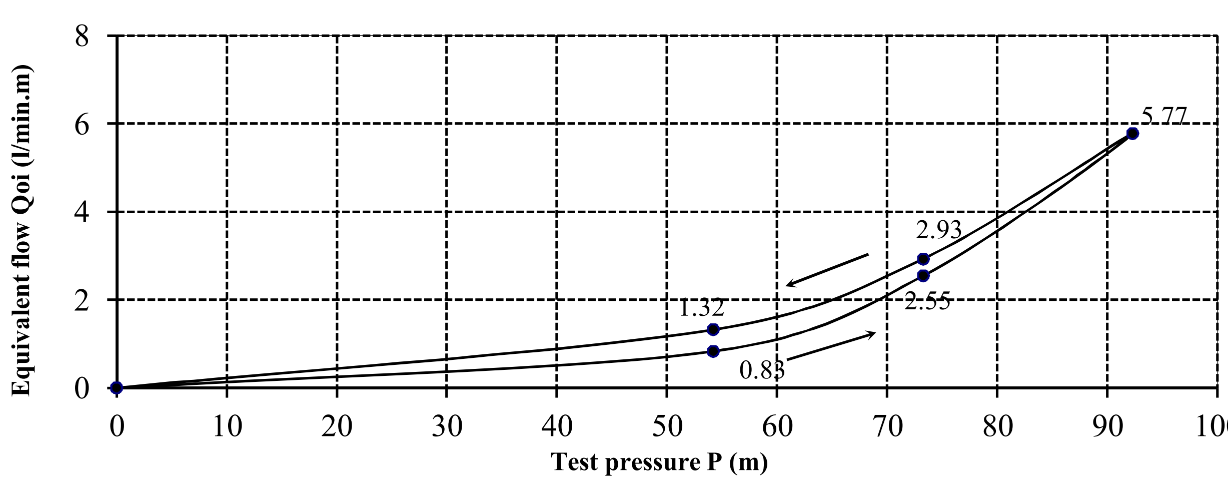
Recorded by: Hanh	Checked by: Dong

GeoTech	**RECORD & CALCULATION** **LUGEON TEST**	**BOREHOLE:**	HTBG001
		Test No.:	P7

PROJECT: Frieda River Project	Depth of borehole at the time of test:		270	m
	Test section: from (H_2)	260.0 to 270	Length 10.0	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)		1.0	m
	Inclination of borehole from Horizontal (ϕ):	70		
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 31.7 (kG/cm^2)	Date of test:	8:00 9/01/2015	
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 261.0	Initial groudwater level (H_3)	16.2	m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	4.05	40.5	10171.8	10296.4	124.6	8.31	- Test conducted in: Horse Microdiorite. - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	6.08	60.8	10320	10702	382	25.47	
15	8.10	81.0	10799	11665	866	57.73	
15	6.08	60.8	11726	12166	440	29.33	
15	4.05	40.5	12199	12397	198	13.20	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.83	0	54.2	0.015	1.53	q= 0.0374 (l/min.m)
2.55	0	73.3	0.035	3.47	
5.77	0	92.3	0.063	6.26	
2.93	0	73.3	0.040	4.00	
1.32	0	54.2	0.024	2.43	uL= 3.74



Recorded by: Hanh	Checked by: Dong

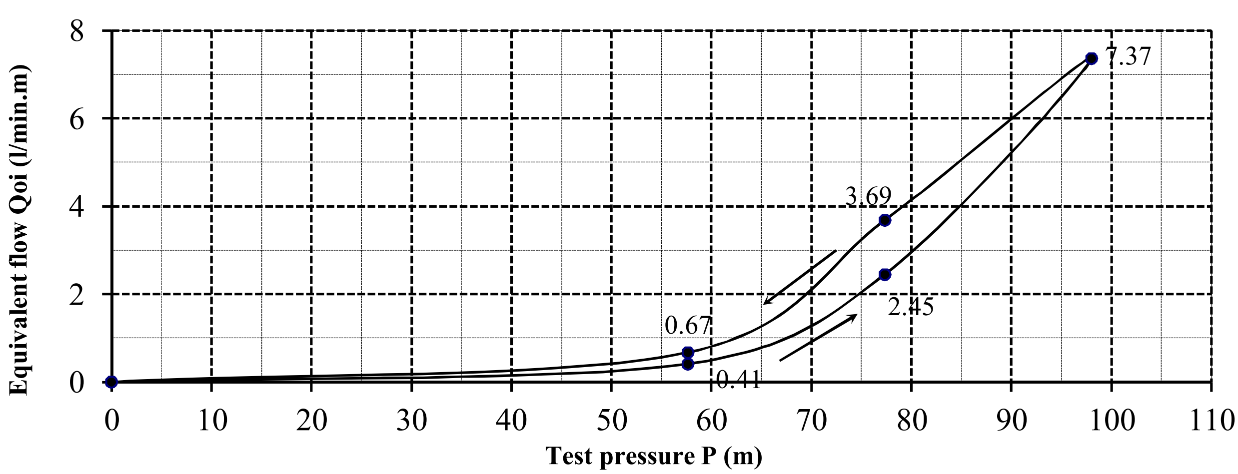
RECORD & CALCULATION LUGEON TEST

GeoTech	**RECORD & CALCULATION LUGEON TEST**	**BOREHOLE:** HTBG001 / **Test No.:** P8

PROJECT: Frieda River Project	Depth of borehole at the time of test: 290.0 m
	Test section: from (H_2) 280.0 to 290.0 Length 10.0 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 33.9 (kG/cm^2) Date of test: 1:00 10/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 281 Initial groudwater level (H_3) 16.3 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	4.40	44.0	0	62	62.0	4.13	- Test conducted in: Debom Pyroclastics (DVp) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	6.50	65.0	62.0	430	368.0	24.53	
15	8.70	87.0	430.0	1535	1105.0	73.67	
15	6.50	65.0	1535.0	2088	553.0	36.87	
15	4.40	44.0	2088.0	2189	101.0	6.73	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.41	0	57.6	0.007	0.72	q= 0.0397 (l/min.m)
2.45	0	77.3	0.032	3.17	
7.37	0	98.0	0.075	7.52	
3.69	0	77.3	0.048	4.77	uL= 3.97
0.67	0	57.6	0.012	1.17	



Recorded by: Thanh | Checked by: Quang

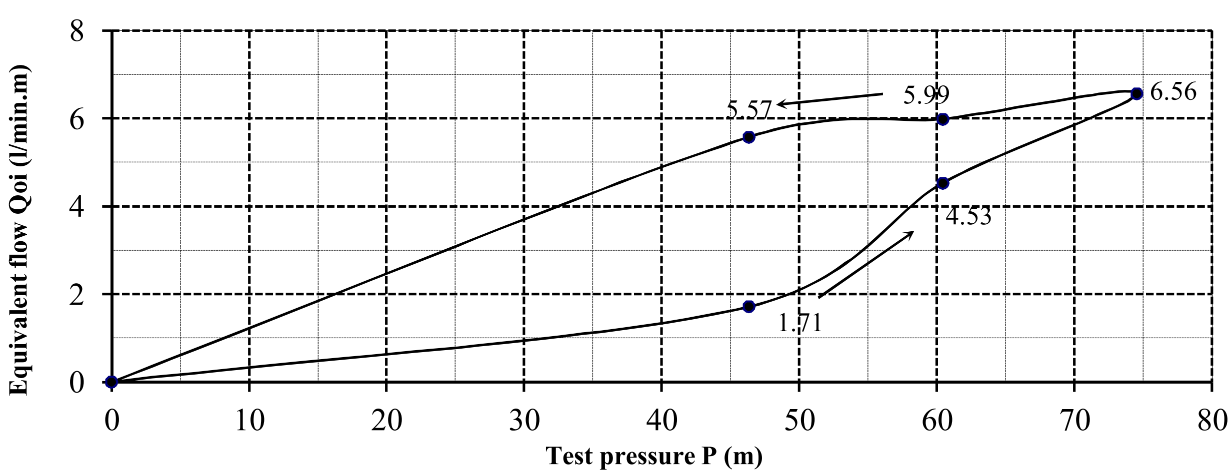
RECORD & CALCULATION
LUGEON TEST

Geo Tech	RECORD & CALCULATION LUGEON TEST	BOREHOLE:	HTBG001
		Test No.:	P9

PROJECT: Frieda River Project	Depth of borehole at the time of test: 310.0 m
	Test section: from (H_2) 300.0 to 310.0 Length 10.0 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 36.1 (kG/cm^2) — Date of test: 19:00 10/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 301 — Initial groudwater level (H_3) 18.3 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	3.00	30.0	0	257	257.0	17.13	- Test conducted in: Debom Pyroclastics (DVp) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	4.50	45.0	257.0	936	679.0	45.27	
15	6.00	60.0	936.0	1920	984.0	65.60	
15	4.50	45.0	1920.0	2818	898.0	59.87	
15	3.00	30.0	2818.0	3654	836.0	55.73	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES — WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
1.71	0	46.3	0.037	3.70	q= 0.1203 (l/min.m)
4.53	0	60.4	0.075	7.49	
6.56	0	74.5	0.088	8.80	
5.99	0	60.4	0.099	9.91	uL= 12.03
5.57	0	46.3	0.120	12.03	



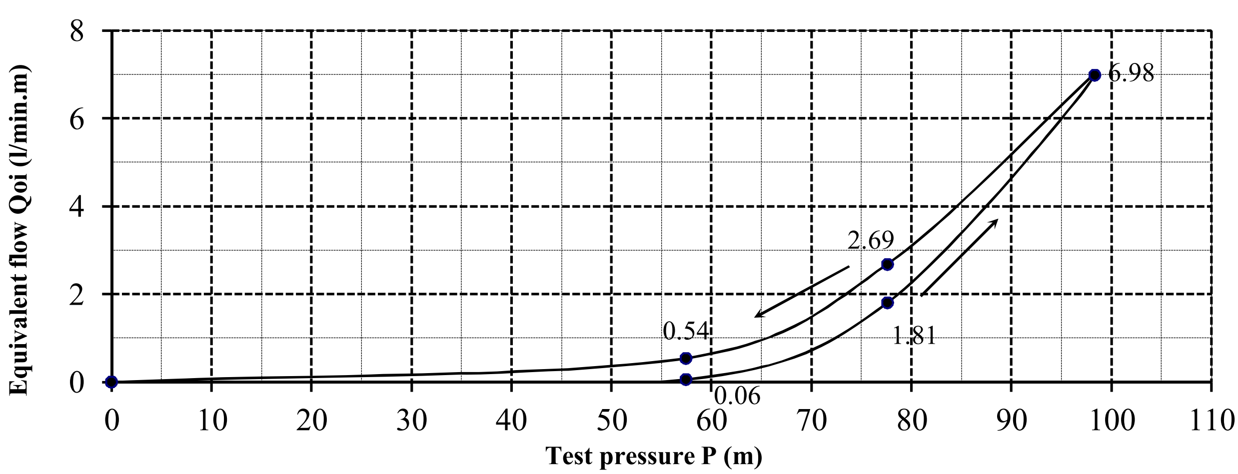
Recorded by: Thanh	Checked by: Quang

GeoTech	**RECORD & CALCULATION** **LUGEON TEST**	**BOREHOLE:**	HTBG001
		Test No.:	P10

PROJECT: Frieda River Project	Depth of borehole at the time of test: 330.6 m
	Test section: from (H_2) 320.0 to 330.6 Length 10.6 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 38.37 (kG/cm^2) Date of test: 14:00 10/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 321 Initial groudwater level (H_3) 16.6 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	4.35	43.5	0	9	9.0	0.60	- Test conducted in: Debom Pyroclastics (DVp) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	6.50	65.0	9.0	297	288.0	19.20	
15	8.70	87.0	297.0	1407	1110.0	74.00	
15	6.50	65.0	1407.0	1834	427.0	28.47	
15	4.35	43.5	1834.0	1920	86.0	5.73	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.06	0	57.4	0.001	0.10	q= 0.0290 (l/min.m)
1.81	0	77.6	0.023	2.33	
6.98	0	98.3	0.071	7.10	
2.69	0	77.6	0.035	3.46	uL= 2.90
0.54	0	57.4	0.009	0.94	



Recorded by: Hanh	Checked by: Dong

Geo Tech	RECORD & CALCULATION LUGEON TEST	BOREHOLE:	HTBG001
		Test No.:	P11

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test: 349.5 m

Test section: from (H_2) 340.0 to 349.5 Length 9.5 m

Height of pressure gage from ground level: (H_1) 1.0 m

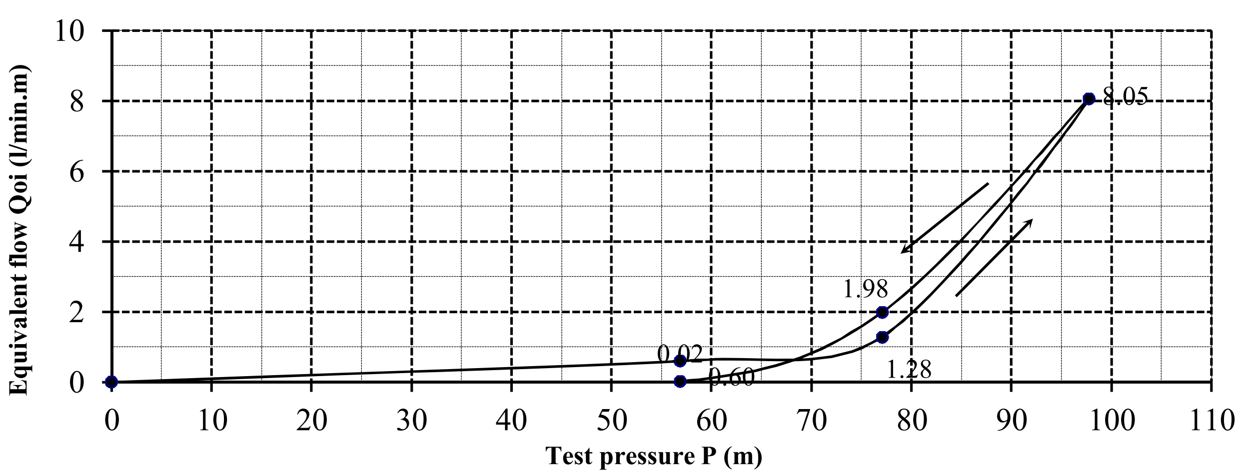
Inclination of borehole from Horizontal (ϕ): 70

TYPE OF PACKER: GeoPro Wireline Single | PARKER PRESSURE: 40.45 (kG/cm^2) | Date of test: 8:10 12/1/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 341 | Initial groudwater level (H_3) 16.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	4.35	43.5	0	86	86.0	5.73	- Test conducted in: Debom Pyroclastics (DVp) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	6.50	65.0	86.0	269	183.0	12.20	
15	8.70	87.0	269.0	1416	1147.0	76.47	
15	6.50	65.0	1416.0	1698	282.0	18.80	
15	4.35	43.5	1698.0	1701	3.0	0.20	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.60	0	56.9	0.011	1.06	q= 0.0212 (l/min.m)
1.28	0	77.1	0.017	1.67	
8.05	0	97.7	0.082	8.24	
1.98	0	77.1	0.026	2.57	uL= 2.12
0.02	0	56.9	0.000	0.04	



Recorded by: Hanh | Checked by: Dong

RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG001
Test No.:	P12

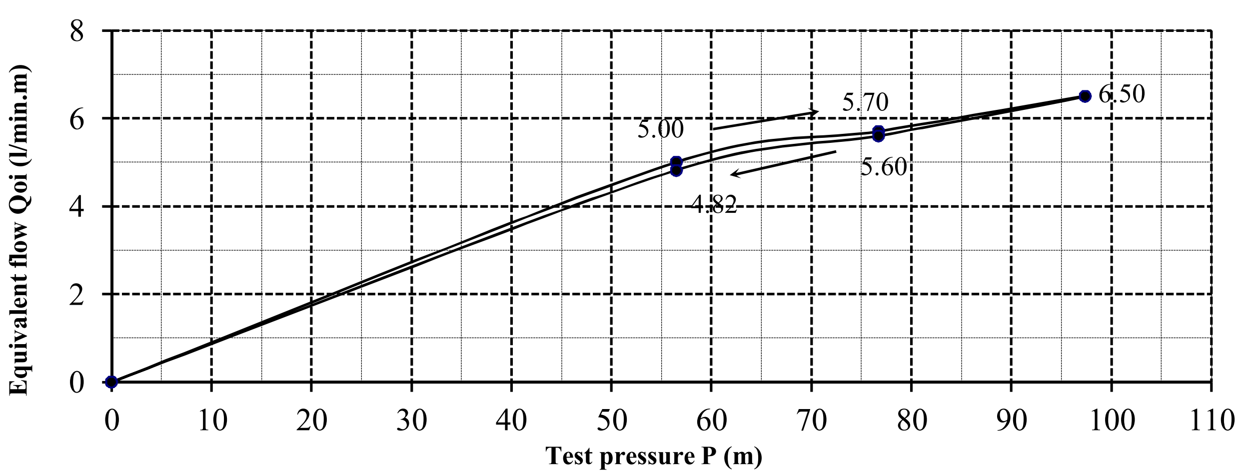
PROJECT: Frieda River Project	Depth of borehole at the time of test:			370.0	m
	Test section: from (H_2)	360.0 to 370.0	Length	10.0	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)			1.0	m
	Inclination of borehole from Horizontal (ϕ):	70			

TYPE OF PACKER: GeoPro Wireline Single | **PARKER PRESSURE:** 42.70 (kG/cm^2) | Date of test: 1:30 13/1/2015

Water hose from pressure gauge to parker: | Length: $l = H_1 + H_2 =$ 361 | Initial groudwater level (H_3) 15.6 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	4.35	43.5	0	750	750.0	50.00	- Test conducted in: Debom Pyroclastics (DVp) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	6.50	65.0	750.0	1605.0	855.0	57.00	
15	8.70	87.0	1605.0	2580.0	975.0	65.00	
15	6.50	65.0	2580.0	3420.0	840.0	56.00	
15	4.35	43.5	3420.0	4143.0	723.0	48.20	

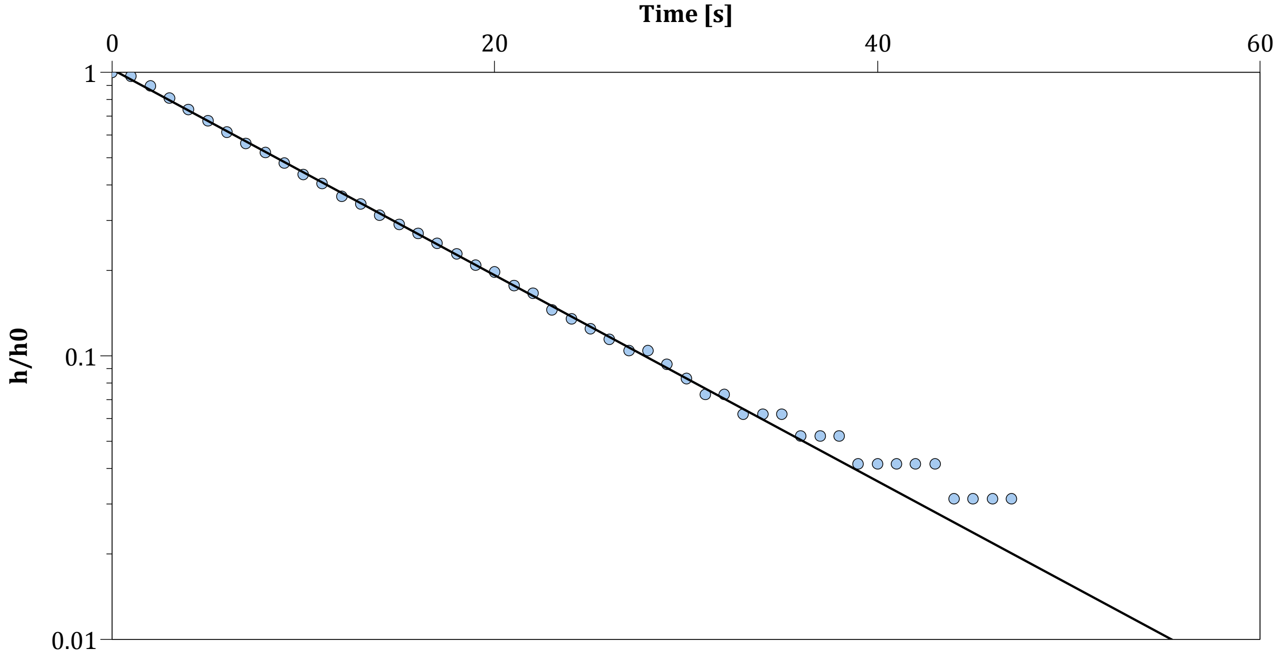
EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
5.00	0	56.5	0.089	8.85	q= 0.0668 (l/min.m)
5.70	0	76.7	0.074	7.43	
6.50	0	97.4	0.067	6.68	
5.60	0	76.7	0.073	7.30	uL= 6.68
4.82	0	56.5	0.085	8.53	



Recorded by: Thanh | Checked by: Quang

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report**
	Project: Frieda River
	Number: I1049
	Client: PanAust

Location: Frieda River, PNG	Slug Test: 4.5 - 9.3 m	Test Well: HTBG002: Test 01
Test Conducted by: Geotech International		Test Date: 21/01/2015
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/03/2015
Aquifer Thickness: 4.50 m		



Calculation using Hvorslev

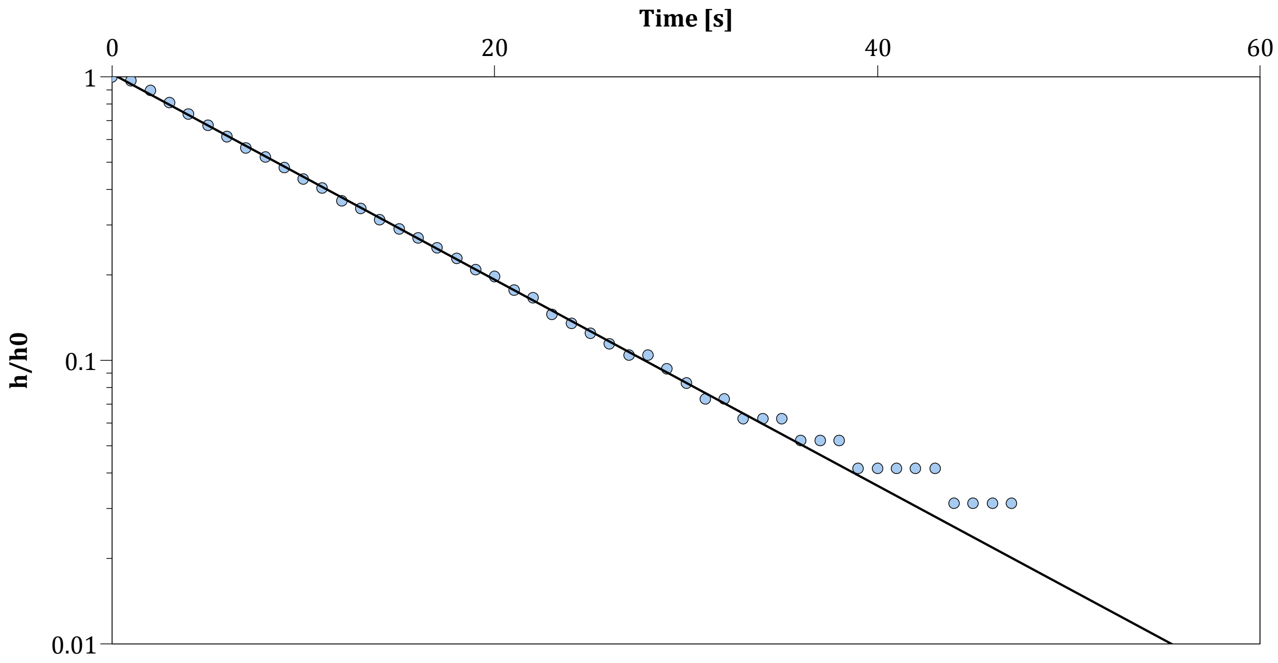
Observation Well	Hydraulic Conductivity [m/d]
HTBG002: Test 01	1.24×10^{1}

AGE Consultants
Level 2/15 Mallon St
Bowen Hills, QLD, 4006

GROUNDWATER & ENVIRONMENTAL

Slug Test Analysis Report
Project: Frieda River
Number: I1049
Client: PanAust

Location: Frieda River, PNG	Slug Test: 4.5 - 9.3 m	Test Well: HTBG002: Test 01
Test Conducted by: Geotech International		Test Date: 21/01/2015
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 23/01/2015
Aquifer Thickness: 4.50 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
HTBG002: Test 01	9.55×10^{0}	

RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG002
Test No.:	P1

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test: 40.5 m

Test section: from (H_2) 31.5 to 40.5 Length 9.0 m

Height of pressure gage from ground level: (H_1) 1.0 m

Inclination of borehole from Horizontal (ϕ): 65

TYPE OF PACKER: GeoPro Wireline Single

PARKER PRESSURE: 6.46 (kG/cm^2)

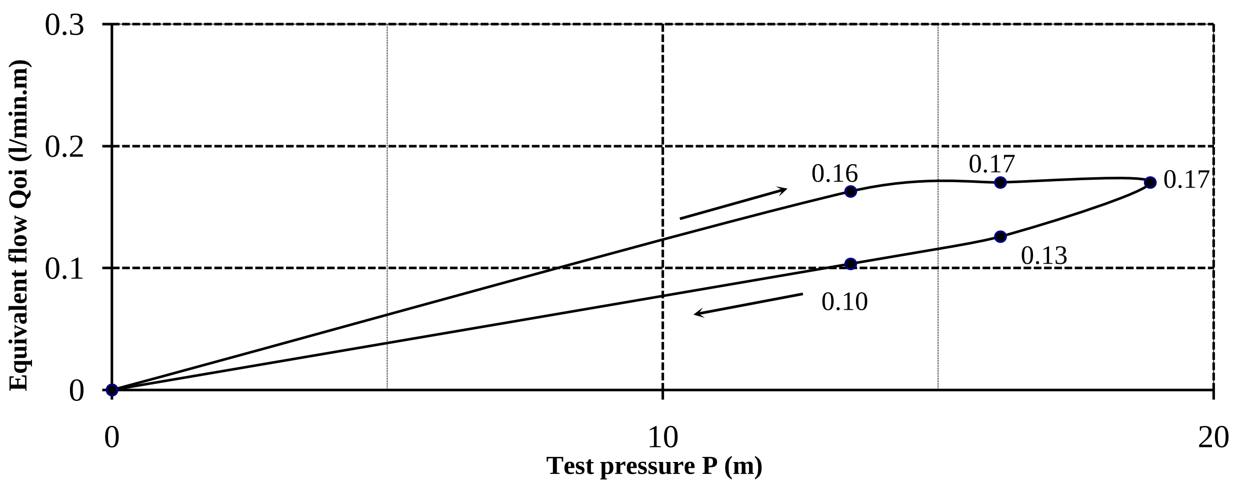
Date of test: 3:10 23/1/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 32.5

Initial groudwater level (H_3) 7.8 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	0.60	6.0	0	22	22.0	1.47	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	0.90	9.0	22.0	45.0	23.0	1.53	
15	1.20	12.0	45.0	68.0	23.0	1.53	
15	0.90	9.0	68.0	85.0	17.0	1.13	
15	0.60	6.0	85.0	99.0	14.0	0.93	

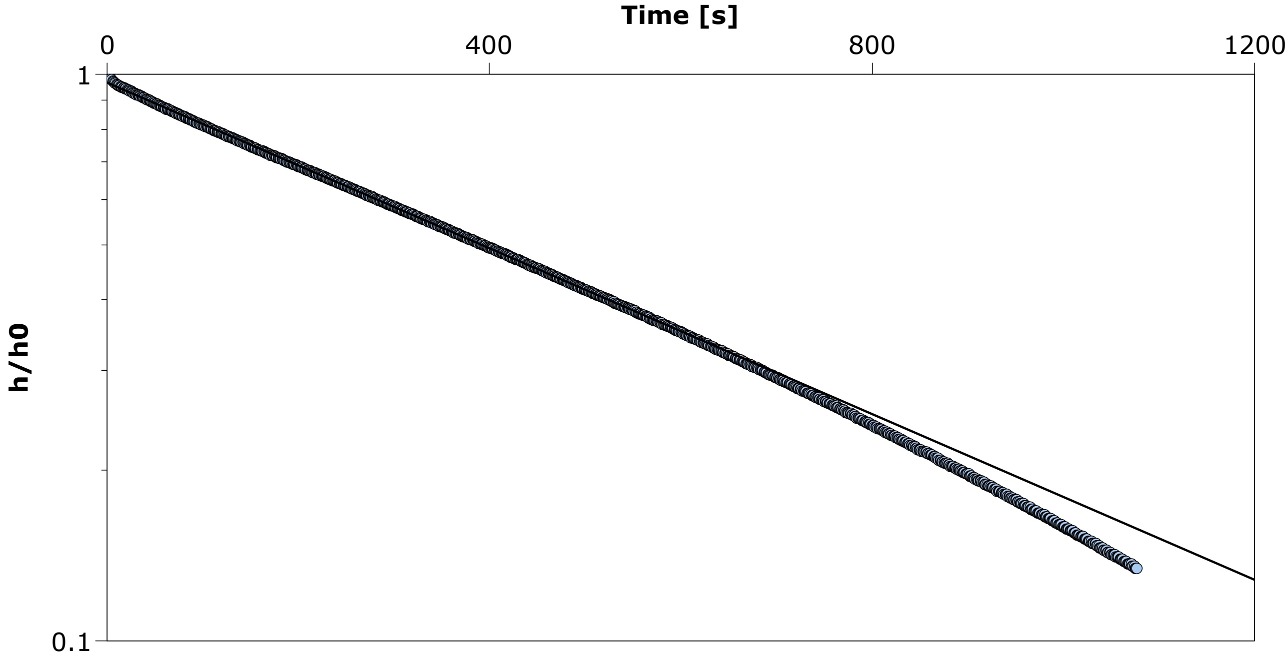
EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.16	0	13.4	0.012	1.21	q= 0.0077 (l/min.m)
0.17	0	16.1	0.011	1.06	
0.17	0	18.9	0.009	0.90	
0.13	0	16.1	0.008	0.78	uL= 0.77
0.10	0	13.4	0.008	0.77	



Recorded by: Hien	Checked by: M. Cuong

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report**
	Project: Frieda River
	Number: I1049
	Client: PanAust

Location: Frieda River, PNG	Slug Test: 34 - 40.5 m	Test Well: HTBG002: Test 02
Test Conducted by: Geotech International		Test Date: 23/01/2015
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 26/03/2015
Aquifer Thickness: 6.50 m		

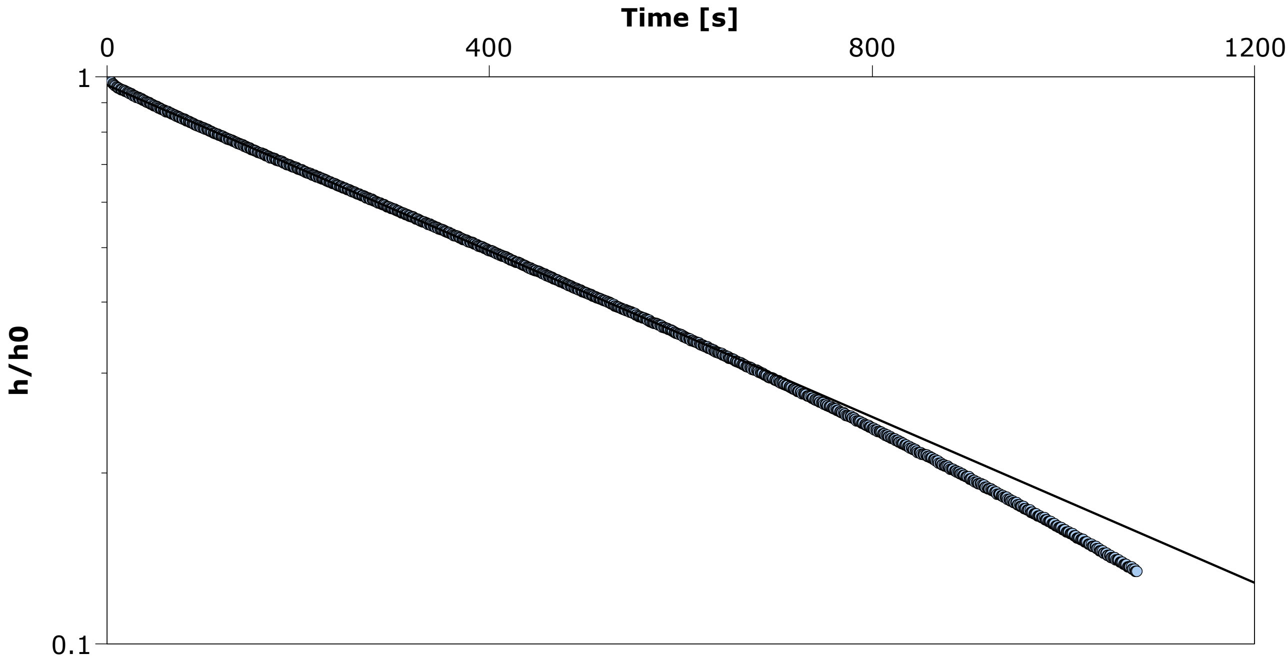


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
HTBG002: Test 02	1.97×10^{-1}	

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report**
	Project: Frieda River
	Number: I1049
	Client: PanAust

Location: Frieda River, PNG	Slug Test: 34 - 40.5 m	Test Well: HTBG002: Test 02
Test Conducted by: Geotech International		Test Date: 23/01/2015
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 26/03/2015
Aquifer Thickness: 6.50 m		



Calculation using Bouwer & Rice

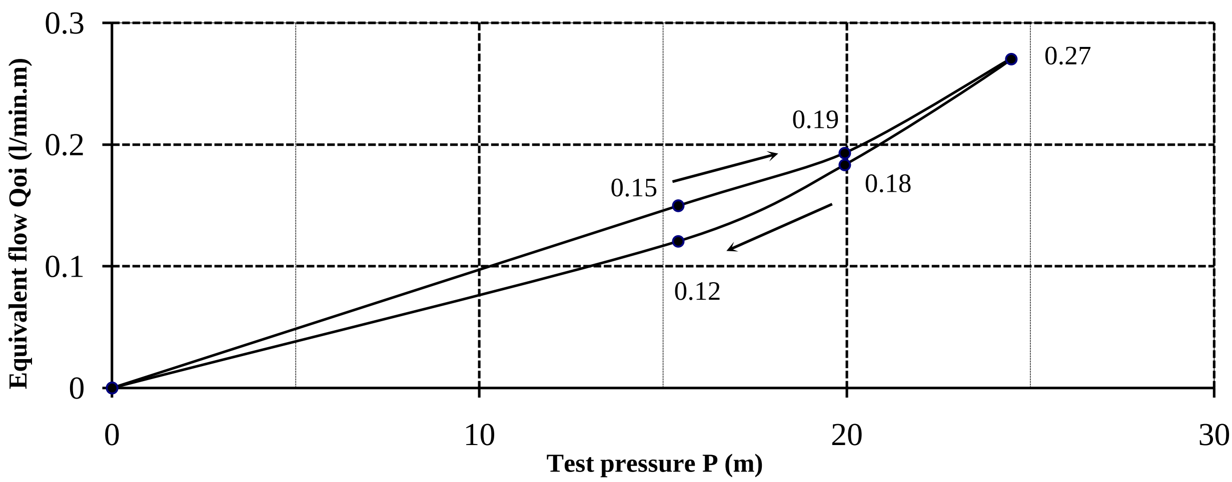
Observation Well	Hydraulic Conductivity [m/d]	
HTBG002: Test 02	1.52×10^{-1}	

GeoTech	**RECORD & CALCULATION** **LUGEON TEST**	**BOREHOLE:**	HTBG002
		Test No.:	P2

PROJECT: Frieda River Project	Depth of borehole at the time of test: 63.8 m
	Test section: from (H_2) 50.0 to 63.8 Length 13.8 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 65
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 9.02 (kG/cm²) — Date of test: 18:05 23/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 51 — Initial groudwater level (H_3) 6.0 m

Reading time	**Pressure gauge reading (Poi)**		**Flowmeter reading (liter)**			**Average flow**	**Remark**
(minute)	(kG/cm²)	(m)	Before	After	Take	Qi (l/min)	
15	1.00	10.0	0	31	31.0	2.07	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	1.50	15.0	31.0	71.0	40.0	2.67	
15	2.00	20.0	71.0	127.0	56.0	3.73	
15	1.50	15.0	127.0	165.0	38.0	2.53	
15	1.00	10.0	165.0	190.0	25.0	1.67	

EQUIVALENT FLOW	**HEAD LOSS**	**TEST PRESSURE**	**TEST VALUES**		**VALUE CHOSEN FOR THE TEST SECTION**
			WATER LOSS	**LUGEON**	
Qoi=Qi/L (l/min/m)	H_f (m)	$Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	qi=Qoi/Pi (l/min.m)	uLi = 100qi	
0.15	0	15.4	0.010	0.97	q= 0.0095 (l/min.m)
0.19	0	19.9	0.010	0.97	
0.27	0	24.5	0.011	1.11	
0.18	0	19.9	0.009	0.92	uL= 0.95
0.12	0	15.4	0.008	0.78	



Recorded by: Hien	Checked by: M. Cuong

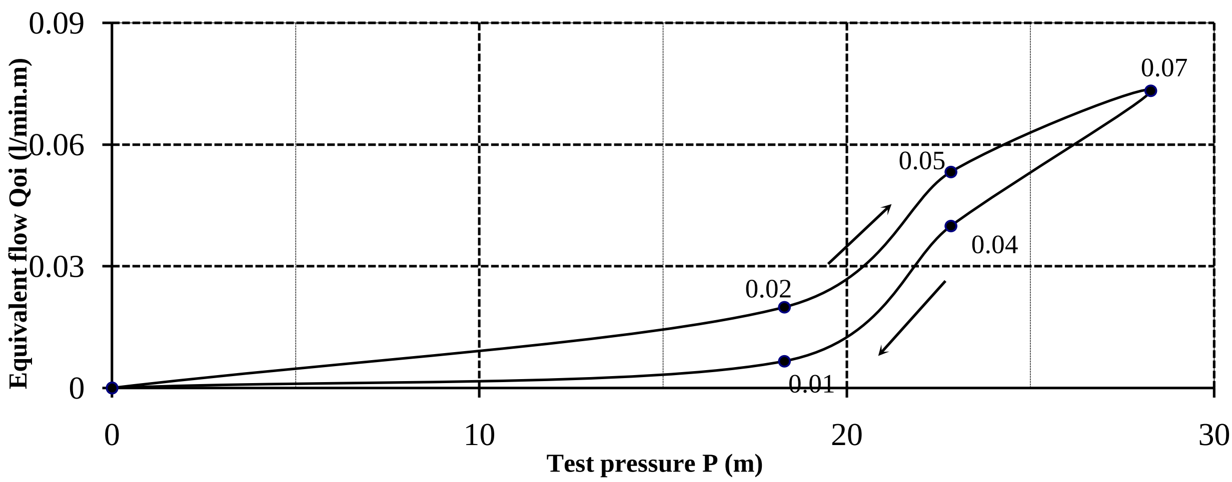
RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG002
Test No.:	P3

PROJECT: Frieda River Project	Depth of borehole at the time of test: 83.3 m
	Test section: from (H_2) 73.3 to 83.3 Length 10.0 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 65
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 11.16 (kG/cm²) — Date of test: 6:10 24/1/2015
Water hose from pressure gauge to parker:	Length: l = H_1 + H_2 = 74.3 — Initial groudwater level (H_3) 8.2 m

Reading time	Pressure gauge reading (Poi)		Flowmeter reading (liter)			Average flow	Remark
(minute)	(kG/cm²)	(m)	Before	After	Take	Qi (l/min)	
15	1.10	11.0	0	3	3.0	0.20	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	1.60	16.0	3.0	11.0	8.0	0.53	
15	2.20	22.0	11.0	22.0	11.0	0.73	
15	1.60	16.0	22.0	28.0	6.0	0.40	
15	1.10	11.0	28.0	29.0	1.0	0.07	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE Pi=(Poi+H_1+H_2-H_f)*Sinϕ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.02	0	18.3	0.001	0.11	q= 0.0020 (l/min.m)
0.05	0	22.8	0.002	0.23	
0.07	0	28.3	0.003	0.26	
0.04	0	22.8	0.002	0.18	uL= 0.20
0.01	0	18.3	0.000	0.04	



Recorded by: Duc	Checked by: Huy

RECORD & CALCULATION LUGEON TEST

Geo Tech	RECORD & CALCULATION LUGEON TEST	BOREHOLE:	HTBG002
		Test No.:	P4

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test: 106.2 m

Test section: from (H_2) 96.2 to 106.2 Length 10.0 m

Height of pressure gage from ground level: (H_1) 1.0 m

Inclination of borehole from Horizontal (ϕ): 65

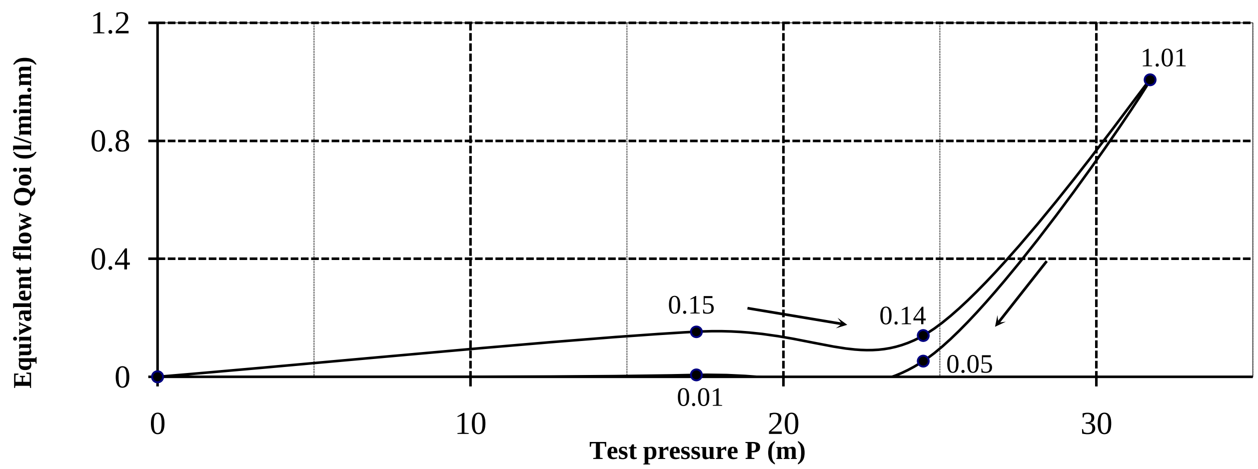
TYPE OF PACKER: GeoPro Wireline Single

PARKER PRESSURE: 13.68 (kG/cm^2) Date of test: 2:15 25/1/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 97.2 Initial groudwater level (H_3) 2.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	1.60	16.0	0	23	23.0	1.53	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	2.40	24.0	23.0	44.0	21.0	1.40	
15	3.20	32.0	44.0	195.0	151.0	10.07	
15	2.40	24.0	195.0	203.0	8.0	0.53	
15	1.60	16.0	203.0	204.0	1.0	0.07	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.15	0	17.2	0.009	0.89	q= 0.0098 (l/min.m)
0.14	0	24.5	0.006	0.57	
1.01	0	31.7	0.032	3.17	
0.05	0	24.5	0.002	0.22	uL= 0.98
0.01	0	17.2	0.000	0.04	



Recorded by: Hien | Checked by: M. Cuong

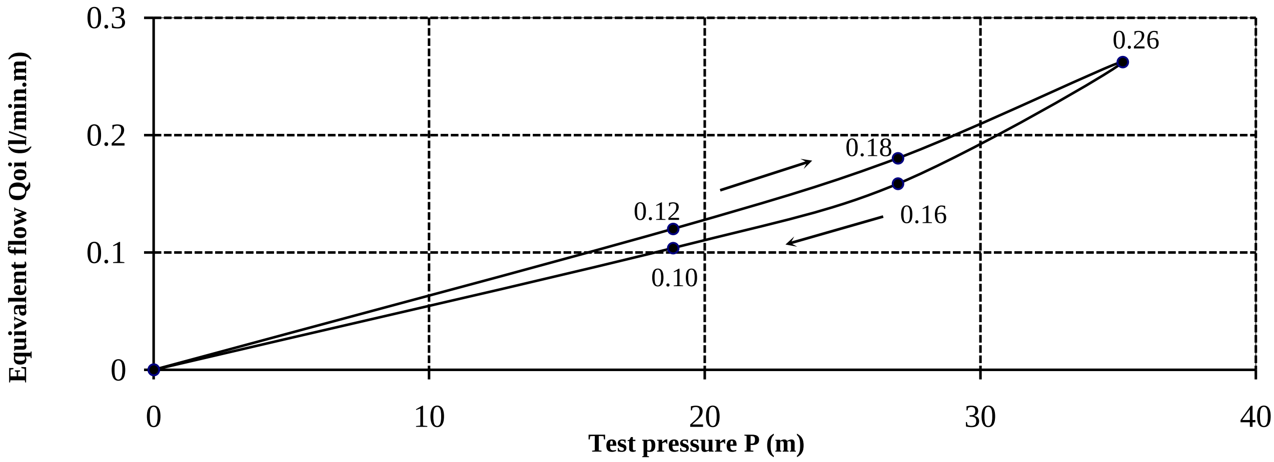
RECORD & CALCULATION LUGEON TEST

BOREHOLE:	HTBG002
Test No.:	P5

PROJECT: Frieda River Project	Depth of borehole at the time of test:				121.2	m	
	Test section: from (H_2)	109.0	to	121.2	Length	12.2	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)				1.0	m	
	Inclination of borehole from Horizontal (ϕ):	65					
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE:	15.33	(kG/cm^2)	Date of test:	11:00 25/1/2015		
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$	110	Initial groudwater level (H_3)	1.8	m		

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	Flowmeter reading (liter) After	Flowmeter reading (liter) Take	Average flow Qi (l/min)	Remark
15	1.80	18.0	0	22	22.0	1.47	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	2.70	27.0	22.0	55.0	33.0	2.20	
15	3.60	36.0	55.0	103.0	48.0	3.20	
15	2.70	27.0	103.0	132.0	29.0	1.93	
15	1.80	18.0	132.0	151.0	19.0	1.27	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.12	0	18.9	0.006	0.64	q= 0.0063 (l/min.m)
0.18	0	27.0	0.007	0.67	
0.26	0	35.2	0.007	0.75	
0.16	0	27.0	0.006	0.59	uL= 0.63
0.10	0	18.9	0.006	0.55	



Recorded by: Duc	Checked by: Huy

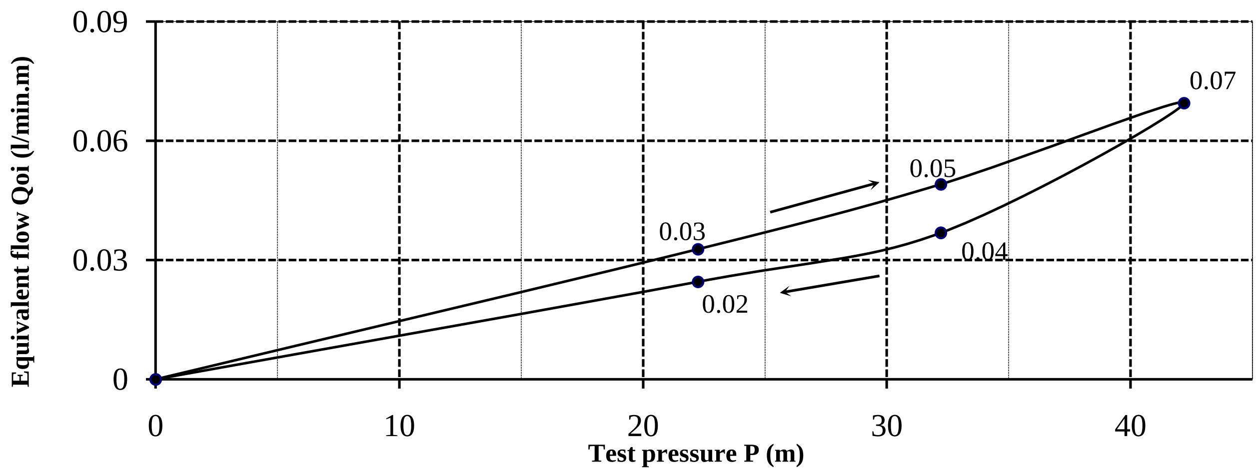
RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG002
Test No.:	P6

PROJECT: Frieda River Project	Depth of borehole at the time of test: 143.3 m
	Test section: from (H_2) 127.0 to 143.3 Length 16.3 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 65
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 17.76 (kG/cm^2) Date of test: 2:09 26/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 128 Initial groudwater level (H_3 2.6 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	2.10	21.0	0	8	8.0	0.53	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	3.20	32.0	8.0	20.0	12.0	0.80	
15	4.30	43.0	20.0	37.0	17.0	1.13	
15	3.20	32.0	37.0	46.0	9.0	0.60	
15	2.10	21.0	46.0	52.0	6.0	0.40	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.03	0	22.2	0.001	0.15	q= 0.0013 (l/min.m)
0.05	0	32.2	0.002	0.15	
0.07	0	42.2	0.002	0.16	
0.04	0	32.2	0.001	0.11	uL= 0.13
0.02	0	22.2	0.001	0.11	



Recorded by: Hien	Checked by: M. Cuong

RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG002
Test No.:	P7

PROJECT: Frieda River Project	Depth of borehole at the time of test:			161.3	m
	Test section: from (H_2)	150.0	to 161.3	Length 11.3	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)			1.0	m
	Inclination of borehole from Horizontal (ϕ):	65			
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE:	19.74	(kG/cm^2)	Date of test:	15:40 26/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$	151	Initial groudwater level (H_3)	0.95	m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	Flowmeter reading (liter) After	Flowmeter reading (liter) Take	Average flow Qi (l/min)	Remark
15	0.00	0.0	0	260	260.0	17.33	- Test conducted in: Horse Microdiorite (Hmd) - Seepage from top of borehole. - Parker pressure is constant throughout the test

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
1.53	0	1.8	0.868	86.79	q= 0.0000 (l/min.m)
0.00	0	1.8	0.000	0.00	
0.00	0	1.8	0.000	0.00	
0.00	0	1.8	0.000	0.00	
0.00	0	1.8	0.000	0.00	uL= 0.00

