

FY22 Mick's Bore SUR Phase 2 Hydrogeological Drilling Completion Report

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Key Stakeholders

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EXECUTIVE SUMMARY

The primary objective of this program was to build upon the data collected in the Phase 1 program and drill a series of pilot and production bores to assess the viability for a Managed Aquifer Recharge (MAR) scheme at Mick's Bore.

The drilling program successfully installed eight monitoring bores and three production bores. However, not all planned monitoring bores were completed and consequently, not all program objectives were achieved due to the difficult ground conditions of the Tertiary Detritals Sequence (TDS). HMKB0006 and HMKB0010 were abandoned due to collapse of surface detritals zone. 30 – 40 metres of unstable and loose material (TD3) and 10 – 20 metres of broken calcrete (CA2) or vuggy breccia (VB2) was logged as Detrital unit above Dales Gorge bedrock.

The drilling of eight monitoring bores was executed by Welldrill Water Well Drilling (Rig 05) with Conventional drilling Method. During the execution of this phase, drilling difficulties with the unconsolidated nature of TDS were encountered. However, all the technical objectives were fully achieved with the conventional technique, even if the Percussion method was probably not the best option for the purpose of this program. The ground met was quite loose and unstable in TDS, with a thickness of 44 – 60 metres. For this reason, in most of the bores, a deeper surface casing was installed to case the Detrital zone. However, a Yield of 20+ L/s was estimated in most of the monitoring bores.

Considering the difficulties faced with the poor ground conditions in the detrital zone and especially in the TD3, Mud Rotary or Dual Rotary drilling would have been a better drilling method. Extremely broken ground was also recorded in most of the bores.

All production bores were drilled using Dual rotary methods (DR) performed by Ventia (DR04), to avoid drilling complications encountered with the Tertiary Detritals Sequence. A final yield of 40 – 45 L/s was estimated at HMKB0016P and HMKB0017P, respectively while in HMKB0015P was noted broken ground between 68 – 118 mbgl with an estimated final yield of 25 L/s.

The broken ground and high airlift yields intersected at the production bores suggest that the aquifers at Mick Bore may be suitable for use as a MAR scheme. The thickness and extent of the inferred high permeability fractured bedrock aquifer is likely to provide high transmissivity to allow for injected water to be efficiently distributed in the aquifer. However, hydraulic testing at the production bores will provide a better assessment of the aquifer for this purpose.

Chemically speaking, the groundwater Total Dissolved Solids values for the aquifers at Mick's Bore are higher than the groundwater at Dead End, West Packsaddle and South Flank. This is a positive factor for re-injection because a fresher source will be introduced into the Mick's Bore aquifer.

The slight differences in hydrochemistry in the West Packsaddle and Mick's Bore samples suggests that these two aquifers are not directly connected. Also, the source water bores in Mick's Bore contain slightly higher concentrations of Barium, Boron and Chromium compared with Dead End and South Flank aquifer.

For environmental purposes, the calcrete unit and TD3 gravels may require assessment for stygofauna and troglifauna populations as these would be affected by mounding of the water table.

It would be beneficial to carry out a field sampling and testing exercise at selected monitoring bores or production bores to assess the aquifer REDOX conditions as part of the design planning for any future MAR scheme. Furthermore, it would be relevant to run a mixing model with Phreeqc to get a first rough idea of compatibility and potential over/undersaturation in respect to common minerals.

A final summary of the various components that require consideration when planning a MAR scheme at Mick's Bore with a ranking potential is shown in the table below:

Prospective Injection Bore Site	High potential	Moderate potential	Low potential
Proximal to mining operations		Approximately 20 km to the northwest of the MAC/South Flank mining hub.	
Aquifer Thickness	Thickness of saturated Dales Gorge Member between 74 – 87 m (from bottom of TD2 to the contact with Mt. McRea Shale). Thickness of saturated TD2 between 1.5 – 16 m (from the SWL to the bottom of TD2).		
High transmissivity and storativity	Additional Pump Testing program required, however the ground condition encountered during drilling indicates potentially high transmissivity.		
Structurally enhanced permeability	Broken ground and cavities/voids noted.		
Compatible GW salinity / chemistry	Salinity slightly higher in receiving aquifer, geochemical modelling required.		
Compatible GW trace metal /hydrochemistry	Barium, Boron and Chromium content slightly higher in receiving aquifer.		
Significant depth to GW (Unsaturated zone)	41 – 47 mbgl.		
Proximity to receptors	No GDEs or surface hydro features supported by GW.		