Recorded by: Duc

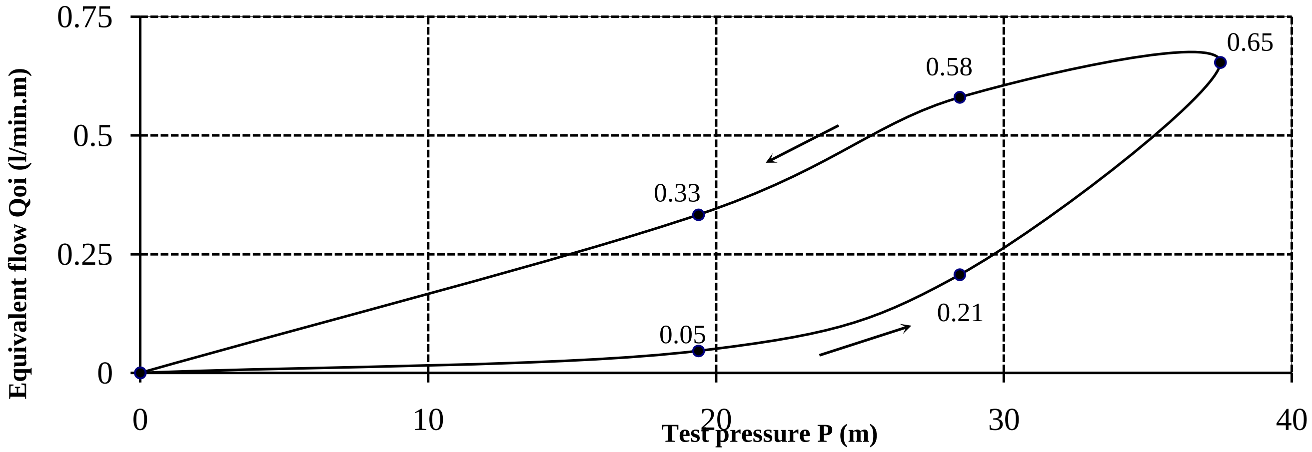
Checked by: Huy

Geo Tech	RECORD & CALCULATION **LUGEON TEST**	BOREHOLE:	HTBG002
		Test No.:	P8

PROJECT: Frieda River Project	Depth of borehole at the time of test: 182.3 m
	Test section: from (H_2) 172.3 to 182.3 Length 10.0 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 65
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 22.05 (kG/cm^2) Date of test: 6:25 27/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 173.3 Initial groudwater level (H_3) 0.4 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	2.00	20.0	0	7	7.0	0.47	- Test conducted in: Horse Microdiorite (Hmd)
15	3.00	30.0	7.0	38.0	31.0	2.07	- No seepage from top of borehole.
15	4.00	40.0	38.0	136.0	98.0	6.53	- Parker pressure is constant throughout the test
15	3.00	30.0	136.0	223.0	87.0	5.80	- Pressure water outflows from borehole
15	2.00	20.0	223.0	273.0	50.0	3.33	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.05	0	19.4	0.002	0.24	q= 0.0129 (l/min.m)
0.21	0	28.5	0.007	0.73	
0.65	0	37.5	0.017	1.74	
0.58	0	28.5	0.020	2.04	
0.33	0	19.4	0.017	1.72	uL= 1.29



Recorded by: Duc	Checked by: Huy

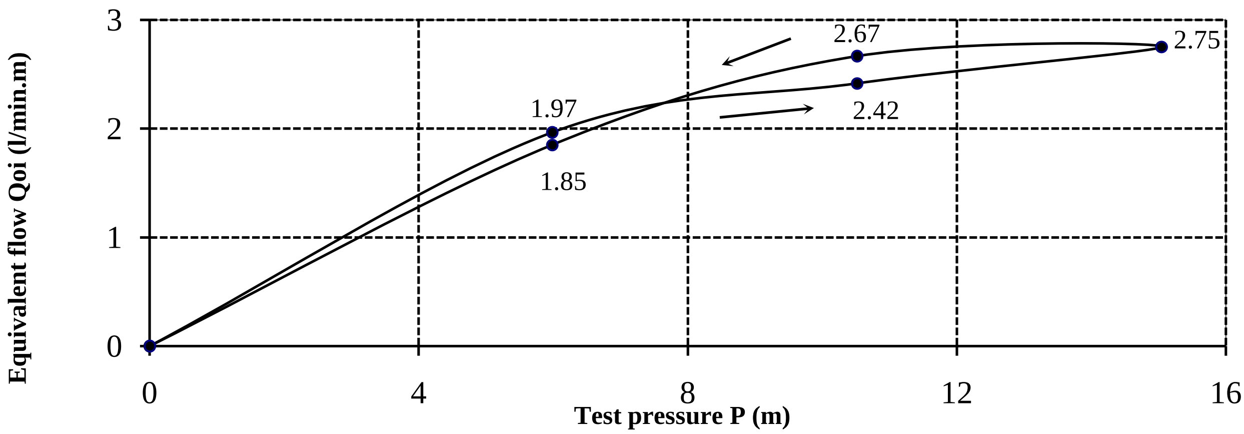
RECORD & CALCULATION LUGEON TEST

BOREHOLE:	HTBG002
Test No.:	P9

PROJECT: Frieda River Project	Depth of borehole at the time of test: 200.3 m
	Test section: from (H_2) 185.0 to 200.3 Length 15.3 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 65
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 24.03 (kG/cm^2) Date of test: 20:25 27/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 186 Initial groundwater level (H_3) 0.6 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	0.50	5.0	0	451	451.0	30.07	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test - Pressure water outflows from borehole
15	1.00	10.0	451.0	1006.0	555.0	37.00	
15	1.50	15.0	1006.0	1638.0	632.0	42.13	
15	1.00	10.0	1638.0	2250.0	612.0	40.80	
15	0.50	5.0	2250.0	2675.0	425.0	28.33	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
1.97	0	6.0	0.329	32.85	q= 0.1830 (l/min.m)
2.42	0	10.5	0.230	23.00	
2.75	0	15.0	0.183	18.30	
2.67	0	10.5	0.254	25.37	uL= 18.30
1.85	0	6.0	0.310	30.96	



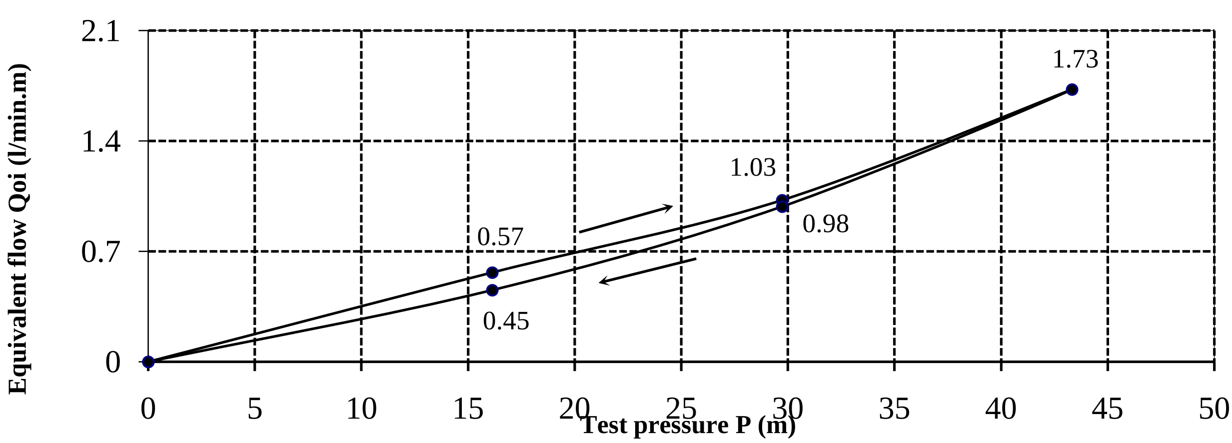
Recorded by: Hien	Checked by: M. Cuong

	RECORD & CALCULATION LUGEON TEST	BOREHOLE:	HTBG002
		Test No.:	P10

PROJECT: Frieda River Project	Depth of borehole at the time of test: 220.2 m
	Test section: from (H_2) 207.0 to 220.2 Length 13.2 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 65
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 26.22 (kG/cm^2) — Date of test: 21:00 28/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 208 — Initial groudwater level (H_3) 1.8 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	1.50	15.0	0	112	112.0	7.47	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test - Pressure water outflows from borehole
15	3.00	30.0	112.0	315.0	203.0	13.53	
15	4.50	45.0	315.0	657.0	342.0	22.80	
15	3.00	30.0	657.0	852.0	195.0	13.00	
15	1.50	15.0	852.0	942.0	90.0	6.00	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.57	0	16.1	0.035	3.51	q= 0.0341 (l/min.m)
1.03	0	29.7	0.034	3.45	
1.73	0	43.3	0.040	3.99	
0.98	0	29.7	0.033	3.31	uL= 3.41
0.45	0	16.1	0.028	2.82	



Recorded by: Hien	Checked by: M. Cuong

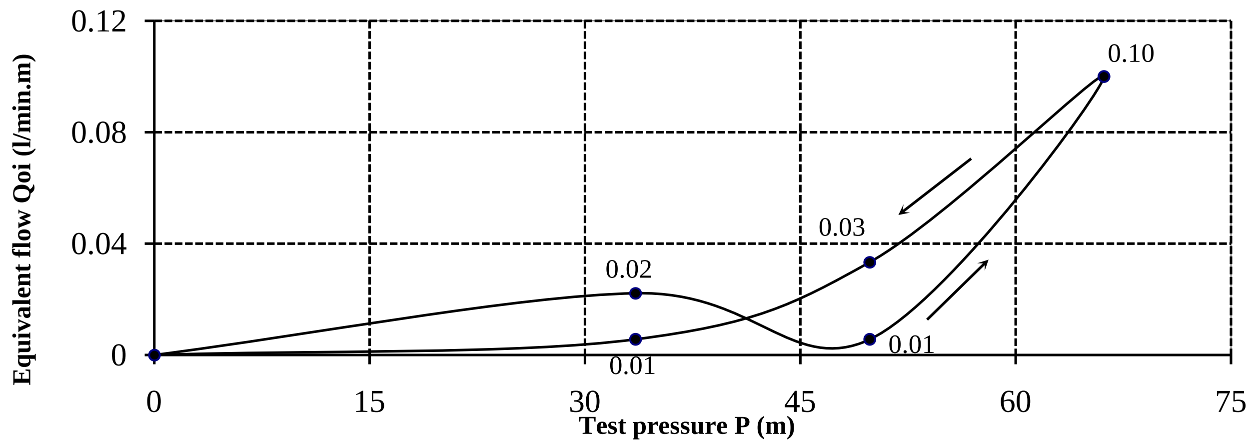
RECORD & CALCULATION LUGEON TEST

GeoTech	RECORD & CALCULATION LUGEON TEST	BOREHOLE:	HTBG002
		Test No.:	P11

PROJECT: Frieda River Project	Depth of borehole at the time of test: 242.6 m
	Test section: from (H_2) 230.6 to 242.6 Length 12.0 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 65
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 28.69 (kG/cm²) — Date of test: 15:00 29/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 231.6 — Initial groudwater level (H_3) 0.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm²)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	3.60	36.0	0	4	4.0	0.27	- Test conducted in: Horse Microdiorite (Hmd)
15	5.40	54.0	4.0	5.0	1.0	0.07	- No seepage from top of borehole.
15	7.20	72.0	5.0	23.0	18.0	1.20	- Parker pressure is constant throughout the test
15	5.40	54.0	23.0	29.0	6.0	0.40	- Pressure water outflows from borehole
15	3.60	36.0	29.0	30.0	1.0	0.07	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.02	0	33.5	0.001	0.07	q= 0.0006 (l/min.m)
0.01	0	49.8	0.000	0.01	
0.10	0	66.2	0.002	0.15	
0.03	0	49.8	0.001	0.07	
0.01	0	33.5	0.000	0.02	uL= 0.06



Recorded by: Duc	Checked by: Huy

RECORD & CALCULATION LUGEON TEST

BOREHOLE:	HTBG002
Test No.:	P12

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test:		262.2	m
Test section: from (H_2)	251.0 to 262.2	Length 11.2	m
Height of pressure gage from ground level: (H_1)		1.0	m
Inclination of borehole from Horizontal (ϕ):		65	

TYPE OF PACKER: GeoPro Wireline Single

PARKER PRESSURE: 30.84 (kG/cm^2)

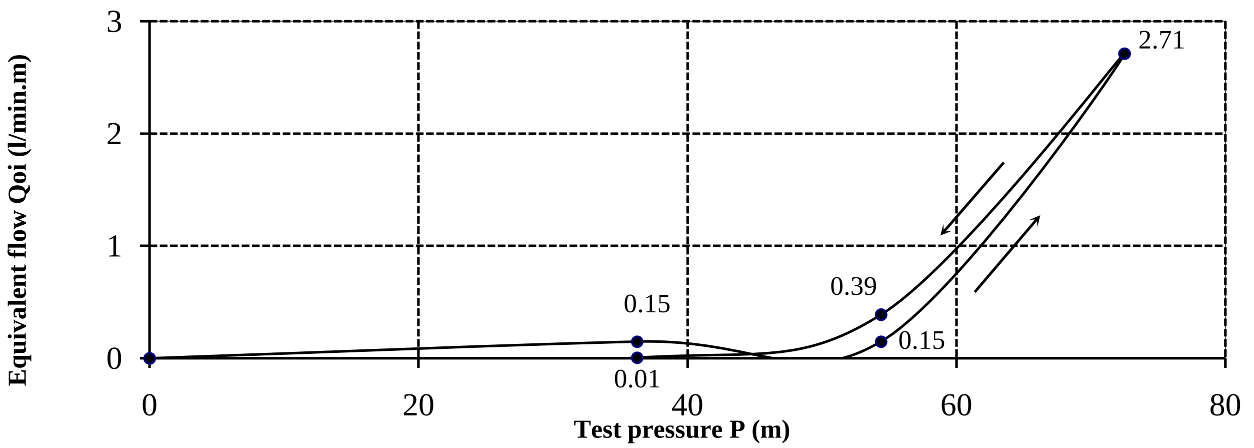
Date of test: 04:02 30/1/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 252

Initial groudwater level (H_3) 0.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	Flowmeter reading (liter) After	Flowmeter reading (liter) Take	Average flow Qi (l/min)	Remark
15	3.90	39.0	0	25	25.0	1.67	- Test conducted in: Horse Microdiorite (Hmd)
15	5.90	59.0	25.0	50.0	25.0	1.67	- No seepage from top of borehole.
15	7.90	79.0	50.0	506.0	456.0	30.40	- Parker pressure is constant throughout the test
15	5.90	59.0	506.0	571.0	65.0	4.33	- Pressure water outflows from borehole
15	3.90	39.0	571.0	572.0	1.0	0.07	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.15	0	36.3	0.004	0.41	q= 0.0103 (l/min.m)
0.15	0	54.4	0.003	0.27	
2.71	0	72.5	0.037	3.74	
0.39	0	54.4	0.007	0.71	uL= 1.03
0.01	0	36.3	0.000	0.02	



Recorded by: Hien

Checked by: M. Cuong

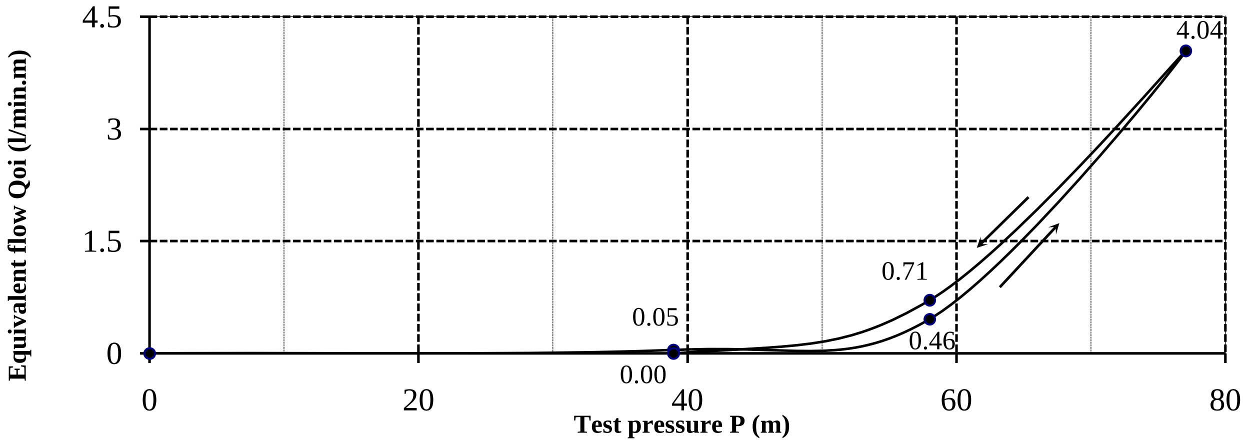
RECORD & CALCULATION LUGEON TEST

	RECORD & CALCULATION LUGEON TEST	BOREHOLE:	HTBG002
		Test No.:	P13

PROJECT: Frieda River Project	Depth of borehole at the time of test:	280.2 m
	Test section: from (H_2) 266.0 to 280.2	Length 14.2 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)	1.0 m
	Inclination of borehole from Horizontal (ϕ):	65
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 32.82 (kG/cm^2)	Date of test: 19:30 30/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 267	Initial groudwater level (H_3) 0.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	4.20	42.0	0	10	10.0	0.67	- Test conducted in: Horse Microdiorite (Hmd)
15	6.30	63.0	10.0	108.0	98.0	6.53	- No seepage from top of borehole.
15	8.40	84.0	108.0	969.0	861.0	57.40	- Parker pressure is constant throughout the test
15	6.30	63.0	969.0	1120.0	151.0	10.07	- Pressure water outflows from borehole
15	4.20	42.0	1120.0	1120.0	0.0	0.00	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.05	0	39.0	0.001	0.12	q= 0.0101 (l/min.m)
0.46	0	58.0	0.008	0.79	
4.04	0	77.0	0.052	5.25	
0.71	0	58.0	0.012	1.22	uL= 1.01
0.00	0	39.0	0.000	0.00	



Recorded by: Hien	Checked by: M. Cuong

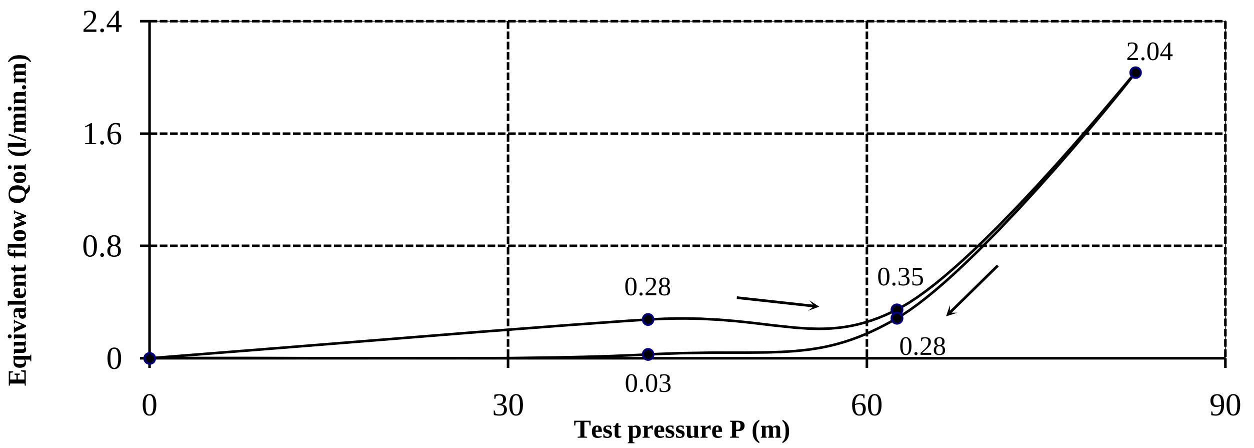
RECORD & CALCULATION
LUGEON TEST

GeoTech	RECORD & CALCULATION LUGEON TEST	BOREHOLE:	HTBG002
		Test No.:	P14

PROJECT: Frieda River Project	Depth of borehole at the time of test: 300.8 m
	Test section: from (H_2) 285.8 to 300.8 Length 15.0 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 65
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 35.09 (kG/cm^2) Date of test: 12:30 31/1/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 286.8; Initial groudwater level (H_3) 0.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	4.50	45.0	0	62	62.0	4.13	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test - Pressure water outflows from borehole
15	6.80	68.0	62.0	140.0	78.0	5.20	
15	9.00	90.0	140.0	598.0	458.0	30.53	
15	6.80	68.0	598.0	662.0	64.0	4.27	
15	4.50	45.0	662.0	668.0	6.0	0.40	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.28	0	41.7	0.007	0.66	q= 0.0084 (l/min.m)
0.35	0	62.5	0.006	0.55	
2.04	0	82.5	0.025	2.47	
0.28	0	62.5	0.005	0.45	uL= 0.84
0.03	0	41.7	0.001	0.06	



Recorded by: Duc | Checked by: Huy

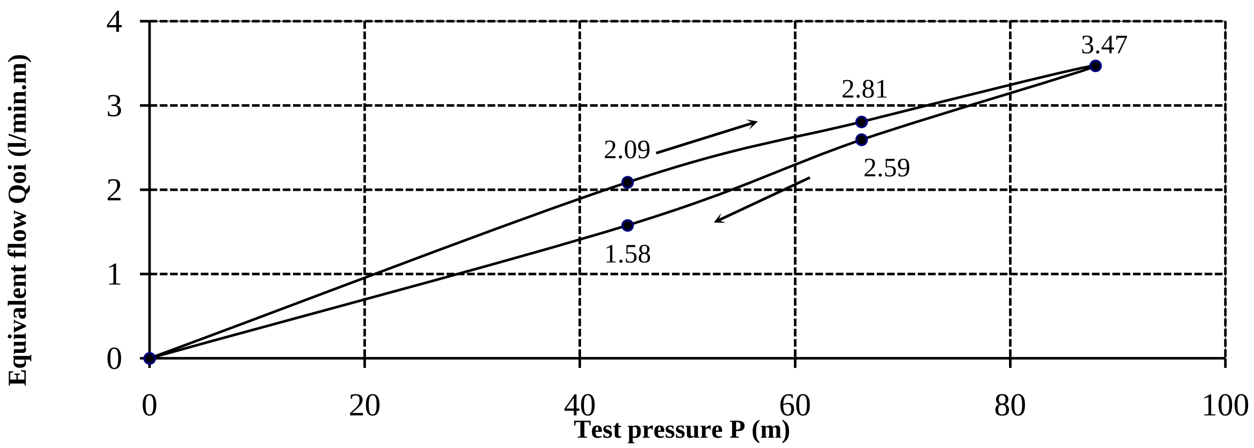
RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG002
Test No.:	P15

PROJECT: Frieda River Project	Depth of borehole at the time of test: 320.5 m
	Test section: from (H_2) 310.5 to 320.5 Length 10.0 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 65
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 37.26 (kG/cm²) Date of test: 3:02 1/2/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 311.5 Initial groudwater level (H_3) 0.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm²)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	4.80	48.0	0	313	313.0	20.87	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test - Pressure water outflows from borehole
15	7.20	72.0	313.0	734.0	421.0	28.07	
15	9.60	96.0	734.0	1255.0	521.0	34.73	
15	7.20	72.0	1255.0	1644.0	389.0	25.93	
15	4.80	48.0	1644.0	1881.0	237.0	15.80	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
2.09	0	44.4	0.047	4.70	q= 0.0356 (l/min.m)
2.81	0	66.2	0.042	4.24	
3.47	0	87.9	0.040	3.95	
2.59	0	66.2	0.039	3.92	uL= 3.56
1.58	0	44.4	0.036	3.56	



Recorded by: Hien	Checked by: M. Cuong

RECORD & CALCULATION LUGEON TEST		BOREHOLE:	HTBG002
		Test No.:	P16

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test:	337.3	m
Test section: from (H_2) 322.3 to 337.3	Length 15.0	m
Height of pressure gage from ground level: (H_1)	1.0	m
Inclination of borehole from Horizontal (ϕ):	65	

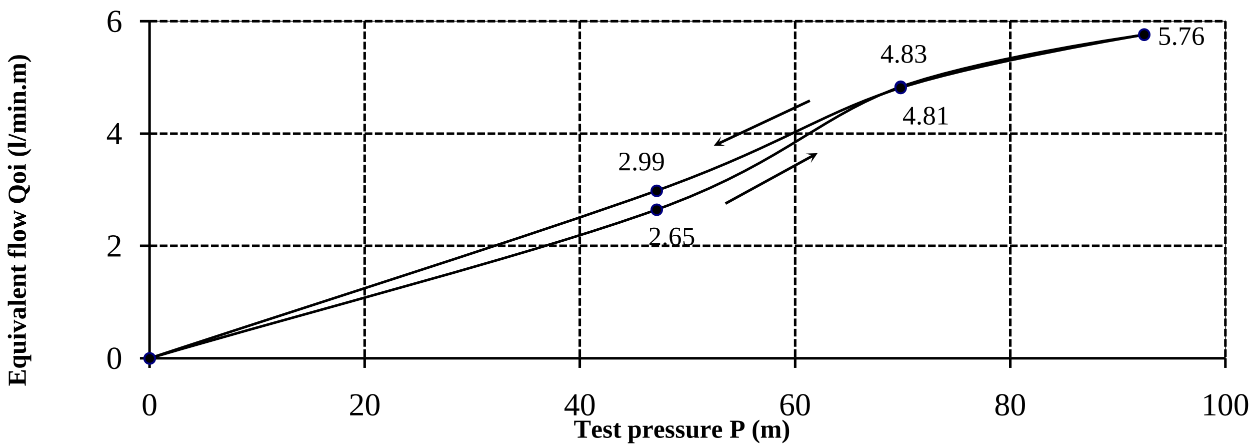
TYPE OF PACKER: GeoPro Wireline Single

PARKER PRESSURE: 39.10 (kG/cm²) Date of test: 9:30 2/2/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 323.3 Initial groudwater level (H_3) 0.0 m

Reading time	Pressure gauge reading (Poi)		Flowmeter reading (liter)			Average flow	Remark
(minute)	(kG/cm²)	(m)	Before	After	Take	Qi (l/min)	
15	5.10	51.0	0	596	596.0	39.73	- Test conducted in contact between highly fracture zone and fresh rock: Horse Microdiorite (Hmd)
15	7.60	76.0	596.0	1683.0	1087.0	72.47	- No seepage from top of borehole.
15	10.10	101.0	1683.0	2979.0	1296.0	86.40	- Parker pressure is constant throughout the test
15	7.60	76.0	2979.0	4062.0	1083.0	72.20	- Pressure water outflows from borehole
15	5.10	51.0	4062.0	4734.0	672.0	44.80	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
2.65	0	47.1	0.056	5.62	q= 0.0640 (l/min.m)
4.83	0	69.8	0.069	6.92	
5.76	0	92.4	0.062	6.23	
4.81	0	69.8	0.069	6.90	uL= 6.40
2.99	0	47.1	0.063	6.34	



Recorded by: Duc Checked by: Huy

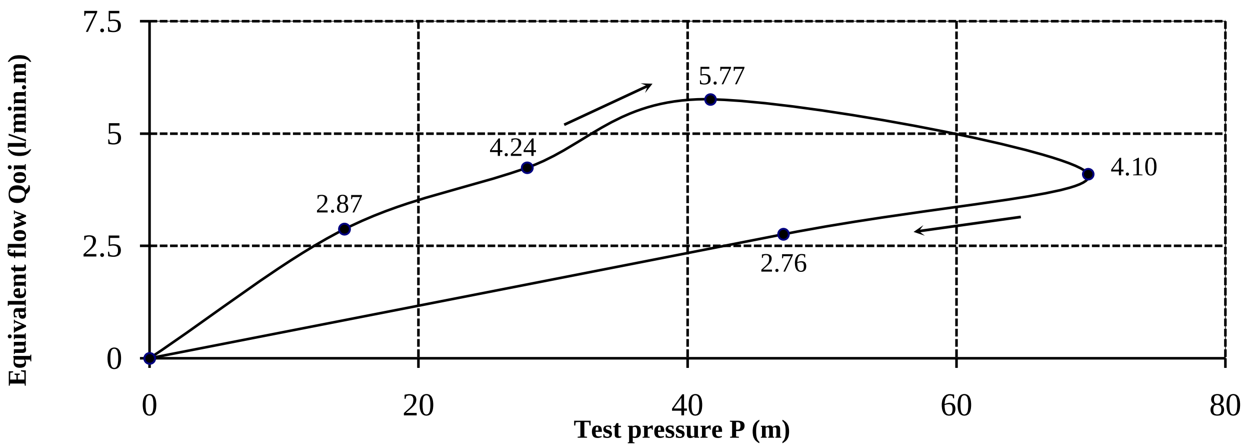
RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG002
Test No.:	P17

PROJECT: Frieda River Project	Depth of borehole at the time of test:		361.2 m
	Test section: from (H_2)	350.2 to 361.2	Length 11.0 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)		1.0 m
	Inclination of borehole from Horizontal (ϕ):		65
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 41.73 (kG/cm^2)	Date of test:	4:09 3/2/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 351.2	Initial groudwater level (H_3)	0.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	1.50	15.0	284	757.8	473.8	31.59	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test - Pressure water outflows from borehole
15	3.00	30.0	816.0	1516.2	700.2	46.68	
15	4.50	45.0	1646.0	2597.3	951.3	63.42	
15	7.60	76.0	2664.0	3340.5	676.5	45.10	
15	5.10	51.0	3380.0	3835.2	455.2	30.35	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
2.87	0	14.5	0.198	19.80	q= 0.0585 (l/min.m)
4.24	0	28.1	0.151	15.10	
5.77	0	41.7	0.138	13.83	
4.10	0	69.8	0.059	5.88	uL= 5.85
2.76	0	47.1	0.059	5.85	



Recorded by: Hien	Checked by: M. Cuong

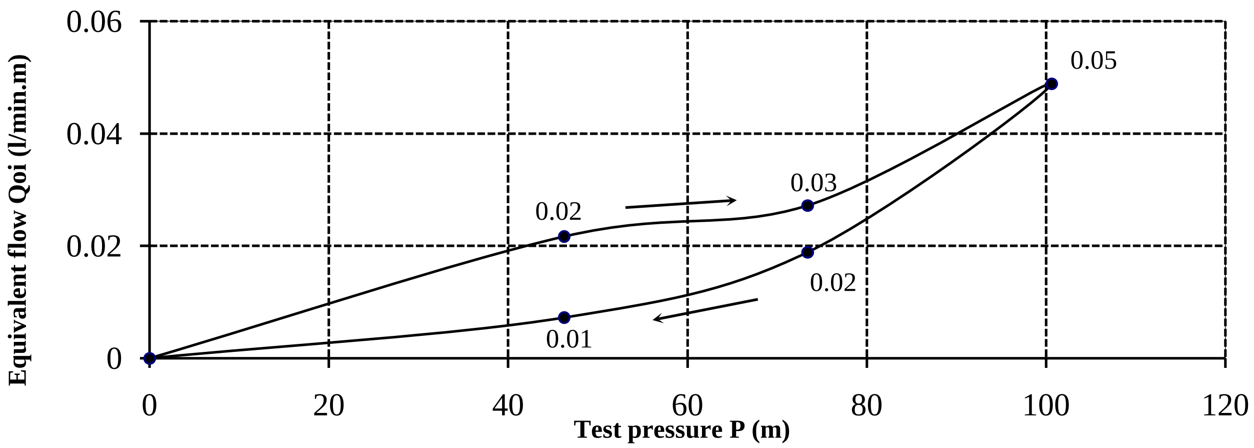
RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG002
Test No.:	P18

PROJECT: Frieda River Project	Depth of borehole at the time of test:		361.2	m
	Test section: from (H_2)	364.2 to 376.2	Length 12.0	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)		1.0	m
	Inclination of borehole from Horizontal (ϕ):		65	
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 41.73 (kG/cm^2)	Date of test: 14:50 3/2/2015		
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 365.2	Initial groudwater level (H_3)	0.0	m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	5.00	50.0	1387	1390.9	3.9	0.26	- Test conducted in: Horse Microdiorite (Hmd)
15	8.00	80.0	1391.3	1396.2	4.9	0.33	- No seepage from top of borehole.
15	11.00	110.0	1397.1	1405.9	8.8	0.59	- Parker pressure is constant throughout the test
15	8.00	80.0	1406.1	1409.5	3.4	0.23	- Pressure water outflows from borehole
15	5.00	50.0	1409.6	1410.9	1.3	0.09	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.02	0	46.2	0.000	0.05	q= 0.0003 (l/min.m)
0.03	0	73.4	0.000	0.04	
0.05	0	100.6	0.000	0.05	
0.02	0	73.4	0.000	0.03	uL= 0.03
0.01	0	46.2	0.000	0.02	



Recorded by: Duc | Checked by: Huy

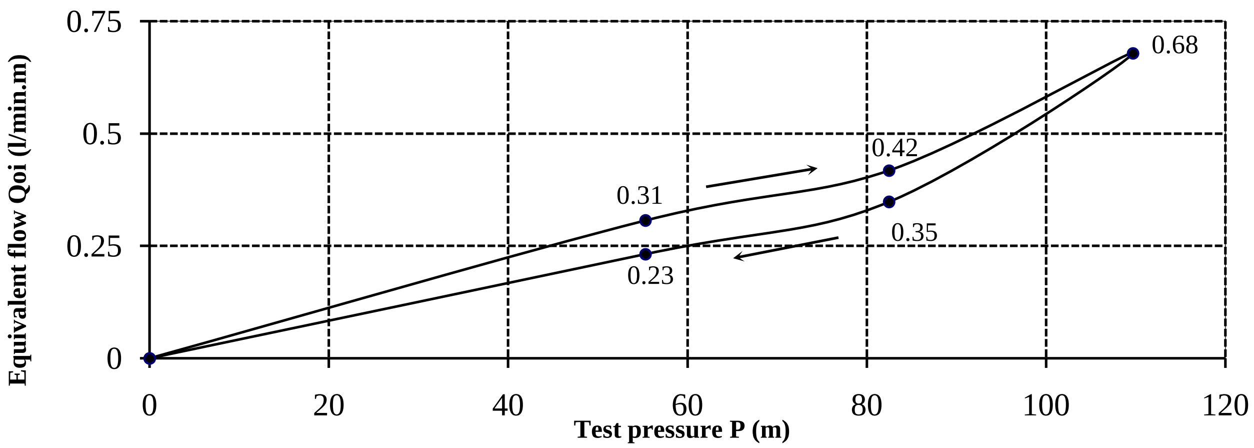
RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG002
Test No.:	P19

PROJECT: Frieda River Project	Depth of borehole at the time of test: 392.9 m
	Test section: from (H_2) 376.8 to 392.9 Length 16.1 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 65
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 44.00 (kG/cm^2) Date of test: 7:10am 4/2/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 377.8 Initial groudwater level (H_3) 0.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	6.00	60.0	1502	1576	74.0	4.93	- Test conducted in: Horse Microdiorite (Hmd)
15	9.00	90.0	1580.0	1681.0	101.0	6.73	- No seepage from top of borehole.
15	12.00	120.0	1700.0	1864.0	164.0	10.93	- Parker pressure is constant throughout the test
15	9.00	90.0	1882.0	1966.0	84.0	5.60	- Pressure water outflows from borehole
15	6.00	60.0	1959.0	2015.0	56.0	3.73	

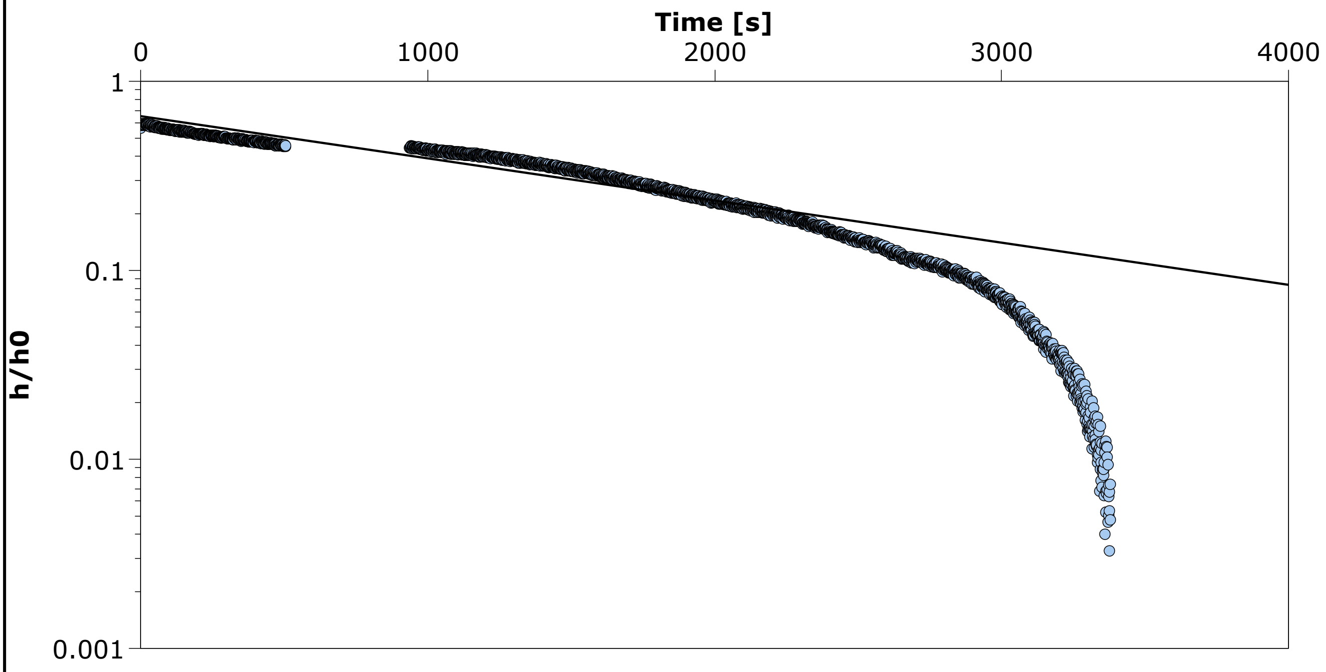
EQUIVALENT FLOW $Qoi=Qi/L$ (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS $qi=Qoi/Pi$ (l/min.m)	LUGEON $uLi = 100qi$	VALUE CHOSEN FOR THE TEST SECTION
0.31	0	55.3	0.006	0.55	q= 0.0050 (l/min.m)
0.42	0	82.5	0.005	0.51	
0.68	0	109.7	0.006	0.62	
0.35	0	82.5	0.004	0.42	uL= 0.50
0.23	0	55.3	0.004	0.42	



Recorded by: Duc | Checked by: Huy

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report**	
	Project: Frieda River	
	Number: I1049	
	Client: PanAust	

Location: Frieda River, PNG	Slug Test: 10.5 - 13 m	Test Well: HTBG003: Test 01
Test Conducted by: Geotech International		Test Date: 14/02/2015
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 24/03/2015
Aquifer Thickness: 2.90 m		



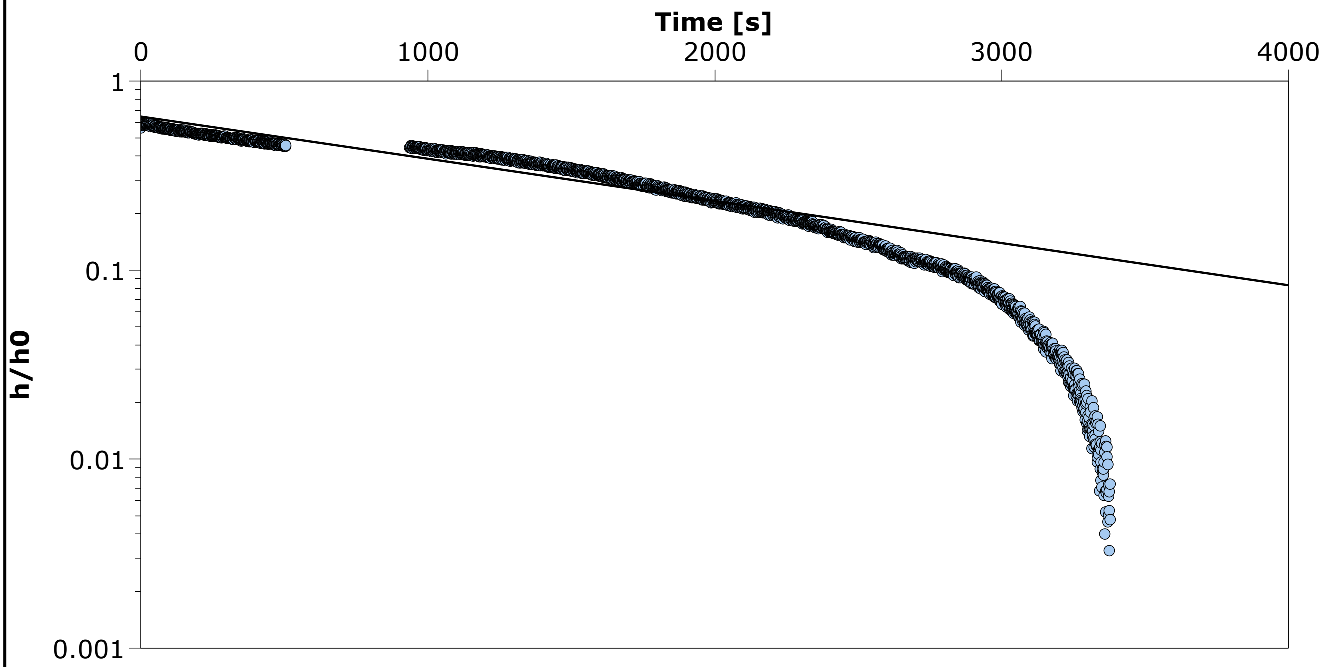
Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
HTBG003: Test 01	8.53×10^{-2}	

AGE Consultants
Level 2/15 Mallon St
Bowen Hills, QLD, 4006

Slug Test Analysis Report

Project: Frieda River		
Number: I1049		
Client: PanAust		
Location: Frieda River, PNG	Slug Test: 10.5 - 13 m	Test Well: HTBG003: Test 01
Test Conducted by: Geotech International		Test Date: 14/02/2015
Analysis Performed by: H.McCarthy	Hvorslev	Analysis Date: 24/03/2015
Aquifer Thickness: 2.90 m		



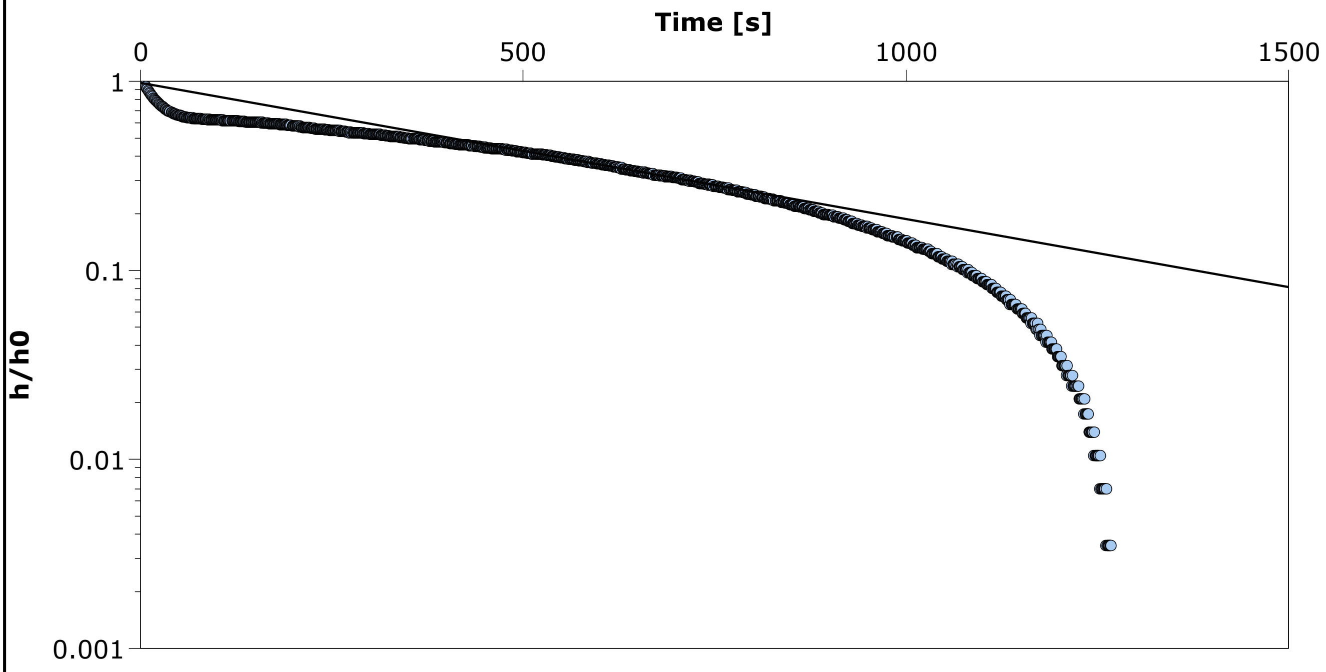
Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]
HTBG003: Test 01	1.12×10^{-1}

AGE Consultants
Level 2/15 Mallon St
Bowen Hills, QLD, 4006

Slug Test Analysis Report
Project: Frieda River
Number: I1049
Client: PanAust

Location: Frieda River, PNG	Slug Test: 17.4 - 26.9 m	Test Well: HTBG003: Test 02
Test Conducted by: Geotech International		Test Date: 15/02/2015
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 24/03/2015
Aquifer Thickness: 9.50 m		

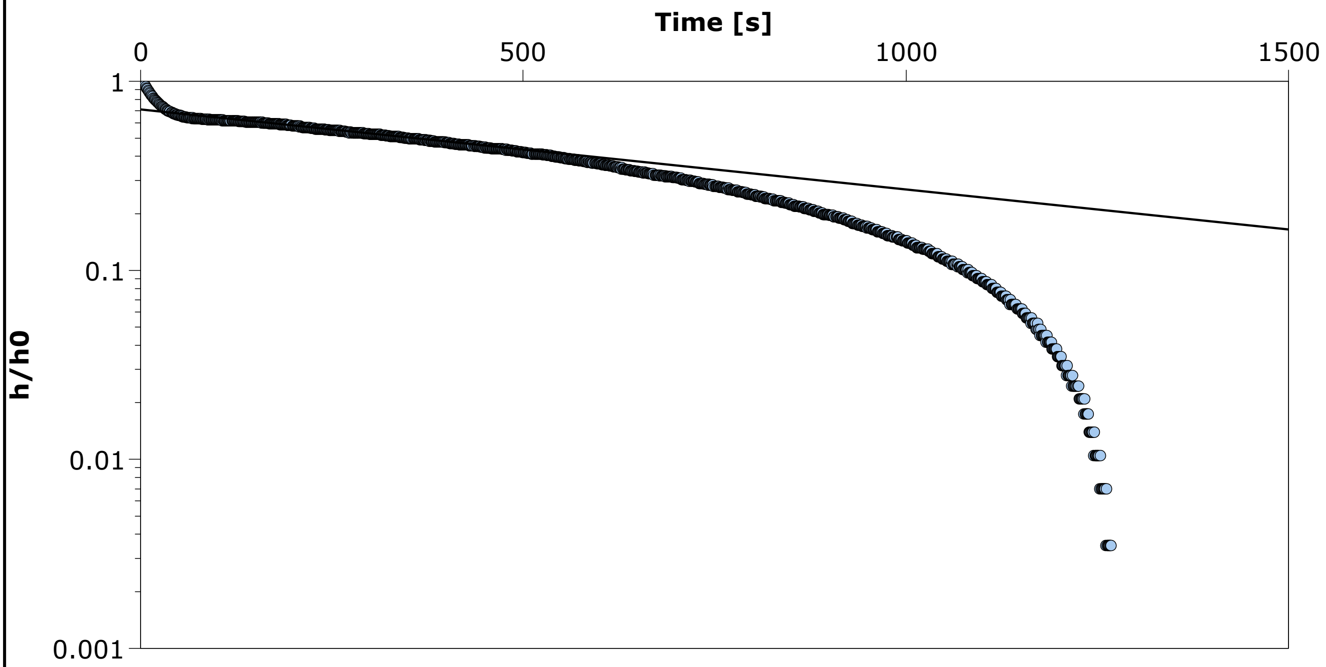


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
HTBG003: Test 02	1.43×10^{-1}	

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report** Project: Frieda River Number: I1049 Client: PanAust

Location: Frieda River, PNG	Slug Test: 17.4 - 26.9 m	Test Well: HTBG003: Test 02
Test Conducted by: Geotech International		Test Date: 15/02/2015
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 24/03/2015
Aquifer Thickness: 9.50 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
HTBG003: Test 02	6.59×10^{-2}	

RECORD & CALCULATION LUGEON TEST

Geo Tech	RECORD & CALCULATION LUGEON TEST	BOREHOLE: HTBG003 / Test No.: P1

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test: 26.9 m

Test section: from (H_2) 17.4 to 26.9 Length 9.5 m

Height of pressure gage from ground level: (H_1) 1.0 m

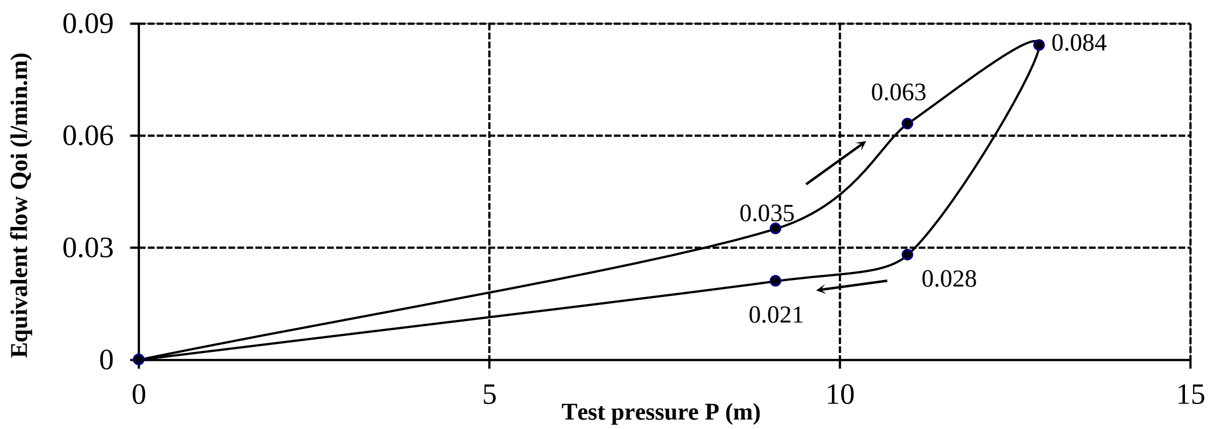
Inclination of borehole from Horizontal (ϕ): 70

TYPE OF PACKER: GeoPro Wireline Sing | PARKER PRESSURE: 4.96 (kG/cm^2) | Date of test: 23:00 14/2/2015

Water hose from pressure gauge to park | Length: $l = H_1 + H_2 =$ 18.4 | Initial groudwater level (H_3) 4.7 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	0.40	4.0	0	5	5.0	0.33	- Test conducted in: Horse microdiorite (Hmd) and Frieda diorite porphyry (Fdp) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	0.60	6.0	5.0	14.0	9.0	0.60	
15	0.80	8.0	14.0	26.0	12.0	0.80	
15	0.60	6.0	26.0	30.0	4.0	0.27	
15	0.40	4.0	30.0	33.0	3.0	0.20	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.035	0	9.1	0.004	0.39	q= 0.0042 (l/min.m)
0.063	0	11.0	0.006	0.58	
0.084	0	12.8	0.007	0.66	
0.028	0	11.0	0.003	0.26	uL= 0.42
0.021	0	9.1	0.002	0.23	

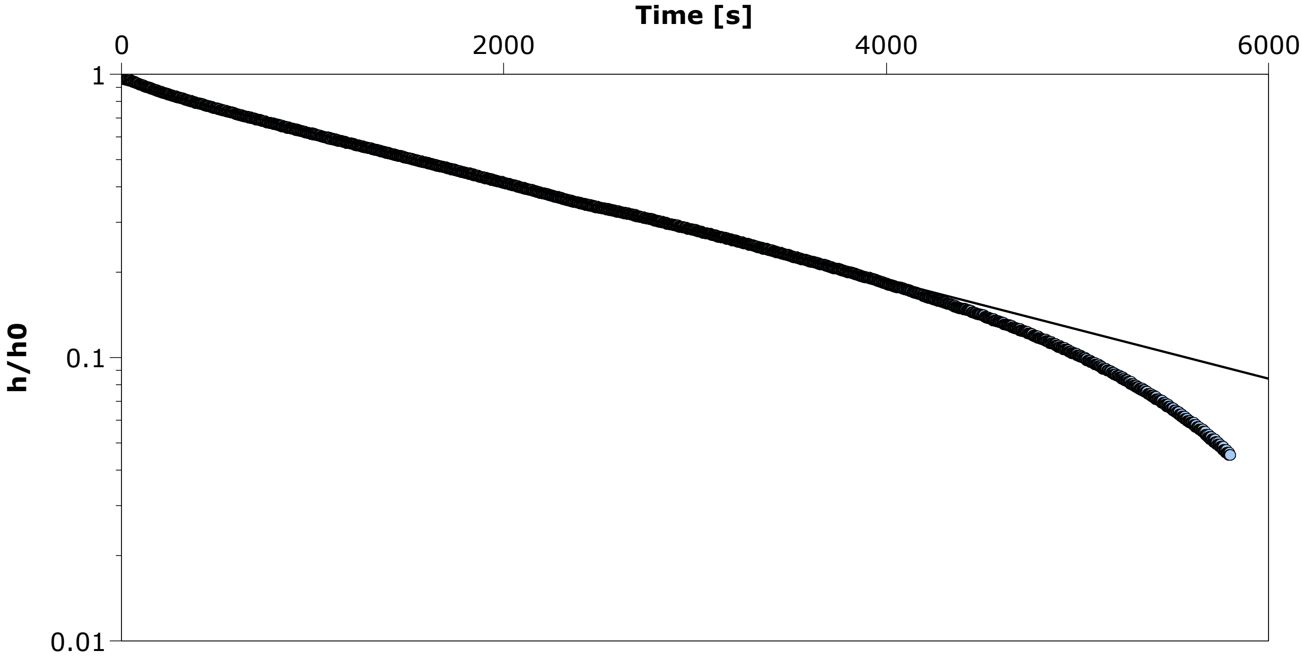


Recorded by: Hien	Checked by: Manh Cuong

AGE Consultants
Level 2/15 Mallon St
Bowen Hills, QLD, 4006

Slug Test Analysis Report
Project: Frieda River
Number: I1049
Client: PanAust

Location: Frieda River, PNG	Slug Test: 37 - 49 m	Test Well: HTBG003: Test 03
Test Conducted by: Geotech International		Test Date: 15/02/2015
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 24/03/2015
Aquifer Thickness: 12.30 m		

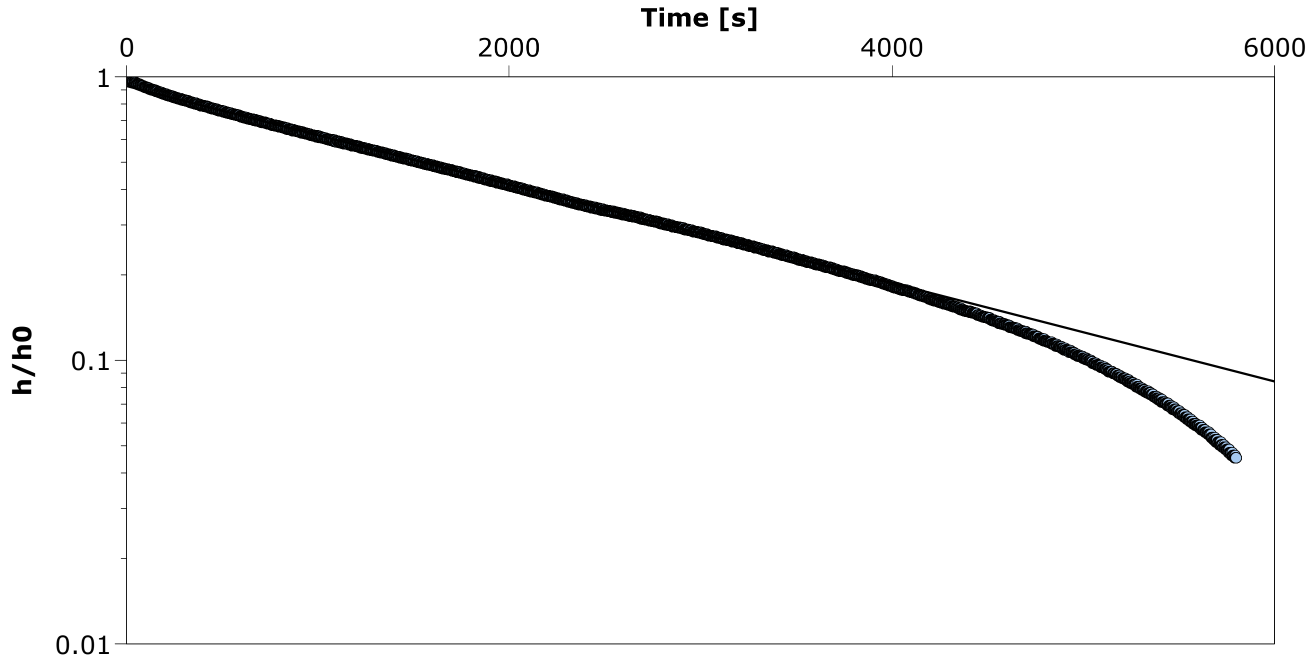


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]
HTBG003: Test 03	2.82×10^{-2}

AGE Consultants Level 2/15 Mallon St Bowen Hills, QLD, 4006	**Slug Test Analysis Report** Project: Frieda River Number: I1049 Client: PanAust

Location: Frieda River, PNG	Slug Test: 37 - 49 m	Test Well: HTBG003: Test 03
Test Conducted by: Geotech International		Test Date: 15/02/2015
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 24/03/2015
Aquifer Thickness: 12.30 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
HTBG003: Test 03	2.20×10^{-2}	

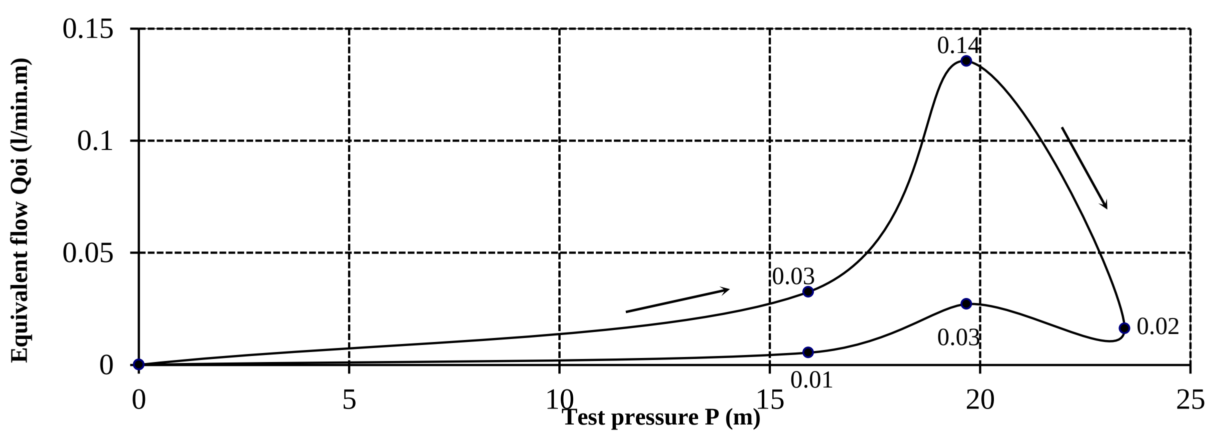
RECORD & CALCULATION
LUGEON TEST

BOREHOLE: HTBG003
Test No.: P2

PROJECT: Frieda River Project	Depth of borehole at the time of test: 49.3 m
	Test section: from (H_2) 37.0 to 49.3 Length 12.3 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Sing	**PARKER PRESSURE:** 7.42 (kG/cm^2) — Date of test: 17:06 15/2/2015
Water hose from pressure gauge to park	Length: $l = H_1 + H_2 =$ 38 — Initial groudwater level (H_3) 8.9 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	0.70	7.0	0	6	6.0	0.40	- Test conducted in: Horse microdiorite (Hmd)
15	1.10	11.0	6.0	31.0	25.0	1.67	- No seepage from top of borehole.
15	1.50	15.0	31.0	34.0	3.0	0.20	- Parker pressure is constant throughout the test
15	1.10	11.0	34.0	39.0	5.0	0.33	
15	0.70	7.0	39.0	40.0	1.0	0.07	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.03	0	15.9	0.002	0.20	q= 0.0023 (l/min.m)
0.14	0	19.7	0.007	0.69	
0.02	0	23.4	0.001	0.07	
0.03	0	19.7	0.001	0.14	uL= 0.23
0.01	0	15.9	0.000	0.03	



Recorded by: Hien	Checked by: Manh Cuong

RECORD & CALCULATION LUGEON TEST

BOREHOLE:	HTBG003
Test No.:	P3

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

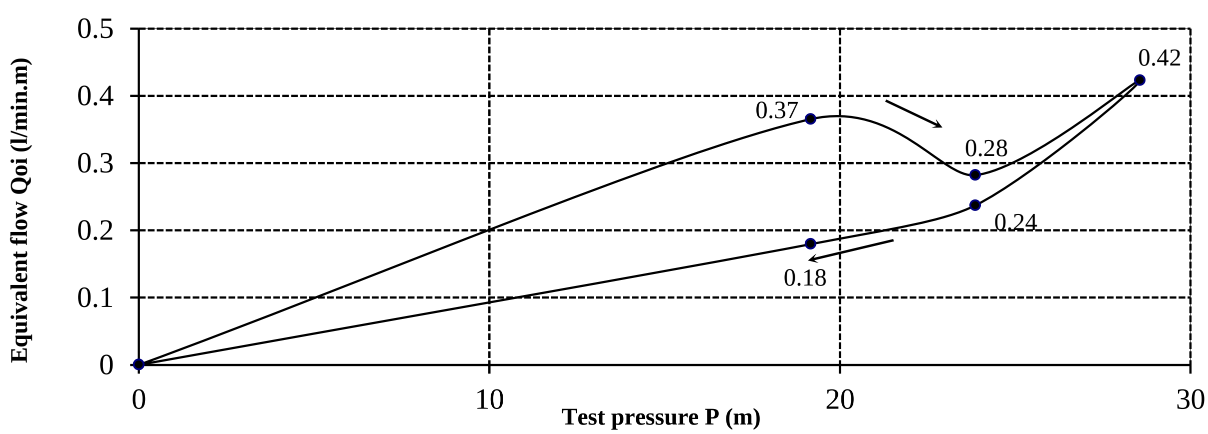
Depth of borehole at the time of test:					70.4	m
Test section: from (H_2)	60.0	to	70.4	Length	10.4	m
Height of pressure gage from ground level: (H_1)					1.0	m
Inclination of borehole from Horizontal (ϕ):			70			

TYPE OF PACKER: GeoPro Wireline Sing | PARKER PRESSURE: 9.74 (kG/cm^2) | Date of test: 12:10 16/2/2015

Water hose from pressure gauge to park | Length: $l = H_1 + H_2 =$ 61 | Initial groudwater level (H_3) 8.4 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	1.10	11.0	0	57	57.0	3.80	- Test conducted in: Horse microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	1.60	16.0	57.0	101.0	44.0	2.93	
15	2.10	21.0	101.0	167.0	66.0	4.40	
15	1.60	16.0	167.0	204.0	37.0	2.47	
15	1.10	11.0	204.0	232.0	28.0	1.87	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.37	0	19.2	0.019	1.91	q= 0.0130 (l/min.m)
0.28	0	23.9	0.012	1.18	
0.42	0	28.6	0.015	1.48	
0.24	0	23.9	0.010	0.99	uL= 1.30
0.18	0	19.2	0.009	0.94	

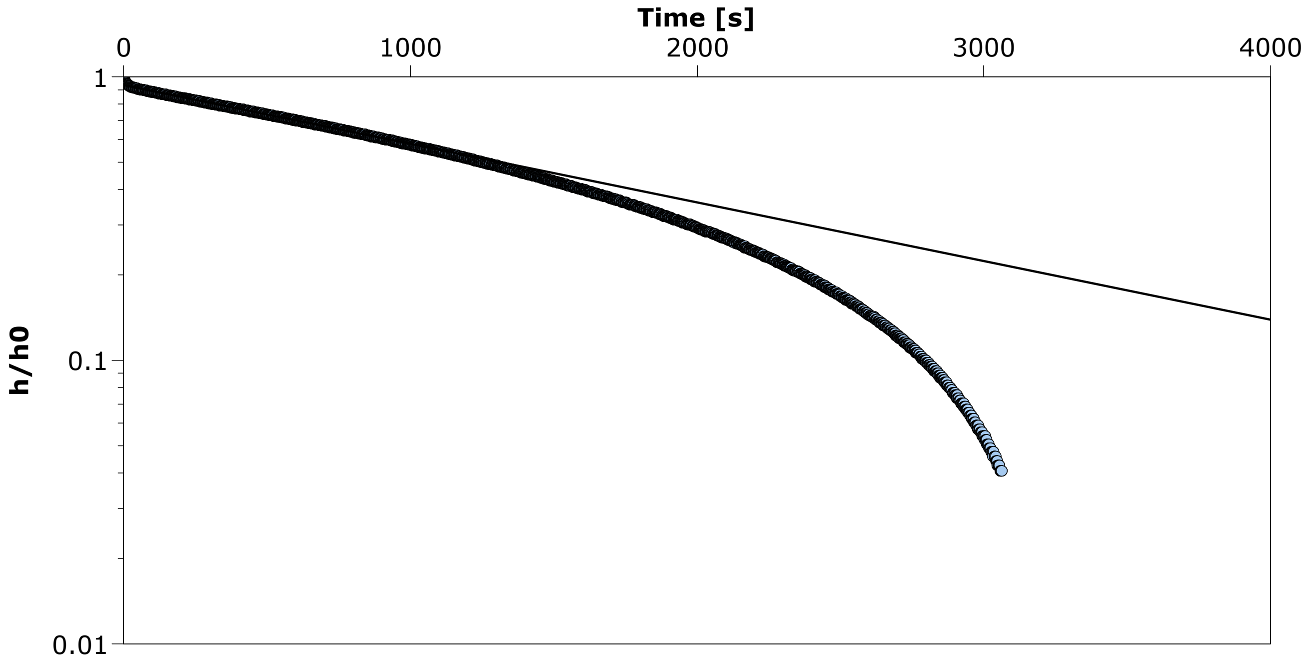


Recorded by: Duc | Checked by: Huy

AGE Consultants
Level 2/15 Mallon St
Bowen Hills, QLD, 4006

Slug Test Analysis Report
Project: Frieda River
Number: I1049
Client: PanAust

Location: Frieda River, PNG	Slug Test: 81.3 - 90 m	Test Well: HTBG003: Test 04
Test Conducted by: Geotech International		Test Date: 17/02/2015
Analysis Performed by: H. McCarthy	Bouwer & Rice	Analysis Date: 24/03/2015
Aquifer Thickness: 8.40 m		

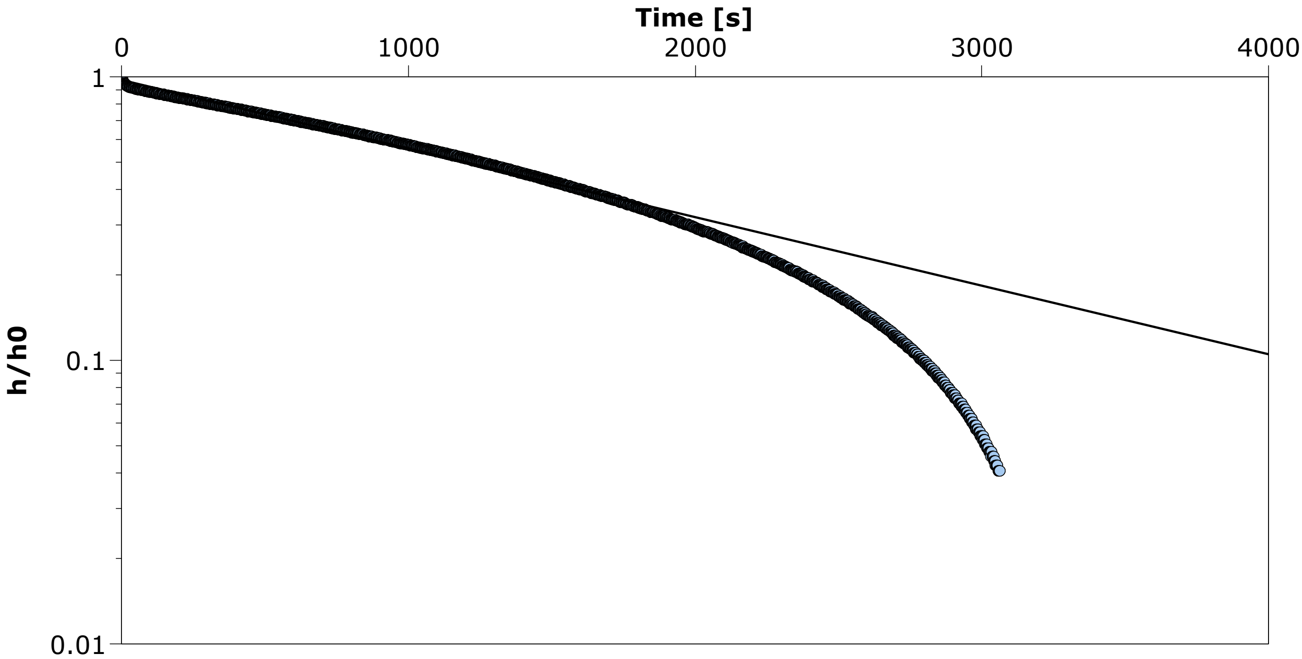


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
HTBG003: Test 04	3.53×10^{-2}	

AGE Consultants
Level 2/15 Mallon St
Bowen Hills, QLD, 4006

Slug Test Analysis Report		
Project: Frieda River		
Number: I1049		
Client: PanAust		
Location: Frieda River, PNG	Slug Test: 81.3 - 90 m	Test Well: HTBG003: Test 04
Test Conducted by: Geotech International		Test Date: 17/02/2015
Analysis Performed by: H. McCarthy	Hvorslev	Analysis Date: 24/03/2015
Aquifer Thickness: 8.40 m		



Calculation using Hvorslev

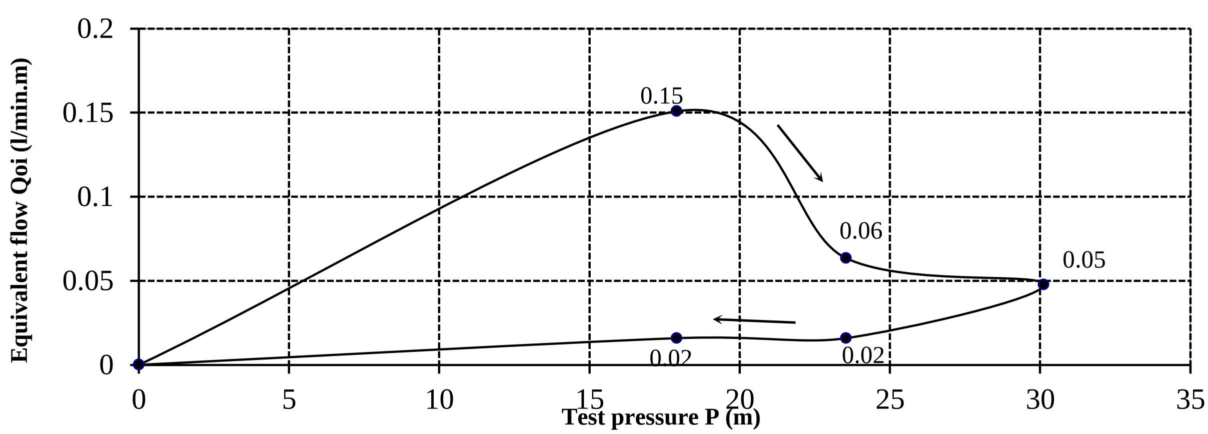
Observation Well	Hydraulic Conductivity [m/d]	
HTBG003: Test 04	5.33×10^{-2}	

GeoTech	RECORD & CALCULATION **LUGEON TEST**	BOREHOLE:	HTBG003
		Test No.:	P4

PROJECT: Frieda River Project	Depth of borehole at the time of test:			89.7	m
	Test section: from (H_2)	81.3	to 89.7	Length 8.4	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)			1.0	m
	Inclination of borehole from Horizontal (ϕ):	70			
TYPE OF PACKER: GeoPro Wireline Sing	PARKER PRESSURE: 11.87 (kG/cm^2)		Date of test:	01:25 17/2/2015	
Water hose from pressure gauge to park	Length: $l = H_1 + H_2 =$ 82.3		Initial groudwater level (H_3)	4.1	m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	1.40	14.0	0	19	19.0	1.27	- Test conducted in: Horse microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	2.00	20.0	19.0	27.0	8.0	0.53	
15	2.70	27.0	27.0	33.0	6.0	0.40	
15	2.00	20.0	33.0	35.0	2.0	0.13	
15	1.40	14.0	35.0	37.0	2.0	0.13	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE Pi=(Poi+H_1+H_2-H_f)*Sinϕ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.15	0	17.9	0.008	0.84	q= 0.0029 (l/min.m)
0.06	0	23.5	0.003	0.27	
0.05	0	30.1	0.002	0.16	
0.02	0	23.5	0.001	0.07	uL= 0.29
0.02	0	17.9	0.001	0.09	



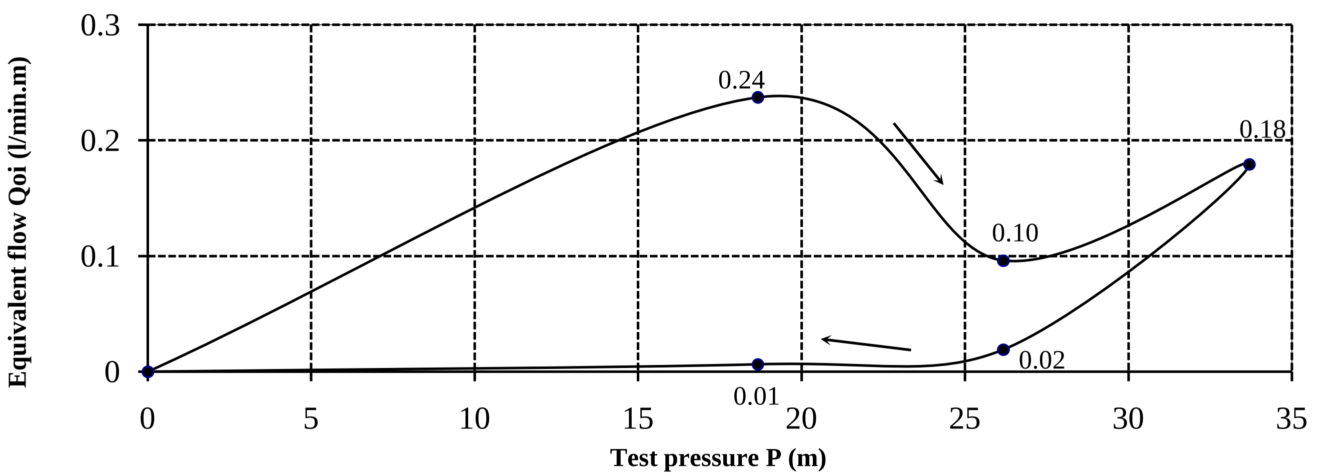
Recorded by: Hien	Checked by: M. Cuong

GeoTech	**RECORD & CALCULATION** **LUGEON TEST**	**BOREHOLE:**	HTBG003
		Test No.:	P5

PROJECT: Frieda River Project	Depth of borehole at the time of test:	111.1	m
	Test section: from (H_2) 100.7 to 111.1 Length	10.4	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)	1.0	m
	Inclination of borehole from Horizontal (ϕ):	70	
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 14.22 (kG/cm^2)	Date of test:	10:25 18/2/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 101.7	Initial groudwater level (H_3)	1.86 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	1.70	17.0	0	37	37.0	2.47	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	2.50	25.0	37.0	52.0	15.0	1.00	
15	3.30	33.0	52.0	80.0	28.0	1.87	
15	2.50	25.0	80.0	83.0	3.0	0.20	
15	1.70	17.0	83.0	84.0	1.0	0.07	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.24	0	18.7	0.013	1.27	q= 0.0046 (l/min.m)
0.10	0	26.2	0.004	0.37	
0.18	0	33.7	0.005	0.53	
0.02	0	26.2	0.001	0.07	uL= 0.46
0.01	0	18.7	0.000	0.03	



Recorded by: Duc	Checked by: Huy

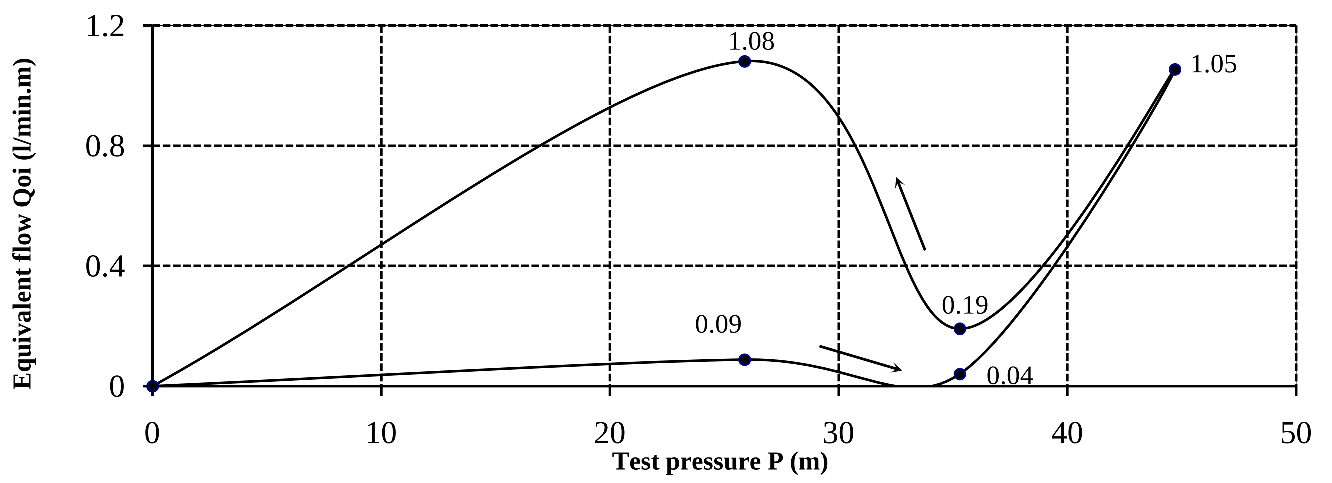
RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG003
Test No.:	P6

PROJECT: Frieda River Project	Depth of borehole at the time of test: 134.8 m
	Test section: from (H_2) 125.0 to 134.8 Length 9.8 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 16.83 (kG/cm^2) Date of test: 4:00 20/2/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 126 Initial groudwater level (H_3 6.56 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	Flowmeter reading (liter) After	Flowmeter reading (liter) Take	Average flow Qi (l/min)	Remark
15	2.00	20.0	0	13	13.0	0.87	- Test conducted in: Horse Microdiorite (Hmd)
15	3.00	30.0	13.0	19.0	6.0	0.40	- No seepage from top of borehole.
15	4.00	40.0	19.0	174.0	155.0	10.33	- Parker pressure is constant throughout the test
15	3.00	30.0	174.0	202.0	28.0	1.87	
15	2.00	20.0	202.0	361.0	159.0	10.60	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.09	0	25.9	0.003	0.34	q= 0.0151 (l/min.m)
0.04	0	35.3	0.001	0.12	
1.05	0	44.7	0.024	2.36	
0.19	0	35.3	0.005	0.54	uL= 1.51
1.08	0	25.9	0.042	4.18	



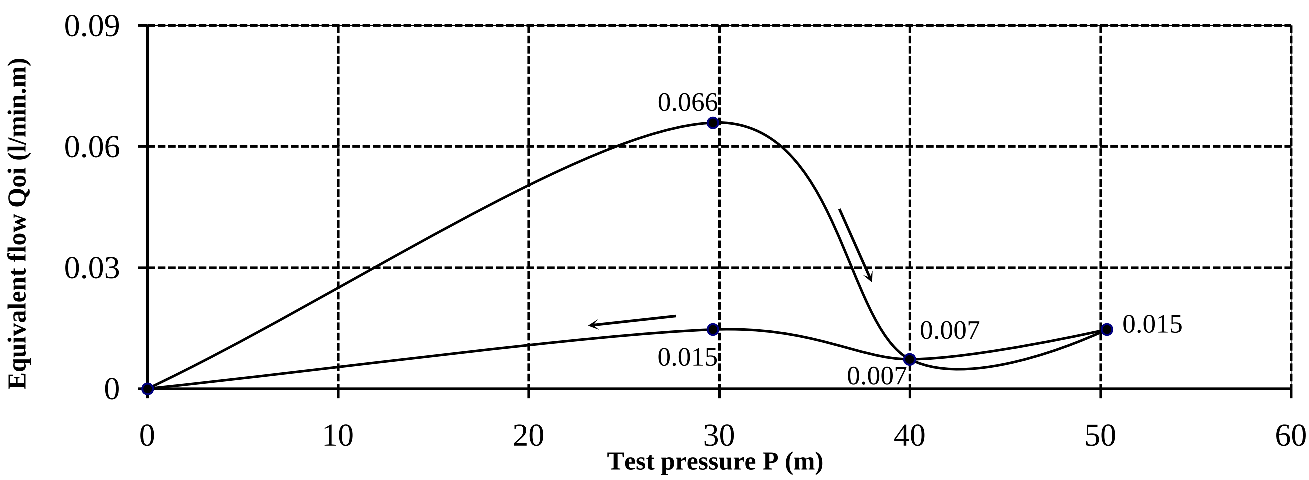
Recorded by: Hien	Checked by: Cuong

RECORD & CALCULATION LUGEON TEST		BOREHOLE:	HTBG003
		Test No.:	P7

PROJECT: Frieda River Project	Depth of borehole at the time of test:		150.6	m
	Test section: from (H_2)	141.5 to 150.6	Length 9.1	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)		1.0	m
	Inclination of borehole from Horizontal (ϕ):	70		
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 18.57 (kG/cm^2)	Date of test: 18:50 20/2/2015		
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 142.5	Initial groudwater level (H_3) 7.56		m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	Flowmeter reading (liter) After	Flowmeter reading (liter) Take	Average flow Qi (l/min)	Remark
15	2.30	23.0	0	9	9.0	0.60	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	3.40	34.0	9.0	10.0	1.0	0.07	
15	4.50	45.0	10.0	12.0	2.0	0.13	
15	3.40	34.0	12.0	13.0	1.0	0.07	
15	2.30	23.0	13.0	15.0	2.0	0.13	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.066	0	29.7	0.002	0.22	q= 0.0007 (l/min.m)
0.007	0	40.0	0.000	0.02	
0.015	0	50.3	0.000	0.03	
0.007	0	40.0	0.000	0.02	uL= 0.07
0.015	0	29.7	0.000	0.05	



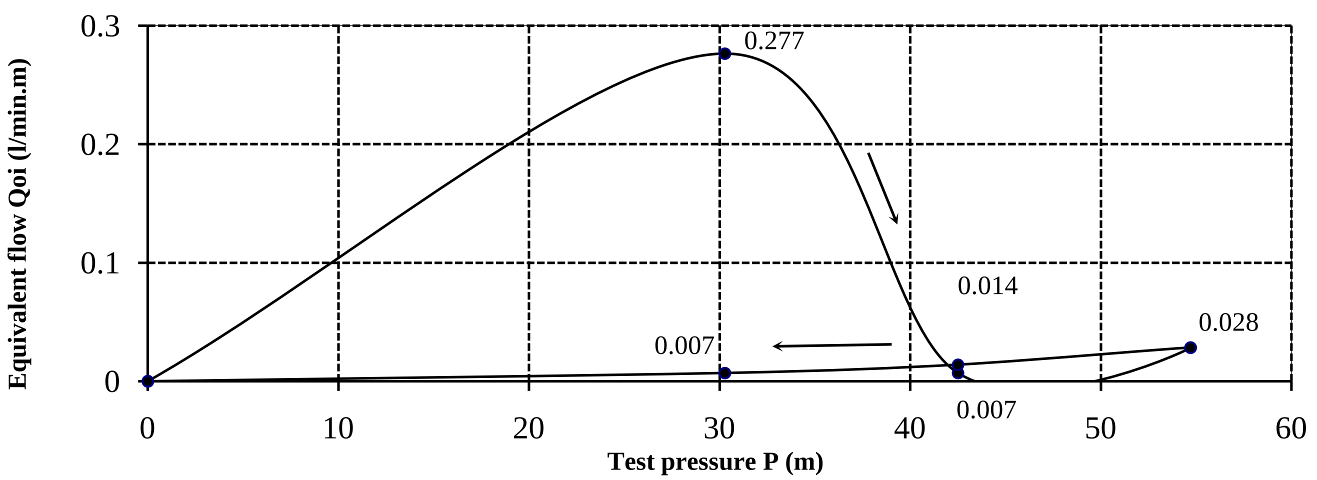
Recorded by: Hien	Checked by: Cuong

GeoTech	**RECORD & CALCULATION** **LUGEON TEST**	**BOREHOLE:**	HTBG003
		Test No.:	P8

PROJECT: Frieda River Project	Depth of borehole at the time of test:			171.9	m
	Test section: from (H_2)	162.5 to 171.9	Length	9.4	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)			1.0	m
	Inclination of borehole from Horizontal (ϕ):	70			
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 20.91 (kG/cm^2)	Date of test: 12:00 21/2/2015			
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 163.5	Initial groudwater level (H_3) 5.23 m			

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	2.60	26.0	0	39	39.0	2.60	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	3.90	39.0	39.0	40.0	1.0	0.07	
15	5.20	52.0	40.0	44.0	4.0	0.27	
15	3.90	39.0	44.0	46.0	2.0	0.13	
15	2.60	26.0	46.0	47.0	1.0	0.07	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.277	0	30.3	0.009	0.91	q= 0.0021 (l/min.m)
0.007	0	42.5	0.000	0.02	
0.028	0	54.7	0.001	0.05	
0.014	0	42.5	0.000	0.03	uL= 0.21
0.007	0	30.3	0.000	0.02	



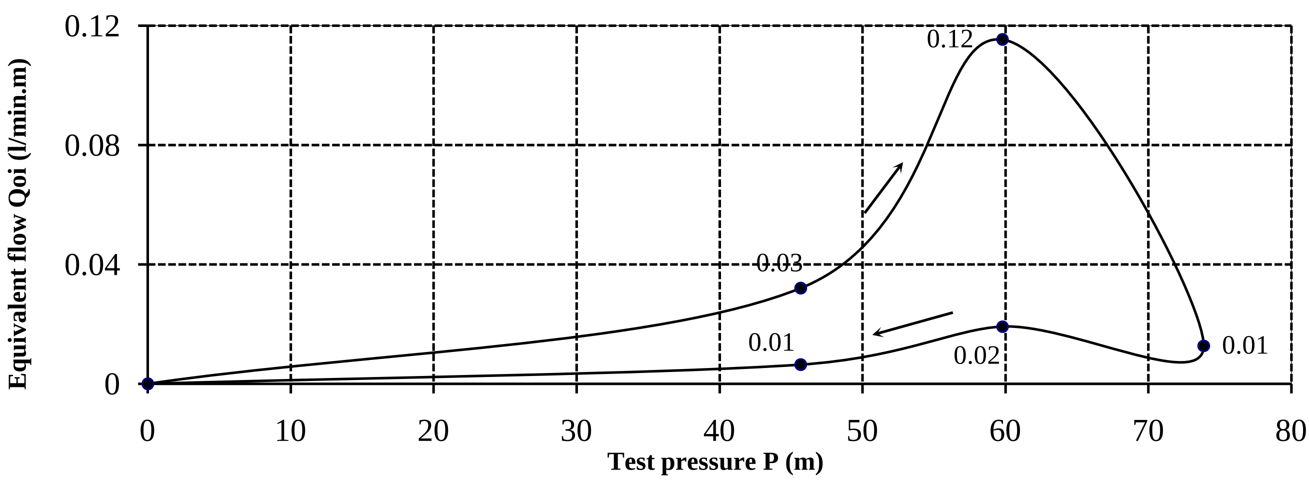
Recorded by: Duc	Checked by: Huy

GeoTech	RECORD & CALCULATION LUGEON TEST	BOREHOLE:	HTBG003
		Test No.:	P9

PROJECT: Frieda River Project	Depth of borehole at the time of test: 193.0 m
	Test section: from (H_2) 182.6 to 193.0 Length 10.4 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 23.23 (kG/cm²) — Date of test: 9:50 22/2/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 183.6 — Initial groudwater level (H_3) 17.62 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm²)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	3.00	30.0	0	5	5.0	0.33	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	4.50	45.0	5.0	23.0	18.0	1.20	
15	6.00	60.0	23.0	25.0	2.0	0.13	
15	4.50	45.0	25.0	28.0	3.0	0.20	
15	3.00	30.0	28.0	29.0	1.0	0.07	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.03	0	45.7	0.001	0.07	q= 0.0007 (l/min.m)
0.12	0	59.8	0.002	0.19	
0.01	0	73.9	0.000	0.02	
0.02	0	59.8	0.000	0.03	uL= 0.07
0.01	0	45.7	0.000	0.01	



Recorded by: Duc	Checked by: Huy

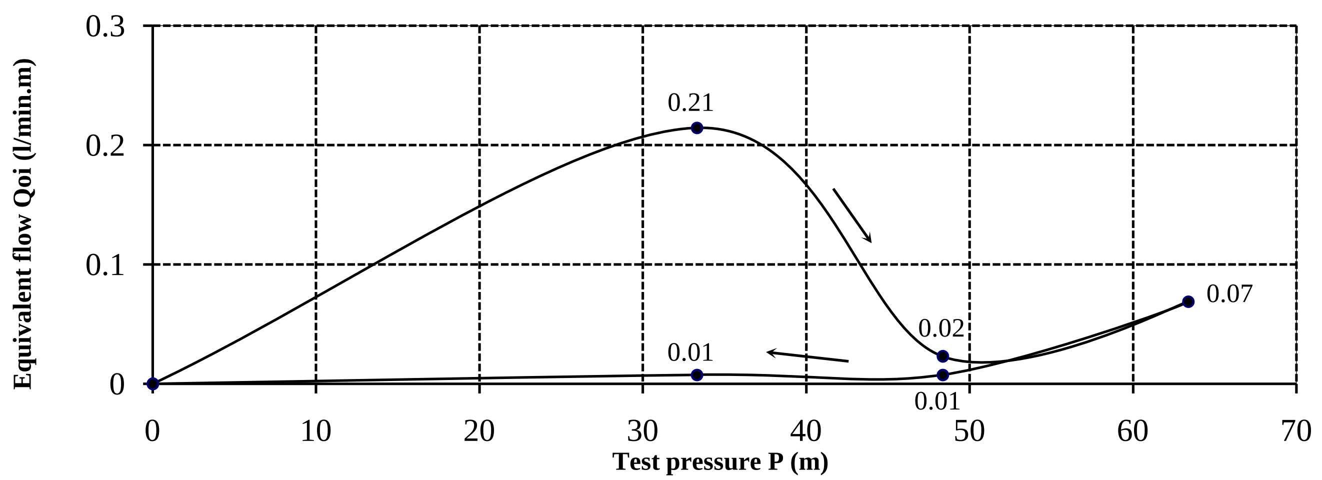
RECORD & CALCULATION
LUGEON TEST

BOREHOLE: HTBG003
Test No.: P10

PROJECT: Frieda River Project	Depth of borehole at the time of test: 211.7 m
	Test section: from (H_2) 203.0 to 211.7 Length 8.7 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 25.29 (kG/cm^2) Date of test: 01:18 23/2/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 204 Initial groudwater level (H_3) 2.45 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	Flowmeter reading (liter) After	Flowmeter reading (liter) Take	Average flow Qi (l/min)	Remark
15	3.20	32.0	0	28.0	28.0	1.87	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	4.80	48.0	28.0	31.0	3.0	0.20	
15	6.40	64.0	31.0	40.0	9.0	0.60	
15	4.80	48.0	40.0	41.0	1.0	0.07	
15	3.20	32.0	41.0	42.0	1.0	0.07	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.21	0	33.3	0.006	0.64	q= 0.0017 (l/min.m)
0.02	0	48.3	0.000	0.05	
0.07	0	63.4	0.001	0.11	
0.01	0	48.3	0.000	0.02	uL= 0.17
0.01	0	33.3	0.000	0.02	



Recorded by: Hien | Checked by: Cuong

RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG003
Test No.:	P11

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test: 232.0 m

Test section: from (H_2) 223.8 to 232.0 Length 8.2 m

Height of pressure gage from ground level: (H_1) 1.0 m

Inclination of borehole from Horizontal (ϕ): 70

TYPE OF PACKER: GeoPro Wireline Single

PARKER PRESSURE: 27.52 (kG/cm^2)

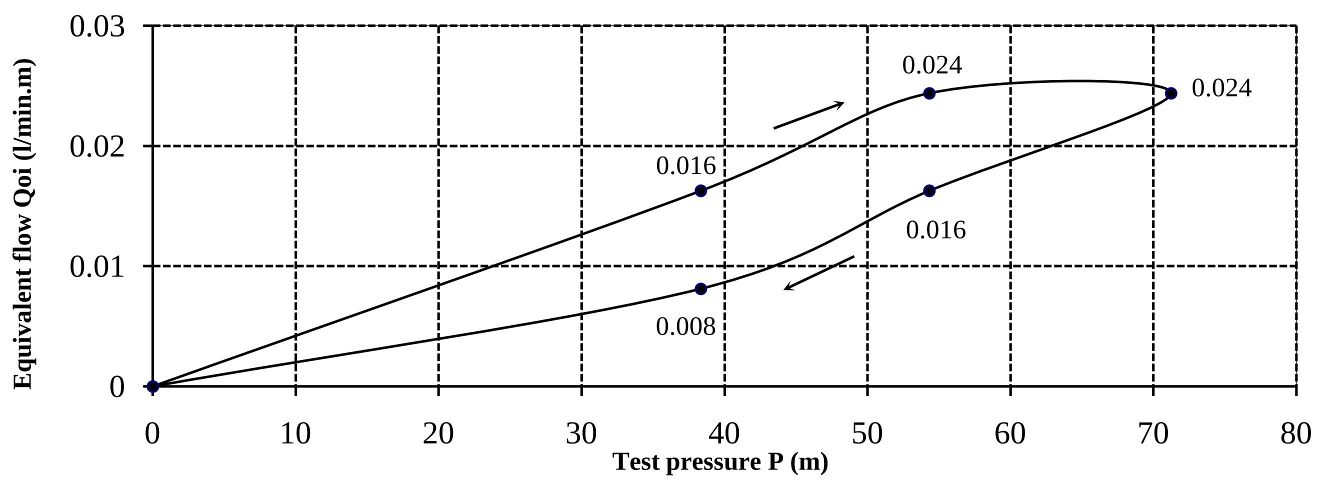
Date of test: 15:00 23/2/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 224.8

Initial groudwater level (H_3): 4.8 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	3.50	35.0	0	2.0	2.0	0.13	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	5.20	52.0	2.0	5.0	3.0	0.20	
15	7.00	70.0	5.0	8.0	3.0	0.20	
15	5.20	52.0	8.0	10.0	2.0	0.13	
15	3.50	35.0	10.0	11.0	1.0	0.07	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.016	0	38.3	0.000	0.04	q= 0.0003 (l/min.m)
0.024	0	54.3	0.000	0.04	
0.024	0	71.2	0.000	0.03	
0.016	0	54.3	0.000	0.03	uL= 0.03
0.008	0	38.3	0.000	0.02	



Recorded by: Duc

Checked by: Huy

RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG003
Test No.:	P12

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test: 250.1 m

Test section: from (H_2) 240.0 to 250.1 Length 10.1 m

Height of pressure gage from ground level: (H_1) 1.0 m

Inclination of borehole from Horizontal (ϕ): 70

TYPE OF PACKER: GeoPro Wireline Single

PARKER PRESSURE: 29.51 (kG/cm^2)

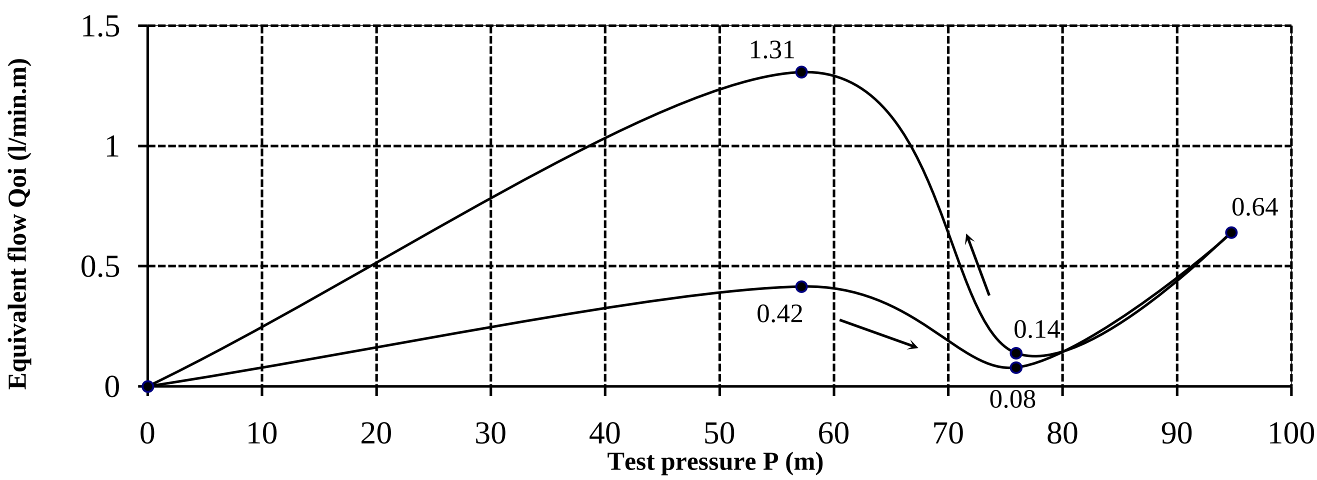
Date of test: 9:55 24/2/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 241

Initial groudwater level (H_3) 19.82 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	Flowmeter reading (liter) After	Flowmeter reading (liter) Take	Average flow Qi (l/min)	Remark
15	4.00	40.0	0	63.0	63.0	4.20	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	6.00	60.0	63.0	75.0	12.0	0.80	
15	8.00	80.0	75.0	172.0	97.0	6.47	
15	6.00	60.0	172.0	193.0	21.0	1.40	
15	4.00	40.0	193.0	391.0	198.0	13.20	

EQUIVALENT FLOW $Qoi=Qi/L$ (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS $qi=Qoi/Pi$ (l/min.m)	TEST VALUES: LUGEON $uLi = 100qi$	VALUE CHOSEN FOR THE TEST SECTION
0.42	0	57.2	0.007	0.73	q= 0.0080 (l/min.m)
0.08	0	75.9	0.001	0.10	
0.64	0	94.7	0.007	0.68	
0.14	0	75.9	0.002	0.18	uL= 0.80
1.31	0	57.2	0.023	2.29	



Recorded by: Duc

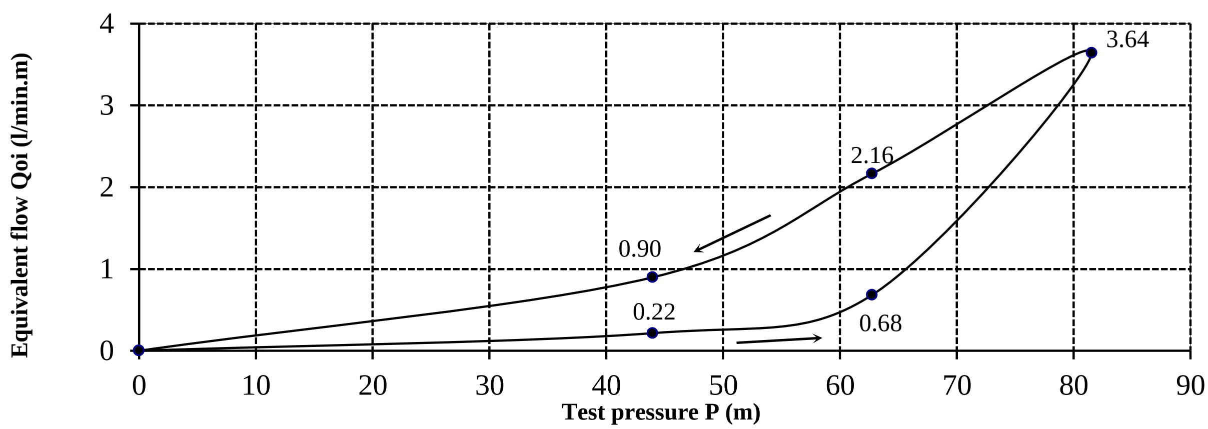
Checked by: Huy

Geo Tech	RECORD & CALCULATION **LUGEON TEST**	BOREHOLE:	HTBG003
		Test No.:	P13

PROJECT: Frieda River Project	Depth of borehole at the time of test:	271.5	m
	Test section: from (H_2) 258.5 to 271.5 Length	13.0	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)	1.0	m
	Inclination of borehole from Horizontal (ϕ):	70	
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 34.00 (kG/cm^2)	Date of test:	3:55 25/2/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 259.5	Initial groudwater level (H_3)	4.78 m