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1 INTRODUCTION

This report presents the findings of the **FY22 Mick Bore SUR Phase 2 Hydro Drilling** executed and supervised by the Water Planning Field Hydrogeology team between the 24th of July 2022 and the 31st of March 2023.

All work was conducted in accordance with the proposal and plan from Nick Quaglia dated 22nd of March 2022 and further revised in accordance with the site conditions.

1.1 Project Purpose

The detrital valley that forms the Northern Run Away Valley (RAV) investigation area is quite similar to the geological setting seen across WAIO with detrital valleys weaving in amongst Brockman and Marra Mamba Formation ridges. The shallow alluvium and the tertiary detrital sequence (primarily TD3 and TD2) are being investigated as the main receptor for infiltration, as opposed to the dolomites and ore body aquifers being investigated for other MAR options. MAR could become a viable option here, once further investigation into the bedrock has been completed to determine the viability.

The Hydro drilling program Mick's Bore SUR Phase 1 Programme and the ENV Phase 1 RC Programme has increased understanding on Mick's Bore conceptual hydrogeology through the drilling of five monitoring bores and eleven RC holes.

This Phase 2 program is the continuation of Phase 1 with three planned production bores and nine monitoring bores.

1.2 Location

The Northern RAV (Mick's Bore) Investigation area is approximately 20km to the northwest of the MAC/South Flank mining hub. The investigation area resides within the eastern corner of the Tandanya Tenement which consists of Brockman Formation and Marra Mamba Formation ridges separated by alluvial valleys.