Reading time	Pressure gauge reading (Poi)		Flowmeter reading (liter)			Average flow	Remark
(minute)	(kG/cm^2)	(m)	Before	After	Take	Qi (l/min)	
15	4.10	41.0	0	42.0	42.0	2.80	- Test conducted in: Horse Microdiorite (Hmd) - Seepage from top of borehole. - Parker pressure is constant throughout the test
15	6.10	61.0	42.0	175.0	133.0	8.87	
15	8.10	81.0	175.0	885.0	710.0	47.33	
15	6.10	61.0	885.0	1307.0	422.0	28.13	
15	4.10	41.0	1307.0	1482.0	175.0	11.67	

EQUIVALENT FLOW	HEAD LOSS	TEST PRESSURE	TEST VALUES		VALUE CHOSEN FOR THE TEST SECTION
			WATER LOSS	LUGEON	
Qoi=Qi/L (l/min/m)	H_f (m)	$Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	qi=Qoi/Pi (l/min.m)	uLi = 100qi	
0.22	0	44.0	0.005	0.49	q= 0.0227 (l/min.m)
0.68	0	62.8	0.011	1.09	
3.64	0	81.5	0.045	4.46	
2.16	0	62.8	0.034	3.45	
0.90	0	44.0	0.020	2.04	uL= 2.27



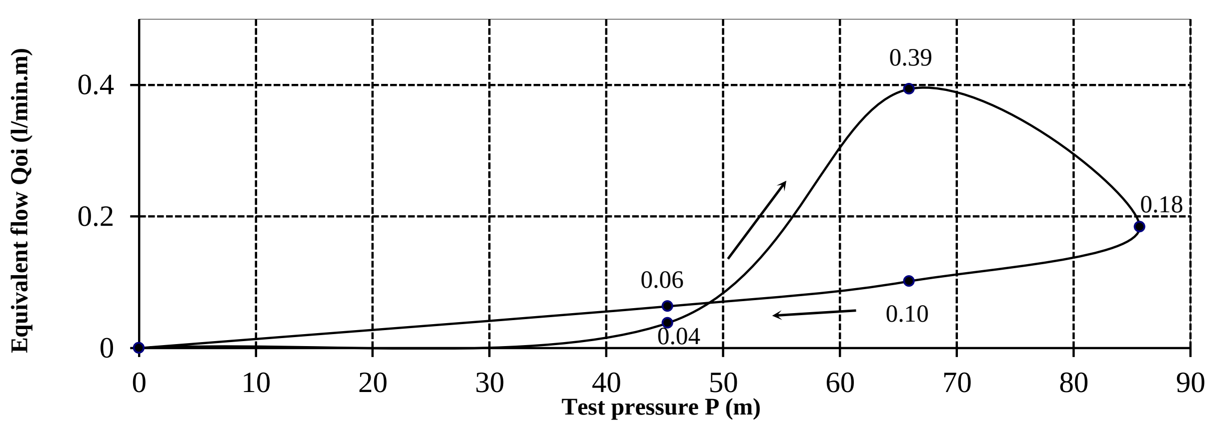
Recorded by: Hien	Checked by: Cuong

GeoTech	**RECORD & CALCULATION** **LUGEON TEST**	**BOREHOLE:** HTBG003 **Test No.:** P14

PROJECT: Frieda River Project	Depth of borehole at the time of test: 291.5 m
	Test section: from (H_2) 281.0 to 291.5 Length 10.5 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 34.07 (kG/cm^2) Date of test: 20:25 25/2/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 282 Initial groudwater level (H_3) 3.16 m

Reading time	**Pressure gauge reading (Poi)**		**Flowmeter reading (liter)**			**Average flow**	**Remark**
(minute)	(kG/cm^2)	(m)	Before	After	Take	Qi (l/min)	
15	4.40	44.0	0	6.0	6.0	0.40	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	6.60	66.0	6.0	68.0	62.0	4.13	
15	8.70	87.0	68.0	97.0	29.0	1.93	
15	6.60	66.0	97.0	113.0	16.0	1.07	
15	4.40	44.0	113.0	123.0	10.0	0.67	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.04	0	45.3	0.001	0.08	q= 0.0024 (l/min.m)
0.39	0	65.9	0.006	0.60	
0.18	0	85.7	0.002	0.21	
0.10	0	65.9	0.002	0.15	uL= 0.24
0.06	0	45.3	0.001	0.14	



Recorded by: Hien	Checked by: Cuong

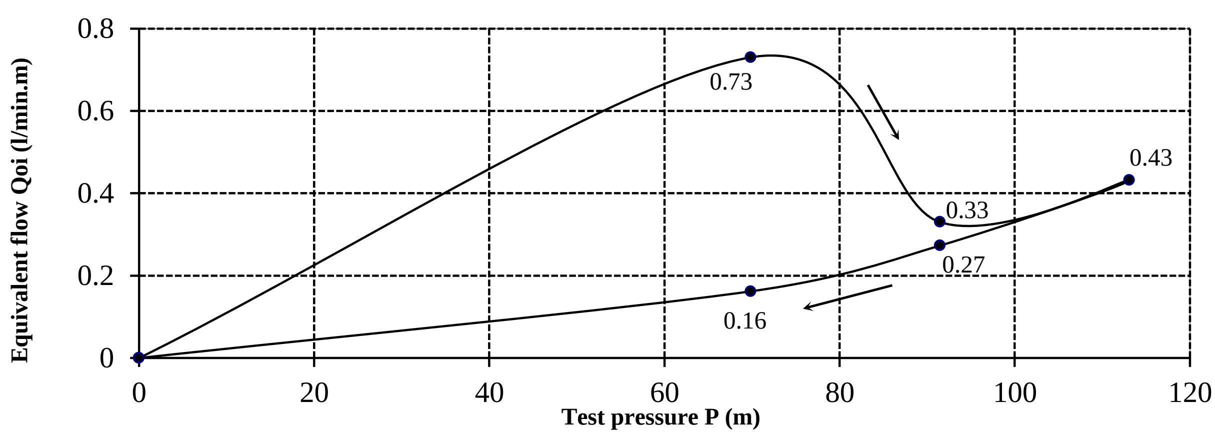
RECORD & CALCULATION LUGEON TEST

GeoTech	RECORD & CALCULATION **LUGEON TEST**	**BOREHOLE:** HTBG003 / **Test No.:** P15

PROJECT: Frieda River Project	Depth of borehole at the time of test: 310.5 m
	Test section: from (H_2) 300.0 to 310.5 Length 10.5 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 36.16 (kG/cm^2) Date of test: 14:00 26/2/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 301 Initial groudwater level (H_3) 26.32 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	4.70	47.0	0	115.0	115.0	7.67	- Test conducted in: Horse Microdiorite (Hmd)
15	7.00	70.0	115.0	167.0	52.0	3.47	- No seepage from top of borehole.
15	9.30	93.0	167.0	235.0	68.0	4.53	- Parker pressure is constant throughout the test
15	7.00	70.0	235.0	278.0	43.0	2.87	
15	4.70	47.0	278.0	303.5	25.5	1.70	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.73	0	69.8	0.010	1.05	q= 0.0046 (l/min.m)
0.33	0	91.5	0.004	0.36	
0.43	0	113.1	0.004	0.38	
0.27	0	91.5	0.003	0.30	uL= 0.46
0.16	0	69.8	0.002	0.23	



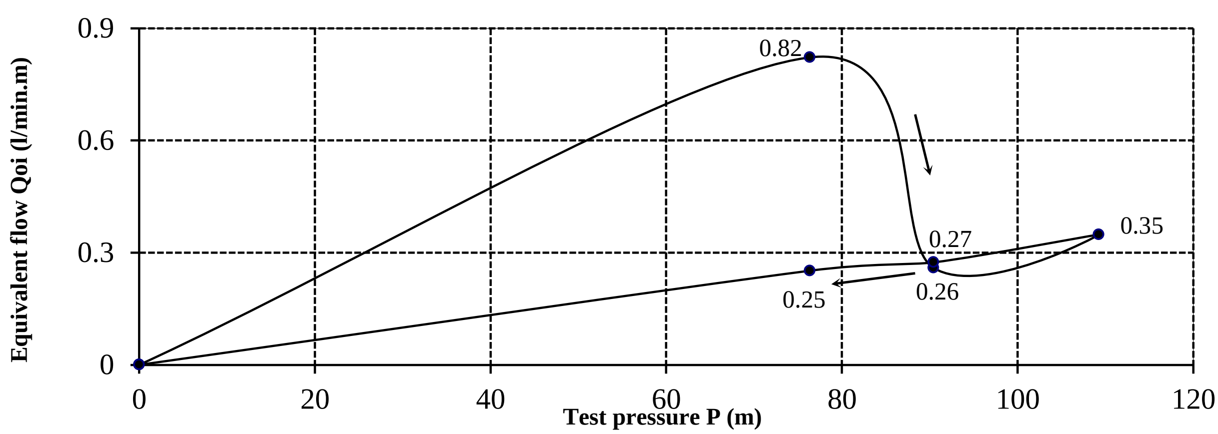
Recorded by: Duc	Checked by: Huy

Geo Tech	**RECORD & CALCULATION** **LUGEON TEST**		**BOREHOLE:**	HTBG003
			Test No.:	P16

PROJECT: Frieda River Project	Depth of borehole at the time of test:		331.5	m
	Test section: from (H_2) 322.5 to 331.5	Length	9.0	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)		1.0	m
	Inclination of borehole from Horizontal (ϕ):	70		
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 46.00 (kG/cm^2)	Date of test:	10:50 27/2/2015	
Water hose from pressure gauge to parker:	Length: l = H_1 + H_2 = 323.5	Initial groudwater level (H_3)	30.25	m

Reading time	**Pressure gauge reading (Poi)**		**Flowmeter reading (liter)**			**Average flow**	**Remark**
(minute)	(kG/cm^2)	(m)	Before	After	Take	Qi (l/min)	
15	5.00	50.0	0	111.0	111.0	7.40	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	6.50	65.0	111.0	146.0	35.0	2.33	
15	8.50	85.0	146.0	193.0	47.0	3.13	
15	6.50	65.0	193.0	230.0	37.0	2.47	
15	5.00	50.0	230.0	264.0	34.0	2.27	

EQUIVALENT FLOW	**HEAD LOSS**	**TEST PRESSURE**	**TEST VALUES**		**VALUE CHOSEN FOR THE TEST SECTION**
			WATER LOSS	**LUGEON**	
Qoi=Qi/L (l/min/m)	H_f (m)	Pi=(Poi+H_1+H_2-H_f)*Sinϕ (Meter of water column)	qi=Qoi/Pi (l/min.m)	uLi = 100qi	
0.82	0	76.4	0.011	1.08	q= 0.0046 (l/min.m)
0.26	0	90.4	0.003	0.29	
0.35	0	109.2	0.003	0.32	
0.27	0	90.4	0.003	0.30	
0.25	0	76.4	0.003	0.33	uL= 0.46



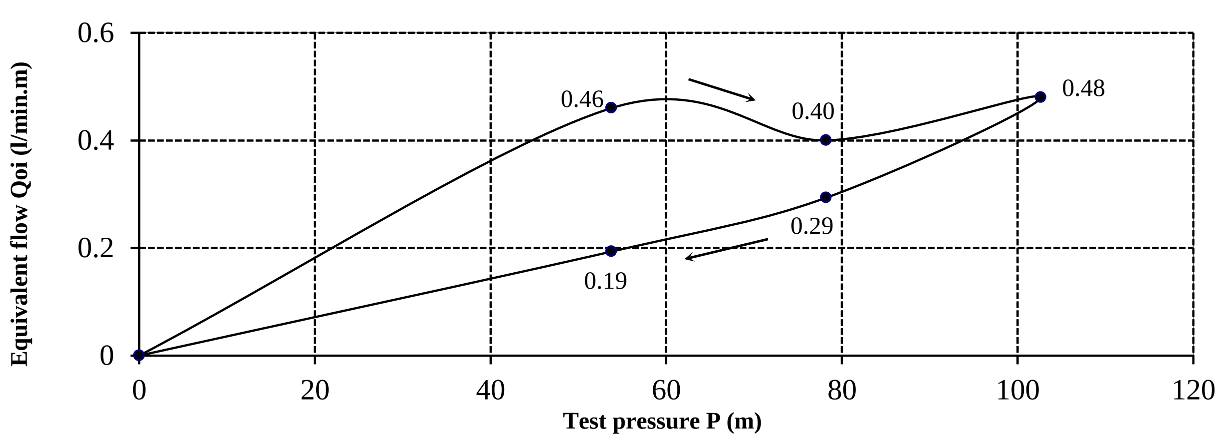
Recorded by: Duc	Checked by: Huy

GeoTech	**RECORD & CALCULATION** **LUGEON TEST**	**BOREHOLE:**	HTBG003
		Test No.:	P17

PROJECT: Frieda River Project	Depth of borehole at the time of test: 350.5 m
	Test section: from (H_2) 340.5 to 350.5 Length 10.0 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 46.00 (kG/cm^2) Date of test: 3:52 28/2/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 341.5 Initial groudwater level (H_3) 3.21 m

Reading time	**Pressure gauge reading (Poi)**		**Flowmeter reading (liter)**			**Average flow**	**Remark**
(minute)	(kG/cm^2)	(m)	Before	After	Take	Qi (l/min)	
15	5.30	53.0	0	69.0	69.0	4.60	- Test conducted in: Horse Microdiorite (Hmd)
15	7.90	79.0	69.0	129.0	60.0	4.00	- No seepage from top of borehole.
15	10.50	105.0	129.0	201.0	72.0	4.80	- Parker pressure is constant throughout the test
15	7.90	79.0	201.0	245.0	44.0	2.93	
15	5.30	53.0	245.0	274.0	29.0	1.93	

EQUIVALENT FLOW	**HEAD LOSS**	**TEST PRESSURE**	**TEST VALUES**		**VALUE CHOSEN FOR THE TEST SECTION**
			WATER LOSS	**LUGEON**	
Qoi=Qi/L (l/min/m)	H_f (m)	$Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	qi=Qoi/Pi (l/min.m)	uLi = 100qi	
0.46	0	53.8	0.009	0.86	q= 0.0036 (l/min.m)
0.40	0	78.2	0.005	0.51	
0.48	0	102.6	0.005	0.47	
0.29	0	78.2	0.004	0.38	
0.19	0	53.8	0.004	0.36	uL= 0.36



Recorded by: Hien	Checked by: Cuong

GeoTech	RECORD & CALCULATION **LUGEON TEST**	BOREHOLE:	HTBG003
		Test No.:	P18

PROJECT: Frieda River Project

Depth of borehole at the time of test: 370.4 m

Test section: from (H_2) 360.0 to 370.4 Length 10.4 m

STRUCTURE: Proposed Pit

Height of pressure gage from ground level: (H_1) 1.0 m

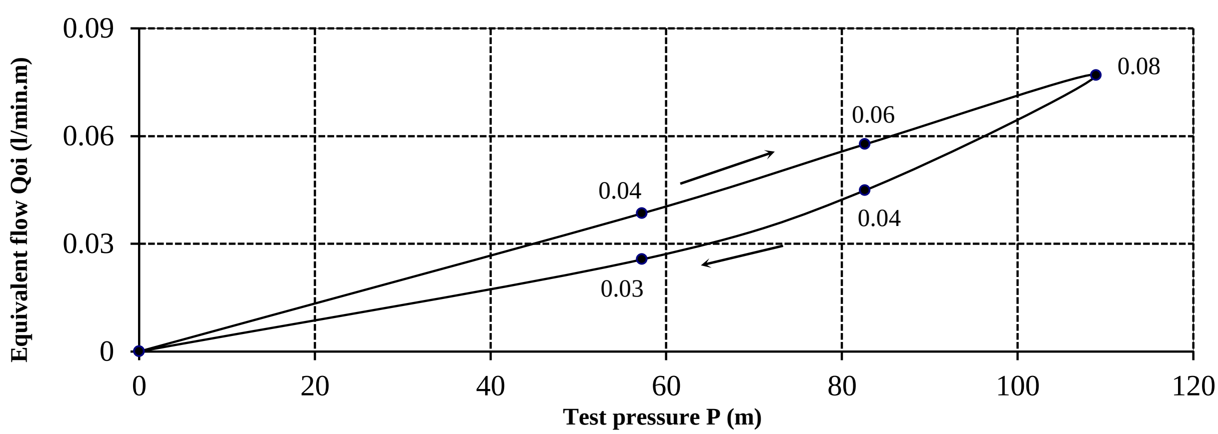
Inclination of borehole from Horizontal (ϕ): 70

TYPE OF PACKER: GeoPro Wireline Single | PARKER PRESSURE: 48.00 (kG/cm^2) | Date of test: 3:20 01/03/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 361 | Initial groudwater level (H_3) 3.92 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	Flowmeter reading (liter) After	Flowmeter reading (liter) Take	Average flow Qi (l/min)	Remark
15	5.60	56.0	0	6.0	6.0	0.40	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	8.30	83.0	6.0	15.0	9.0	0.60	
15	11.10	111.0	15.0	27.0	12.0	0.80	
15	8.30	83.0	27.0	34.0	7.0	0.47	
15	5.60	56.0	34.0	38.0	4.0	0.27	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.04	0	57.2	0.001	0.07	q= 0.0006 (l/min.m)
0.06	0	82.6	0.001	0.07	
0.08	0	108.9	0.001	0.07	
0.04	0	82.6	0.001	0.05	uL= 0.06
0.03	0	57.2	0.000	0.04	



Recorded by: Hien	Checked by: Cuong

RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG003
Test No.:	P19

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test: 390.4 m

Test section: from (H_2) 381.4 to 390.4 Length 9.0 m

Height of pressure gage from ground level: (H_1) 1.0 m

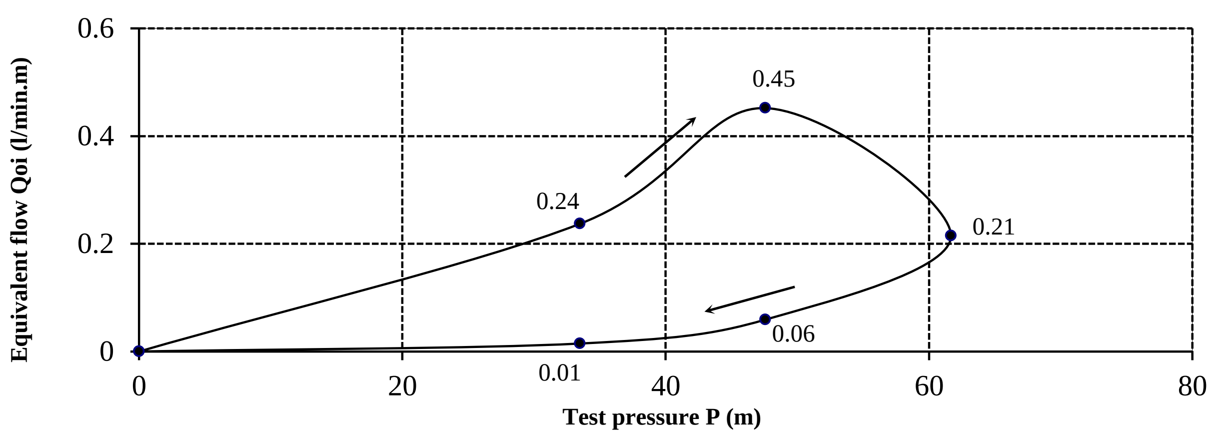
Inclination of borehole from Horizontal (ϕ): 70

TYPE OF PACKER: GeoPro Wireline Single | **PARKER PRESSURE:** 50.00 (kG/cm^2) | Date of test: 9:30 03/03/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 382.4 | Initial groudwater level (H_3) 4.63 m

Reading time	Pressure gauge reading (Poi)		Flowmeter reading (liter)			Average flow	Remark
(minute)	(kG/cm^2)	(m)	Before	After	Take	Qi (l/min)	
15	3.00	30.0	0	32.0	32.0	2.13	- Test conducted in: Horse Microdiorite (Hmd)
15	4.50	45.0	32.0	93.0	61.0	4.07	- No seepage from top of borehole.
15	6.00	60.0	93.0	122.0	29.0	1.93	- Parker pressure is constant throughout the test
15	4.50	45.0	122.0	130.0	8.0	0.53	
15	3.00	30.0	130.0	132.0	2.0	0.13	

EQUIVALENT FLOW	HEAD LOSS	TEST PRESSURE	TEST VALUES		VALUE CHOSEN FOR THE TEST SECTION
			WATER LOSS	LUGEON	
Qoi=Qi/L (l/min/m)	H_f (m)	$Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	qi=Qoi/Pi (l/min.m)	uLi = 100qi	
0.24	0	33.5	0.007	0.71	q= 0.0043 (l/min.m)
0.45	0	47.6	0.009	0.95	
0.21	0	61.7	0.003	0.35	
0.06	0	47.6	0.001	0.12	uL= 0.43
0.01	0	33.5	0.000	0.04	



Recorded by: Duc | Checked by: Huy

RECORD & CALCULATION LUGEON TEST

BOREHOLE:	HTBG004
Test No.:	P01

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

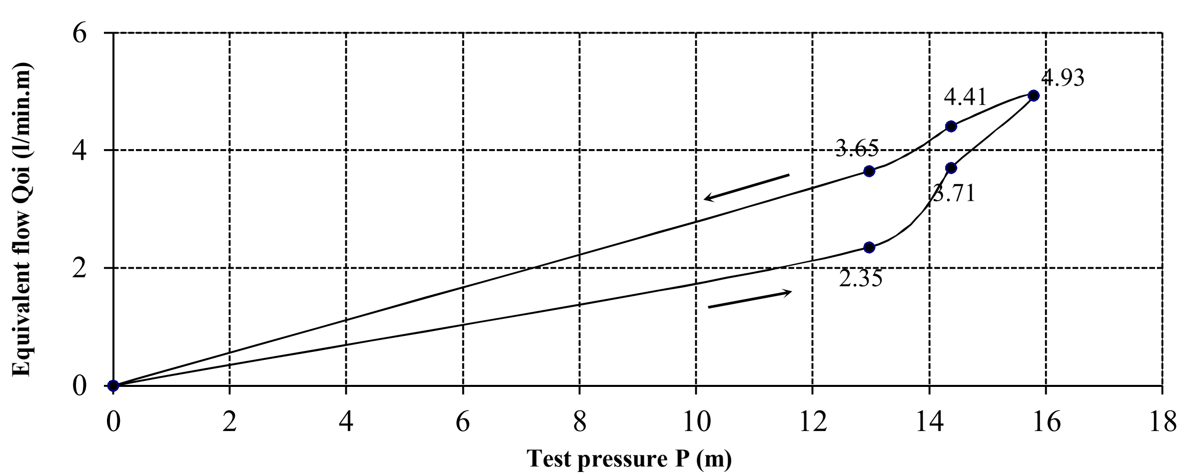
Depth of borehole at the time of test:	20.5 m
Test section: from (H_2)	11.0 to 20.5 Length 9.5 m
Height of pressure gage from ground level: (H_1)	1.0 m
Inclination of borehole from Horizontal (ϕ):	70

TYPE OF PACKER: GeoPro Wireline Single | **PARKER PRESSURE:** 4.255 (kG/cm^2) | Date of test: 18:30 11/3/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 12 | Initial groudwater level (H_3 9.8 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	0.30	3.0	0	335	335	22.33	- Test conducted in: Horse Microdiorite (Hmd)
15	0.45	4.5	0	528	528	35.20	- No seepage from top of borehole.
15	0.60	6.0	0	703	703	46.87	- Parker pressure is constant throughout the test
15	0.45	4.5	0	629	629	41.93	
15	0.30	3.0	0	520	520	34.67	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
2.35	0	13.0	0.181	18.13	q= 0.2824 (l/min.m)
3.71	0	14.4	0.258	25.77	
4.93	0	15.8	0.312	31.25	
4.41	0	14.4	0.307	30.70	uL= 28.24
3.65	0	13.0	0.281	28.14	



Recorded by: Thanh | Checked by: Quang

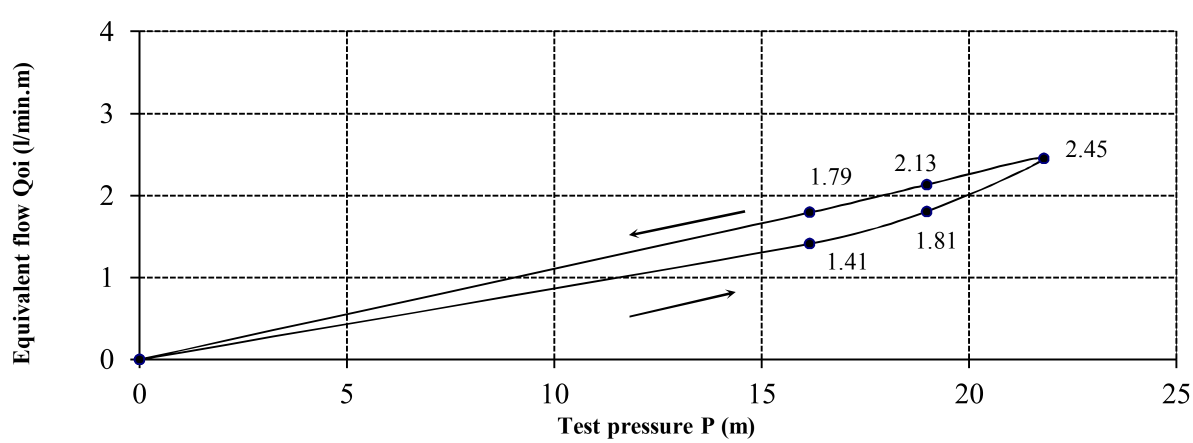
RECORD & CALCULATION LUGEON TEST

BOREHOLE:	HTBG004
Test No.:	P02

PROJECT: Frieda River Project	Depth of borehole at the time of test: 40.0 m
	Test section: from (H_2) 30.0 to 40.0 Length 10.0 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 6.40 (kG/cm^2) Date of test: 9:40 12/03/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 31 Initial groudwater level (H_3) 10.20 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	0.60	6.0	0	212.0	212.0	14.13	- Test conducted in: Horse Microdiorite (Hmd)
15	0.90	9.0	212.0	483.0	271.0	18.07	- No seepage from top of borehole.
15	1.20	12.0	483.0	851.0	368.0	24.53	- Parker pressure is constant throughout the test
15	0.90	9.0	851.0	1171.0	320.0	21.33	
15	0.60	6.0	1171.0	1440.0	269.0	17.93	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE Pi=(Poi+H_1+H_2-H_f)*Sinϕ (Meter of water column)	TEST VALUES WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
1.41	0	16.2	0.087	8.74	q= 0.1038 (l/min.m)
1.81	0	19.0	0.095	9.52	
2.45	0	21.8	0.113	11.25	
2.13	0	19.0	0.112	11.24	
1.79	0	16.2	0.111	11.10	uL= 10.38



Recorded by: Hanh	Checked by: Quang

RECORD & CALCULATION
LUGEON TEST

BOREHOLE: HTBG004
Test No.: P03

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test: 60.3 m

Test section: from (H_2) 49.3 to 60.3 Length 11 m

Height of pressure gage from ground level: (H_1) 1.0 m

Inclination of borehole from Horizontal (ϕ): 70

TYPE OF PACKER: GeoPro Wireline Single

PARKER PRESSURE: 8.633 (kG/cm^2)

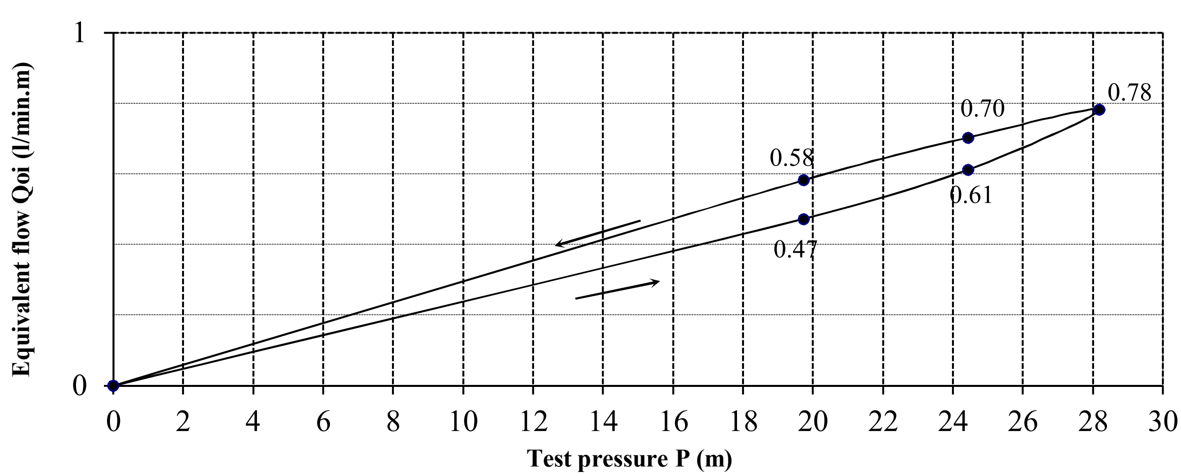
Date of test: 18:30 11/3/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 50.3

Initial groudwater level (H_3 11.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	0.90	9.0	0	78	78	5.20	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	1.40	14.0	78	179	101	6.73	
15	1.80	18.0	179	308	129	8.60	
15	1.40	14.0	308	424	116	7.73	
15	0.90	9.0	424	520	96	6.40	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $P_i=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.47	0	19.7	0.024	2.40	q= 0.0295 (l/min.m)
0.61	0	24.4	0.025	2.51	
0.78	0	28.2	0.028	2.77	
0.70	0	24.4	0.029	2.88	uL= 2.95
0.58	0	19.7	0.029	2.95	



Recorded by: Thanh

Checked by: Quang

RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG004
Test No.:	P04

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

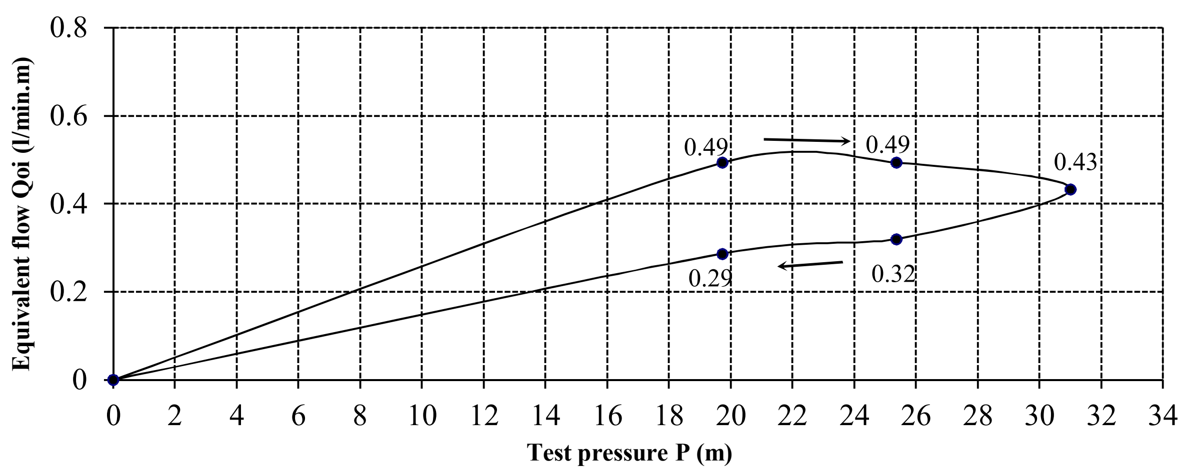
Depth of borehole at the time of test:					80	m
Test section: from (H_2)	70.0	to	80	Length	10	m
Height of pressure gage from ground level: (H_1)					1.0	m
Inclination of borehole from Horizontal (ϕ):		70				

TYPE OF PACKER: GeoPro Wireline Single | **PARKER PRESSURE:** 10.8 (kG/cm^2) | Date of test: 19:30 13/3/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 71.0 | Initial groudwater level (H_3 8.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	Flowmeter reading (liter) After	Flowmeter reading (liter) Take	Average flow Qi (l/min)	Remark
15	1.20	12.0	0	74	74	4.93	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	1.80	18.0	74	148	74	4.93	
15	2.40	24.0	148	213	65	4.33	
15	1.80	18.0	213	261	48	3.20	
15	1.20	12.0	261	304	43	2.87	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.49	0	19.7	0.025	2.50	q= 0.0171 (l/min.m)
0.49	0	25.4	0.019	1.94	
0.43	0	31.0	0.014	1.40	
0.32	0	25.4	0.013	1.26	uL= 1.71
0.29	0	19.7	0.015	1.45	



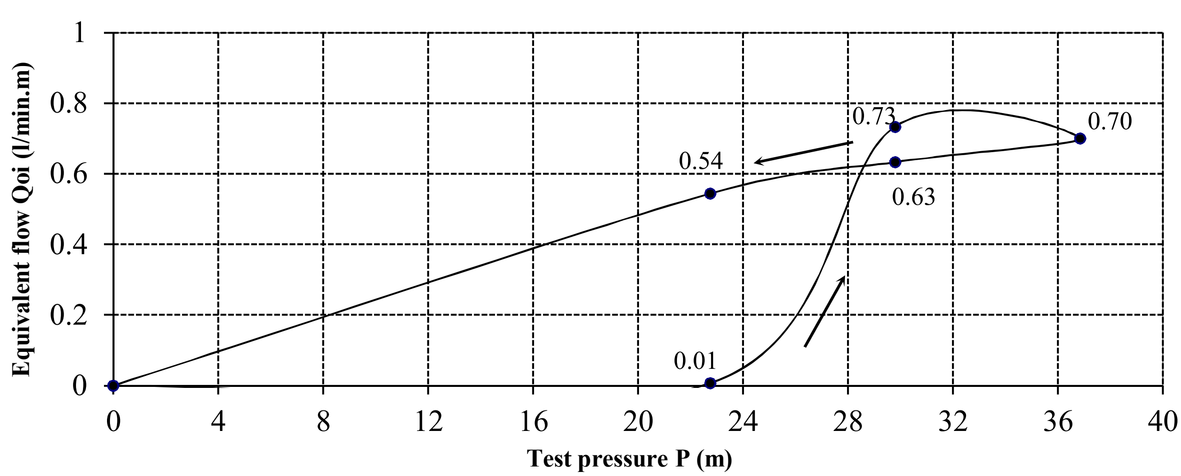
Recorded by: Thanh	Checked by: Quang

Geo Tech	**RECORD & CALCULATION** **LUGEON TEST**	**BOREHOLE:**	HTBG004
		Test No.:	P05

PROJECT: Frieda River Project	Depth of borehole at the time of test:				100	m
	Test section: from (H_2)	90.0	to	100	Length 10	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)				1.0	m
	Inclination of borehole from Horizontal (ϕ):		70			
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:**	13	(kG/cm^2)	Date of test:	08:30 14/3/2015	
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$	91.0	Initial groudwater level (H_3		8.2	m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	1.50	15.0	0	1	1	0.07	- The first test failed after 40 minutes due to problems of the water pump. This is the second test
9	2.25	22.5	1	67	66	7.33	- Test conducted in: Horse Microdiorite (Hmd)
9	3.00	30.0	67	130	63	7.00	- No seepage from top of borehole.
9	2.25	22.5	130	187	57	6.33	- Parker pressure is constant throughout the test
9	1.50	15.0	187	236	49	5.44	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.01	0	22.7	0.000	0.03	q= 0.0178 (l/min.m)
0.73	0	29.8	0.025	2.46	
0.70	0	36.8	0.019	1.90	
0.63	0	29.8	0.021	2.13	uL= 1.78
0.54	0	22.7	0.024	2.39	



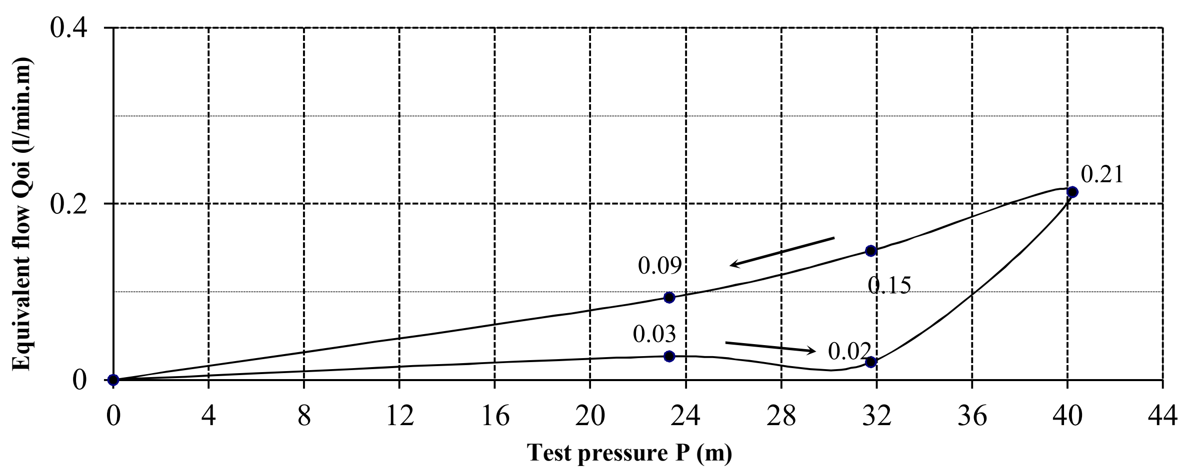
Recorded by: Thanh | Checked by: Quang

GeoTech	RECORD & CALCULATION LUGEON TEST	BOREHOLE:	HTBG004
		Test No.:	P06

PROJECT: Frieda River Project	Depth of borehole at the time of test: 120 m
	Test section: from (H_2) 110.0 to 120 Length 10 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.5 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 15.2 (kG/cm^2) — Date of test: 05:10 15/3/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 111.5 — Initial groudwater level (H_3 5.3 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	1.80	18.0	0	4	4	0.27	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	2.70	27.0	4	7	3	0.20	
15	3.60	36.0	7	39	32	2.13	
15	2.70	27.0	39	61	22	1.47	
15	1.80	18.0	61	75	14	0.93	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.03	0	23.3	0.001	0.11	q= 0.0031 (l/min.m)
0.02	0	31.8	0.001	0.06	
0.21	0	40.2	0.005	0.53	
0.15	0	31.8	0.005	0.46	uL= 0.31
0.09	0	23.3	0.004	0.40	



Recorded by: Thanh	Checked by: Quang

RECORD & CALCULATION LUGEON TEST

BOREHOLE:	HTBG004
Test No.:	P07

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test: 140 m

Test section: from (H_2) 130.0 to 140 Length 10 m

Height of pressure gage from ground level: (H_1) 1.0 m

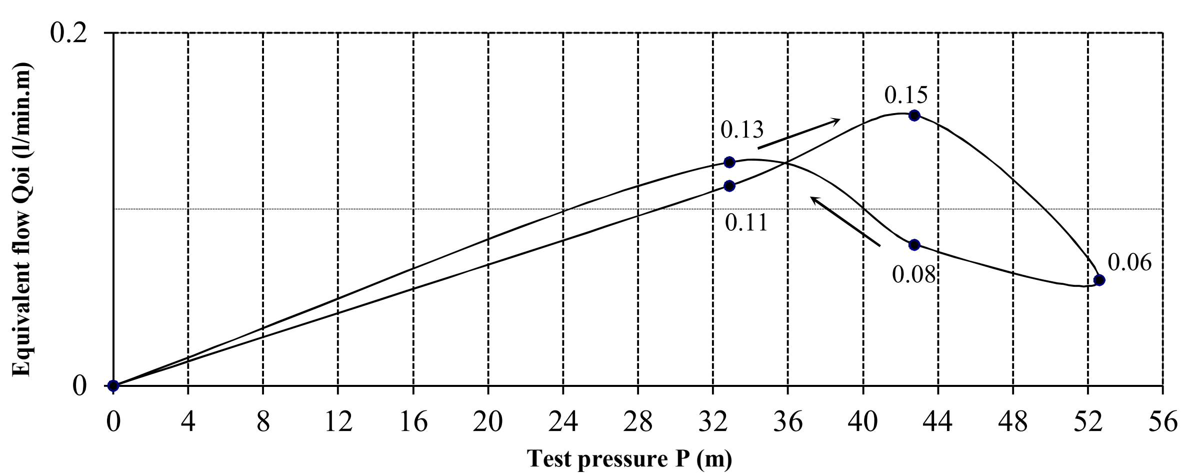
Inclination of borehole from Horizontal (ϕ): 70

TYPE OF PACKER: GeoPro Wireline Single | PARKER PRESSURE: 17.4 (kG/cm^2) | Date of test: 07:40 16/3/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 131.0 | Initial groudwater level (H_3 13.0 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	2.10	21.0	0	17	17	1.13	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	3.15	31.5	17	40	23	1.53	
15	4.20	42.0	40	49	9	0.60	
15	3.15	31.5	49	61	12	0.80	
15	2.10	21.0	61	80	19	1.27	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $P_i=(P_{oi}+H_1+H_2-H_f)*\sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.11	0	32.9	0.003	0.34	q= 0.0028 (l/min.m)
0.15	0	42.8	0.004	0.36	
0.06	0	52.6	0.001	0.11	
0.08	0	42.8	0.002	0.19	uL= 0.28
0.13	0	32.9	0.004	0.39	



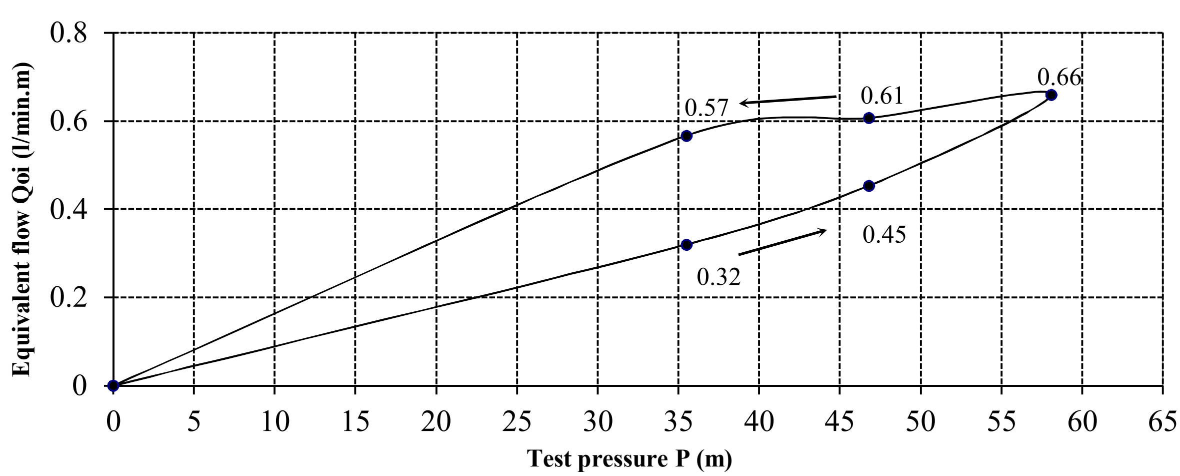
Recorded by: Thanh | Checked by: Quang

Geo Tech	RECORD & CALCULATION **LUGEON TEST**	BOREHOLE:	HTBG004
		Test No.:	P08

PROJECT: Frieda River Project	Depth of borehole at the time of test: 160 m
	Test section: from (H_2) 150.0 to 160 Length 10 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 19.6 (kG/cm^2) — Date of test: 23:30 16/3/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 151.0 — Initial groudwater level (H_3 12.8 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	2.40	24.0	0	48	48	3.20	- Test conducted in: Horse Microdiorite (Hmd)
15	3.60	36.0	48	116	68	4.53	- No seepage from top of borehole.
15	4.80	48.0	116	215	99	6.60	- Parker pressure is constant throughout the test
15	3.60	36.0	215	306	91	6.07	
15	2.40	24.0	306	391	85	5.67	

EQUIVALENT FLOW $Qoi=Qi/L$ (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS $qi=Qoi/Pi$ (l/min.m)	LUGEON $uLi = 100qi$	VALUE CHOSEN FOR THE TEST SECTION
0.32	0	35.5	0.009	0.90	q= 0.0160 (l/min.m)
0.45	0	46.8	0.010	0.97	
0.66	0	58.1	0.011	1.14	
0.61	0	46.8	0.013	1.30	uL= 1.60
0.57	0	35.5	0.016	1.60	



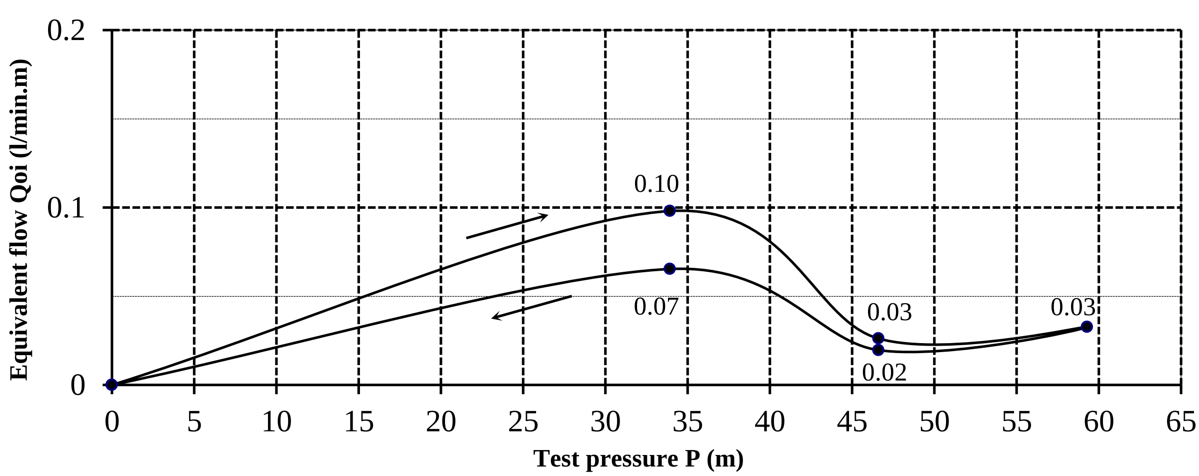
Recorded by: Thanh | Checked by: Quang

GeoTech	RECORD & CALCULATION **LUGEON TEST**	BOREHOLE:	HTBG004
		Test No.:	P09

PROJECT: Frieda River Project	Depth of borehole at the time of test: 180.2 m
	Test section: from (H_2) 170.0 to 180.2 Length 10.2 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 21.822 (kG/cm^2) Date of test: 23:30 16/3/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 171.0 Initial groudwater level (H_3 8.1 m

Reading time	**Pressure gauge reading (Poi)**		**Flowmeter reading (liter)**			**Average flow**	**Remark**
(minute)	(kG/cm^2)	(m)	Before	After	Take	Qi (l/min)	
15	2.70	27.0	0	15	15	1.00	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	4.05	40.5	15	19	4	0.27	
15	5.40	54.0	19	24	5	0.33	
15	4.05	40.5	24	27	3	0.20	
15	2.70	27.0	27	37	10	0.67	

EQUIVALENT FLOW	**HEAD LOSS**	**TEST PRESSURE**	**TEST VALUES: WATER LOSS**	**TEST VALUES: LUGEON**	**VALUE CHOSEN FOR THE TEST SECTION**
Qoi=Qi/L (l/min/m)	H_f (m)	$Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	qi=Qoi/Pi (l/min.m)	uLi = 100qi	
0.10	0	33.9	0.003	0.29	q= 0.0013 (l/min.m)
0.03	0	46.6	0.001	0.06	
0.03	0	59.3	0.001	0.06	
0.02	0	46.6	0.000	0.04	uL= 0.13
0.07	0	33.9	0.002	0.19	



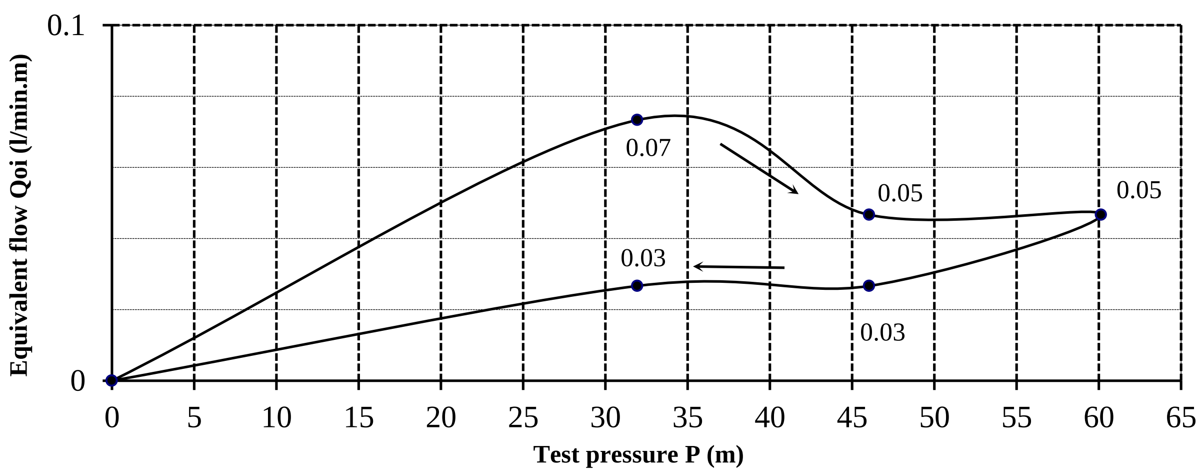
Recorded by: Thanh	Checked by: Quang

GeoTech	**RECORD & CALCULATION** **LUGEON TEST**	**BOREHOLE:** HTBG004 **Test No.:** P10

PROJECT: Frieda River Project	Depth of borehole at the time of test: 200 m
	Test section: from (H_2) 190.0 to 200 Length 10 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 24 (kG/cm^2) — Date of test: 10:00 18/3/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 191.0 — Initial groudwater level (H_3 3.0 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	3.00	30.0	0	11	11	0.73	- Test conducted in: Horse Microdiorite (Hmd)
15	4.50	45.0	11	18	7	0.47	- No seepage from top of borehole.
15	6.00	60.0	18	25	7	0.47	- Parker pressure is constant throughout the test
15	4.50	45.0	25	29	4	0.27	
15	3.00	30.0	29	33	4	0.27	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** — **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.07	0	31.9	0.002	0.23	q= 0.0011 (l/min.m)
0.05	0	46.0	0.001	0.10	
0.05	0	60.1	0.001	0.08	
0.03	0	46.0	0.001	0.06	uL= 0.11
0.03	0	31.9	0.001	0.08	



Recorded by: Thanh	Checked by: Quang

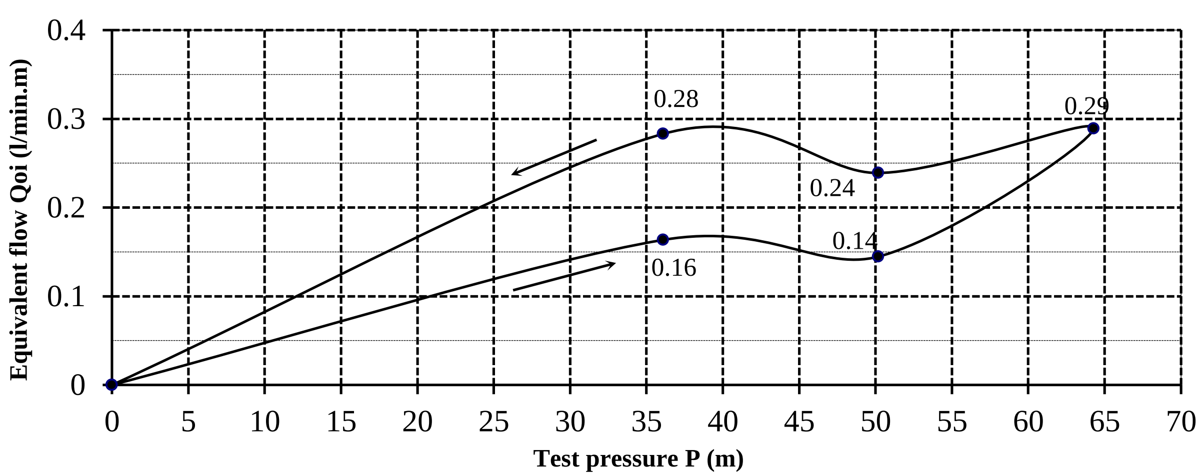
RECORD & CALCULATION
LUGEON TEST

BOREHOLE:	HTBG004
Test No.:	P11

PROJECT: Frieda River Project	Depth of borehole at the time of test: 220.6 m
	Test section: from (H_2) 210.0 to 220.6 Length 10.6 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 26.266 (kG/cm^2) — Date of test: 0:30 19/3/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 211.0 — Initial groudwater level (H_3 7.4 m

Reading time	Pressure gauge reading (Poi)		Flowmeter reading (liter)			Average flow	Remark
(minute)	(kG/cm^2)	(m)	Before	After	Take	Qi (l/min)	
15	3.00	30.0	0	26	26	1.73	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	4.50	45.0	26	49	23	1.53	
15	6.00	60.0	49	95	46	3.07	
15	4.50	45.0	95	133	38	2.53	
15	3.00	30.0	133	178	45	3.00	

EQUIVALENT FLOW	HEAD LOSS	TEST PRESSURE	TEST VALUES: WATER LOSS	TEST VALUES: LUGEON	VALUE CHOSEN FOR THE TEST SECTION
Qoi=Qi/L (l/min/m)	H_f (m)	$Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	qi=Qoi/Pi (l/min.m)	uLi = 100qi	
0.16	0	36.1	0.005	0.45	q= 0.0049 (l/min.m)
0.14	0	50.2	0.003	0.29	
0.29	0	64.3	0.005	0.45	
0.24	0	50.2	0.005	0.48	
0.28	0	36.1	0.008	0.78	uL= 0.49



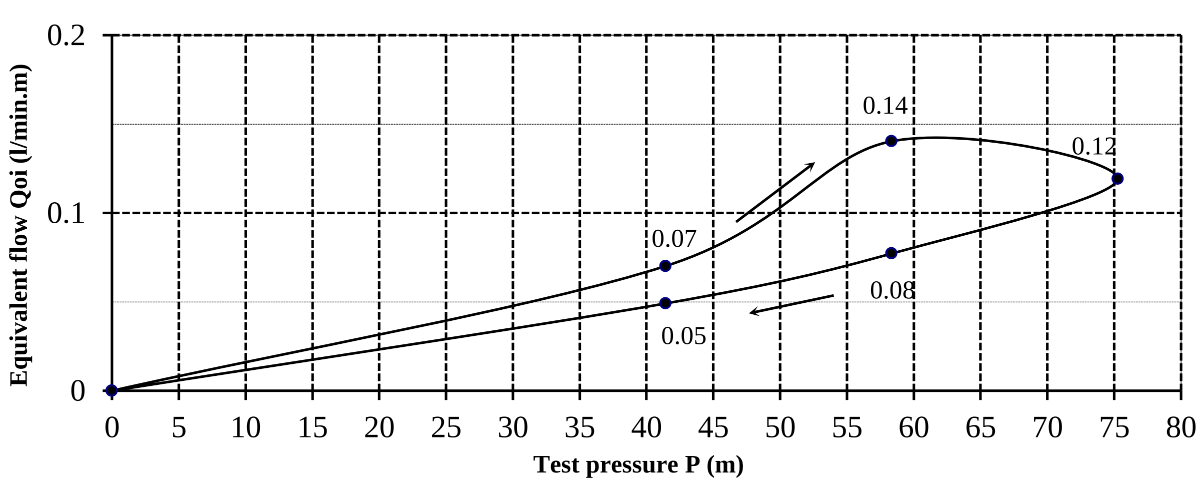
Recorded by: Thanh	Checked by: Quang

GeoTech	RECORD & CALCULATION **LUGEON TEST**	BOREHOLE:	HTBG004
		Test No.:	P12

PROJECT: Frieda River Project	Depth of borehole at the time of test: 239.5 m
	Test section: from (H_2) 230.0 to 239.5 Length 9.5 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 28.345 (kG/cm^2) — Date of test: 0:30 20/3/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 231.0 — Initial groudwater level (H_3 7.1 m

Reading time	**Pressure gauge reading (Poi)**		**Flowmeter reading (liter)**			**Average flow**	**Remark**
(minute)	(kG/cm^2)	(m)	Before	After	Take	Qi (l/min)	
15	3.60	36.0	0	10	10	0.67	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	5.40	54.0	10	30	20	1.33	
15	7.20	72.0	30	47	17	1.13	
15	5.40	54.0	47	58	11	0.73	
15	3.60	36.0	58	65	7	0.47	

EQUIVALENT FLOW	**HEAD LOSS**	**TEST PRESSURE**	**TEST VALUES**		**VALUE CHOSEN FOR THE TEST SECTION**
			WATER LOSS	**LUGEON**	
Qoi=Qi/L (l/min/m)	H_f (m)	$Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	qi=Qoi/Pi (l/min.m)	uLi = 100qi	
0.07	0	41.4	0.002	0.17	q= 0.0016 (l/min.m)
0.14	0	58.4	0.002	0.24	
0.12	0	75.3	0.002	0.16	
0.08	0	58.4	0.001	0.13	uL= 0.16
0.05	0	41.4	0.001	0.12	



Recorded by: Thanh	Checked by: Quang

	RECORD & CALCULATION LUGEON TEST	BOREHOLE: HTBG004 Test No.: P13

PROJECT: Frieda River Project

STRUCTURE: Proposed Pit

Depth of borehole at the time of test: 260.3 m

Test section: from (H_2) 250.0 to 260.3 Length 10.3 m

Height of pressure gage from ground level: (H_1) 1.0 m

Inclination of borehole from Horizontal (ϕ): 70

TYPE OF PACKER: GeoPro Wireline Single

PARKER PRESSURE: 30.633 (kG/cm^2)

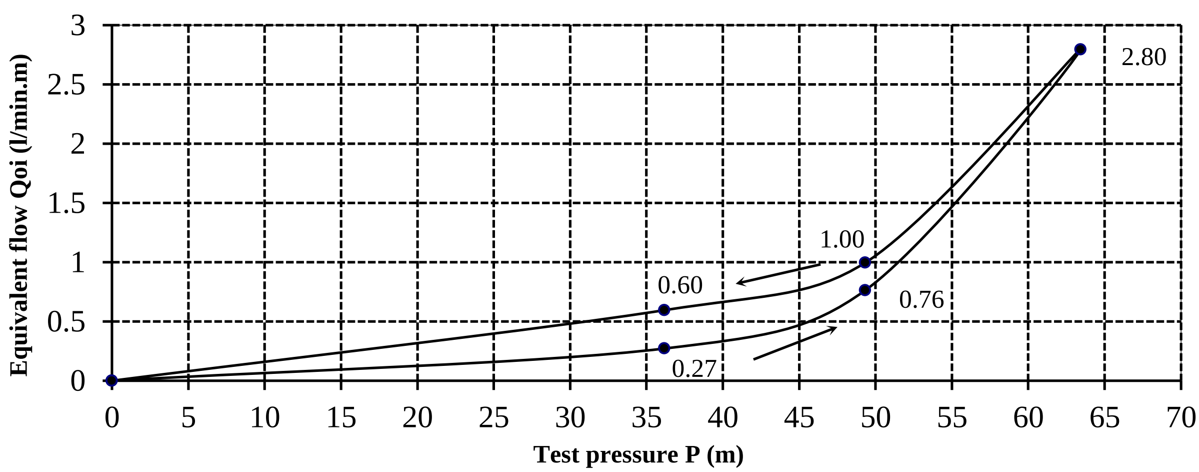
Date of test: 23:30 20/3/2015

Water hose from pressure gauge to parker: Length: $l = H_1 + H_2 =$ 251.0

Initial groudwater level (H_3 7.5 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	3.00	30.0	0	42	42	2.80	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	4.40	44.0	42	160	118	7.87	
15	5.90	59.0	163	595	432	28.80	
15	4.40	44.0	595	749	154	10.27	
15	3.00	30.0	749	841	92	6.13	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	TEST VALUES: LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.27	0	36.2	0.008	0.75	q= 0.0178 (l/min.m)
0.76	0	49.3	0.015	1.55	
2.80	0	63.4	0.044	4.41	
1.00	0	49.3	0.020	2.02	uL= 1.78
0.60	0	36.2	0.016	1.65	



Recorded by: Thanh

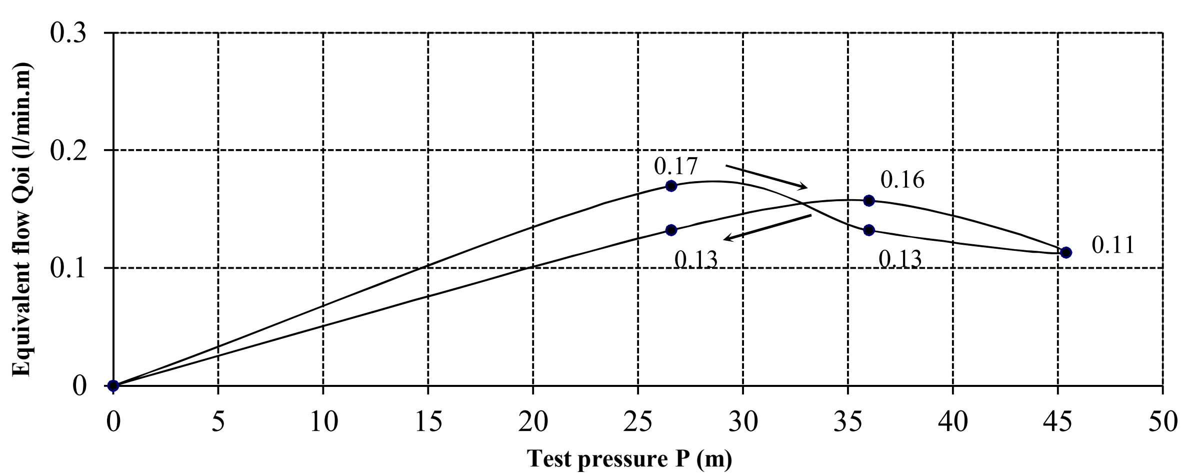
Checked by: Quang

Geo Tech	RECORD & CALCULATION LUGEON TEST	BOREHOLE: HTBG004 Test No.: P14

PROJECT: Frieda River Project	Depth of borehole at the time of test: 280.6 m
	Test section: from (H_2) 270.0 to 280.6 Length 10.6 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	PARKER PRESSURE: 41.284 (kG/cm^2) — Date of test: 21:30 21/3/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 271.0 — Initial groudwater level (H_3 7.3 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	(m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	2.00	20.0	0	27	27	1.80	- Maximum tested water pressure prior to testing equal to 4.0 bars
15	3.00	30.0	27	48	21	1.40	- Test conducted in: Horse Microdiorite (Hmd)
15	4.00	40.0	48	66	18	1.20	- No seepage from top of borehole.
15	3.00	30.0	66	91	25	1.67	- Parker pressure is constant throughout the test
15	2.00	20.0	91	112	21	1.40	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $P_i=(P_{oi}+H_1+H_2-H_f)*\sin\phi$ (Meter of water column)	TEST VALUES: WATER LOSS qi=Qoi/Pi (l/min.m)	LUGEON uLi = 100qi	VALUE CHOSEN FOR THE TEST SECTION
0.17	0	26.6	0.006	0.64	q= 0.0025 (l/min.m)
0.13	0	36.0	0.004	0.37	
0.11	0	45.4	0.002	0.25	
0.16	0	36.0	0.004	0.44	uL= 0.25
0.13	0	26.6	0.005	0.50	



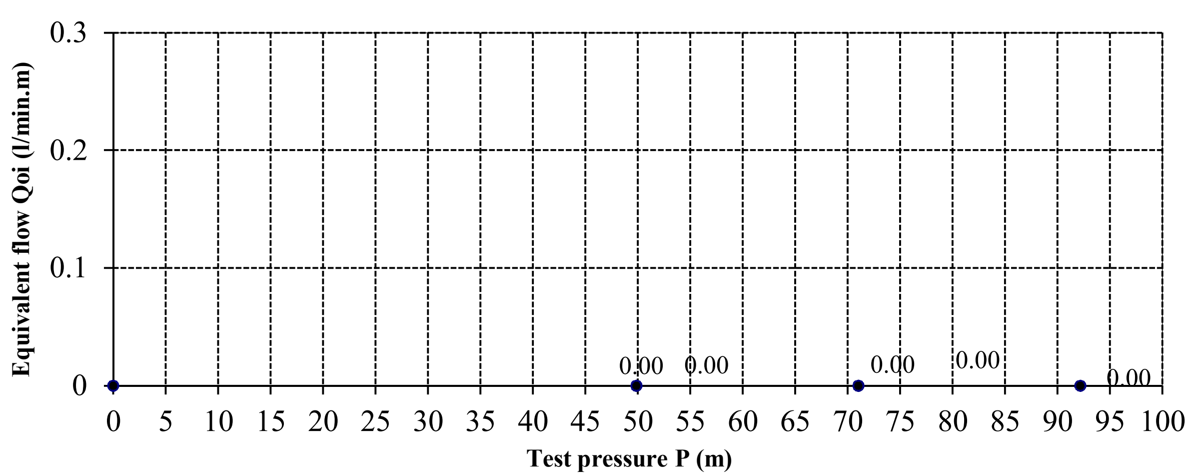
Recorded by: Thanh	Checked by: Quang

Geo Tech	**RECORD & CALCULATION** **LUGEON TEST**	**BOREHOLE:**	HTBG004
		Test No.:	P15

PROJECT: Frieda River Project	Depth of borehole at the time of test:		300.0	m
	Test section: from (H_2)	290.0 to 300	Length 10	m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1)		1.0	m
	Inclination of borehole from Horizontal (ϕ):	70		
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 44.00 (kG/cm^2)	Date of test: 14:50 22/3/2015		
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 291.0	Initial groudwater level (H_3 7.1		m

Reading time	**Pressure gauge reading (Poi)**		**Flowmeter reading (liter)**			**Average flow**	**Remark**
(minute)	(kG/cm^2)	(m)	Before	After	Take	Qi (l/min)	
15	4.50	45.0	0	0	0	0.00	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	6.75	67.5	0	0	0	0.00	
15	9.00	90.0	0	0	0	0.00	
15	6.75	67.5	0	0	0	0.00	
15	4.50	45.0	0	0	0	0.00	

EQUIVALENT FLOW	**HEAD LOSS**	**TEST PRESSURE**	**TEST VALUES**		**VALUE CHOSEN FOR THE TEST SECTION**
			WATER LOSS	**LUGEON**	
Qoi=Qi/L (l/min/m)	H_f (m)	$Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	qi=Qoi/Pi (l/min.m)	uLi = 100qi	
0.00	0	49.9	0.000	0.00	q= 0.0000 (l/min.m)
0.00	0	71.0	0.000	0.00	
0.00	0	92.2	0.000	0.00	
0.00	0	71.0	0.000	0.00	uL= 0.00
0.00	0	49.9	0.000	0.00	



Recorded by: Thanh	Checked by: Quang

RECORD & CALCULATION
LUGEON TEST

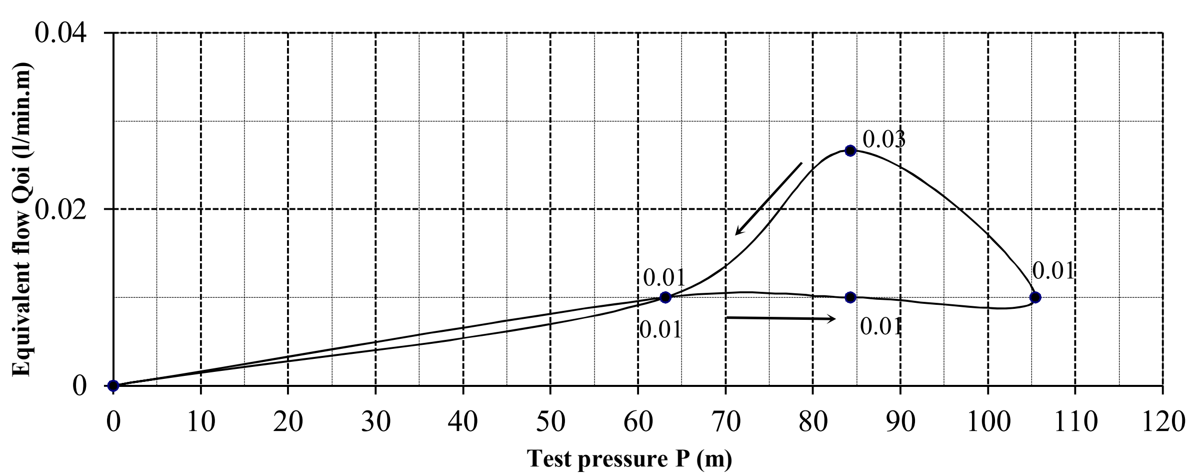
GeoTech

BOREHOLE: HTBG004
Test No.: P16

PROJECT: Frieda River Project	Depth of borehole at the time of test: 300.0 m
	Test section: from (H_2) 280.0 to 300 Length 20 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 44.00 (kG/cm^2) Date of test: 17:10 22/3/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 281.0 Initial groudwater level (H_3 21.2 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	4.50	45.0	0	3	3	0.20	- Test conducted in: Horse Microdiorite (Hmd)
15	6.75	67.5	3	6	3	0.20	- No seepage from top of borehole.
15	9.00	90.0	6	9	3	0.20	- Parker pressure is constant throughout the test
15	6.75	67.5	9	17	8	0.53	
15	4.50	45.0	17	20	3	0.20	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.01	0	63.1	0.000	0.02	q= 0.0002 (l/min.m)
0.01	0	84.3	0.000	0.01	
0.01	0	105.4	0.000	0.01	
0.03	0	84.3	0.000	0.03	uL= 0.02
0.01	0	63.1	0.000	0.02	



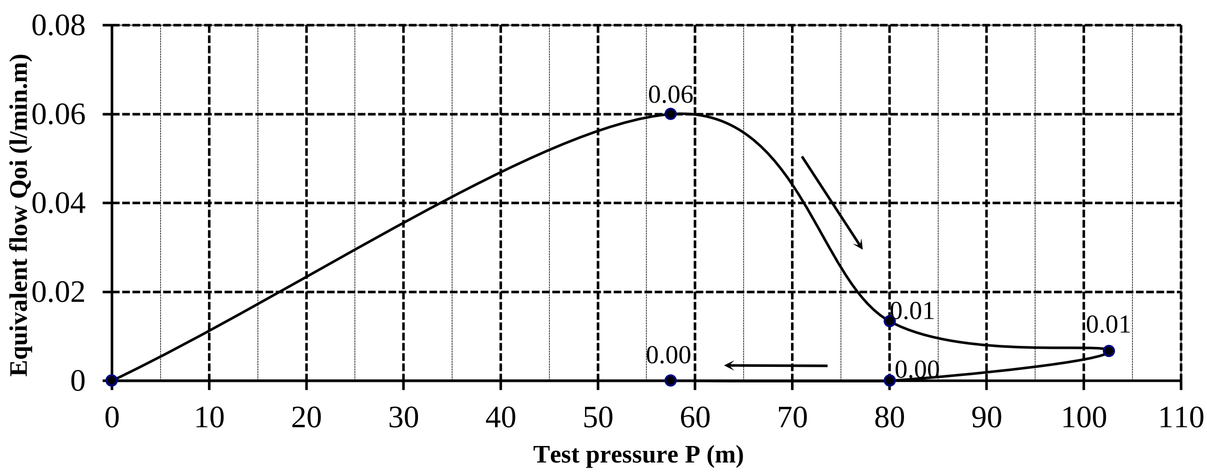
Recorded by: Thanh	Checked by: Quang

GeoTech	RECORD & CALCULATION **LUGEON TEST**	BOREHOLE:	HTBG004
		Test No.:	P17

PROJECT: Frieda River Project	Depth of borehole at the time of test: 321.7 m
	Test section: from (H_2) 311.7 to 321.7 Length 10 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 47.04 (kG/cm^2) — Date of test: 12:30 23/3/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 312.7 — Initial groudwater level (H_3 12.2 m

Reading time (minute)	Pressure gauge reading (Poi) (kG/cm^2)	Pressure gauge reading (Poi) (m)	Flowmeter reading (liter) Before	After	Take	Average flow Qi (l/min)	Remark
15	4.80	48.0	0	9	9	0.60	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	7.20	72.0	9	11	2	0.13	
15	9.60	96.0	11	12	1	0.07	
15	7.20	72.0	12	12	0	0.00	
15	4.80	48.0	12	12	0	0.00	

EQUIVALENT FLOW $Qoi=Qi/L$ (l/min/m)	HEAD LOSS H_f (m)	TEST PRESSURE $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	TEST VALUES — WATER LOSS $qi=Qoi/Pi$ (l/min.m)	LUGEON $uLi = 100qi$	VALUE CHOSEN FOR THE TEST SECTION
0.06	0	57.5	0.001	0.10	q= 0.0000 (l/min.m)
0.01	0	80.1	0.000	0.02	
0.01	0	102.6	0.000	0.01	
0.00	0	80.1	0.000	0.00	uL= 0.00
0.00	0	57.5	0.000	0.00	



Recorded by: Thanh	Checked by: Quang

RECORD & CALCULATION
LUGEON TEST

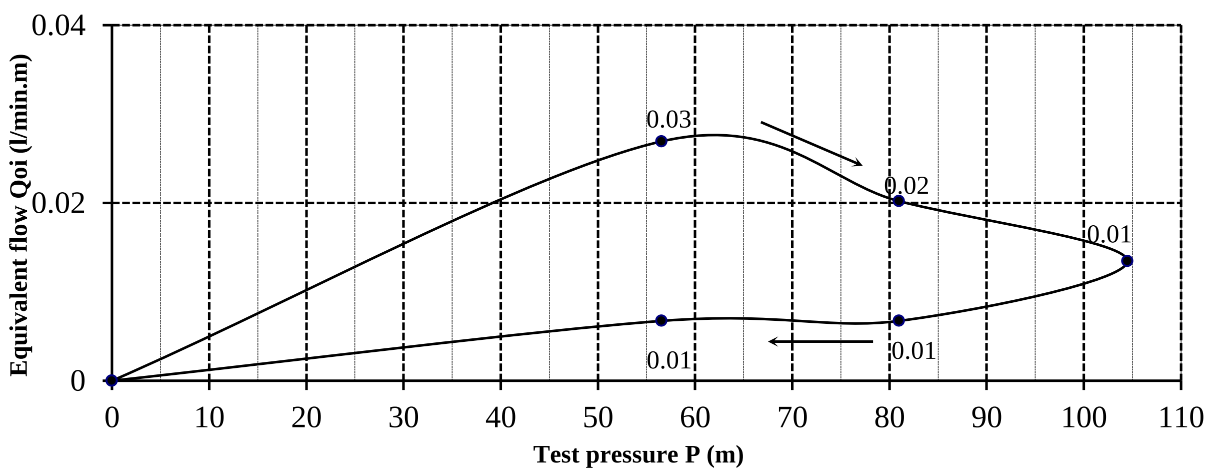
BOREHOLE: HTBG004

Test No.: P18

PROJECT: Frieda River Project	Depth of borehole at the time of test: 339.9 m
	Test section: from (H_2) 330.0 to 339.9 Length 9.9 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 49.59 (kG/cm^2) Date of test: 13:15 24/3/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 331.0 Initial groudwater level (H_3 8.2 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	5.10	51.0	0	4	4	0.27	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	7.70	77.0	4	7	3	0.20	
15	10.20	102.0	7	9	2	0.13	
15	7.70	77.0	9	10	1	0.07	
15	5.10	51.0	10	11	1	0.07	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.03	0	56.6	0.000	0.05	q= 0.0002 (l/min.m)
0.02	0	81.0	0.000	0.02	
0.01	0	104.5	0.000	0.01	
0.01	0	81.0	0.000	0.01	
0.01	0	56.6	0.000	0.01	uL= 0.02



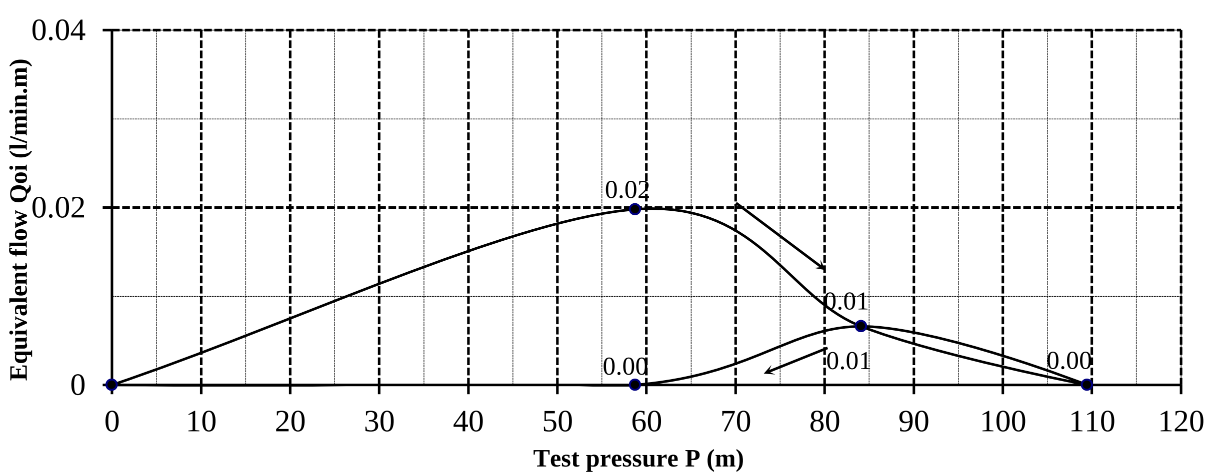
Recorded by: Thanh	Checked by: Quang

GeoTech	RECORD & CALCULATION **LUGEON TEST**	**BOREHOLE:**	HTBG004
		Test No.:	P19

PROJECT: Frieda River Project	Depth of borehole at the time of test: 360.1 m
	Test section: from (H_2) 350.0 to 360.1 Length 10.1 m
STRUCTURE: Proposed Pit	Height of pressure gage from ground level: (H_1) 1.0 m
	Inclination of borehole from Horizontal (ϕ): 70
TYPE OF PACKER: GeoPro Wireline Single	**PARKER PRESSURE:** 52.41 (kG/cm^2) | Date of test: 9:15 25/3/2015
Water hose from pressure gauge to parker:	Length: $l = H_1 + H_2 =$ 351.0 | Initial groudwater level (H_3 7.5 m

Reading time (minute)	**Pressure gauge reading (Poi)** (kG/cm^2)	(m)	**Flowmeter reading (liter)** Before	After	Take	**Average flow** Qi (l/min)	**Remark**
15	5.40	54.0	0	3	3	0.20	- Test conducted in: Horse Microdiorite (Hmd) - No seepage from top of borehole. - Parker pressure is constant throughout the test
15	8.10	81.0	3	4	1	0.07	
15	10.80	108.0	4	4	0	0.00	
15	8.10	81.0	4	5	1	0.07	
15	5.40	54.0	5	5	0	0.00	

EQUIVALENT FLOW Qoi=Qi/L (l/min/m)	**HEAD LOSS** H_f (m)	**TEST PRESSURE** $Pi=(Poi+H_1+H_2-H_f)*Sin\phi$ (Meter of water column)	**TEST VALUES** **WATER LOSS** qi=Qoi/Pi (l/min.m)	**LUGEON** uLi = 100qi	**VALUE CHOSEN FOR THE TEST SECTION**
0.02	0	58.7	0.000	0.03	q= 0.0001 (l/min.m)
0.01	0	84.1	0.000	0.01	
0.00	0	109.5	0.000	0.00	
0.01	0	84.1	0.000	0.01	uL= 0.01
0.00	0	58.7	0.000	0.00	



Recorded by: Hanh	Checked by: Quang

Appendix C **Water quality**

Attachments:

A – Water sample locations

B - Laboratory analysis results from the December 2014 field campaign.

C – Water quality summary data

D - Major ion analysis

E - Metals analysis

C1 Methodology

During December 2014, AGE collected 136 water samples within the Project area. Locations for all water quality samples are shown on Figure C 1.1 and summarised in Attachment A.

At each location, physico-chemical parameters were measured in the field and included pH, electrical conductivity (EC) and temperature. Where possible, a flow rate (L/s) from the drill hole or stream was also recorded. The following samples were collected:

- 33 groundwater samples from artesian exploration drill holes;
- 102 surface water samples from streams; and
- one rainfall sample.

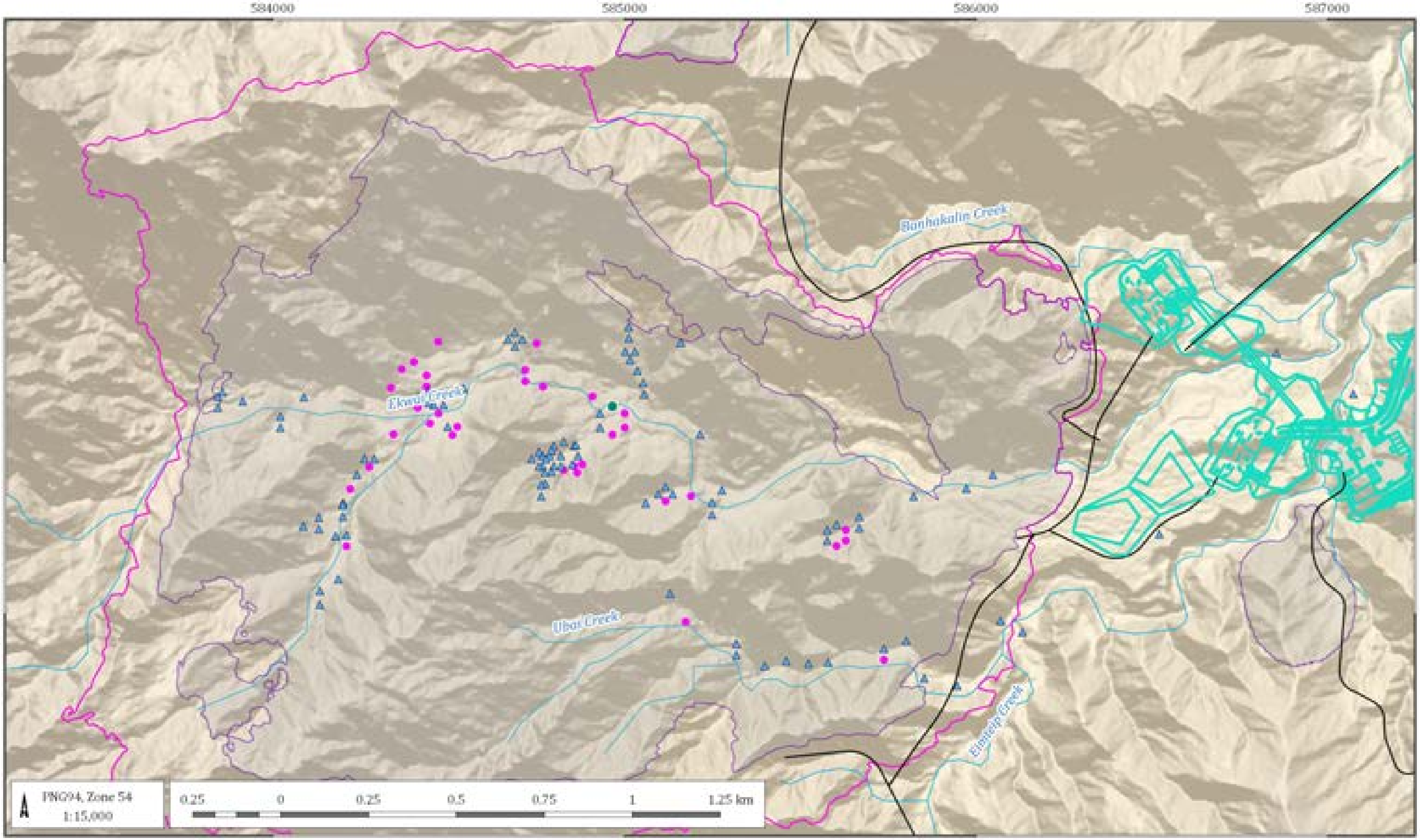
No sub-artesian exploration drill holes were sampled. However, sub-artesian drill holes are known to exist within the Project area. Table C 1.1 summarises the water quality measurements made during this period.

Table C 1.1 Summary of field water quality

Parameter		Electrical conductivity (µS/cm)	pH	Temperature (°C)
Artesian exploration drill hole samples	minimum	97	4.2	22.7
	5th percentile	165	4	23
	10th percentile	224	4	23
	mean	967	6.2	24.3
	90th percentile	1,891	7	26
	95th percentile	2,059	7	26
	maximum	2,266	7.4	26.2
	count	30	30	30
Surface water samples	minimum	10	3.7	21.7
	5th percentile	16	4	23
	10th percentile	24	4	23
	mean	183	4.9	23.8
	90th percentile	467	7	25
	95th percentile	571	7	25
	maximum	1,023	7.7	32.1
	count	98	98	98

All water samples were collected in accordance with Australian industry standards and AGE's Standard Operating Procedure (SOP) for water quality sampling. This SOP includes provision for:

- collecting and field filtering all water quality samples;
- storing samples in appropriate containers (i.e. with necessary preservatives); and
- transporting samples in appropriate insulated containers with cooler packs to help regulate temperature.



LEGEND

- Open-pit extent (Year 33)
- Drainage
- FRHEP / ISF extent
- Mining infrastructures
- Road (proposed)

Water sample locations

- Groundwater
- Surface water
- Frieda rainfall

Sepik Development Project (I1051A)

AGE

Water sample locations

DATE
19/07/2018

FIGURE No:
C - 1.1

Field measured water quality parameters were used to determine which samples were selected for laboratory analysis. Of the 135 water samples collected, 42 samples were sent to Australian Laboratory Services Pty Ltd (ALS) in Brisbane (Australia). ALS is a NATA accredited laboratory. The samples included the following:

- 29 groundwater samples from artesian exploration drill holes;
- 12 surface water samples from various streams; and
- one rainfall sample.

All laboratory documentation including Chain of Custody (COC) information, laboratory quality assurance (QA) information, and the laboratory sample receipts are attached.

All 42 samples were analysed for the following suite of parameters, using the standard ALS limit of reporting (LOR):

- physical parameters (pH, EC, total dissolved solids [TDS], total hardness, and sodium adsorption ratio);
- alkalinity (CO_3, HCO_3, and total alkalinity);
- major anions (Cl and SO_4);
- major cations (Ca, Mg, Na, and K);
- bromide, silicon as SiO_2, and fluoride; and
- dissolved and total metals (Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe^{2+}, Hg, Mn, Mo, Ni, Pb, Sr, Se, V, and Zn).

A subset of 32 samples were analysed for the following suite of parameters, using the ALS trace level LOR:

- major anions (Cl and SO_4); and
- major cations (Ca, Mg, Na, and K).

Attachment B presents the laboratory analysis results (for the standard LOR analyses and the trace LOR analyses) from the December 2014 field campaign.

C2 Project area water quality data

To supplement the water quality data collected during the current field program, groundwater quality data was collated from previous investigations undertaken within the Project area undertaken by SKM (2011) and Hydrobiology (2015). The historical water quality data includes:

- 6 groundwater samples from artesian exploration drill holes (SKM, 2011); and
- 78 surface water samples from various streams (Hydrobiology, 2015).

The six artesian exploration drill holes sampled by SKM were re-sampled during the December 2014 field campaign.

Hydrobiology (2015) collected multiple samples at some locations for laboratory analysis. For the purpose of this assessment the water quality analysis from these individual sites has been averaged as shown in Table C 2.1.

Locations for all water quality samples are shown on Figure C 1.1 and summarised in Attachment A. Attachment C presents water quality summary statistics, Attachment D contains the major ion analysis and Attachment E the metals analysis.

Table C 2.1 Summary of surface water quality sampling within Project area (Hydrobiology, 2015)

Sample ID	No. of samples	Date range
Basecamp	2	21/1/2009 – 11/8/2010
W18	10	31/8/2007 – 8/8/2010
W27	12	31/8//2007 – 11/10/2010
W28	12	31/8//2007 – 11/10/2010
W29	11	31/8/2007 – 12/8/2010
W42	9	31/8/2007 – 10/8/2010
W43	12	31/8//2007 – 11/10/2010
W48	9	31/8/2007 – 10/8/2010
W49	1	10/12/2008

C3 Water quality

C3.1 Salinity

Water salinity is assessed directly by measuring the electrical conductivity (EC) of samples. The following EC ranges (µS/cm) are commonly used to categorise salinity (Table C 3.1):

- Fresh 0 µS/cm to 750 µS/cm
- Slightly brackish 750 µS/cm to 1,500 µS/cm
- Brackish 1,500 µS/cm to 4,550 µS/cm

Surface waters and rainfall in the Project area are predominantly fresh. Some artesian groundwaters are fresh (Figure C 3.1), however the groundwaters also exhibit slightly brackish to brackish quality. A histogram of EC is presented in Figure C 3.1.

Table C 3.1 Electrical conductivity ranges

Electrical conductivity range (µS/cm) (Lab. data)	Water sample source		
	Rainfall	Surface water	Artesian groundwater
0 – 250	1	85	3
250 - 500	0	18	7
500 - 750	0	6	1
750 – 1,500	0	2	8
1,500 – 4,550	0	0	8
Total Samples	**1**	**111**	**27**

Note: **No EC recorded for surface water sample W49*

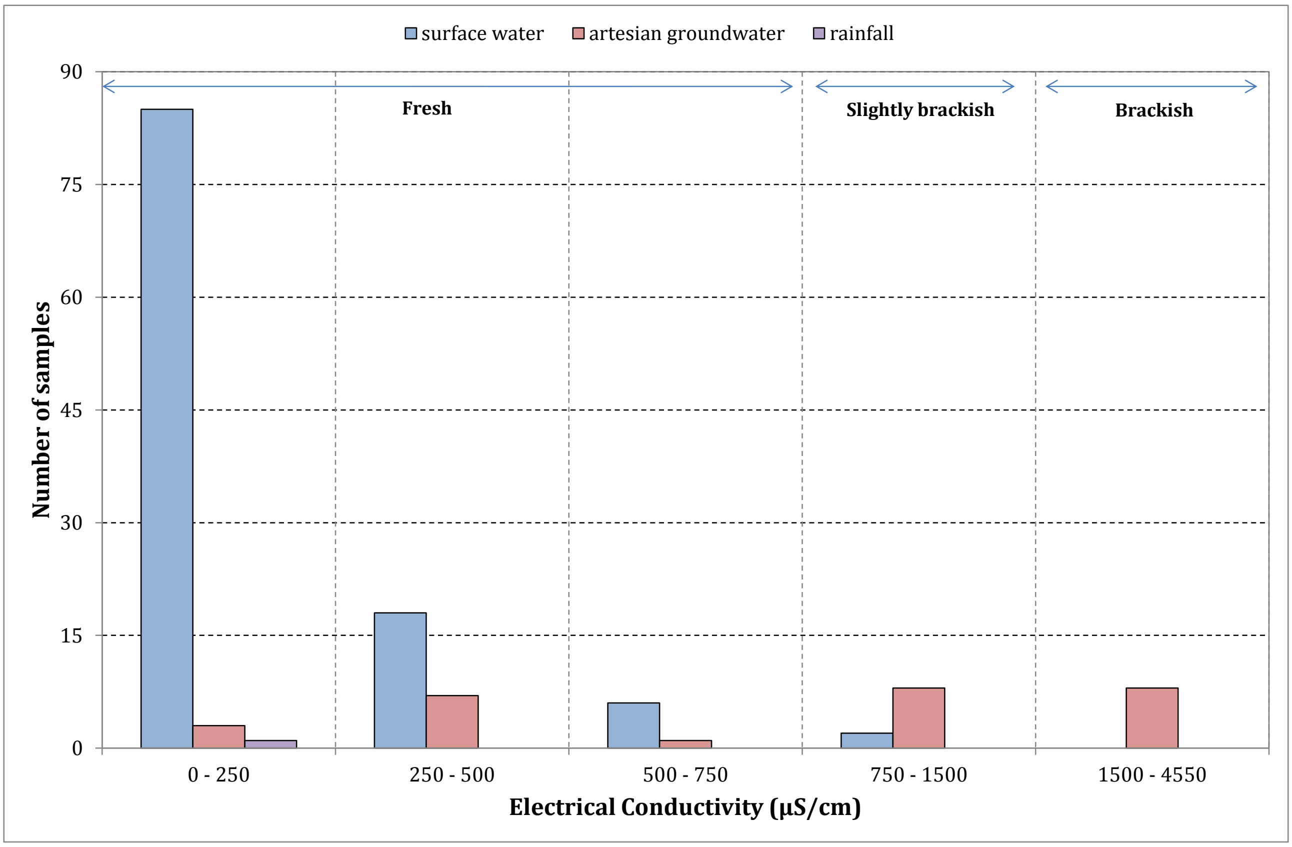


Figure C 3.1 Electrical conductivity histogram

Attachment D shows that of the artesian groundwater and surface water samples, 14 of the 27 artesian groundwater samples exceed the aesthetic total dissolved solids (TDS) concentrations in the Australian Drinking Water Guidelines (ADWG, 2011). Surface water samples exhibit TDS values within the guideline levels. Based upon this comparison, groundwater within the Project area is generally not fit for drinking.

C3.2 pH

Water sample pH has been measured and is categorised as follows:

- acidic pH < 5
- weak acid to neutral pH 5-7
- neutral to weakly alkaline pH 7+

Groundwater within the Project area is characterised as weakly acidic to weakly alkaline (Table C 3.2). Moderately acidic waters (pH < 5) are more predominant in the surface waters (Figure C 3.2).

Table C 3.2 pH (laboratory) ranges

pH Range (Lab. data)	Water sample source		
	Rainfall	Surface water	Artesian groundwater
3 - 4	0	18	5
4 - 5	0	56	2
5 - 6	0	12	1
6 - 7	1	14	5
7 - 8	0	11	14
Total Samples	**1**	**111**	**27**

***Note**: *No pH recorded for surface water sample W49, 291xC09 recorded a pH of 0.02*

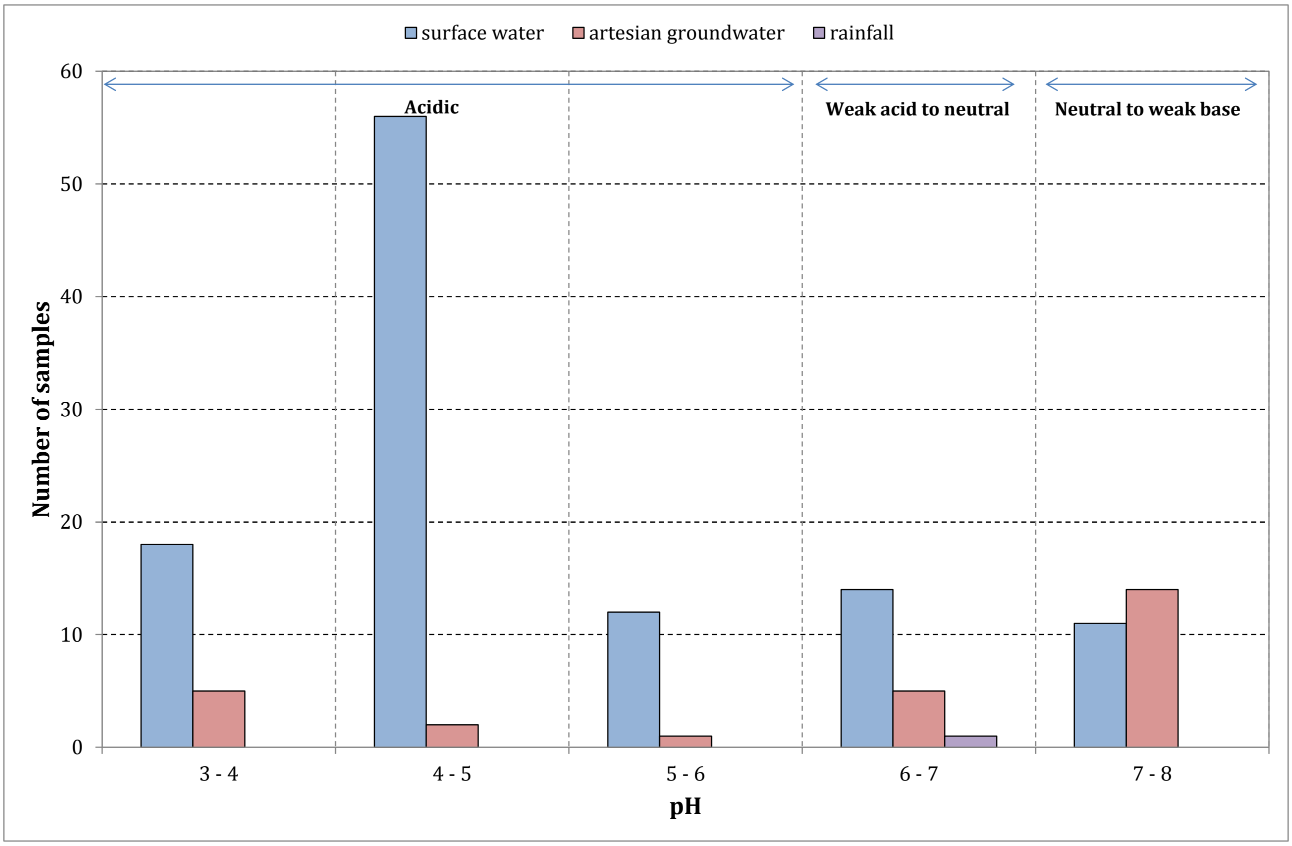


Figure C 3.2 pH histogram

Attachment D shows that of the artesian groundwater and surface water samples, 8 of the 27 artesian groundwater samples, 87 of 112 surface water samples, and the single rainfall sample analysed, showed pH outside the aesthetic range in ADWG (2011). Based upon this comparison, groundwaters and surface water within the Project area are generally not fit for drinking.

C3.3 Metals

Attachment E shows that some artesian groundwaters and surface waters within the Project area have elevated concentrations of metals above the aesthetic drinking water guideline (ADWG, 2011). This includes:

- aluminium, with exceedances in 8 of 27 artesian groundwater samples and 10 of 20 surface water samples; and
- iron, with exceedances in 8 of 27 artesian groundwater samples.

Attachment E also shows that some artesian groundwaters have metal concentrations above the health drinking water guidelines (AGWG, 2011). This includes:

- arsenic, with exceedances in 2 of 27 groundwater samples; and
- manganese, with exceedances in 6 of 27 groundwater samples.

C3.4 Major ions

Figure C 3.3 and Figure C 3.4 show the analytical results plotted on a Durov plot and a Piper diagram, respectively. These figures are intended to demonstrate groundwater type groupings based on cation-anion ratios.

Figure C 3.3 shows that surface waters have very similar EC (less than 250 µS/cm) whereas the artesian groundwaters have a broader range of EC. As the exploration drill holes are not cased or screened as a monitoring bores, the water sample is representative of a composite of lithologies and cannot be related to a specific geology type.

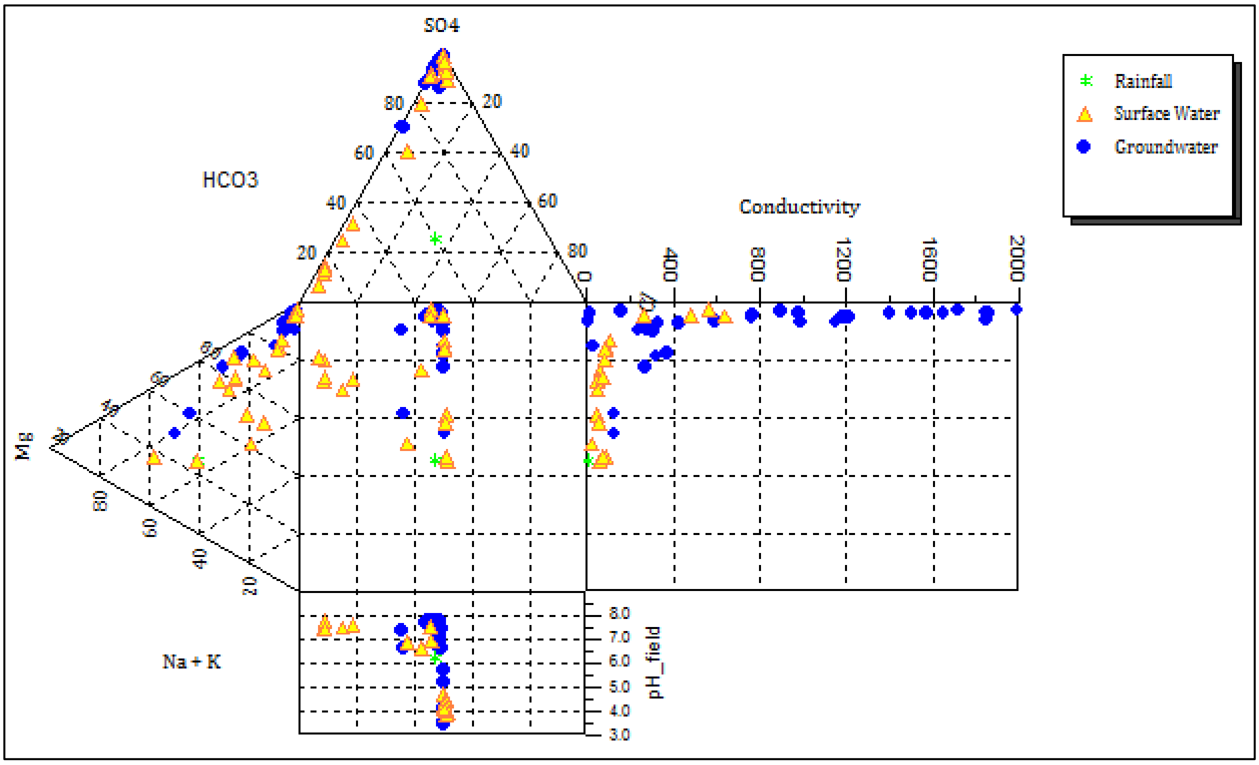


Figure C 3.3 Durov plot of water sample chemistry

Figure C 3.4 suggests that major ion ratios are similar for all artesian exploration drill holes with samples plotting in a similar section of the piper diagram (dominated by Ca and SO_4).

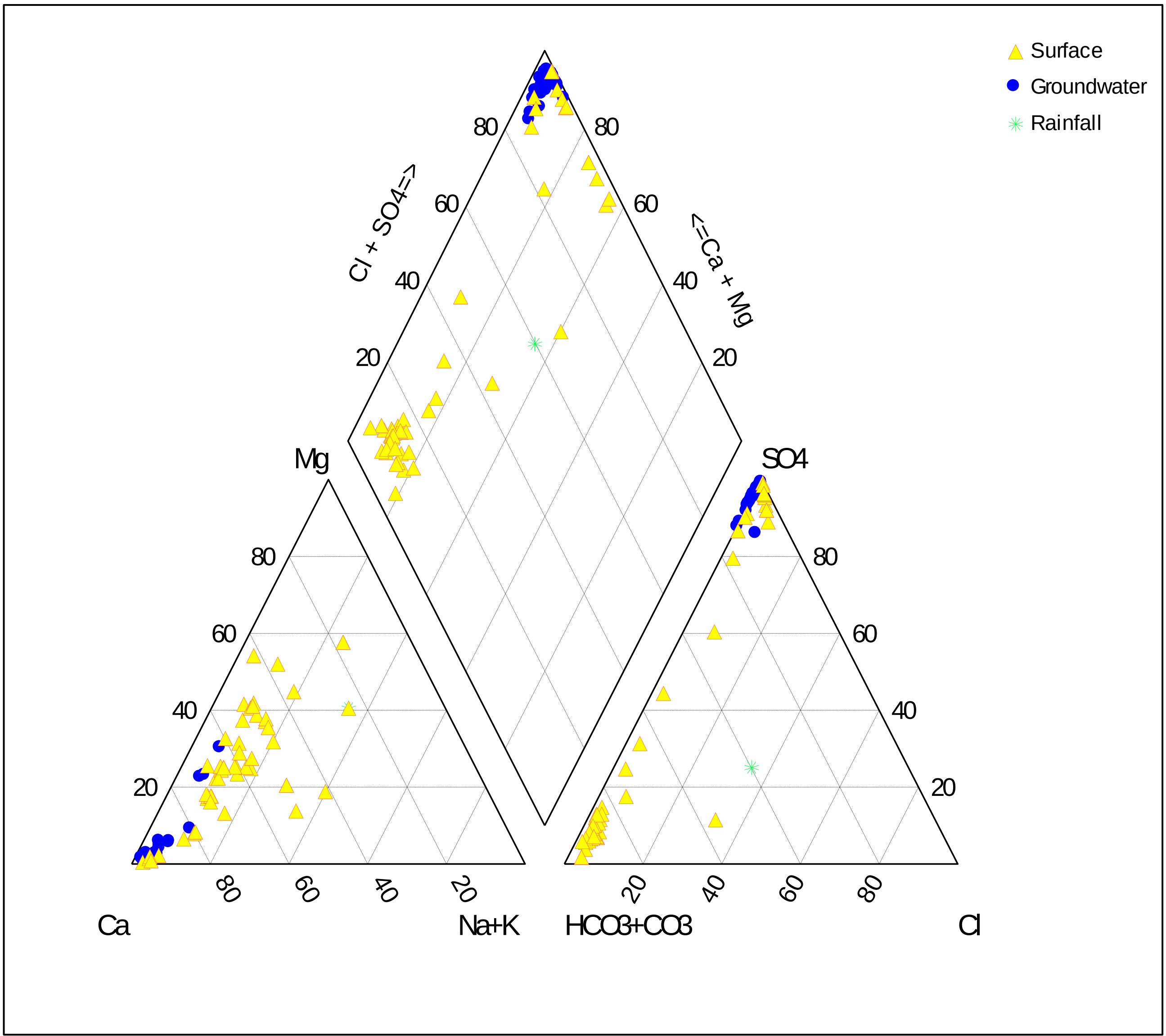


Figure C 3.4 Piper plot of water sample chemistry

The Durov Plot (Figure C 3.3) shows a similar major ion grouping, although the EC variations show that enrichment of some groundwater samples over others is occurring. Figure C 3.3 also shows a wide range of pH from the groundwater samples. Both graphs show similarity in some surface water samples to the pits area groundwater and some other distinct groups. The two distinct groups observed on the Piper and Durov Plots are Ca-SO_4 type groundwaters and Ca-HCO_3 type surface waters.

Further assessment of the major ion water quality data indicates that there are two chemical processes occurring. These are:

- the dissolution of anhydrite ($CaSO_4$) which is occurring within the artesian groundwaters; and
- the oxidation of sulphide which is evident in a number of surface water samples and a limited number of groundwater samples.

Anhydrite dissolution and pyrite oxidation are the dominant sources of dissolved sulphate in these waters. Distinct trends of mixing between water dominated by anhydrite dissolution and water dominated by pyrite oxidation are inferred from the data and some spatial correlation between these mixed waters is apparent. By plotting the ratio of SO_4 and HCO_3 versus pH (Figure C 3.5) the waters being affected by these two processes are visible.

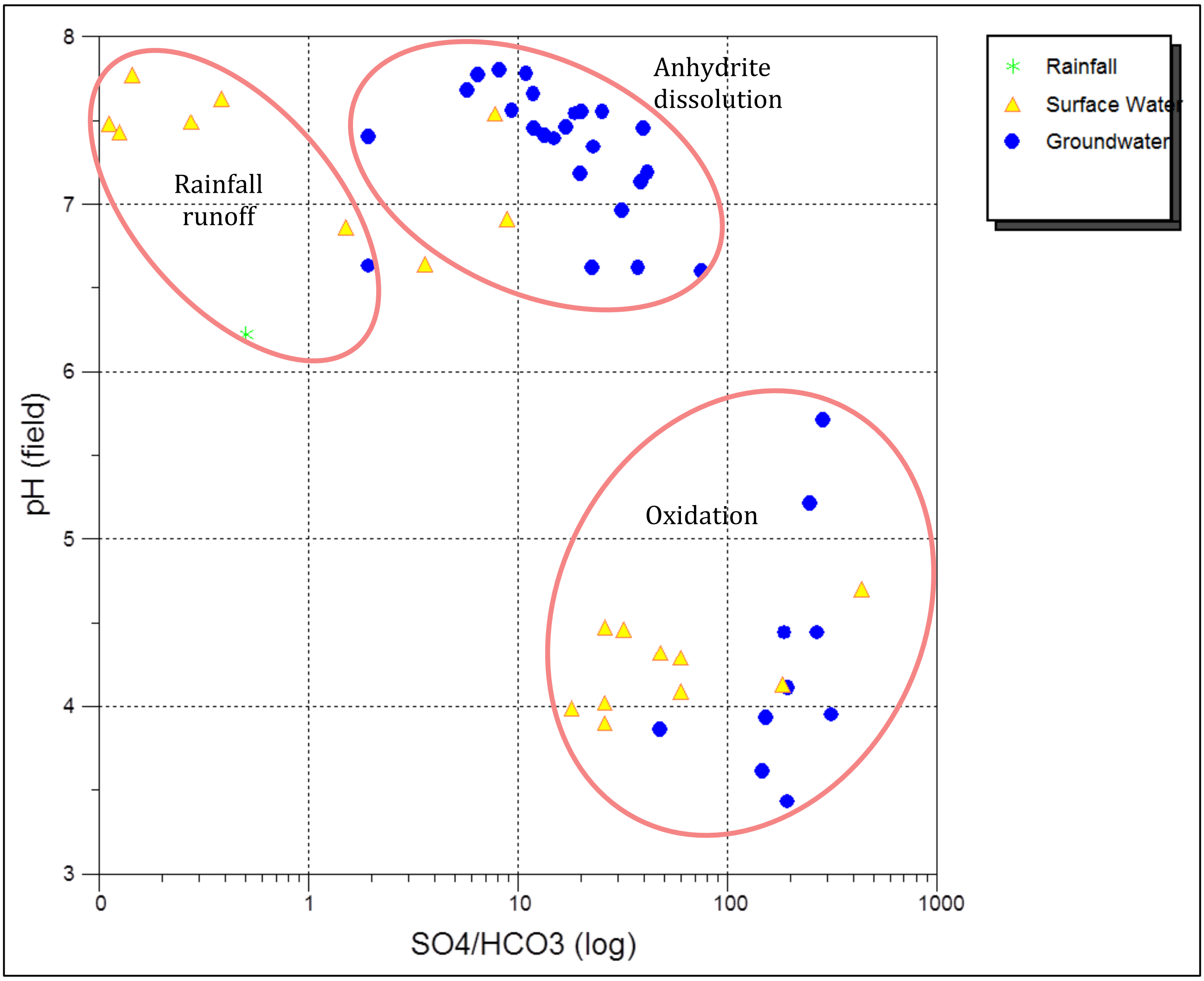


Figure C 3.5 Scatter plot SO_4/HCO_3 versus pH

The surface waters with near neutral pH (6 – 8) and a SO_4/HCO_3 ratio less than 1 represent rainfall runoff water with a low residence time. The groundwaters from the artesian exploration drill holes typically have near neutral pH (6 – 8) and a SO_4/HCO_3 ratio between 1 and 100, that is enriched in sulphate. Hounslow (1995) states that anhydrite dissolution can be determined if $Ca/(Ca+SO_4) = 0.5$. These waters are also enriched in Ca and satisfy this condition. The deeper groundwater chemistry is therefore dominated by the dissolution of anhydrite ($CaSO_4$) from the country rock. These is some mixing of these deeper groundwaters with the surface water samples and this is likely to occur at the surface once the artesian groundwaters have discharged to a surface water feature.

The remaining water samples (groundwater and surface waters) have more acidic pH (less than 6) and a SO_4/HCO_3 ratio between 10 and 1000. Hounslow (1995) states that if $Ca/(Ca+SO_4) < 0.5$ and if $pH < 5.5$, then pyrite oxidation is said to be occurring. Assessment of the data shows that these chemical conditions are met suggesting that oxidation processes are contributing both SO_4 and acidity within surface water and groundwater. The oxidation process would be occurring at shallow depths, and infers local mixing between surface waters, deeper groundwaters and water in contact with oxidising material in the unsaturated zone.

Figure C 3.6 shows a clear linear relationship between Ca and SO_4 concentration within groundwater samples.

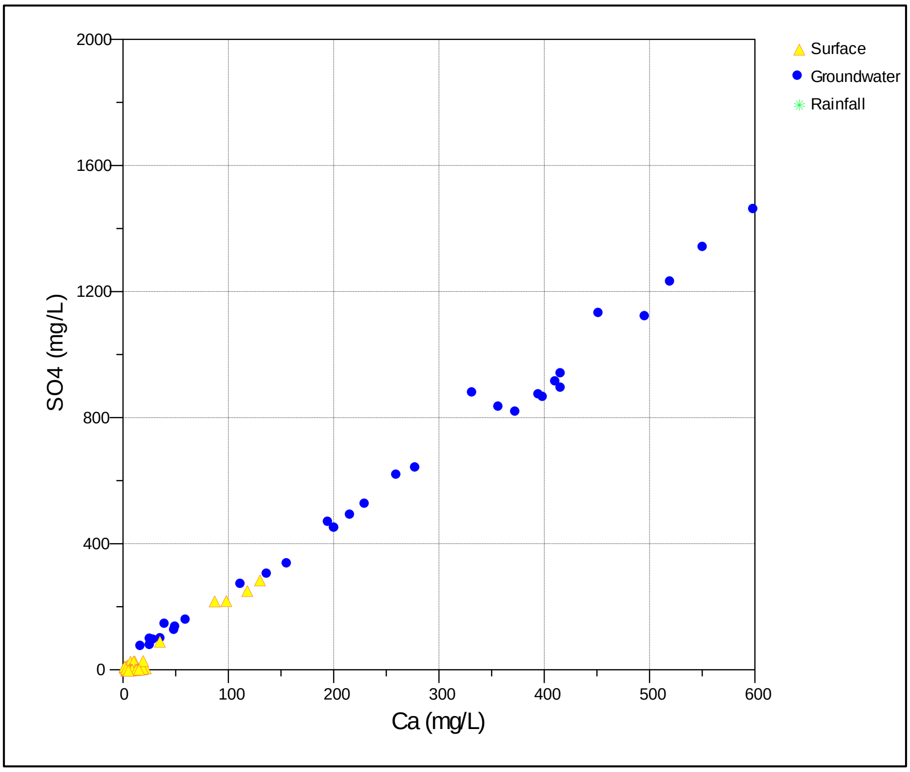


Figure C 3.6 Scatter plot Ca versus SO_4

C4 References

Hounslow A.W. (1995). "*Water Quality Data. Analysis and Interpretation*".

Hydrobiology (2015), "*Hydrobiology, Aquatic Biology and Surface Water Quality, Frieda River Project*", 2015.

National Health and Medical Research Council (2011), "*Australian Drinking Water Guidelines*".

Sinclair Knight Merz (2011). "*Frieda River Pit Water Management Strategy Hydrogeology*". Project No. FRP03-AAAA-MN-RF-003, 2011.

Attachment A Water sample locations

ID	Easting	Northing	Water source	Reference
127XC07	584338	9480640	Groundwater	AGE 2014
133XC08	585117	9480345	Groundwater	AGE 2014
157XC08	584435	9480661	Groundwater	AGE 2014
178XC08	584829	9480447	Groundwater	AGE 2014
196XC08	584966	9480543	Groundwater	AGE 2014
204XC09	584367	9480694	Groundwater	AGE 2014
207XC09	584398	9480599	Groundwater	AGE 2014
212XC09	584272	9480433	Groundwater	AGE 2014
291XC09	584439	9480661	Groundwater	AGE 2014
300XC09	584473	9480585	Groundwater	AGE 2014
321XC09	585603	9480224	Groundwater	AGE 2014
337XC10	585600	9480225	Groundwater	AGE 2014
341XC10	584725	9480675	Groundwater	AGE 2014
343XC10	585189	9480333	Groundwater	AGE 2014
345XC10	584444	9480546	Groundwater	AGE 2014
364XC10	584749	9480768	Groundwater	AGE 2014
371XC10	584220	9480353	Groundwater	AGE 2014
404XC10	584718	9480676	Groundwater	AGE 2014
405XC10	585752	9479877	Groundwater	AGE 2014
406XC10	584520	9480516	Groundwater	AGE 2014
427XC10	584833	9480437	Groundwater	AGE 2014
449XC10	585174	9479978	Groundwater	AGE 2014
459XC10	584519	9480518	Groundwater	AGE 2014
506XC11	584871	9480401	Groundwater	AGE 2014
518XC10	584222	9480205	Groundwater	AGE 2014
592XC11	584909	9480617	Groundwater	AGE 2014
615XC11	584968	9480543	Groundwater	AGE 2014
SP02	584766	9480341	Surface Water	AGE 2014
ST01	586047	9480394	Surface Water	AGE 2014
ST02	585972	9480354	Surface Water	AGE 2014
ST03	585822	9480332	Surface Water	AGE 2014
ST04	585681	9480257	Surface Water	AGE 2014
ST05	585654	9480265	Surface Water	AGE 2014
ST06	585624	9480226	Surface Water	AGE 2014
ST07	585587	9480220	Surface Water	AGE 2014

ID	Easting	Northing	Water source	Reference
ST08	585251	9480297	Surface Water	AGE 2014
ST09	585277	9480350	Surface Water	AGE 2014
ST10	585215	9480509	Surface Water	AGE 2014
ST11	584976	9480566	Surface Water	AGE 2014
ST12	584838	9480425	Surface Water	AGE 2014
ST13	584862	9480478	Surface Water	AGE 2014
ST14	584847	9480476	Surface Water	AGE 2014
ST15	584836	9480464	Surface Water	AGE 2014
ST16	584813	9480444	Surface Water	AGE 2014
ST17	584809	9480450	Surface Water	AGE 2014
ST18	584789	9480439	Surface Water	AGE 2014
ST19	584786	9480439	Surface Water	AGE 2014
ST20	584756	9480437	Surface Water	AGE 2014
ST21	584033	9480546	Surface Water	AGE 2014
ST22	584009	9480542	Surface Water	AGE 2014
ST23	583847	9480591	Surface Water	AGE 2014
ST24	583839	9480611	Surface Water	AGE 2014
ST25	583856	9480630	Surface Water	AGE 2014
ST26	583914	9480603	Surface Water	AGE 2014
ST27	584088	9480615	Surface Water	AGE 2014
ST28	584427	9480603	Surface Water	AGE 2014
ST29	584280	9480430	Surface Water	AGE 2014
ST31	584197	9480281	Surface Water	AGE 2014
ST32	584197	9480213	Surface Water	AGE 2014
ST33	584186	9480099	Surface Water	AGE 2014
ST34	584133	9480066	Surface Water	AGE 2014
ST35	584133	9480027	Surface Water	AGE 2014
ST35	585108	9480026	Surface Water	AGE 2014
ST36	585310	9479902	Surface Water	AGE 2014
ST37	585326	9479897	Surface Water	AGE 2014
ST38	585399	9479852	Surface Water	AGE 2014
ST39	585460	9479866	Surface Water	AGE 2014
ST40	585460	9479866	Surface Water	AGE 2014
ST41	585579	9479862	Surface Water	AGE 2014
ST42	585723	9479893	Surface Water	AGE 2014

ID	Easting	Northing	Water source	Reference
ST43	585801	9479923	Surface Water	AGE 2014
ST44	585852	9479817	Surface Water	AGE 2014
ST45	585946	9479796	Surface Water	AGE 2014
ST46	586069	9479981	Surface Water	AGE 2014
ST47	586131	9479948	Surface Water	AGE 2014
ST48	586521	9480228	Surface Water	AGE 2014
ST49	584495	9480566	Surface Water	AGE 2014
ST49	585113	9480337	Surface Water	AGE 2014
SW01	584853	9480438	Surface Water	AGE 2014
SW02	584833	9480472	Surface Water	AGE 2014
SW03	584813	9480438	Surface Water	AGE 2014
SW04	584785	9480409	Surface Water	AGE 2014
SW05	584776	9480393	Surface Water	AGE 2014
SW06	584771	9480376	Surface Water	AGE 2014
SW07	584760	9480356	Surface Water	AGE 2014
SW08	585130	9480058	Surface Water	AGE 2014
SW08	584766	9480341	Surface Water	AGE 2014
SW09	584801	9480440	Surface Water	AGE 2014
SW10	584771	9480447	Surface Water	AGE 2014
SW11	584765	9480428	Surface Water	AGE 2014
SW12	584733	9480442	Surface Water	AGE 2014
SW12	584733	9480442	Surface Water	AGE 2014
SW13	584803	9480429	Surface Water	AGE 2014
SW14	584791	9480441	Surface Water	AGE 2014
SW15	584679	9480783	Surface Water	AGE 2014
SW16	584690	9480784	Surface Water	AGE 2014
SW17	584691	9480760	Surface Water	AGE 2014
SW18	584694	9480792	Surface Water	AGE 2014
SW19	584941	9480542	Surface Water	AGE 2014
SW20	584271	9480432	Surface Water	AGE 2014
SW21	584239	9480394	Surface Water	AGE 2014
SW22	584201	9480305	Surface Water	AGE 2014
SW23	584444	9480618	Surface Water	AGE 2014
SW25	584494	9480535	Surface Water	AGE 2014
SW26	584445	9480603	Surface Water	AGE 2014

ID	Easting	Northing	Water source	Reference
SW27	584442	9480612	Surface Water	AGE 2014
SW29	585055	9480623	Surface Water	AGE 2014
SW30	585053	9480656	Surface Water	AGE 2014
SW31	585036	9480690	Surface Water	AGE 2014
SW32	585018	9480736	Surface Water	AGE 2014
SW33	585015	9480744	Surface Water	AGE 2014
SW34	585012	9480799	Surface Water	AGE 2014
SW36	585012	9480798	Surface Water	AGE 2014
SW37	585160	9480770	Surface Water	AGE 2014
SW38	585014	9480731	Surface Water	AGE 2014
SW39	585139	9480345	Surface Water	AGE 2014
SW40	585121	9480338	Surface Water	AGE 2014
SW41	585089	9480327	Surface Water	AGE 2014
SW42	585060	9480314	Surface Water	AGE 2014
SW43	585246	9480301	Surface Water	AGE 2014
Frieda Rain Fall	584971	9480548	Rainfall	AGE 2014
Basecamp	587073	9480624	Surface Water	Hydrobiology 2015
W18	586318	9484650	Surface Water	Hydrobiology 2015
W27	586854	9480741	Surface Water	Hydrobiology 2015
W28	578332	9484259	Surface Water	Hydrobiology 2015
W29	590247	9485879	Surface Water	Hydrobiology 2015
W42	590684	9478171	Surface Water	Hydrobiology 2015
W43	596539	9483113	Surface Water	Hydrobiology 2015
W48	582680	9485915	Surface Water	Hydrobiology 2015
W49	582680	9485915	Surface Water	Hydrobiology 2015

Attachment B **Laboratory analysis results from the December 2014 field campaign**

CERTIFICATE OF ANALYSIS

Work Order	: **EB1500008**	Page	: 1 of 29
Client	: **AUST GROUNDWATER & ENVIRO CONSULTANTS**	Laboratory	: Environmental Division Brisbane
Contact	: MR DOUG MCALISTER	Contact	: Customer Services EB
Address	: LEVEL 2, 15 MALLON STREET BOWEN HILLS QLD, AUSTRALIA 4006	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: doug.mcalister@ageconsultants.com.au	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 32572055	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 32572088	Facsimile	: +61 7 3243 7218
Project	: Frieda River I1049	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 02-JAN-2015
Sampler	: Brydon Hughes	Issue Date	: 12-JAN-2015
Site	: ----		
		No. of samples received	: 43
Quote number	: BNBQ/011/14	No. of samples analysed	: 42

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

WORLD RECOGNISED ACCREDITATION

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics
Andrew Epps	Senior Inorganic Chemist	WB Water Lab Brisbane

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EA006 Sodium Adsorption Ratio (SAR): Results could not be calculated for samples EB1500008018 and 029 as the required Calcium, Magnesium or Sodium analytes were less than reportable limits.**
- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**
- **ED009X (Standard Anions by IC) : The LOR for Bromide has been raised due to matrix interference.**
- **Ionic balances are within acceptable limits as detailed in the 21st Ed. APHA "Standard Methods for the Examination of Water and Wastewater".**
- **It is recognised that EG020-T (Total Metals by ICP-MS) is less than EG020-F (Dissolved Metals by ICP-MS) for some samples. However, the difference is within experimental variation of the methods.**
- **The presence of high Sulfate (ED041G) may bias the Conductivity (EA010-P) low.**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	506XC11	SP02	404XC10	427XC10	157XC08
			Client sampling date / time	17-DEC-2014 15:00	18-DEC-2014 15:00	18-DEC-2014 15:00	18-DEC-2014 15:00	19-DEC-2014 15:00
Compound	*CAS Number*	*LOR*	*Unit*	EB1500008-001	EB1500008-002	EB1500008-003	EB1500008-004	EB1500008-005
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.62**	**6.91**	**7.77**	**7.18**	**3.95**
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	**0.25**	**0.06**	**0.13**	**0.11**	**0.10**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1150**	**564**	**768**	**1720**	**426**
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	1	mg/L	**748**	**367**	**499**	**1120**	**277**
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**591**	**242**	**394**	**1060**	**158**
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	<0.050	<0.020	<0.020	<0.050	<0.010
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**14**	**25**	**52**	**45**	<1
Total Alkalinity as CaCO3	----	1	mg/L	**14**	**25**	**52**	**45**	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**525**	**221**	**336**	**893**	**157**
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**4**	<1	<1	<1	<1
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**230**	**97**	**156**	**416**	**60**
Magnesium	7439-95-4	1	mg/L	**4**	<1	**1**	**4**	**2**
Sodium	7440-23-5	1	mg/L	**14**	**2**	**6**	**8**	**3**
Potassium	7440-09-7	1	mg/L	**2**	<1	**2**	**1**	**1**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.01**	<0.01	<0.01	<0.01	**0.55**
Arsenic	7440-38-2	0.001	mg/L	**0.002**	<0.001	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.025**	**0.031**	**0.006**	**0.013**	**0.019**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	**0.003**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

Compound	CAS Number	LOR	Unit	506XC11	SP02	404XC10	427XC10	157XC08
Client sampling date / time				17-DEC-2014 15:00	18-DEC-2014 15:00	18-DEC-2014 15:00	18-DEC-2014 15:00	19-DEC-2014 15:00
				EB1500008-001	EB1500008-002	EB1500008-003	EB1500008-004	EB1500008-005
EG020F: Dissolved Metals by ICP-MS - Continued								
Copper	7440-50-8	0.001	mg/L	<0.001	**0.120**	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.559**	**0.022**	<0.001	**0.271**	**0.133**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	**0.004**	**0.002**	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	**0.004**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**2.52**	**1.06**	**1.05**	**4.20**	**0.609**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.012**	<0.005	<0.005	**0.055**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**5.42**	<0.05	<0.05	**1.89**	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**1.62**	**0.46**	<0.01	**0.24**	**0.64**
Arsenic	7440-38-2	0.001	mg/L	**0.003**	<0.001	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.025**	**0.032**	**0.007**	**0.015**	**0.017**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	**0.002**	**0.008**	<0.001	**0.001**	**0.003**
Copper	7440-50-8	0.001	mg/L	**0.003**	**0.530**	<0.001	**0.005**	**0.002**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.603**	**0.473**	**0.022**	**0.336**	**0.158**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	**0.009**	**0.004**	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	**0.002**	<0.001	<0.001	**0.002**	**0.005**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**2.53**	**1.11**	**1.06**	**4.42**	**0.590**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.034**	<0.005	<0.005	**0.023**	**0.063**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**6.28**	**0.20**	<0.05	**5.44**	**2.76**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	506XC11	SP02	404XC10	427XC10	157XC08
			Client sampling date / time	17-DEC-2014 15:00	18-DEC-2014 15:00	18-DEC-2014 15:00	18-DEC-2014 15:00	19-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-001	EB1500008-002	EB1500008-003	EB1500008-004	EB1500008-005
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052F: Dissolved Silica by ICPAES								
Silicon as SiO2	14464-46-1	0.1	mg/L	**14.7**	**21.0**	**49.9**	**40.9**	**17.0**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.1**	<0.1	**0.2**	**0.5**	**0.1**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**11.3**	**5.10**	**8.03**	**19.5**	**3.27**
Total Cations	----	0.01	meq/L	**12.5**	**4.93**	**8.18**	**21.5**	**3.31**
Ionic Balance	----	0.01	%	**4.86**	**1.66**	**0.95**	**4.87**	**0.76**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

Compound	CAS Number	LOR	Unit	196XC08	592XC11	SP01	133XC08	178XC08
Client sampling date / time				19-DEC-2014 15:00	19-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00
				EB1500008-006	EB1500008-007	EB1500008-008	EB1500008-009	EB1500008-010
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.56	7.54	7.29	7.68	3.61
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	0.23	0.31	0.18	0.14	0.11
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	991	1850	676	762	268
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	1	mg/L	644	1200	439	495	174
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	499	1060	300	346	63
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	<0.020	<0.050	<0.020	<0.020	<0.010
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	50	50	47	53	<1
Total Alkalinity as CaCO3	----	1	mg/L	50	50	47	53	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	468	939	253	303	74
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	2	4	<1	<1	<1
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	195	416	117	137	17
Magnesium	7439-95-4	1	mg/L	3	6	2	1	5
Sodium	7440-23-5	1	mg/L	12	23	7	6	2
Potassium	7440-09-7	1	mg/L	2	3	1	2	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	0.82
Arsenic	7440-38-2	0.001	mg/L	0.002	0.010	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	0.009	0.011	0.015	0.024	0.017
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.007

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

Compound	CAS Number	LOR	Unit	196XC08	592XC11	SP01	133XC08	178XC08
Client sampling date / time				19-DEC-2014 15:00	19-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00
				EB1500008-006	EB1500008-007	EB1500008-008	EB1500008-009	EB1500008-010
EG020F: Dissolved Metals by ICP-MS - Continued								
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	**0.507**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.322**	**0.642**	**0.170**	**0.154**	**0.120**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	**0.002**	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	**0.004**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**2.03**	**4.97**	**1.28**	**1.29**	**0.142**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	**0.009**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	**0.87**	**0.54**	**0.10**
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	**1.21**
Arsenic	7440-38-2	0.001	mg/L	**0.003**	**0.018**	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.009**	**0.010**	**0.015**	**0.023**	**0.016**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	**0.008**
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	**0.004**	<0.001	**0.715**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.438**	**0.711**	**0.206**	**0.189**	**0.145**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	**0.002**	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.001**	<0.001	<0.001	**0.006**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**1.98**	**4.96**	**1.33**	**1.32**	**0.154**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	**0.007**	<0.005	**0.010**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**0.48**	**0.97**	**1.05**	**0.50**	**5.75**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	196XC08	592XC11	SP01	133XC08	178XC08
			Client sampling date / time	19-DEC-2014 15:00	19-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-006	EB1500008-007	EB1500008-008	EB1500008-009	EB1500008-010
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052F: Dissolved Silica by ICPAES								
Silicon as SiO2	14464-46-1	0.1	mg/L	**46.3**	**50.1**	**42.0**	**49.3**	**21.0**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.2**	**0.1**	**0.1**	**0.2**	<0.1
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**10.8**	**20.7**	**6.21**	**7.37**	**1.54**
Total Cations	----	0.01	meq/L	**10.6**	**22.3**	**6.33**	**7.23**	**1.35**
Ionic Balance	----	0.01	%	**1.11**	**3.94**	**1.06**	**0.88**	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	300XC09	321XC09	341XC10	371XC10	406XC10
			Client sampling date / time	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-011	EB1500008-012	EB1500008-013	EB1500008-014	EB1500008-015
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	6.96	7.66	7.45	7.41	6.60
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	0.16	0.15	0.11	0.20	0.15
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1400	1650	980	1180	1860
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	1	mg/L	910	1070	637	767	1210
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	841	1050	543	662	1160
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	<0.050	<0.050	<0.020	<0.050	<0.050
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	28	77	41	46	15
Total Alkalinity as CaCO3	----	1	mg/L	28	77	41	46	15
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	878	913	490	617	1130
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	2	<1	<1	1	4
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	332	411	216	260	452
Magnesium	7439-95-4	1	mg/L	3	5	1	3	8
Sodium	7440-23-5	1	mg/L	11	11	6	12	12
Potassium	7440-09-7	1	mg/L	2	3	3	2	2
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	0.01	<0.01
Arsenic	7440-38-2	0.001	mg/L	0.014	<0.001	<0.001	0.002	0.002
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	0.014	0.020	0.021	0.019	0.014
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.004

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	300XC09	321XC09	341XC10	371XC10	406XC10
			Client sampling date / time	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-011	EB1500008-012	EB1500008-013	EB1500008-014	EB1500008-015
EG020F: Dissolved Metals by ICP-MS - Continued								
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	**0.006**	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.302**	**0.464**	**0.218**	**0.122**	**0.944**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	**0.001**	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**3.58**	**4.21**	**1.71**	**2.68**	**3.76**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**3.48**	**0.72**	**0.24**	**1.20**	**16.7**
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	**0.04**	**0.05**	**0.12**	<0.01
Arsenic	7440-38-2	0.001	mg/L	**0.015**	<0.001	<0.001	**0.004**	**0.001**
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.013**	**0.021**	**0.021**	**0.021**	**0.014**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	**0.006**
Copper	7440-50-8	0.001	mg/L	**0.002**	**0.002**	**0.017**	**0.007**	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.331**	**0.545**	**0.279**	**0.208**	**1.07**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	**0.002**	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	**0.001**	**0.001**	<0.001	<0.001	**0.002**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**3.66**	**4.56**	**1.77**	**2.85**	**3.97**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.018**	<0.005	<0.005	<0.005	<0.005
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**3.38**	**0.96**	**0.20**	**3.99**	**14.7**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	300XC09	321XC09	341XC10	371XC10	406XC10
			Client sampling date / time	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00	20-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-011	EB1500008-012	EB1500008-013	EB1500008-014	EB1500008-015
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052F: Dissolved Silica by ICPAES								
Silicon as SiO2	14464-46-1	0.1	mg/L	**25.1**	**49.5**	**43.7**	**54.6**	**40.1**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	**0.2**	**0.1**	**0.1**	**0.2**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**18.9**	**20.6**	**11.0**	**13.8**	**23.9**
Total Cations	----	0.01	meq/L	**17.3**	**21.5**	**11.2**	**13.8**	**23.8**
Ionic Balance	----	0.01	%	**4.22**	**2.27**	**0.86**	**0.06**	**0.26**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		518XC10	SW08	SW12	SW19	337XC10
		Client sampling date / time		20-DEC-2014 15:00	24-DEC-2014 15:00	24-DEC-2014 15:00	24-DEC-2014 15:00	24-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-016	EB1500008-017	EB1500008-018	EB1500008-019	EB1500008-020
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.55	4.70	3.99	4.13	6.63
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	0.12	0.09	----	0.05	0.25
Sodium Adsorption Ratio	----	0.01	-	----	----	<0.01	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1990	481	59	262	127
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	1	mg/L	1290	313	38	170	82
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	1320	219	<1	85	47
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	<0.050	<0.010	<0.010	<0.010	<0.010
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	61	<1	<1	<1	16
Total Alkalinity as CaCO3	----	1	mg/L	61	<1	<1	<1	16
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1230	220	9	92	31
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	<1	<1	<1	<1	<1
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	520	86	<1	34	9
Magnesium	7439-95-4	1	mg/L	5	1	<1	<1	6
Sodium	7440-23-5	1	mg/L	10	3	<1	1	4
Potassium	7440-09-7	1	mg/L	2	<1	<1	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	0.66	0.58	0.88	<0.01
Arsenic	7440-38-2	0.001	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	0.010	0.042	0.002	0.011	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

			Client sample ID	518XC10	SW08	SW12	SW19	337XC10
			Client sampling date / time	20-DEC-2014 15:00	24-DEC-2014 15:00	24-DEC-2014 15:00	24-DEC-2014 15:00	24-DEC-2014 15:00
Compound	*CAS Number*	*LOR*	*Unit*	**EB1500008-016**	**EB1500008-017**	**EB1500008-018**	**EB1500008-019**	**EB1500008-020**
EG020F: Dissolved Metals by ICP-MS - Continued								
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.004**	**0.001**	**0.003**	**0.001**
Copper	7440-50-8	0.001	mg/L	<0.001	**0.227**	**0.750**	**1.60**	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.547**	**0.232**	**0.001**	**0.045**	**0.260**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.003**	<0.001	**0.002**	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**4.76**	**0.808**	**0.002**	**0.316**	**0.064**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	**0.007**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**2.68**	<0.05	**0.30**	**0.16**	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	**1.43**	**0.74**	**1.03**	<0.01
Arsenic	7440-38-2	0.001	mg/L	**0.002**	<0.001	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.011**	**0.038**	**0.002**	**0.012**	**0.003**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.005**	**0.002**	**0.004**	**0.001**
Copper	7440-50-8	0.001	mg/L	<0.001	**0.584**	**0.970**	**1.98**	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.665**	**0.240**	**0.002**	**0.054**	**0.312**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.005**	**0.002**	**0.003**	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**4.98**	**0.711**	**0.002**	**0.354**	**0.072**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.007**	<0.005	<0.005	**0.010**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**3.28**	**4.92**	**0.40**	**0.25**	**3.02**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	518XC10	SW08	SW12	SW19	337XC10
			Client sampling date / time	20-DEC-2014 15:00	24-DEC-2014 15:00	24-DEC-2014 15:00	24-DEC-2014 15:00	24-DEC-2014 15:00
Compound	*CAS Number*	*LOR*	*Unit*	EB1500008-016	EB1500008-017	EB1500008-018	EB1500008-019	EB1500008-020
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052F: Dissolved Silica by ICPAES								
Silicon as SiO2	14464-46-1	0.1	mg/L	**40.3**	**24.6**	**2.6**	**8.9**	**35.6**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.1**	<0.1	**0.1**	<0.1	**0.3**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**26.8**	**4.58**	**0.19**	**1.92**	**0.97**
Total Cations	----	0.01	meq/L	**26.8**	**4.50**	<0.01	**1.74**	**1.12**
Ionic Balance	----	0.01	%	**0.10**	**0.78**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	338XC10	345XC10	Frieda Rain Fall	615XC11	127XC07
			Client sampling date / time	24-DEC-2014 15:00	24-DEC-2014 15:00	27-DEC-2014 15:00	19-DEC-2014 15:00	24-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-021	EB1500008-022	EB1500008-023	EB1500008-024	EB1500008-025
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.39	7.46	6.22	5.21	3.93
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	0.20	0.17	----	0.15	0.10
Sodium Adsorption Ratio	----	0.01	-	----	----	<0.01	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1210	1500	2	308	238
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	1	mg/L	786	975	1	200	155
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	711	944	<1	130	69
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	<0.050	<0.050	<0.010	<0.010	<0.010
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	43	48	1	<1	<1
Total Alkalinity as CaCO3	----	1	mg/L	43	48	1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	640	817	<1	125	77
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	1	<1	<1	<1	<1
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	278	373	<1	49	26
Magnesium	7439-95-4	1	mg/L	4	3	<1	2	1
Sodium	7440-23-5	1	mg/L	12	12	<1	4	2
Potassium	7440-09-7	1	mg/L	3	3	<1	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	0.42	2.21
Arsenic	7440-38-2	0.001	mg/L	0.001	0.001	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	0.018	0.011	<0.001	0.016	0.030
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	0.0002	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

Compound	CAS Number	LOR	Unit	338XC10	345XC10	Frieda Rain Fall	615XC11	127XC07
Client sampling date / time				24-DEC-2014 15:00	24-DEC-2014 15:00	27-DEC-2014 15:00	19-DEC-2014 15:00	24-DEC-2014 15:00
				EB1500008-021	EB1500008-022	EB1500008-023	EB1500008-024	EB1500008-025
EG020F: Dissolved Metals by ICP-MS - Continued								
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	**0.003**	**0.002**
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	**0.014**	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.123**	**0.056**	<0.001	**0.101**	**0.086**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	**0.003**	**0.004**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**2.91**	**3.96**	<0.001	**0.480**	**0.268**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	**0.030**	**0.047**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	**13.6**	**2.23**
Arsenic	7440-38-2	0.001	mg/L	**0.002**	<0.001	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.018**	**0.011**	<0.001	**0.017**	**0.036**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	**0.003**	**0.003**
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	**0.034**	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.154**	**0.247**	<0.001	**0.110**	**0.098**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	**0.003**	**0.004**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**2.81**	**3.85**	<0.001	**0.468**	**0.393**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	**0.014**	**0.044**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**1.08**	<0.05	<0.05	**3.67**	**1.29**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

			Client sample ID	338XC10	345XC10	Frieda Rain Fall	615XC11	127XC07
			Client sampling date / time	24-DEC-2014 15:00	24-DEC-2014 15:00	27-DEC-2014 15:00	19-DEC-2014 15:00	24-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-021	EB1500008-022	EB1500008-023	EB1500008-024	EB1500008-025
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052F: Dissolved Silica by ICPAES								
Silicon as SiO2	14464-46-1	0.1	mg/L	**54.6**	**51.0**	<0.1	**24.0**	**13.6**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.1**	**0.1**	<0.1	**0.1**	<0.1
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**14.2**	**18.0**	**0.02**	**2.60**	**1.60**
Total Cations	----	0.01	meq/L	**14.8**	**19.5**	<0.01	**2.78**	**1.47**
Ionic Balance	----	0.01	%	**2.09**	**4.04**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

Compound	CAS Number	LOR	Unit	459XC10	204XC09	207XC09	212XC09	291XC09
			Client sampling date / time	24-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00
				EB1500008-026	EB1500008-027	EB1500008-028	EB1500008-029	EB1500008-030
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.55**	**4.44**	**6.62**	**3.43**	**4.11**
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	**0.16**	**0.08**	**0.15**	**0.09**	**0.09**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2100**	**328**	**589**	**371**	**268**
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	1	mg/L	**1360**	**213**	**383**	**241**	**174**
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**1390**	**133**	**288**	**86**	**94**
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	<0.050	<0.010	<0.020	<0.010	<0.010
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**53**	<1	**12**	<1	<1
Total Alkalinity as CaCO3	----	1	mg/L	**53**	<1	**12**	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1340**	**135**	**271**	**97**	**98**
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**5**	<1	<1	<1	<1
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**551**	**50**	**112**	**26**	**36**
Magnesium	7439-95-4	1	mg/L	**4**	**2**	**2**	**5**	**1**
Sodium	7440-23-5	1	mg/L	**14**	**2**	**6**	**2**	**2**
Potassium	7440-09-7	1	mg/L	**3**	**1**	**1**	**1**	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	**0.49**	<0.01	**0.32**	**2.12**
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.008**	**0.021**	**0.013**	**0.043**	**0.034**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.002**	<0.001	**0.006**	**0.002**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	459XC10	204XC09	207XC09	212XC09	291XC09
			Client sampling date / time	24-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-026	EB1500008-027	EB1500008-028	EB1500008-029	EB1500008-030
EG020F: Dissolved Metals by ICP-MS - Continued								
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	**0.020**	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.756**	**0.119**	**0.187**	**0.188**	**0.089**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.003**	<0.001	**0.006**	**0.003**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**5.12**	**0.481**	**1.16**	**0.186**	**0.374**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.049**	**0.012**	**0.024**	**0.040**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	**0.26**	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	**0.59**	**0.02**	**0.31**	**2.33**
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.001**	**0.009**	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.012**	**0.022**	**0.013**	**0.044**	**0.032**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.003**	<0.001	**0.006**	**0.002**
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	**0.026**	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**1.16**	**0.126**	**0.200**	**0.198**	**0.097**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.004**	<0.001	**0.007**	**0.004**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**5.10**	**0.463**	**1.12**	**0.196**	**0.383**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.053**	**0.015**	**0.026**	**0.051**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**1.41**	**3.72**	**3.40**	**12.8**	**2.30**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

			Client sample ID	459XC10	204XC09	207XC09	212XC09	291XC09
			Client sampling date / time	24-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-026	EB1500008-027	EB1500008-028	EB1500008-029	EB1500008-030
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052F: Dissolved Silica by ICPAES								
Silicon as SiO2	14464-46-1	0.1	mg/L	37.9	17.7	21.2	14.4	15.2
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.1	0.2	<0.1	0.1	<0.1
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	29.1	2.81	5.88	2.02	2.04
Total Cations	----	0.01	meq/L	28.5	2.77	6.04	1.82	1.97
Ionic Balance	----	0.01	%	0.96	----	1.38	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	343XC10	364XC10	SW20	SW26	SW27
			Client sampling date / time	26-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-031	EB1500008-032	EB1500008-033	EB1500008-034	EB1500008-035
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.40	3.86	4.47	4.46	4.32
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	0.20	0.12	0.19	0.32	0.10
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	276	126	46	56	89
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	1	mg/L	179	82	30	36	58
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	120	13	5	7	20
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	44	<1	<1	<1	<1
Total Alkalinity as CaCO3	----	1	mg/L	44	<1	<1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	85	24	13	16	24
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	<1	<1	<1	<1	<1
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	48	2	2	3	8
Magnesium	7439-95-4	1	mg/L	<1	2	<1	<1	<1
Sodium	7440-23-5	1	mg/L	5	1	1	2	1
Potassium	7440-09-7	1	mg/L	<1	1	<1	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	1.05	0.28	0.35	0.52
Arsenic	7440-38-2	0.001	mg/L	0.015	<0.001	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	0.065	0.032	0.007	0.009	0.017
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.004	<0.001	<0.001	0.001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

			Client sample ID	343XC10	364XC10	SW20	SW26	SW27
			Client sampling date / time	26-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-031	EB1500008-032	EB1500008-033	EB1500008-034	EB1500008-035
EG020F: Dissolved Metals by ICP-MS - Continued								
Copper	7440-50-8	0.001	mg/L	**0.002**	**0.117**	**0.014**	**0.016**	**0.037**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.044**	**0.065**	**0.036**	**0.038**	**0.044**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.005**	**0.001**	**0.001**	**0.002**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**0.544**	**0.024**	**0.021**	**0.032**	**0.060**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.011**	**0.018**	**0.018**	**0.016**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	**0.05**	<0.05	**0.07**
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	**1.21**	**0.36**	**0.43**	**0.64**
Arsenic	7440-38-2	0.001	mg/L	**0.019**	**0.002**	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.070**	**0.034**	**0.008**	**0.011**	**0.018**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	**0.0001**	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.004**	**0.001**	**0.001**	**0.002**
Copper	7440-50-8	0.001	mg/L	<0.001	**0.138**	**0.017**	**0.020**	**0.045**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.075**	**0.070**	**0.039**	**0.043**	**0.049**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.005**	**0.002**	**0.002**	**0.002**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**0.525**	**0.026**	**0.023**	**0.035**	**0.068**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.013**	**0.020**	**0.023**	**0.020**
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**0.12**	**3.47**	**0.16**	**0.16**	**0.31**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

Compound	CAS Number	LOR	Unit	343XC10	364XC10	SW20	SW26	SW27
			Client sampling date / time	26-DEC-2014 15:00	26-DEC-2014 15:00	26-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00
				EB1500008-031	EB1500008-032	EB1500008-033	EB1500008-034	EB1500008-035
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052F: Dissolved Silica by ICPAES								
Silicon as SiO2	14464-46-1	0.1	mg/L	**28.1**	**16.5**	**11.2**	**12.0**	**10.1**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.4**	<0.1	<0.1	<0.1	<0.1
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**2.65**	**0.50**	**0.27**	**0.33**	**0.50**
Total Cations	----	0.01	meq/L	**2.61**	**0.33**	**0.14**	**0.24**	**0.44**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

Compound	CAS Number	LOR	Unit	SW28	SW34	SW37	SW38	SW39
			Client sampling date / time	28-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00
				EB1500008-036	EB1500008-037	EB1500008-038	EB1500008-039	EB1500008-040
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**4.06**	**3.90**	**4.02**	**4.29**	**7.54**
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	<0.01	<0.01	<0.01	**0.09**	**0.12**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**109**	**88**	**73**	**108**	**635**
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	1	mg/L	**71**	**57**	**47**	**70**	**413**
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**23**	**4**	**4**	**25**	**326**
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.020
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	<1	<1	**37**
Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	<1	<1	**37**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**29**	**13**	**13**	**30**	**287**
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	<1	<1	<1	<1	<1
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**6**	<1	<1	**10**	**129**
Magnesium	7439-95-4	1	mg/L	**2**	**1**	**1**	<1	**1**
Sodium	7440-23-5	1	mg/L	<1	<1	<1	**1**	**5**
Potassium	7440-09-7	1	mg/L	<1	<1	<1	<1	**2**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.79**	**1.10**	**0.74**	**0.58**	<0.01
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.006**	**0.007**	**0.006**	**0.016**	**0.023**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	**0.002**	**0.002**	**0.003**	**0.001**	<0.001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SW28	SW34	SW37	SW38	SW39
			Client sampling date / time	28-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00
Compound	CAS Number	LOR	Unit	EB1500008-036	EB1500008-037	EB1500008-038	EB1500008-039	EB1500008-040
EG020F: Dissolved Metals by ICP-MS - Continued								
Copper	7440-50-8	0.001	mg/L	**0.014**	**0.021**	**0.040**	**0.031**	**0.007**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.032**	**0.020**	**0.022**	**0.048**	**0.084**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	**0.002**
Nickel	7440-02-0	0.001	mg/L	**0.001**	**0.002**	**0.001**	**0.002**	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**0.059**	**0.005**	**0.009**	**0.095**	**1.08**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.007**	**0.006**	**0.006**	**0.018**	<0.005
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**0.06**	**0.11**	**0.24**	**0.06**	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.96**	**1.30**	**0.91**	**0.68**	<0.01
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.006**	**0.008**	**0.007**	**0.017**	**0.024**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	**0.002**	**0.002**	**0.003**	**0.002**	<0.001
Copper	7440-50-8	0.001	mg/L	**0.017**	**0.026**	**0.047**	**0.036**	**0.019**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**0.033**	**0.022**	**0.024**	**0.052**	**0.092**
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	**0.003**
Nickel	7440-02-0	0.001	mg/L	**0.002**	**0.002**	**0.002**	**0.002**	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L	**0.066**	**0.005**	**0.010**	**0.100**	**1.02**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.008**	**0.008**	**0.008**	**0.020**	<0.005
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	7439-89-6	0.05	mg/L	**0.74**	**0.16**	**0.92**	**0.26**	**0.19**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	SW28	SW34	SW37	SW38	SW39
			Client sampling date / time	28-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00	28-DEC-2014 15:00
				EB1500008-036	EB1500008-037	EB1500008-038	EB1500008-039	EB1500008-040
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052F: Dissolved Silica by ICPAES								
Silicon as SiO2	14464-46-1	0.1	mg/L	**9.1**	**6.8**	**9.8**	**11.4**	**38.1**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	**0.2**	<0.1	**0.1**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**0.60**	**0.27**	**0.27**	**0.62**	**6.71**
Total Cations	----	0.01	meq/L	**0.46**	**0.08**	**0.08**	**0.54**	**6.79**
Ionic Balance	----	0.01	%	----	----	----	----	**0.60**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	405XC10	449XC10	----	----	----
			Client sampling date / time	28-DEC-2014 15:00	28-DEC-2014 15:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1500008-041	EB1500008-042	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.19	7.34	----	----	----
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	0.16	0.15	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	2260	1570	----	----	----
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	1	mg/L	1470	1020	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	1520	1000	----	----	----
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	<0.100	<0.050	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	35	38	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	35	38	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1460	872	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	3	2	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	599	395	----	----	----
Magnesium	7439-95-4	1	mg/L	5	4	----	----	----
Sodium	7440-23-5	1	mg/L	14	11	----	----	----
Potassium	7440-09-7	1	mg/L	2	2	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.001	<0.001	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Barium	7440-39-3	0.001	mg/L	0.009	0.017	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

Compound	CAS Number	LOR	Unit	405XC10	449XC10	----	----	----
			Client sampling date / time	28-DEC-2014 15:00	28-DEC-2014 15:00	----	----	----
				EB1500008-041	**EB1500008-042**	**----**	**----**	**----**
EG020F: Dissolved Metals by ICP-MS - Continued								
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.605**	**0.401**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Strontium	7440-24-6	0.001	mg/L	**5.56**	**3.80**	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.008**	<0.005	----	----	----
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.01**	<0.01	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.020**	**0.010**	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.019**	**0.018**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.670**	**0.473**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Strontium	7440-24-6	0.001	mg/L	**5.45**	**3.78**	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.007**	<0.005	----	----	----
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	----	----	----
Iron	7439-89-6	0.05	mg/L	**3.67**	**3.44**	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS								

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Client sample ID	**405XC10**	**449XC10**	----	----	----
			Client sampling date / time	28-DEC-2014 15:00	28-DEC-2014 15:00	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1500008-041**	**EB1500008-042**	----	----	----
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EG052F: Dissolved Silica by ICPAES								
Silicon as SiO2	14464-46-1	0.1	mg/L	**25.9**	**26.8**	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**31.2**	**19.0**	----	----	----
Total Cations	----	0.01	meq/L	**31.0**	**20.6**	----	----	----
Ionic Balance	----	0.01	%	**0.29**	**4.11**	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1511545**	Page	: 1 of 9
Client	: **AUST GROUNDWATER & ENVIRO CONSULTANTS**	Laboratory	: Environmental Division Brisbane
Contact	: HENRY MCCARTHY	Contact	: Customer Services EB
Address	: LEVEL 2, 15 MALLON STREET BOWEN HILLS QLD, AUSTRALIA 4006	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: henry.mccarthy@ageconsultants.com.au	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 32572055	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 32572088	Facsimile	: +61-7-3243 7218
Project	: I1049: Frieda River	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 28-Jan-2015 11:36
C-O-C number	: ----	Date Analysis Commenced	: 31-Jan-2015
Sampler	: ----	Issue Date	: 03-Feb-2015 17:24
Site	: ----		
		No. of samples received	: 32
Quote number	: ----	No. of samples analysed	: 32

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	WB Water Lab Brisbane

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

- **ED009-X: The LOR for chloride has been raised due to matrix interference.**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SP02	404XC10	427XC10	157XC08	SP01
			Client sampling date / time	[18-Dec-2014]	[18-Dec-2014]	[18-Dec-2014]	[19-Dec-2014]	[20-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1511545-001	EB1511545-002	EB1511545-003	EB1511545-004	EB1511545-005
				Result	Result	Result	Result	Result
ED009: Anions								
Chloride	16887-00-6	0.1	mg/L	<0.200	<0.200	**0.705**	**0.411**	**0.238**
Sulfate	14808-79-8	0.1	mg/L	----	----	----	----	----
ED093F-DW: Dissolved Major Cations - Drinking Water								
Calcium	7440-70-2	0.1	mg/L	**109**	----	----	----	----
Magnesium	7439-95-4	0.1	mg/L	**0.9**	----	----	----	----
Potassium	7440-09-7	0.1	mg/L	**0.8**	----	----	----	----
Sodium	7440-23-5	0.1	mg/L	**2.7**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	133XC08	178XC08	321XC09	341XC10	518XC10
			Client sampling date / time	[20-Dec-2014]	[20-Dec-2014]	[20-Dec-2014]	[20-Dec-2014]	[20-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1511545-006	EB1511545-007	EB1511545-008	EB1511545-009	EB1511545-010
				Result	Result	Result	Result	Result
ED009: Anions								
Chloride	16887-00-6	0.1	mg/L	**0.492**	**0.265**	<0.500	**0.648**	**0.655**
Sulfate	14808-79-8	0.1	mg/L	----	----	----	----	----
ED093F-DW: Dissolved Major Cations - Drinking Water								
Calcium	7440-70-2	0.1	mg/L	----	**14.2**	----	----	----
Magnesium	7439-95-4	0.1	mg/L	----	**4.8**	----	----	----
Potassium	7440-09-7	0.1	mg/L	----	**1.0**	----	----	----
Sodium	7440-23-5	0.1	mg/L	----	**2.6**	----	----	----

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Client sample ID	SW08	SW12	SW19	337XC10	345XC10
			Client sampling date / time	[21-Dec-2014]	[21-Dec-2014]	[21-Dec-2014]	[21-Dec-2014]	[21-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1511545-011	EB1511545-012	EB1511545-013	EB1511545-014	EB1511545-015
				Result	Result	Result	Result	Result
ED009: Anions								
Chloride	16887-00-6	0.1	mg/L	**0.813**	<0.100	**0.327**	**0.134**	**0.715**
Sulfate	14808-79-8	0.1	mg/L	----	----	----	----	----
ED093F-DW: Dissolved Major Cations - Drinking Water								
Calcium	7440-70-2	0.1	mg/L	**81.6**	<0.1	**31.6**	**9.2**	----
Magnesium	7439-95-4	0.1	mg/L	**1.1**	**0.1**	**0.9**	**5.5**	----
Potassium	7440-09-7	0.1	mg/L	**1.0**	**0.1**	**0.4**	**1.0**	----
Sodium	7440-23-5	0.1	mg/L	**3.0**	<0.1	**1.3**	**4.6**	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Frieda Rain Fall	615XC11	127XC07	204XC09	207XC09
			Client sampling date / time	[27-Dec-2014]	[19-Dec-2014]	[24-Dec-2014]	[26-Dec-2014]	[26-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1511545-016	EB1511545-017	EB1511545-018	EB1511545-019	EB1511545-020
				Result	Result	Result	Result	Result
ED009: Anions								
Chloride	16887-00-6	0.1	mg/L	<0.100	**0.383**	**0.236**	**0.322**	**0.560**
Sulfate	14808-79-8	0.1	mg/L	**0.151**	----	----	----	----
ED093F-DW: Dissolved Major Cations - Drinking Water								
Calcium	7440-70-2	0.1	mg/L	<0.1	**49.5**	**23.6**	----	----
Magnesium	7439-95-4	0.1	mg/L	<0.1	**2.1**	**1.2**	----	----
Potassium	7440-09-7	0.1	mg/L	**0.1**	**1.1**	**1.1**	----	----
Sodium	7440-23-5	0.1	mg/L	<0.1	**3.8**	**1.8**	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	212XC09	291XC09	343XC10	364XC10	SW20
			Client sampling date / time	[26-Dec-2014]	[26-Dec-2014]	[26-Dec-2014]	[26-Dec-2014]	[26-Dec-2014]
Compound	*CAS Number*	*LOR*	*Unit*	EB1511545-021	EB1511545-022	EB1511545-023	EB1511545-024	EB1511545-025
				Result	Result	Result	Result	Result
ED009: Anions								
Chloride	16887-00-6	0.1	mg/L	**0.344**	**0.216**	**0.276**	**0.212**	**0.118**
Sulfate	14808-79-8	0.1	mg/L	----	----	----	----	----
ED093F-DW: Dissolved Major Cations - Drinking Water								
Calcium	7440-70-2	0.1	mg/L	----	**34.1**	**46.6**	----	**1.8**
Magnesium	7439-95-4	0.1	mg/L	----	**1.2**	**0.4**	----	**0.6**
Potassium	7440-09-7	0.1	mg/L	----	**1.1**	**1.0**	----	**0.3**
Sodium	7440-23-5	0.1	mg/L	----	**2.0**	**5.5**	----	**1.4**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SW26	SW27	SW28	SW34	SW37
			Client sampling date / time	[28-Dec-2014]	[28-Dec-2014]	[28-Dec-2014]	[28-Dec-2014]	[28-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1511545-026	EB1511545-027	EB1511545-028	EB1511545-029	EB1511545-030
				Result	Result	Result	Result	Result
ED009: Anions								
Chloride	16887-00-6	0.1	mg/L	<0.100	<0.100	<0.100	<0.100	<0.100
Sulfate	14808-79-8	0.1	mg/L	----	----	----	----	----
ED093F-DW: Dissolved Major Cations - Drinking Water								
Calcium	7440-70-2	0.1	mg/L	2.8	7.0	6.1	0.1	0.2
Magnesium	7439-95-4	0.1	mg/L	0.6	0.6	1.6	1.2	1.2
Potassium	7440-09-7	0.1	mg/L	0.3	0.4	0.6	0.5	0.5
Sodium	7440-23-5	0.1	mg/L	1.6	1.2	0.5	0.1	0.5

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**SW38**	**SW39**	----	----	----
			Client sampling date / time	[28-Dec-2014]	[28-Dec-2014]	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1511545-031**	**EB1511545-032**	--------	--------	--------
				Result	Result	Result	Result	Result
ED009: Anions								
Chloride	16887-00-6	0.1	mg/L	**0.139**	**0.680**	----	----	----
Sulfate	14808-79-8	0.1	mg/L	----	----	----	----	----
ED093F-DW: Dissolved Major Cations - Drinking Water								
Calcium	7440-70-2	0.1	mg/L	**9.5**	**121**	----	----	----
Magnesium	7439-95-4	0.1	mg/L	**0.7**	**1.2**	----	----	----
Potassium	7440-09-7	0.1	mg/L	**0.4**	**2.1**	----	----	----
Sodium	7440-23-5	0.1	mg/L	**1.4**	**5.3**	----	----	----

Attachment C Water quality summary data

Statistical summary of laboratory water quality data – ALS standard LOR

Parameter	Groundwater								Surface water								Rainfall	
	min	5th	10th	mean	90th	95th	max	count	min	5th	10th	mean	90th	95th	max	count	-	count
pH	3.43	3.69	3.90	6.32	7.60	7.67	7.77	27	3.69	3.91	3.96	5.03	6.94	7.46	7.77	111	6.22	1
Sodium Adsorption Ratio	0.08	0.09	0.10	0.15	0.24	0.25	0.31	27	0.01	0.01	0.01	0.09	0.19	0.26	0.32	11	0.01	1
EC (µS/cm)	126	160	256	1002	1912	2067	2260	27	10	19	28	175	460	598	1023	111	2.00	1
TDS	82	104	166	651	1242	1339	1470	27	30	32	33	103	324	372	413	19	1.00	1
Total Hardness	13	52	67	577	1224	1369	1520	27	0.50	3.83	4.00	59	221	246	326	20	0.50	1
Bromide	0.01	0.01	0.01	0.02	0.03	0.03	0.05	27	0.01	0.01	0.01	0.01	0.01	0.01	0.01	11	0.01	1
Hydroxide Alkalinity	0.50	0.50	0.50	0.50	0.50	0.50	0.50	27	0.50	0.50	0.50	0.50	0.50	0.50	0.50	20	0.50	1
Carbonate Alkalinity	0.50	0.50	0.50	0.50	0.50	0.50	0.50	27	0.50	0.50	0.50	0.50	0.50	0.50	0.50	20	0.50	1
Bicarbonate Alkalinity	0.50	0.50	0.50	28.96	53.00	58.60	77.00	27	0.50	0.50	0.50	12.71	37.20	39.45	48.00	20	1.00	1
Total Alkalinity	0.50	0.50	0.50	28.96	53.00	58.60	77.00	27	0.50	0.50	0.50	12.71	37.20	39.45	48.00	20	1.00	1
SO_4	24.00	43.90	75.80	532.78	1170.00	1307.00	1460.00	27	2.68	2.98	3.23	51.13	220.10	224.30	287.00	20	0.50	1
Chloride	0.50	0.50	0.50	1.33	4.00	4.00	5.00	27	0.44	0.44	0.44	0.51	0.50	0.53	1.00	20	0.50	1
Calcium	2.00	11.40	22.40	225.70	479.20	541.70	599.00	27	0.50	0.50	0.50	22.14	87.10	98.60	129.00	20	0.50	1
Magnesium	0.50	1.00	1.00	3.28	5.40	6.00	8.00	27	0.50	0.50	0.50	1.11	2.06	2.13	3.00	20	0.50	1
Sodium	1.00	2.00	2.00	7.96	14.00	14.00	23.00	27	0.50	0.50	0.50	1.56	2.16	3.10	5.00	20	0.50	1
Potassium	0.50	0.50	0.50	1.63	3.00	3.00	3.00	27	0.46	0.46	0.47	0.57	0.50	0.58	2.00	20	0.50	1
Aluminium	0.005	0.005	0.005	0.299	0.912	1.799	2.210	27	0.005	0.005	0.012	0.319	0.754	0.891	1.100	20	0.005	1
Arsenic	0.0005	0.0005	0.0005	0.0022	0.0052	0.0128	0.0150	27	0.0005	0.0005	0.0005	0.0007	0.0010	0.0010	0.0010	20	0.0005	1
Beryllium	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	27	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	11	0.0005	1
Barium	0.0005	0.0066	0.0086	0.0193	0.0328	0.0403	0.0650	27	0.0020	0.0040	0.0060	0.0155	0.0310	0.0365	0.0420	11	0.0005	1

Parameter	Groundwater								Surface water								Rainfall	
	min	5th	10th	mean	90th	95th	max	count	min	5th	10th	mean	90th	95th	max	count	-	count
Cadmium	0.00005	0.00005	0.00005	0.00006	0.00005	0.00005	0.00020	27	0.00000	0.00000	0.00000	0.00003	0.00005	0.00005	0.00010	20	0.00005	1
Chromium	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	27	0.0005	0.0005	0.0005	0.0007	0.0010	0.0010	0.0010	20	0.0005	1
Cobalt	0.0005	0.0005	0.0005	0.0016	0.0040	0.0054	0.0070	27	0.0005	0.0010	0.0010	0.0020	0.0041	0.0052	0.0080	20	0.0005	1
Copper	0.0005	0.0005	0.0005	0.0257	0.0164	0.0879	0.5070	27	0.0010	0.0010	0.0010	0.1463	0.2793	0.7925	1.6000	20	0.0005	1
Lead	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	27	0.0005	0.0005	0.0005	0.0007	0.0010	0.0010	0.0010	20	0.0005	1
Manganese	0.0005	0.0476	0.0614	0.2872	0.6198	0.7218	0.9440	27	0.0010	0.0029	0.0030	0.0359	0.0516	0.0914	0.2320	20	0.0005	1
Molybdenum	0.0005	0.0005	0.0005	0.0006	0.0005	0.0009	0.0020	27	0.0005	0.0005	0.0005	0.0010	0.0020	0.0030	0.0040	11	0.0005	1
Nickel	0.0005	0.0005	0.0005	0.0018	0.0040	0.0047	0.0060	27	0.0005	0.0005	0.0005	0.0012	0.0020	0.0021	0.0030	20	0.0005	1
Selenium	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	27	0.0040	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	20	0.0050	1
Strontium	0.0240	0.0874	0.1684	2.2049	4.8440	5.0750	5.5600	27	0.0020	0.0035	0.0050	0.3171	1.0600	1.0700	1.0800	11	0.0005	1
Vanadium	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	27	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	11	0.0050	1
Zinc	0.0025	0.0025	0.0025	0.0153	0.0468	0.0524	0.0630	27	0.0025	0.0025	0.0025	0.0081	0.0200	0.0202	0.0230	20	0.0025	1
Boron	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	27	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	0.0250	11	0.0250	1
Iron	0.025	0.025	0.025	1.246	3.000	4.838	16.700	27	0.025	0.025	0.025	0.099	0.240	0.270	0.300	11	0.025	1
Mercury	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	27	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	11	0.00005	1
Silicon as SiO_2	13.60	14.49	15.00	32.24	49.98	50.73	54.60	27	2.60	4.70	6.80	14.23	24.60	31.35	38.10	11	0.05	1
Fluoride	0.05	0.05	0.05	0.14	0.24	0.37	0.50	27	0.05	0.05	0.05	0.07	0.10	0.15	0.20	11	0.05	1

Notes: *All values in mg/L unless otherwise stated.*

**For laboratory results less than Limit of Reporting (LOR), a concentration of one half of the LOR has been adopted.*

Statistical summary of laboratory water quality data – ALS trace LOR

Parameter	Groundwater								Surface water								Rainfall	
	min	5th %ile	10th %ile	mean	90th %ile	95th %ile	max	count	min	5th %ile	10th %ile	mean	90th %ile	95th %ile	max	count	-	count
SO_4	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	0	0.15	1
Chloride	0.10	0.13	0.19	0.31	0.68	0.71	0.72	18	0.05	0.05	0.05	0.21	0.61	0.73	0.81	13	0.05	1
Calcium	9.20	10.45	11.70	32.23	92.56	48.78	49.50	6	0.10	0.15	0.20	33.70	109.0	115.0	121.0	11	0.05	1
Magnesium	0.40	0.60	0.80	1.44	2.91	5.33	5.50	6	0.10	0.38	0.60	0.89	1.20	1.38	1.60	12	0.05	1
Sodium	1.80	1.85	1.90	2.31	4.88	5.28	5.50	6	0.10	0.30	0.50	1.73	3.00	4.15	5.30	11	0.05	1
Potassium	1.00	1.00	1.00	0.76	1.10	1.10	1.10	6	0.10	0.21	0.30	0.62	0.98	1.50	2.10	12	0.10	1

Notes: *All values in mg/L unless otherwise stated.*

For laboratory results less than Limit of Reporting (LOR), a concentration of one half of the LOR has been adopted.

Attachment D Major ion analysis

ID	Water source	pH	Sodium adsorption ratio	Electrical conductivity (µS/cm)	Total dissolved solids (mg/L)	Total hardness (mg/L)	Bromide (mg/L)	Total alkalinity (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)
ADWG (2011)	**Aesthetic**	**6.5 - 8.5**	**-**	**-**	**600**	**-**	**-**	**-**	**250**	**250**	**-**	**-**	**180**	**-**
	Health	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**500**	**-**	**-**	**-**	**-**	**-**
127XC07	GW	**3.93**	0.10	238	155	69	0.005	0.50	77	0.50	26	1.00	2.00	0.50
133XC08	GW	7.68	0.14	762	495	346	0.010	53.00	303	0.50	137	1.00	6.00	2.00
157XC08	GW	**3.95**	0.10	426	277	158	0.005	0.50	157	0.50	60	2.00	3.00	1.00
178XC08	GW	**3.61**	0.11	268	174	63	0.005	0.50	74	0.50	17	5.00	2.00	0.50
196XC08	GW	7.56	0.23	991	**644**	499	0.010	50.00	468	2.00	195	3.00	12.00	2.00
204XC09	GW	**4.44**	0.08	328	213	133	0.005	0.50	135	0.50	50	2.00	2.00	1.00
207XC09	GW	6.62	0.15	589	383	288	0.010	12.00	271	0.50	112	2.00	6.00	1.00
212XC09	GW	**3.43**	0.09	371	241	86	0.005	0.50	97	0.50	26	5.00	2.00	1.00
291XC09	GW	**4.11**	0.09	268	174	94	0.005	0.50	98	0.50	36	1.00	2.00	0.50
300XC09	GW	6.96	0.16	1400	**910**	841	0.025	28.00	**878**	2.00	332	3.00	11.00	2.00
321XC09	GW	7.66	0.15	1650	**1070**	1050	0.025	77.00	**913**	0.50	411	5.00	11.00	3.00
337XC10	GW	6.63	0.25	127	82	47	0.005	16.00	31	0.50	9	6.00	4.00	0.50
341XC10	GW	7.45	0.11	980	**637**	543	0.010	41.00	490	0.50	216	1.00	6.00	3.00
343XC10	GW	7.40	0.20	276	179	120	0.005	44.00	85	0.50	48	0.50	5.00	0.50

ID	Water source	pH	Sodium adsorption ratio	Electrical conductivity (µS/cm)	Total dissolved solids (mg/L)	Total hardness (mg/L)	Bromide (mg/L)	Total alkalinity (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)
ADWG (2011)	**Aesthetic**	**6.5 - 8.5**	-	-	**600**	-	-	-	**250**	**250**	-	-	**180**	-
	Health	-	-	-	-	-	-	-	**500**	-	-	-	-	-
345XC10	GW	7.46	0.17	1500	**975**	944	0.025	48.00	**817**	0.50	373	3.00	12.00	3.00
364XC10	GW	**3.86**	0.12	126	82	13	0.005	0.50	24	0.50	2	2.00	1.00	1.00
371XC10	GW	7.41	0.20	1180	**767**	662	0.025	46.00	**617**	1.00	260	3.00	12.00	2.00
404XC10	GW	7.77	0.13	768	499	394	0.010	52.00	336	0.50	156	1.00	6.00	2.00
405XC10	GW	7.19	0.16	2260	**1470**	1520	0.050	35.00	**1460**	3.00	599	5.00	14.00	2.00
406XC10	GW	6.60	0.15	1860	**1210**	1160	0.025	15.00	**1130**	4.00	452	8.00	12.00	2.00
427XC10	GW	7.18	0.11	1720	**1120**	1060	0.025	45.00	**893**	0.50	416	4.00	8.00	1.00
449XC10	GW	7.34	0.15	1570	**1020**	1000	0.025	38.00	**872**	2.00	395	4.00	11.00	2.00
459XC10	GW	7.55	0.16	2100	**1360**	1390	0.025	53.00	**1340**	5.00	551	4.00	14.00	3.00
506XC11	GW	6.62	0.25	1150	**748**	591	0.025	14.00	**525**	4.00	230	4.00	14.00	2.00
518XC10	GW	7.55	0.12	1990	**1290**	1320	0.025	61.00	**1230**	0.50	520	5.00	10.00	2.00
592XC11	GW	7.54	0.31	1850	**1200**	1060	0.025	50.00	**939**	4.00	416	6.00	23.00	3.00
615XC11	GW	**5.21**	0.15	308	200	130	0.005	0.50	125	0.50	49	2.00	4.00	0.50
Basecamp	SW	6.64	-	61.4	62	25.5	-	6.00	21.5	0.50	9	1.00	2.00	0.50
SP02	SW	6.91	0.06	564	367	242	0.010	25.00	221	0.50	97	0.50	2.00	0.50

ID		Water source	pH	Sodium adsorption ratio	Electrical conductivity (µS/cm)	Total dissolved solids (mg/L)	Total hardness (mg/L)	Bromide (mg/L)	Total alkalinity (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)
ADWG (2011)	**Aesthetic**		**6.5 - 8.5**	**-**	**-**	**600**	**-**	**-**	**-**	**250**	**250**	**-**	**-**	**180**	**-**
	Health		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**500**	**-**	**-**	**-**	**-**	**-**
SP02		SW	**5.79**	-	55.67	-	-	-	-	-	-	-	-	-	-
SP02		SW	**5.79**	-	55.67	-	-	-	-	-	-	-	-	-	-
ST01		SW	**4.42**	-	138	-	-	-	-	-	-	-	-	-	-
ST02		SW	6.8	-	427	-	-	-	-	-	-	-	-	-	-
ST03		SW	6.94	-	458	-	-	-	-	-	-	-	-	-	-
ST04		SW	7.07	-	677	-	-	-	-	-	-	-	-	-	-
ST05		SW	7.26	-	740	-	-	-	-	-	-	-	-	-	-
ST06		SW	7.16	-	803	-	-	-	-	-	-	-	-	-	-
ST07		SW	**5.78**	-	18	-	-	-	-	-	-	-	-	-	-
ST08		SW	**4.24**	-	1023	-	-	-	-	-	-	-	-	-	-
ST09		SW	**4.6**	-	146.6	-	-	-	-	-	-	-	-	-	-
ST10		SW	**4.3**	-	125.9	-	-	-	-	-	-	-	-	-	-
ST11		SW	**4.09**	-	280.2	-	-	-	-	-	-	-	-	-	-
ST12		SW	**4.14**	-	53.5	-	-	-	-	-	-	-	-	-	-
ST13		SW	**4.11**	-	352.5	-	-	-	-	-	-	-	-	-	-

ID	Water source		pH	Sodium adsorption ratio	Electrical conductivity (µS/cm)	Total dissolved solids (mg/L)	Total hardness (mg/L)	Bromide (mg/L)	Total alkalinity (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)
ADWG (2011)	**Aesthetic**		**6.5 - 8.5**	**-**	**-**	**600**	**-**	**-**	**-**	**250**	**250**	**-**	**-**	**180**	**-**
	Health		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**500**	**-**	**-**	**-**	**-**	**-**
ST14	SW		**4.12**	-	355.9	-	-	-	-	-	-	-	-	-	-
ST15	SW		**4.09**	-	307.2	-	-	-	-	-	-	-	-	-	-
ST16	SW		**3.99**	-	283	-	-	-	-	-	-	-	-	-	-
ST17	SW		**4.37**	-	344.9	-	-	-	-	-	-	-	-	-	-
ST18	SW		**3.98**	-	146.9	-	-	-	-	-	-	-	-	-	-
ST19	SW		**3.96**	-	146.4	-	-	-	-	-	-	-	-	-	-
ST20	SW		**3.9**	-	101.2	-	-	-	-	-	-	-	-	-	-
ST21	SW		**4.95**	-	26.02	-	-	-	-	-	-	-	-	-	-
ST22	SW		**4.72**	-	15.02	-	-	-	-	-	-	-	-	-	-
ST23	SW		**4.28**	-	77.27	-	-	-	-	-	-	-	-	-	-
ST24	SW		**3.95**	-	219.9	-	-	-	-	-	-	-	-	-	-
ST25	SW		**3.69**	-	406.2	-	-	-	-	-	-	-	-	-	-
ST26	SW		**4.23**	-	87.7	-	-	-	-	-	-	-	-	-	-
ST27	SW		**4.39**	-	61.5	-	-	-	-	-	-	-	-	-	-
ST28	SW		**4.3**	-	63.5	-	-	-	-	-	-	-	-	-	-

ID	Water source	pH	Sodium adsorption ratio	Electrical conductivity (µS/cm)	Total dissolved solids (mg/L)	Total hardness (mg/L)	Bromide (mg/L)	Total alkalinity (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)
ADWG (2011)	**Aesthetic**	**6.5 - 8.5**	**-**	**-**	**600**	**-**	**-**	**-**	**250**	**250**	**-**	**-**	**180**	**-**
	Health	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**500**	**-**	**-**	**-**	**-**	**-**
ST29	SW	**4.3**	-	34.15	-	-	-	-	-	-	-	-	-	-
ST31	SW	**4.32**	-	26.4	-	-	-	-	-	-	-	-	-	-
ST32	SW	**4.51**	-	31.35	-	-	-	-	-	-	-	-	-	-
ST33	SW	**5.56**	-	47.6	-	-	-	-	-	-	-	-	-	-
ST34	SW	**5.61**	-	33.4	-	-	-	-	-	-	-	-	-	-
ST35	SW	**4.68**	-	30.23	-	-	-	-	-	-	-	-	-	-
ST35	SW	**4.58**	-	27.8	-	-	-	-	-	-	-	-	-	-
ST36	SW	**4.28**	-	86.58	-	-	-	-	-	-	-	-	-	-
ST37	SW	**5.71**	-	91.1	-	-	-	-	-	-	-	-	-	-
ST38	SW	**5.21**	-	81	-	-	-	-	-	-	-	-	-	-
ST39	SW	**5.83**	-	46.2	-	-	-	-	-	-	-	-	-	-
ST40	SW	**5.64**	-	77.3	-	-	-	-	-	-	-	-	-	-
ST41	SW	6.6	-	214	-	-	-	-	-	-	-	-	-	-
ST42	SW	7.02	-	109.4	-	-	-	-	-	-	-	-	-	-
ST43	SW	7.74	-	19.2	-	-	-	-	-	-	-	-	-	-

ID		Water source	pH	Sodium adsorption ratio	Electrical conductivity (µS/cm)	Total dissolved solids (mg/L)	Total hardness (mg/L)	Bromide (mg/L)	Total alkalinity (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)
ADWG (2011)	**Aesthetic**		**6.5 - 8.5**	**-**	**-**	**600**	**-**	**-**	**-**	**250**	**250**	**-**	**-**	**180**	**-**
	Health		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**500**	**-**	**-**	**-**	**-**	**-**
ST44		SW	6.84	-	143.1	-	-	-	-	-	-	-	-	-	-
ST45		SW	**4.71**	-	33.9	-	-	-	-	-	-	-	-	-	-
ST46		SW	**6.42**	-	144	-	-	-	-	-	-	-	-	-	-
ST47		SW	6.61	-	94.43	-	-	-	-	-	-	-	-	-	-
ST48		SW	**4.8**	-	16.08	-	-	-	-	-	-	-	-	-	-
ST49		SW	**4.59**	-	9.55	-	-	-	-	-	-	-	-	-	-
ST49		SW	6.87	-	432	-	-	-	-	-	-	-	-	-	-
SW01		SW	**5.77**	-	264.7	-	-	-	-	-	-	-	-	-	-
SW02		SW	**4.21**	-	199.7	-	-	-	-	-	-	-	-	-	-
SW03		SW	**3.98**	-	201.5	-	-	-	-	-	-	-	-	-	-
SW04		SW	**4.02**	-	205.6	-	-	-	-	-	-	-	-	-	-
SW05		SW	**4.07**	-	212	-	-	-	-	-	-	-	-	-	-
SW06		SW	**4.12**	-	222.7	-	-	-	-	-	-	-	-	-	-
SW07		SW	**4.91**	-	387.2	-	-	-	-	-	-	-	-	-	-
SW08		SW	**4.7**	0.09	481	313	219	0.005	0.50	220	0.50	86	1.00	3.00	0.50

ID		Water source	pH	Sodium adsorption ratio	Electrical conductivity (µS/cm)	Total dissolved solids (mg/L)	Total hardness (mg/L)	Bromide (mg/L)	Total alkalinity (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)
ADWG (2011)		**Aesthetic**	**6.5 - 8.5**	**-**	**-**	**600**	**-**	**-**	**-**	**250**	**250**	**-**	**-**	**180**	**-**
		Health	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**500**	**-**	**-**	**-**	**-**	**-**
SW08		SW	**5.53**	-	482.3	-	-	-	-	-	-	-	-	-	-
SW09		SW	**4.19**	-	171.1	-	-	-	-	-	-	-	-	-	-
SW10		SW	**4.01**	-	85.3	-	-	-	-	-	-	-	-	-	-
SW11		SW	**3.96**	-	59.3	-	-	-	-	-	-	-	-	-	-
SW12		SW	**3.99**	0.005	59	38	0.5	0.005	0.50	9	0.50	1	0.50	0.50	0.50
SW12		SW	**3.97**	-	59.5	-	-	-	-	-	-	-	-	-	-
SW13		SW	**3.99**	-	111	-	-	-	-	-	-	-	-	-	-
SW14		SW	**4.05**	-	149.1	-	-	-	-	-	-	-	-	-	-
SW15		SW	**4.37**	-	70.6	-	-	-	-	-	-	-	-	-	-
SW16		SW	**4.6**	-	35.6	-	-	-	-	-	-	-	-	-	-
SW17		SW	**3.77**	-	113.1	-	-	-	-	-	-	-	-	-	-
SW18		SW	**3.78**	-	114	-	-	-	-	-	-	-	-	-	-
SW19		SW	**4.13**	0.05	262	170	85	0.005	0.50	92	0.50	34	0.50	1.00	0.50
SW19		SW	**4.32**	-	255.6	-	-	-	-	-	-	-	-	-	-
SW20		SW	**4.47**	0.19	46	30	5	0.005	0.50	13	0.50	2	0.50	1.00	0.50

ID	Water source	pH	Sodium adsorption ratio	Electrical conductivity (µS/cm)	Total dissolved solids (mg/L)	Total hardness (mg/L)	Bromide (mg/L)	Total alkalinity (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)
ADWG (2011)	**Aesthetic**	**6.5 - 8.5**	**-**	**-**	**600**	**-**	**-**	**-**	**250**	**250**	**-**	**-**	**180**	**-**
	Health	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**500**	**-**	**-**	**-**	**-**	**-**
SW20	SW	**4.48**	-	44.7	-	-	-	-	-	-	-	-	-	-
SW21	SW	**5.71**	-	13.3	-	-	-	-	-	-	-	-	-	-
SW22	SW	**4.62**	-	22.6	-	-	-	-	-	-	-	-	-	-
SW23	SW	**4.4**	-	80.2	-	-	-	-	-	-	-	-	-	-
SW25	SW	**4.64**	-	10.4	-	-	-	-	-	-	-	-	-	-
SW26	SW	**4.46**	0.32	56	36	7	0.005	0.50	16	0.50	3	0.50	2.00	0.50
SW26	SW	**4.83**	-	54.2	-	-	-	-	-	-	-	-	-	-
SW27	SW	**4.32**	0.1	89	58	20	0.005	0.50	24	0.50	8	0.50	1.00	0.50
SW27	SW	**4.25**	-	88.1	-	-	-	-	-	-	-	-	-	-
SW29	SW	**4.09**	-	64.4	-	-	-	-	-	-	-	-	-	-
SW30	SW	**4.05**	-	119.4	-	-	-	-	-	-	-	-	-	-
SW31	SW	**3.95**	-	103.4	-	-	-	-	-	-	-	-	-	-
SW32	SW	**3.92**	-	105.4	-	-	-	-	-	-	-	-	-	-
SW33	SW	**3.91**	-	106	-	-	-	-	-	-	-	-	-	-
SW34	SW	**3.9**	0.005	88	57	4	0.005	0.50	13	0.50	1	1.00	0.50	0.50

ID	Water source	pH	Sodium adsorption ratio	Electrical conductivity (µS/cm)	Total dissolved solids (mg/L)	Total hardness (mg/L)	Bromide (mg/L)	Total alkalinity (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)
ADWG (2011)	**Aesthetic**	**6.5 - 8.5**	**-**	**-**	**600**	**-**	**-**	**-**	**250**	**250**	**-**	**-**	**180**	**-**
	Health	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**500**	**-**	**-**	**-**	**-**	**-**
SW34	SW	**3.86**	-	88.9	-	-	-	-	-	-	-	-	-	-
SW36	SW	**4.08**	-	62.7	-	-	-	-	-	-	-	-	-	-
SW37	SW	**4.02**	0.005	73	47	4	0.005	0.50	13	0.50	1	1.00	0.50	0.50
SW37	SW	**4.03**	-	69.1	-	-	-	-	-	-	-	-	-	-
SW38	SW	**4.29**	0.09	108	70	25	0.005	0.50	30	0.50	10	0.50	1.00	0.50
SW38	SW	**4.26**	-	106	-	-	-	-	-	-	-	-	-	-
SW39	SW	7.54	0.12	635	413	326	0.010	37.00	287	0.50	129	1.00	5.00	2.00
SW39	SW	6.93	-	631.9	-	-	-	-	-	-	-	-	-	-
SW40	SW	6.9	-	460	-	-	-	-	-	-	-	-	-	-
SW41	SW	6.62	-	485.5	-	-	-	-	-	-	-	-	-	-
SW42	SW	6.58	-	508.6	-	-	-	-	-	-	-	-	-	-
SW43	SW	**4.39**	-	102.1	-	-	-	-	-	-	-	-	-	-
W18	SW	7.63	-	52.66	33.67	22.75	-	19.00	7.25	0.50	6	1.63	1.31	0.50
W27	SW	**4.09**	-	83.17	68.5	26.9	-	0.50	30	0.45	9	0.60	1.21	0.49
W28	SW	7.48	-	46.38	52.75	23.7	-	24.20	2.68	0.44	6	2.06	1.07	0.48

ID	Water source	pH	Sodium adsorption ratio	Electrical conductivity (µS/cm)	Total dissolved solids (mg/L)	Total hardness (mg/L)	Bromide (mg/L)	Total alkalinity (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)
ADWG (2011)	**Aesthetic**	**6.5 - 8.5**	**-**	**-**	**600**	**-**	**-**	**-**	**250**	**250**	**-**	**-**	**180**	**-**
	Health	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**500**	**-**	**-**	**-**	**-**	**-**
W29	SW	7.49	-	47.36	33.6	23.45	-	21.18	5.791	0.45	6	1.88	1.79	0.48
W42	SW	7.77	-	81.74	44	42.57	-	39.00	5.571	0.44	14	2.09	2.07	0.46
W43	SW	7.43	-	72.82	37.75	26.9	-	26.20	3.26	0.44	8	1.92	1.57	0.46
W48	SW	6.86	-	21.69	32	8.86	-	3.71	5.571	0.50	2	0.50	1.64	0.50
W49	SW	-	-	-	-	45	-	48.00	3	1.00	13	3.00	1.00	0.50
Frieda rainfall	Rainfall	**6.22**	0.005	2	1	0.5	0.005	1.00	0.5	0.50	1	0.50	0.50	0.50

Attachment E Metals analysis

ID	Water source	Aluminium mg/L	Arsenic mg/L	Beryllium mg/L	Barium mg/L	Cadmium mg/L	Chromium mg/L	Cobalt mg/L	Copper mg/L	Lead mg/L	Manganese mg/L	Molybdenum mg/L	Nickel mg/L	Selenium mg/L	Strontium mg/L	Vanadium mg/L	Zinc mg/L	Boron mg/L	Iron mg/L	Mercury mg/L	Silicon as SiO_2 mg/L	Fluoride mg/L
ADWG (2011)	Aesthetic	0.2	-	-	-	-	-	-	1	-	0.1	-	-	-	-	-	3	-	0.3	-	80	-
	Health		0.01	0.06	2	0.002	0.05	-	2	-	0.5	0.05	0.02	0.01	-	-	-	4	-	0.001	-	1.5
127XC07	GW	**2.210**	0.0005	0.0005	0.0300	0.00005	0.0005	0.0020	0.0005	0.0005	0.0860	0.0005	0.0040	0.005	0.268	0.005	0.0440	0.025	0.025	0.00005	13.60	0.05
133XC08	GW	0.005	0.0005	0.0005	0.0240	0.00005	0.0005	0.0005	0.0005	0.0005	0.1540	0.0005	0.0005	0.005	1.290	0.005	0.0025	0.025	**0.540**	0.00005	49.30	0.20
157XC08	GW	**0.550**	0.0005	0.0005	0.0190	0.00005	0.0005	0.0030	0.0020	0.0005	0.1330	0.0005	0.0040	0.005	0.609	0.005	0.0630	0.025	0.025	0.00005	17.00	0.10
178XC08	GW	**0.820**	0.0005	0.0005	0.0170	0.00005	0.0005	0.0070	0.5070	0.0005	0.1200	0.0005	0.0040	0.005	0.142	0.005	0.0100	0.025	0.100	0.00005	21.00	0.05
196XC08	GW	0.005	0.0020	0.0005	0.0090	0.00005	0.0005	0.0005	0.0005	0.0005	0.3220	0.0005	0.0005	0.005	2.030	0.005	0.0025	0.025	0.025	0.00005	46.30	0.20
204XC09	GW	**0.490**	0.0005	0.0005	0.0210	0.00005	0.0005	0.0020	0.0005	0.0005	0.1190	0.0005	0.0030	0.005	0.481	0.005	0.0530	0.025	0.025	0.00005	17.70	0.20
207XC09	GW	0.005	0.0005	0.0005	0.0130	0.00005	0.0005	0.0005	0.0005	0.0005	0.1870	0.0005	0.0005	0.005	1.160	0.005	0.0150	0.025	0.025	0.00005	21.20	0.05
212XC09	GW	**0.320**	0.0005	0.0005	0.0430	0.00005	0.0005	0.0060	0.0200	0.0005	0.1880	0.0005	0.0060	0.005	0.186	0.005	0.0260	0.025	0.260	0.00005	14.40	0.10
291XC09	GW	**2.120**	0.0005	0.0005	0.0340	0.00005	0.0005	0.0020	0.0005	0.0005	0.0890	0.0005	0.0030	0.005	0.374	0.005	0.0510	0.025	0.025	0.00005	15.20	0.05
300XC09	GW	0.005	**0.0140**	0.0005	0.0140	0.00005	0.0005	0.0005	0.0020	0.0005	0.3020	0.0005	0.0010	0.005	3.580	0.005	0.0180	0.025	**3.480**	0.00005	25.10	0.05
321XC09	GW	0.005	0.0005	0.0005	0.0200	0.00005	0.0005	0.0005	0.0020	0.0005	0.4640	0.0010	0.0010	0.005	4.210	0.005	0.0025	0.025	**0.720**	0.00005	49.50	0.20
337XC10	GW	0.005	0.0005	0.0005	0.0005	0.00005	0.0005	0.0010	0.0005	0.0005	0.2600	0.0005	0.0005	0.005	0.064	0.005	0.0100	0.025	0.025	0.00005	35.60	0.30
341XC10	GW	0.005	0.0005	0.0005	0.0210	0.00005	0.0005	0.0005	0.0060	0.0005	0.2180	0.0005	0.0005	0.005	1.710	0.005	0.0025	0.025	0.240	0.00005	43.70	0.10
343XC10	GW	0.005	**0.0150**	0.0005	0.0650	0.00005	0.0005	0.0005	0.0020	0.0005	0.0440	0.0005	0.0005	0.005	0.544	0.005	0.0025	0.025	0.025	0.00005	28.10	0.40
345XC10	GW	0.005	0.0010	0.0005	0.0110	0.00005	0.0005	0.0005	0.0005	0.0005	0.0560	0.0005	0.0005	0.005	3.960	0.005	0.0025	0.025	0.025	0.00005	51.00	0.10
364XC10	GW	**1.050**	0.0005	0.0005	0.0320	0.00005	0.0005	0.0040	0.1170	0.0005	0.0650	0.0005	0.0050	0.005	0.024	0.005	0.0130	0.025	0.025	0.00005	16.50	0.05
371XC10	GW	0.010	0.0020	0.0005	0.0190	0.00005	0.0005	0.0005	0.0070	0.0005	0.1220	0.0005	0.0005	0.005	2.680	0.005	0.0025	0.025	**1.200**	0.00005	54.60	0.10
404XC10	GW	0.005	0.0005	0.0005	0.0060	0.00005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0020	0.0005	0.005	1.050	0.005	0.0025	0.025	0.025	0.00005	49.90	0.20
405XC10	GW	0.005	0.0010	0.0005	0.0090	0.00005	0.0005	0.0005	0.0005	0.0005	**0.6050**	0.0005	0.0005	0.005	5.560	0.005	0.0070	0.025	0.025	0.00005	25.90	0.05
406XC10	GW	0.005	0.0020	0.0005	0.0140	0.00005	0.0005	0.0040	0.0005	0.0005	**0.9440**	0.0005	0.0020	0.005	3.760	0.005	0.0025	0.025	**16.700**	0.00005	40.10	0.20
427XC10	GW	0.005	0.0005	0.0005	0.0130	0.00005	0.0005	0.0010	0.0050	0.0005	0.2710	0.0005	0.0020	0.005	4.200	0.005	0.0230	0.025	**1.890**	0.00005	40.90	0.50
449XC10	GW	0.005	0.0005	0.0005	0.0170	0.00005	0.0005	0.0005	0.0005	0.0005	0.4010	0.0005	0.0005	0.005	3.800	0.005	0.0025	0.025	0.025	0.00005	26.80	0.05
459XC10	GW	0.005	0.0005	0.0005	0.0080	0.00005	0.0005	0.0005	0.0005	0.0005	**0.7560**	0.0005	0.0005	0.005	5.120	0.005	0.0025	0.025	0.025	0.00005	37.90	0.10
506XC11	GW	0.010	0.0020	0.0005	0.0250	0.00005	0.0005	0.0020	0.0030	0.0005	**0.5590**	0.0005	0.0020	0.005	2.520	0.005	0.0340	0.025	**5.420**	0.00005	14.70	0.10
518XC10	GW	0.005	0.0010	0.0005	0.0100	0.00005	0.0005	0.0005	0.0005	0.0005	**0.5470**	0.0005	0.0005	0.005	4.760	0.005	0.0025	0.025	**2.680**	0.00005	40.30	0.10
592XC11	GW	0.005	0.0100	0.0005	0.0110	0.00005	0.0005	0.0005	0.0005	0.0005	**0.6420**	0.0005	0.0010	0.005	4.970	0.005	0.0025	0.025	0.025	0.00005	50.10	0.10
615XC11	GW	**0.420**	0.0005	0.0005	0.0160	0.00020	0.0005	0.0030	0.0140	0.0005	0.1010	0.0005	0.0030	0.005	0.480	0.005	0.0140	0.025	0.025	0.00005	24.00	0.10

ID	Water source	Aluminium mg/L	Arsenic mg/L	Beryllium mg/L	Barium mg/L	Cadmium mg/L	Chromium mg/L	Cobalt mg/L	Copper mg/L	Lead mg/L	Manganese mg/L	Molybdenum mg/L	Nickel mg/L	Selenium mg/L	Strontium mg/L	Vanadium mg/L	Zinc mg/L	Boron mg/L	Iron mg/L	Mercury mg/L	Silicon as SiO_2 mg/L	Fluoride mg/L
ADWG (2011)	Aesthetic	0.2	-	-	-	-	-	-	1	-	0.1	-	-	-	-	-	3	-	0.3	-	80	-
	Health		0.01	0.06	2	0.002	0.05	-	2	-	0.5	0.05	0.02	0.01	-	-	-	4	-	0.001	-	1.5
Basecamp	SW	0.03	0.0010	-	-	0.00000	0.0010	0.0010	0.0030	0.0010	0.0410	-	0.001	0.005	-	-	0.005	-	-	-	-	-
SP02	SW	0.01	0.0005	0.0005	0.031	0.00005	0.0005	0.0080	0.1200	0.0005	0.0220	0.004	0.001	0.005	1.060	0.005	0.003	0.025	0.025	0.00005	21.00	0.05
SW08	SW	**0.66**	0.0005	0.0005	0.042	0.00005	0.0005	0.0050	0.2270	0.0005	0.2320	0.0005	0.003	0.005	0.808	0.005	0.007	0.025	0.025	0.00005	24.60	0.05
SW12	SW	**0.58**	0.0005	0.0005	0.002	0.00005	0.0005	0.0020	0.7500	0.0005	0.0010	0.0005	0.001	0.005	0.002	0.005	0.003	0.025	0.300	0.00005	2.60	0.10
SW19	SW	**0.88**	0.0005	0.0005	0.011	0.00005	0.0005	0.0040	1.6000	0.0005	0.0450	0.0005	0.002	0.005	0.316	0.005	0.003	0.025	0.160	0.00005	8.90	0.05
SW20	SW	**0.28**	0.0005	0.0005	0.007	0.00005	0.0005	0.0010	0.0140	0.0005	0.0360	0.0005	0.001	0.005	0.021	0.005	0.020	0.025	0.050	0.00005	11.20	0.05
SW26	SW	**0.35**	0.0005	0.0005	0.009	0.00010	0.0005	0.0010	0.0160	0.0005	0.0380	0.0005	0.001	0.005	0.032	0.005	0.023	0.025	0.025	0.00005	12.00	0.05
SW27	SW	**0.52**	0.0005	0.0005	0.017	0.00005	0.0005	0.0020	0.0370	0.0005	0.0440	0.0005	0.002	0.005	0.060	0.005	0.020	0.025	0.070	0.00005	10.10	0.05
SW34	SW	**1.10**	0.0005	0.0005	0.007	0.00005	0.0005	0.0020	0.0210	0.0005	0.0200	0.0005	0.002	0.005	0.005	0.005	0.008	0.025	0.110	0.00005	6.80	0.05
SW37	SW	**0.74**	0.0005	0.0005	0.006	0.00005	0.0005	0.0030	0.0400	0.0005	0.0220	0.0005	0.001	0.005	0.009	0.005	0.008	0.025	0.240	0.00005	9.80	0.20
SW38	SW	**0.58**	0.0005	0.0005	0.016	0.00005	0.0005	0.0020	0.0310	0.0005	0.0480	0.0005	0.002	0.005	0.095	0.005	0.020	0.025	0.060	0.00005	11.40	0.05
SW39	SW	0.01	0.0005	0.0005	0.023	0.00005	0.0005	0.0005	0.0070	0.0005	0.0840	0.002	0.001	0.005	1.080	0.005	0.003	0.025	0.025	0.00005	38.10	0.10
W18	SW	0.06	0.0010	-	-	0.00000	0.0010	0.0010	0.0030	0.0010	0.0040	-	0.001	0.005	-	-	0.003	-	-	-	-	-
W27	SW	**0.39**	0.0010	-	-	0.00000	0.0010	0.0020	0.0480	0.0010	0.0400	-	0.001	0.005	-	-	0.015	-	-	-	-	-
W28	SW	0.03	0.0010	-	-	0.00000	0.0010	0.0010	0.0010	0.0010	0.0030	-	0.001	0.005	-	-	0.003	-	-	-	-	-
W29	SW	0.06	0.0010	-	-	0.00000	0.0010	0.0010	0.0040	0.0010	0.0040	-	0.001	0.005	-	-	0.006	-	-	-	-	-
W42	SW	0.01	0.0010	-	-	0.00000	0.0010	0.0010	0.0010	0.0010	0.0030	-	0.001	0.004	-	-	0.003	-	-	-	-	-
W43	SW	0.01	0.0010	-	-	0.00000	0.0010	0.0010	0.0010	0.0010	0.0050	-	0.001	0.005	-	-	0.003	-	-	-	-	-
W48	SW	0.06	0.0010	-	-	0.00000	0.0010	0.0010	0.0010	0.0010	0.0030	-	0.001	0.005	-	-	0.004	-	-	-	-	-
W49	SW	0.02	0.0010	-	-	0.00000	0.0010	0.0010	0.0010	0.0010	0.0220	-	0.001	0.005	-	-	0.003	-	-	-	-	-
Frieda rainfall	Rainfall	0.01	0.0005	0.0005	0.001	0.00005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.005	0.001	0.005	0.003	0.025	0.025	0.00005	0.05	0.05

Appendix D Numerical model

D1 Introduction

The primary objective of the numerical modelling was to quantify the impact of the Project on the groundwater regime. The design, construction, and calibration of the numerical model was tailored to meet this objective, whilst providing a framework for future iterations during mining. The model was calibrated so that it broadly replicated groundwater flow directions, gradients, and fluxes to the rivers and creeks. The model was used to assess the:

- rate of groundwater inflow to the open-pits as a function of time;
- groundwater heads, hydraulic gradients, and flow vectors around the open-pits;
- extent and area of drawdown and depressurisation;
- changes post closure to groundwater levels and stream baseflow around the open-pits and the integrated storage facility (ISF); and
- areas of potential risk where groundwater impact mitigation / control measures may be necessary.

The key to a successful model is the adequate conceptualisation of the groundwater regime. A conceptual model explains how a groundwater system operates given the available data, and is an idealised and simplified representation of the natural system.

The conceptual groundwater model of the Project area and surrounding area was developed based on geological and topographical maps, geological information from exploration holes drilled across the Project area, geological models developed by the proponent, installation of monitoring bores and vibrating wire piezometers (VWP), and results from previous hydrogeological investigations. Section 4 of the main report details the conceptual model of the hydrogeological regime.

D2 Model construction and development

D2.1 Model code

MODFLOW-USG was determined to be the most suitable modelling code to meet the model objectives. MODFLOW-USG is the latest derivative of the standard MODFLOW code, and has some distinct advantages over MODFLOW that are critical for the simulation of groundwater flow for the Project.

MODFLOW-USG simulates unsaturated conditions, which is critical for mining projects where saturated rock units will be progressively dewatered during active mine operations, and then re-wet following the cessation of mining. MODFLOW-USG is also supplied with more robust numerical solution schemes to handle the more complex numerical problem resulting from the unsaturated flow formulation. Added to the more robust numerical solution schemes is an adaptive time-stepping function that aides the progression of the solution past difficult and complex numerical situations such as oscillations.

The distinct advantage MODFLOW-USG has over its predecessors is the ability to discretise the model using an unstructured mesh, meaning that the cells in the model are not restricted to rectangular shapes. Small cells can be used in the area of interest to represent geological or mining features, with larger cells outside these areas where refinement is not required. This produces an optimal model grid, aiding numerical stability and limiting the number of cells. In addition, model layering does not need to be continuous over the model area, and layers can pinch out where geological units are not present.

The input files for the MODFLOW-USG model were created using Fortran code and a MODFLOW-USG edition of the Groundwater Data Utilities by Watermark Numerical Computing. These were used to allow for the additional capabilities of MODFLOW-USG. The mesh was generated using Algomesh (Hydroalgorithmics, 2015).

D2.2 Model design

D2.2.1 Model geometry

The model boundaries were set at a sufficient distance from the open-pits and ISF, so that the predicted zone of depressurisation was contained within the model. The model dimensions provided a model domain of sufficient size to capture the full extent of any potential impacts on the groundwater regime. The boundaries of the model were assigned at catchment boundaries.

The model domain was discretised using Voronoi shape cells, consisting predominantly of hexagonal polygons. A total of six layers were created. There were 64,016 nodes in each layer with the dimensions of the cells varying from approximately 4 m by 4 m, to approximately 600 m by 600 m distal to the Project area. The mesh was refined to represent detail at the open-pits and ISF areas, which aimed to maintain a maximum resolution of 30 m by 30 m. The cells were also refined using spline sets to represent detail at faults, geological outcrops, and groundwater monitoring bores.

Layer 'pinching' was applied to all layers in the model, determined by a minimum thickness of 0.5 m. As a result, the nodes in layer 1 were limited to areas where the alluvium exists. There were 20,590 nodes in layer 1, comprising a total of 340,670 nodes in the entire model. The model extended approximately 35 km from east to west, and 25 km from north to south, covering a total area of 617 km^2 (Figure D 2.1).

D2.2.2 Model boundary conditions

The base of the model was set as a no-flow boundary. The edges of the model along the major catchment divides were also no flow boundaries.

D2.2.3 Model layers

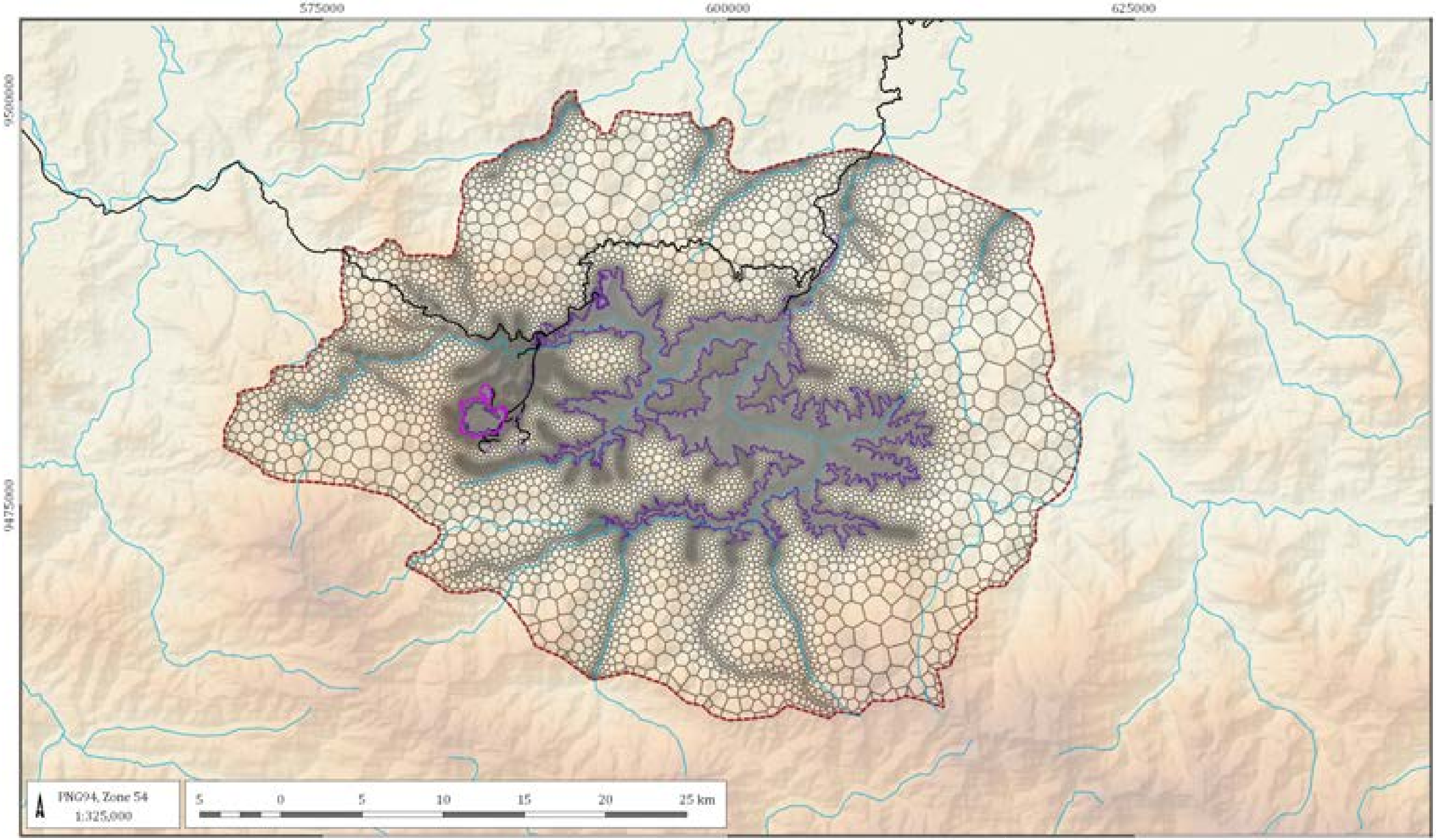
The model had six layers, as summarised in Table D 2.10. The layers were based on stratigraphic horizons in the PanAust geological model, and extrapolated outside of mining areas using all available data.

Table D 2.1 Model layers

Model layer	Stratigraphic unit
1	Surficial alluvium and colluvium (where present).
2	Weathering profile (TOX)
3	Volcanics
4	Anhydrite mineralisation – at base of HIT open-pit floor
5	Anhydrite mineralisation – base of the layer half way between base of layer 4 and layer 6
6	Anhydrite mineralisation – base at –RL 720 m

The proponent provided LIDAR data for the open-pit, which formed the basis for the top of layer 1 across the majority of the model area. Beyond the extent of the LIDAR data, one second SRTM derived digital elevation model (DEM) was used.

The extent of the Quaternary and colluvial sediments (layer 1) was based on surface geology maps, and site exploration data was used to define a representative thickness for the layer. Zones were created within layer 2 to layer 6 to represent the varying geological units and faults. However, the geological zones were not used in the modelling process and only the properties of regional faults were used in the model calibration.



LEGEND

- Open-pit extent (Year 33)
- Model boundary
- Model mesh
- Drainage
- FRHEP / ISF extent
- Road (proposed)

Sepik Development Project (I1051A)

AGE

Model extent

DATE

19/07/2018

FIGURE No:

D - 2.1

G:/Projects/I1051A.Frieda River_[illegible]/3_GIS/Workspaces/001_Deliverable1/D-02.01_I1051A_Model extent.qgs

D2.3 System stresses

D2.3.1 Recharge and evapotranspiration

MODFLOW-USG simulates diffuse rainfall recharge using the recharge package (RCH), and evapotranspiration from shallow water tables with the evapotranspiration package (EVT). The recharge rates for the model area were based upon the conceptual water balance (Section 4.5).

Two recharge zones were created in the model. One for recharge to the alluvium (layer 1) and the second for recharge to the weathered volcanics. Table D 2.2 presents the calibrated rate of recharge for each geological unit. The recharge rates for each unit are the same, as they were tied together during the calibration process. The volume of diffuse recharge (ML/day) presented in is based on the area of outcrop for each unit in the numerical model.

Table D 2.2 Modelled recharge rates

Unit	Diffuse recharge (% of total annual rainfall)	Diffuse recharge (ML/day)
Surficial alluvium	5.9	118
Weathered volcanics	5.9	710
Total	**-**	**828**

Table D 2.2 shows that the highest rate of recharge volumetrically was the weathered volcanics with 710 ML/day estimated. The smaller area of alluvium resulted in a lower volume of recharge estimated at 118 ML/day.

The model represented evapotranspiration in layer 1 or layer 2 (uppermost) with an extinction depth of 2 m. The rate of evapotranspiration (920 mm/year) was taken from the measured evaporation rate in the region (SKM, 2011a), and scaled up to represent likely extraction from the highly forested areas. An evapotranspiration rate of 1,500 mm/year was applied consistently for the steady state and transient simulations.

D2.3.2 Surface drainage

Groundwater interaction with surface drainage was modelled using the MODFLOW-USG river package (RIV). This package requires the level of the riverbed and the depth of perennial water above this level. A river stage height of zero was applied to all surface drainage features in the model, which effectively allows them to simulate drainage (baseflow) only. The riverbed elevation was calculated by extracting the minimum land elevation from the LIDAR data along the drainage alignments and subtracting the depth to represent the creek bed elevation at each surface water feature. The river bed conductance was calculated from river width, riverbed thickness, and the vertical hydraulic conductivity of the riverbed material. Surface drainage was assigned a nominally high vertical bed conductivity rate, to allow free drainage. Table D 2.3 summarises the parameters representing the drainage lines and creeks.

Table D 2.3 Modelled riverbed parameters

ID	Zone	Vertical hydraulic conductivity Kz (m/day)	Width (m)	Minimum depth (m)	Stage height (m)	Bed thickness (m)
Surface drainage	1	100	10	1	0	1

D3 Model calibration

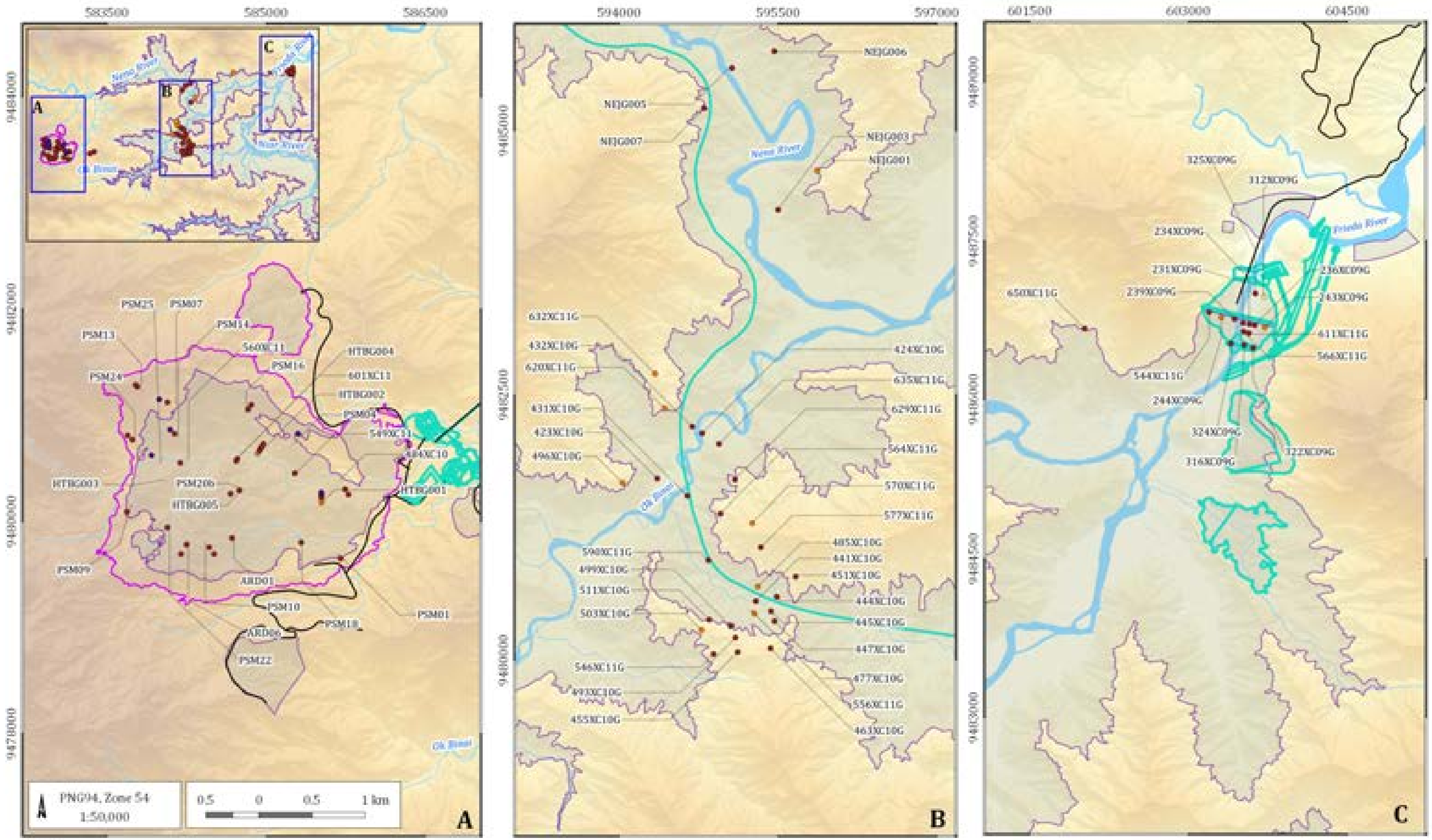
The groundwater model was calibrated in both steady state and transient modes. The steady state model was calibrated by adjusting aquifer parameters (hydraulic conductivity and recharge) and stresses to produce the best match between the observed and simulated water levels / stream baseflow. The transient calibration ensured that the model replicated water level response to rainfall. This was achieved by adjusting specific yield and specific storage, to match the observed groundwater levels.

The automated parameterisation software, PEST, was used to determine optimal hydraulic parameters recharge rates, and riverbed conductance that achieved the best statistical calibration of the groundwater model.

D3.1 Calibration targets

The model simulated water levels in all available monitoring bores and VWPs in the model domain. A total of 90 monitoring points were used to calibrate the model, these are summarised in Section 4.1 of the main report.

Figure D 3.1 presents the observation bores that were used in the steady state and transient calibration simulations. The model also simulates baseflow across six river gauges within the model domain. Estimated baseflow at each stream gauge was used to calibrate steady state simulated baseflow.



LEGEND

- Open-pit extent (Year 33)
- FRHEP / ISF extent
- Drainage
- Mining infrastructretes
- Road (proposed)

Observation site

- Layer1 - Surficial alluvium and colluvium
- Layer2 - Weathering profile (TOX)
- Layer3 - Volcanics
- Layer4 - Anhydrite mineralisation at base of pit floor stage 4

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AGE

Model calibration targets

FIGURE No.
D - 3.1

D3.2 Calibration results

D3.2.1 Steady state

Figure D 3.2 presents the observed and modelled groundwater levels from the steady state calibration as a scattergram. Figure D 3.2 shows the modelled water levels and the observed values correlate well. There are some areas of the model, that over and under predict groundwater levels. These data points represent the VWPs in the proposed HIT open-pit, and indicate that the steady state model generally over-predicts groundwater pressures in layers 3 and 4 in this area.

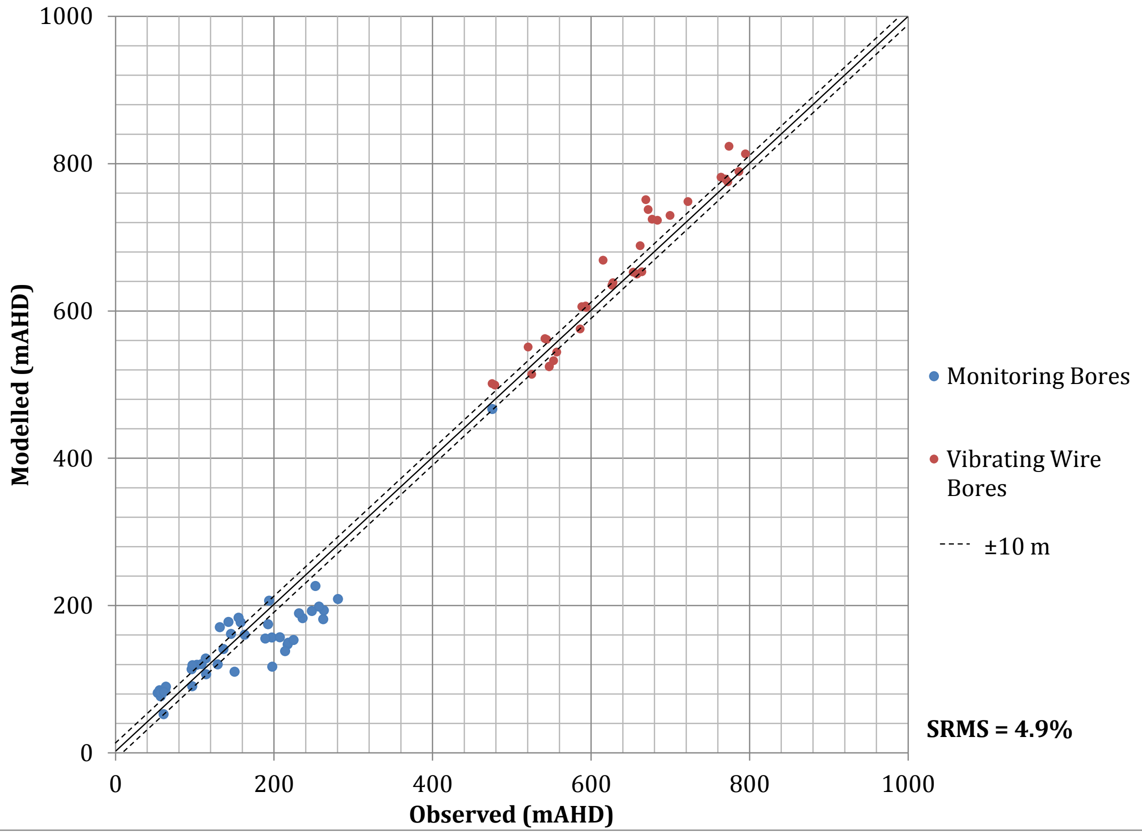


Figure D 3.2 Steady state calibration – modelled vs observed groundwater levels

The standard method to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration. This is done by assessing the error between the modelled and observed (measured) water levels in terms of the root mean square (RMS). A root mean square (RMS) expressed as:

$$RMS = \left[1/n \sum (h_o - h_m)_i^{\,2}\right]^{0.5}$$

where:	n	=	number of measurements
	h_o	=	observed water level
	h_m	=	simulated water level

RMS is considered to be the best measure of error, if errors are normally distributed. The RMS error calculated for the calibrated model was 36 m.

The acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total head change in the system is small, the errors are only a small part of the overall model response. The total measured head change across the model domain is 741.46 m; therefore, the ratio of RMS to the total head loss (SMRS) is 4.9% (Table D 3.1). This indicates a good calibration and is within the Australian guidelines of 10% for SRMS (Barnett *et al.*, 2012).

Table D 3.1 Steady state calibration statistics

Calibration performance measure	Unweighted value
Sum of Residuals (SR) (m)	35.3
Mean Sum of Residuals (MSR) (m)	0.4
Scaled Mean Sum of Residuals (SMSR) (%)	0.06
Sum of Squares (SSQ) (m^2)	103,718.9
Mean Sum of Squares (MSSQ) (m^2)	1,296.5
Root Mean Square (RMS) (m)	36.0
Root Mean Fraction Square (RMFS) (%)	4.4
Scaled RMFS (SRMFS) (%)	2.1
Scaled RMS (SRMS) (%)	**4.9**

Table D 3.2 summarises the water budget reported by the steady state model.

Table D 3.2 Steady state model budget

Parameter	Input (ML/day)	Output (ML/day)
Rainfall recharge	827.8	-
River leakage	-	-
River baseflow	-	814.4
Evapotranspiration	-	13.4
Percent discrepancy	0.00%	
Total	**827.8**	**827.8**

The budget indicates that water enters the model domain at a rate of 827.8 ML/day from diffuse rainfall recharge. The model predicts water discharges at a rate of:

- 814.4 ML/day into rivers and creeks; and
- 13.4 ML/day from evapotranspiration.

PanAust installed three stream gauges to monitor key sub-catchments within the Project area. Table D 3.3 compares the flows to the river cells in the groundwater model with the fluxes estimated / observed at the stream gauges. The tabulated data indicates the model simulates fluxes of water that are comparable to the baseflow derived from stream gauging data, and indicates parameters adopted in the steady state calibration are appropriate.

Table D 3.3 Steady state baseflow calibration

Component	Stream gauge baseflow (ML/day)		
	Ekwai Creek	Nena River	Ok Binai
Modelled flow	6.3	227.8	93.6
Estimated or observed flow	2.5	695	295

Table D 3.3 shows the objective function (i.e. phi) during the steady state calibration. The objective function is also known as the sum of the observation and modelled residuals or the 'model error'. The results show a steady decline during the optimisation process as PEST iteratively determined the optimal parameters. Jumps in the data are indicative of re-weighting of observation targets to ensure the areas of interest (e.g. VWPs) were given the highest priority for calibration.

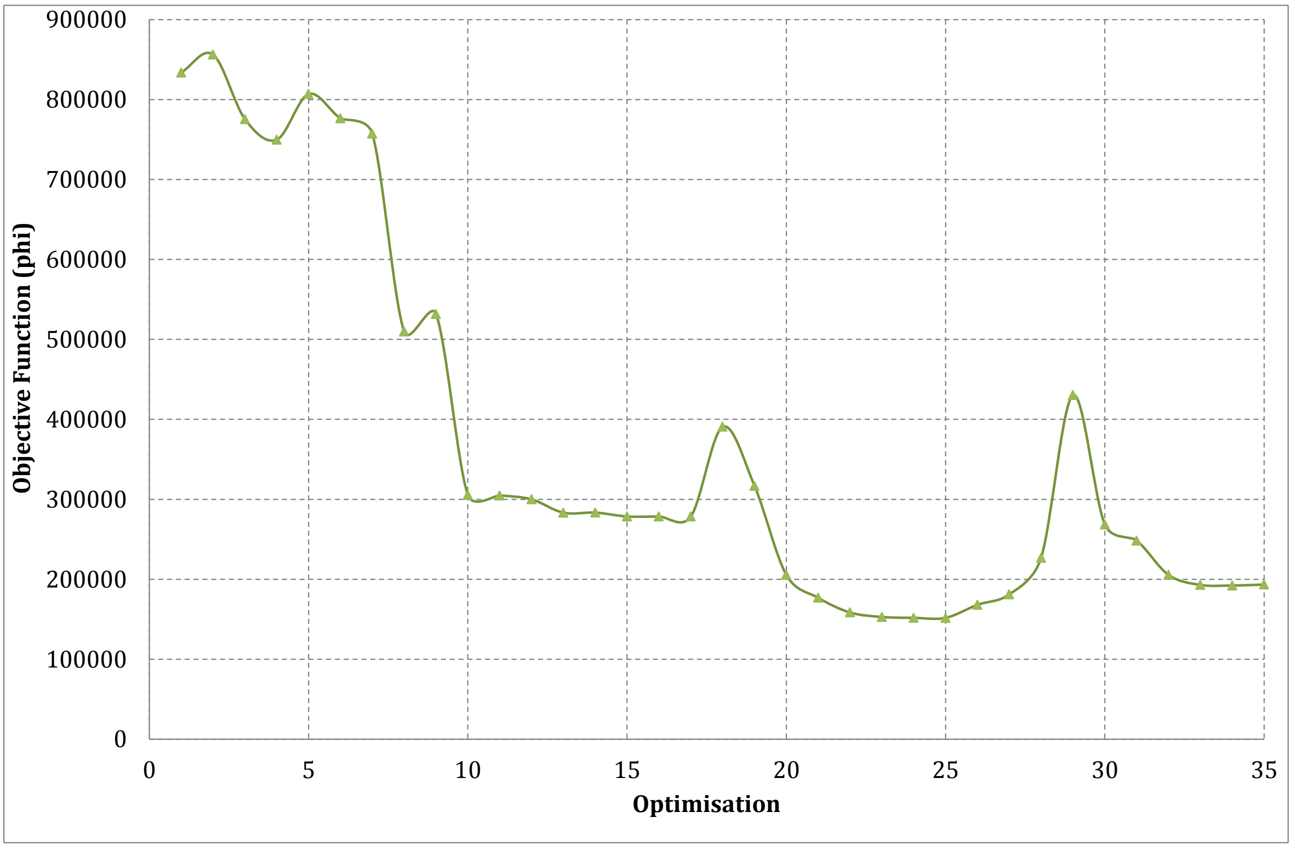


Figure D 3.3 Objective function of PEST process

D3.2.2 Transient

The hydraulic heads and aquifer parameters from the steady state calibration provided the starting values for the transient model calibration. The transient calibration process changed the parameters for storage (specific storage and specific yield) only. Figure D 3.4 presents the observed and modelled groundwater levels graphically as a scattergram.

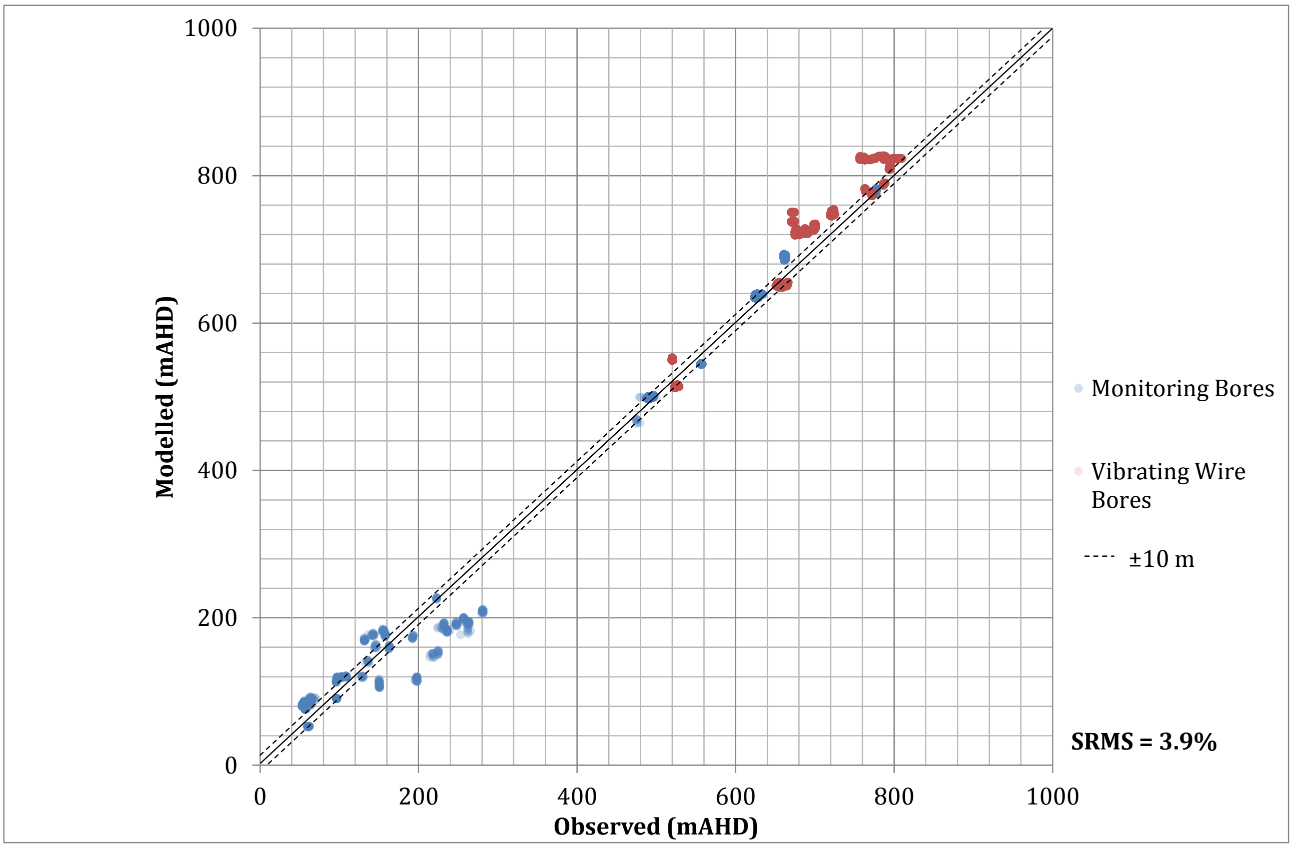


Figure D 3.4 Transient calibration – modelled vs observed groundwater levels

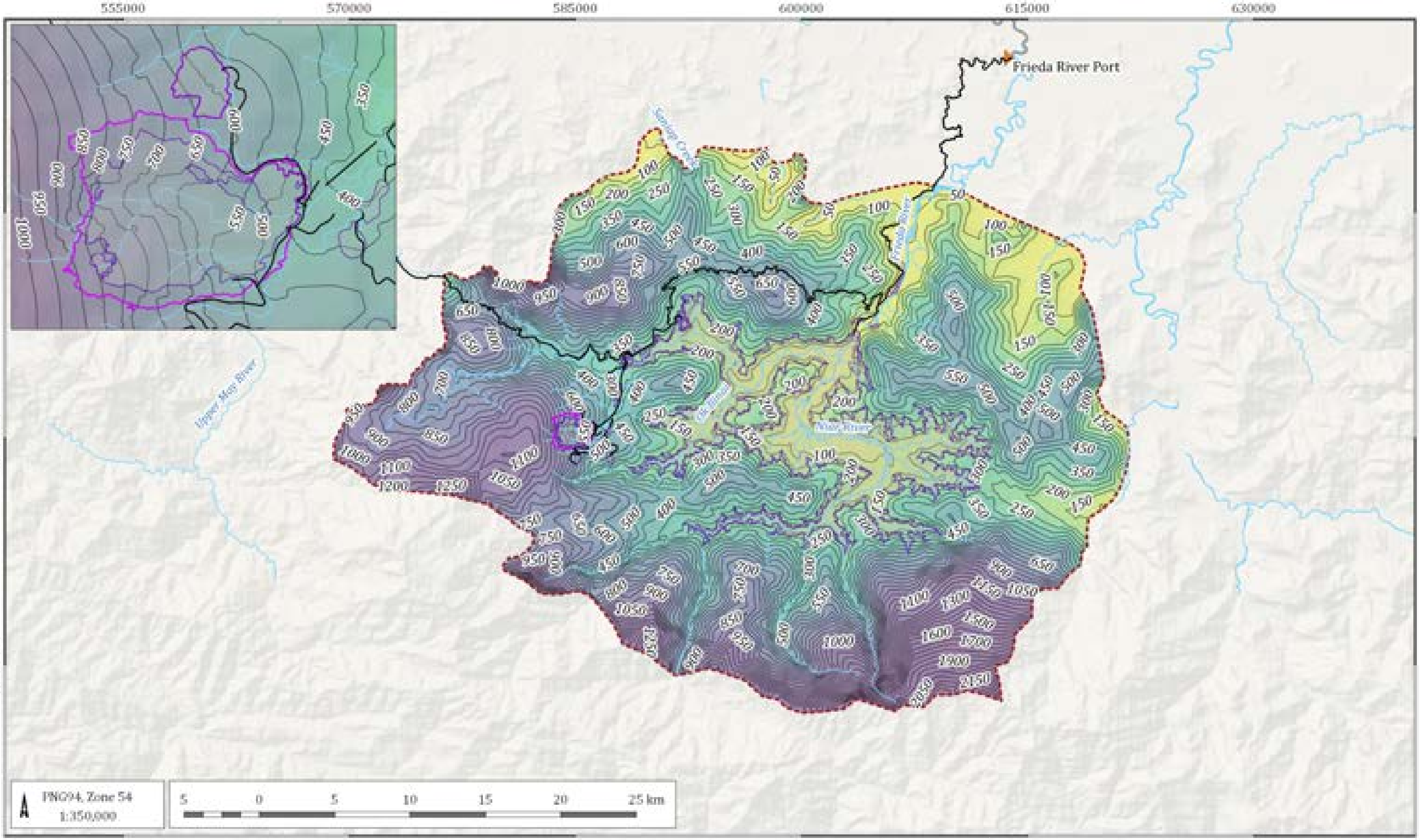
The RMS error calculated for the calibrated model was 30.3 m (Table D 3.4). The total measured head change across the model domain was 773.29 m with a SRMS of 3.9%, indicating a good calibration.

Table D 3.4 Transient calibration statistics

Calibration performance measure	Unweighted value
Sum of Residuals (SR) (m)	621,470.5
Mean Sum of Residuals (MSR) (m)	23.6
Scaled Mean Sum of Residuals (SMSR) (%)	3.1
Sum of Squares (SSQ) (m^2)	24,204,637.5
Mean Sum of Squares (MSSQ) (m^2)	919.9
Root Mean Square (RMS) (m)	30.3
Root Mean Fraction Square (RMFS) (%)	0.6
Scaled RMFS (SRMFS) (%)	0.5
Scaled RMS (SRMS) (%)	**3.9**

D3.2.3 Calibrated heads

Figure D 3.5 presents the calibrated heads for the steady state (pre-mining) and transient (2015) models. The calibrated groundwater levels reflect the groundwater flow regime prior to commencement of proposed mining within the model domain. Regionally groundwater flows towards the northeast, similar to the topography and consistent with the conceptual groundwater model.



LEGEND
- Model boundary
- Open-pit extent (Year 33)
- FRHEP / ISF extent
- Drainage
- Road (proposed)
- Water table contours (RL m)

Water table elevation (RL m)

0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 2000

Sepik Development Project (I1051A)

AGE

Calibrated pre-mine heads - layer 2

DATE 19/07/2018

FIGURE No: **D - 3.5**

D3.2.4 Hydraulic parameters

Table D 3.5 summarises the calibrated hydraulic conductivity for each of the hydrostratigraphic units within the model domain.

Table D 3.5 Model layer hydraulic properties

Model layer	Lithology	Horizontal hydraulic conductivity (kh) (m/day)	Vertical hydraulic conductivity (kz) (m/day)	Specific yield (Sy) (%)	Specific storage (Ss) (m^{-1})
1	Alluvium / Colluvium	6.0	6.0	5.0	5.0×10^{-3}
2	Weathered volcanics (TOX)	1.18	5.7×10^{-1}	0.1	1.0×10^{-4}
3	Volcanics	2.5×10^{-2}	2.5×10^{-2}	0.05	1.0×10^{-5}
4	Anhydrite mineralisation	5.0×10^{-3}	5.0×10^{-4}	0.05	1.0×10^{-6}
5	Anhydrite mineralisation	5.0×10^{-3}	5.0×10^{-4}	0.05	1.0×10^{-6}
6	Anhydrite mineralisation	5.0×10^{-3}	5.0×10^{-4}	0.05	1.0×10^{-7}
3 - 6	Local faults	100% of host layer	100% of host layer	100% of host layer	100% of host layer
3 - 6	Regional faults	39% of host layer	100% of host layer	100% of host layer	100% of host layer

Note: *Parameters used in the model are conservative estimates using a combination of field data, hydrogeological expertise and knowledge of the region.*

Figure D 3.6 compares the distribution of the hydraulic conductivity (horizontal) field measurements against the values used in the model. It shows graphically the match between the observed field data and the model calibrated parameters.

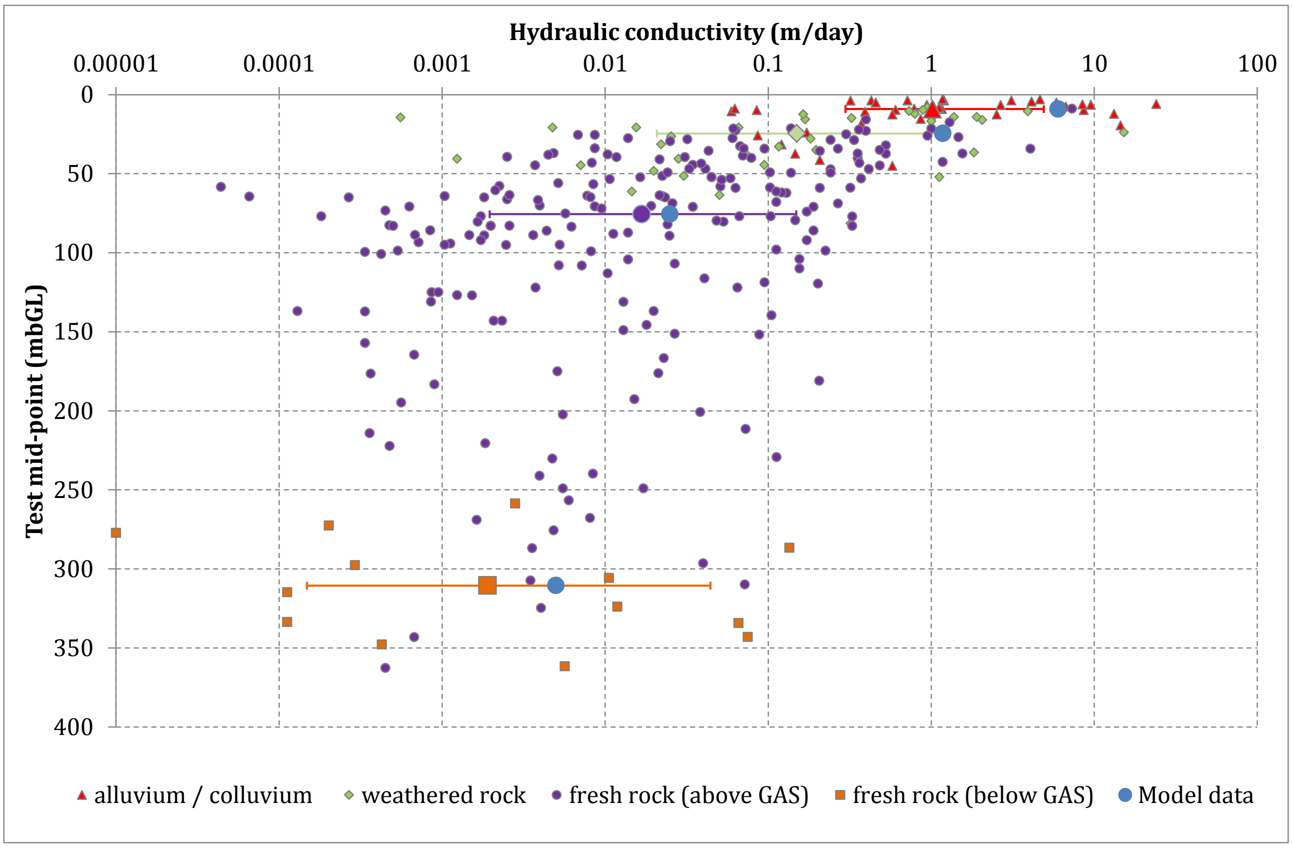


Figure D 3.6 Hydraulic conductivity distribution graph

D3.2.5 Transient water budget

The mass balance error at the completion of the transient calibration was -0.29%, indicating the model is stable and achieved an accurate numerical solution.

Figure D 3.6 shows individual components of the transient model water budget averaged over the transient period.

Table D 3.6 Transient model budgets

Parameter	Average in (ML/day)	Average out (ML/day)	In - Out (ML/day)
Storage	34.5	38.5	-4.0
Rainfall recharge	850.9	-	-
River	0.0	832.9	-832.9
Evapotranspiration	-	14.1	-
Total	**885.4**	**885.5**	**-0.1**

The water budget indicates that recharge to the groundwater system within the model averages 850.9 ML/day, with approximately 832.9 ML/day being discharged via surface drainage, and 14.1 ML/day lost to evapotranspiration in areas where the water table is within 2 m of the land surface.

D3.2.6 Composite model sensitivities

Sensitivity analysis evaluates the effect of changing individual model parameters on model results and indicates the uncertainty in the estimates of model parameters. The sensitivity of simulated heads to parameters was assessed to aid model calibration. The relative composite sensitivity (RCS) was calculated as outlined by Doherty (2010):

$$s_i = (J^tQJ)^{0.5}b_i/m$$

where: J = Jacobian matrix, derivatives of simulated heads at observations with respect to the i^{th} parameter in vector b.

Q = cofactor matrix, a diagonal matrix with the elements being the squared observation weights.

b_i = i^{th} parameter value in vector b.

m number of observations that have non-zero weights.

The composite sensitivity values were calculated during the PEST calibration process for the steady state model and were converted to RCS as shown in Figure D 3.7.

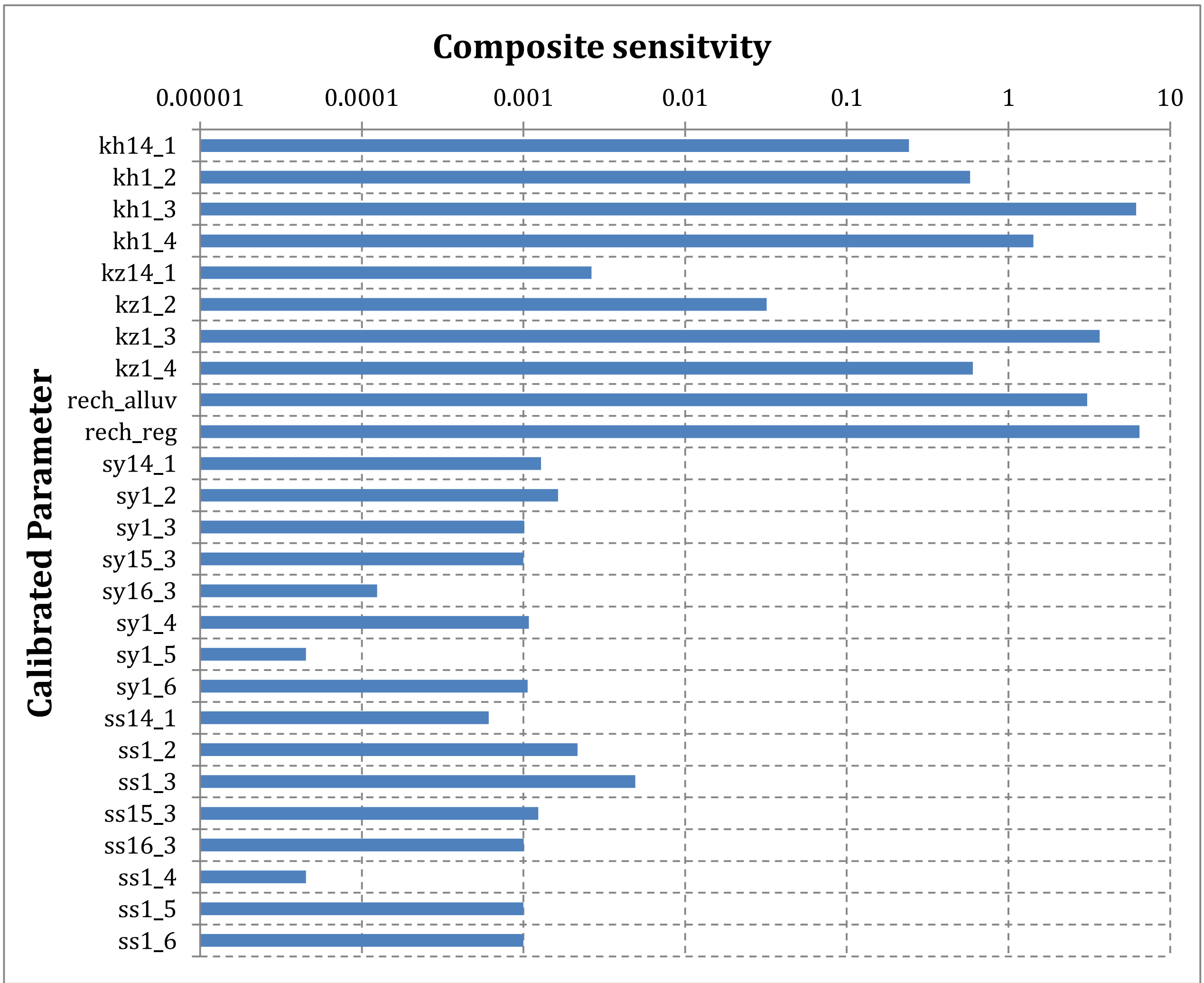


Figure D 3.7 Model composite sensitivities

The reason for scaling the sensitivity data is that sensitivities are typically presented in the units of the simulated value divided by the units of the parameter (Hill and Tiedeman, 2007). For example, the parameter units may consequently be in m^3/day, m/day, or mm/yr and the method of scaling (composite sensitivity) provides sensitivity measures with the same units and a method for comparison. RCS is therefore a dimensionless statistic and is a measure of the composite changes in model outputs that are incurred by a change in the value of the parameter. That is, whether the model calibration is sensitive to an input parameter such as hydraulic conductivity or recharge. This statistic can be used to assess the relative sensitivity of model parameters given the set of observations used in the model.

RCS can reflect the total amount of information provided by the observations for the estimation of each parameter (Hill and Tiedeman, 2007). Generally, if the RCS of a parameter is greater than one, the model is sensitive to this parameter and the model observations have provided enough information to estimate the parameter with greater certainty. shows that parameters with the highest relative RCS are:

- horizontal and vertical hydraulic conductivity of volcanics (kh_3, kz_3);
- horizontal hydraulic conductivity of volcanics (kh_4);
- recharge rates to alluvium (rech_alluv); and
- recharge rates to weathered volcanics (rech_reg).

D3.2.7 Model confidence level classification

Barnett *et al.,* (2012) developed a system to classify the confidence-level for groundwater models. Models are classified as either class 1, 2 or 3 in order of increasing confidence (i.e. class 3 has the highest level of confidence). Several factors are considered in determining the model confidence level:

- available data;
- calibration procedures;
- consistency between calibration and predictive analysis; and
- level of stresses.

The model has achieved and generally exceeded the criteria considered for a class 1 model, and meets the criteria for a class 2 confidence level classification. The model is therefore considered to be fit-for-purpose as an impact assessment model.

D4 Predictive simulations

D4.1 Time slices

The predictive model used monthly stress periods, commencing from the first year of mining. The model simulates mining with drain cells, which progress on a monthly basis. The transient model ran for the life of the Project.

D4.2 Mine drainage

The model represented mining using the drain package (DRN). During the predictive run, drain cells were used to simulate the effect of the open-pits. A nominally high drain conductance of 100 m^2/day was applied to the drain cells and the elevations of the base of the proposed open-pits were used as the drain level, however the drain elevation in each layer did not extend below the base elevation of the layer. Fortran code was written to interpolate a smooth open-pit floor decline at a cell by cell level at each stress period in the model. The DRN package compares groundwater levels to the reference elevation in each drain cell, and when the level is above the reference level, removes water from the model domain at a rate determined by the head difference and the conductance term.

D4.3 Integrated storage facility

The ISF was simulated using the MODFLOW-USG river package using a positive river stage height. This approach meant that water was able to leak through the bed of the ISF into the groundwater system. The ISF was implemented by slowly increasing the river stage height according to the scheduled filling of the ISF. At each stress period, the extent of the ISF in relation to topography was queried in Fortran code, and additional river cells were added once the ISF water level height exceeds the original ground surface. River bed conductance was adjusted according to the thickness of the ISF base at each stress period at a cell by cell level. Table D 4.1 shows the properties assigned to the RIV cells used in the model to represent the ISF.

Table D 4.1 River cell properties of ISF

ID	Zone	Vertical hydraulic conductivity Kz (m/day)	Width (m)	Minimum depth (m)	Stage height (m)	Bed thickness (m)
ISF	2	8.64×10^{-4}	Cell width	0	ISF floor + 10	Varying

The ISF embankment was simulated using different hydraulic parameters to represent the predicted extent of the engineered structure. Table D 4.2 shows the properties assigned to the model cells representing the ISF embankment in layers 1 and 2 only.

Table D 4.2 Hydraulic properties of dam wall cells

Zone	Horizontal hydraulic conductivity (kh) (m/day)	Vertical hydraulic conductivity (kz) (m/day)	Specific yield (Sy) (%)	Specific storage (Ss) (m^{-1})
Dam wall	0.0432	0.00432	5.0	1×10^{-5}

D4.4 Predictive model budgets

The mass balance error at the completion of the transient calibration was -0.39%. This value indicates the model is stable and achieves an accurate numerical solution. Table D 4.3 summarises the water budget for the transient model.

Table D 4.3 Predictive model budgets

Parameter	Average in (ML/day)	Average out (ML/day)	In - Out (ML/day)
Storage	37.3	43.1	-5.8
Rainfall recharge	852.2	-	-
River	14.9	789.1	-774.2
Drain	-	13.4	-
Evapotranspiration	-	58.9	-
Total	**904.4**	**904.5**	**-0.01**

D4.5 Recovery modelling

At the completion of mining, drain cells were removed and the model simulated post-mining conditions (e.g. final void). A transient model was created to ascertain post-mining inflows.

A 2,000-year recovery simulation was run, with all drain cells removed, thus allowing the groundwater levels in the water-bearing strata to recover. Model cells located within the final void of each open-pit were assigned a fixed head cell to simulate a standing lake within the void. The fixed heads were set at RL 475 m (HIT open-pit), RL 462 m (Ekwai open-pit), and RL 539 m (Koki open-pit).

To ensure the groundwater system had reached total equilibrium after 2,000 years, a steady state version of the recovery model was analysed. Both models produced identical results that imply equilibrium conditions were attained in less than 2,000 years.

Mod-PATH3DU (Papadopulos, 2014) was utilised to explore groundwater movement via pathlines at equilibrium conditions. The pathline simulation was run to simulate 10,000 years of groundwater flow to ensure equilibrium conditions were reached.

D4.6 Sensitivity analysis

A sensitivity analysis was carried out to assess the response of the model to varying input parameters. The objective of the sensitivity analysis was to rank the input parameters in terms of their influence on the predicted results. The model parameters were adjusted to encompass the range of likely uncertainty in key parameters. This was achieved by changing and assessing the following:

- ±20% to ±1 order of magnitude change in horizontal and vertical hydraulic conductivity (kh and kv) of all geological units (dependant on field testing upper and lower bounds);
- ±100% to ±1 order of magnitude change in the specific yield (Sy) of all geological units;
- ±100% to ±2 order of magnitude change in the specific storage (Ss) of all geological units; and
- ±0.5 order of magnitude change in the rainfall recharge (Rch) rate across the model domain.

These changes represent the expected bounds of the groundwater regime. A very large range of specific storage values were explored, simply because the calibrated base case values were very low.

D5 Results

The results and discussion of the sensitivity and predictive modelling are presented in the Section 6 of the main report.

D6 References

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Papadopulos, S.S (2014), *"User's Guide for mod-PATH3DU - A groundwater path and travel-time simulator"*

SKM (2011a), "*Frieda River Feasibility Study Mine Water Balance Modelling Report 2011*", Document No: FRP03-0100-EG-RP-0001, Revision D August 2011.