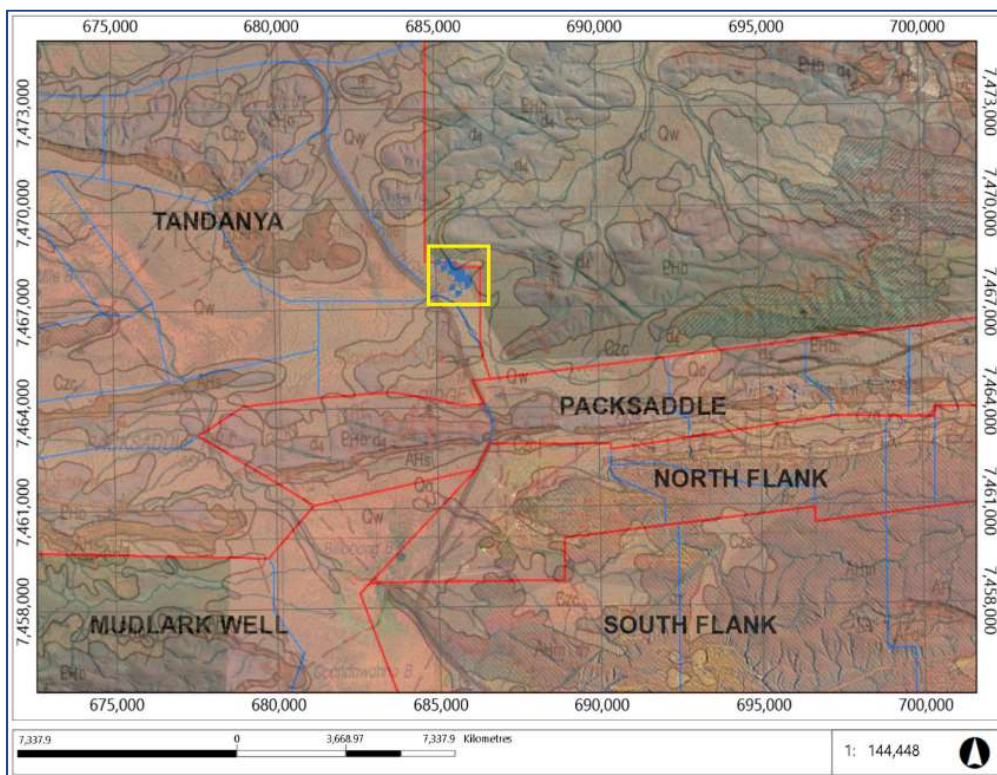


Figure 1: Location Map

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1.3 Technical Objective of the Project

The **Key Objective** were:

- To assess hydrogeological connectivity and injection capacity for MAR.
- To augment the existing monitoring network at Mick's Bore.
- To install three large diameter production bore to establish a preliminary MAR capacity for testing purposes.

1.3.1 Hydrogeological Setting and Targeting Rationale

The scope of work is presented in **Table 1**, and Technical Objective & Termination Criteria in **Table 2**.

Table 1: Scope of Work

Program	CR No. of Holes	CR Total (m)	Gamma	OTV	ATV
Pilot Bores	9	1290	Y	N	N
Production Bores	3	450	N	Y	Y
Scope of work: https://waio-dctm.bhp.com/D2/?docbase=bhpbio_od_prod&locateld=0903c41a8422b672&application=ManagedDocuments					
Daily Drill Summary: https://waio-dctm.bhp.com/D2/?docbase=bhpbio_od_prod&locateld=0903c41a8436cf56&application=ManagedDocuments					

Table 2: Technical Objective & Termination Criteria

Hydro Pad Name	Planned Hole Name	Planned Depth (m)	Technical Objective	Termination Criteria
MB_FY22_PAD01	HMKB0006	120	Drill a pilot hole to determine if ground is perspective for MAR. No installation required as HMKB0002 is installed 15 m north.	Target depth or when ground becomes hard and competent.
MB_FY22_PAD02	HMKB0007	120	Drill a pilot hole to determine if ground is perspective for MAR. No installation required as HMKB0003 is installed 15 m north.	Target depth or when ground becomes hard and competent.
MB_FY22_PAD03	HMKB0008	150	Drill a pilot hole to determine if ground is perspective for MAR.	Target depth or when ground becomes hard and competent.
MB_FY22_PAD04	HMKB0009	150	Drill a pilot hole to determine if ground is perspective for MAR.	Target depth or when ground becomes hard and competent.
MB_FY22_PAD05	HMKB0010	150	Drill a pilot hole to determine if ground is perspective for MAR.	Target depth or when ground becomes hard and competent.
MB_FY22_PAD06	HMKB0011	150	Drill a pilot hole to determine if ground is perspective for MAR.	Target depth or when ground becomes hard and competent.
MB_FY22_PAD07	HMKB0012	150	Drill a pilot hole to determine if ground is perspective for MAR.	Target depth or when ground becomes hard and competent.

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Hydro Pad Name	Planned Hole Name	Planned Depth (m)	Technical Objective	Termination Criteria
MB_FY22_PAD08	HMKB0013	150	Drill a pilot hole to determine if ground is perspective for MAR.	Target depth or when ground becomes hard and competent.
MB_FY22_PAD09	HMKB0014	150	Drill a pilot hole to determine if ground is perspective for MAR.	Target depth or when ground becomes hard and competent.
MB_FY22_PAD05	HMKB0015P	150	Production Bore adjacent to HMKB0010M.	Target depth as per results of pilot hole.
MB_FY22_PAD02	HMKB0016P	150	Production Bore - reaming out of HMKB0007	Target depth as per results of pilot hole.
MB_FY22_PAD07	HMKB0017P	150	Production Bore adjacent to HMKB0012M.	Target depth as per results of pilot hole.

See **Figure 2** below for the planned hole locations.

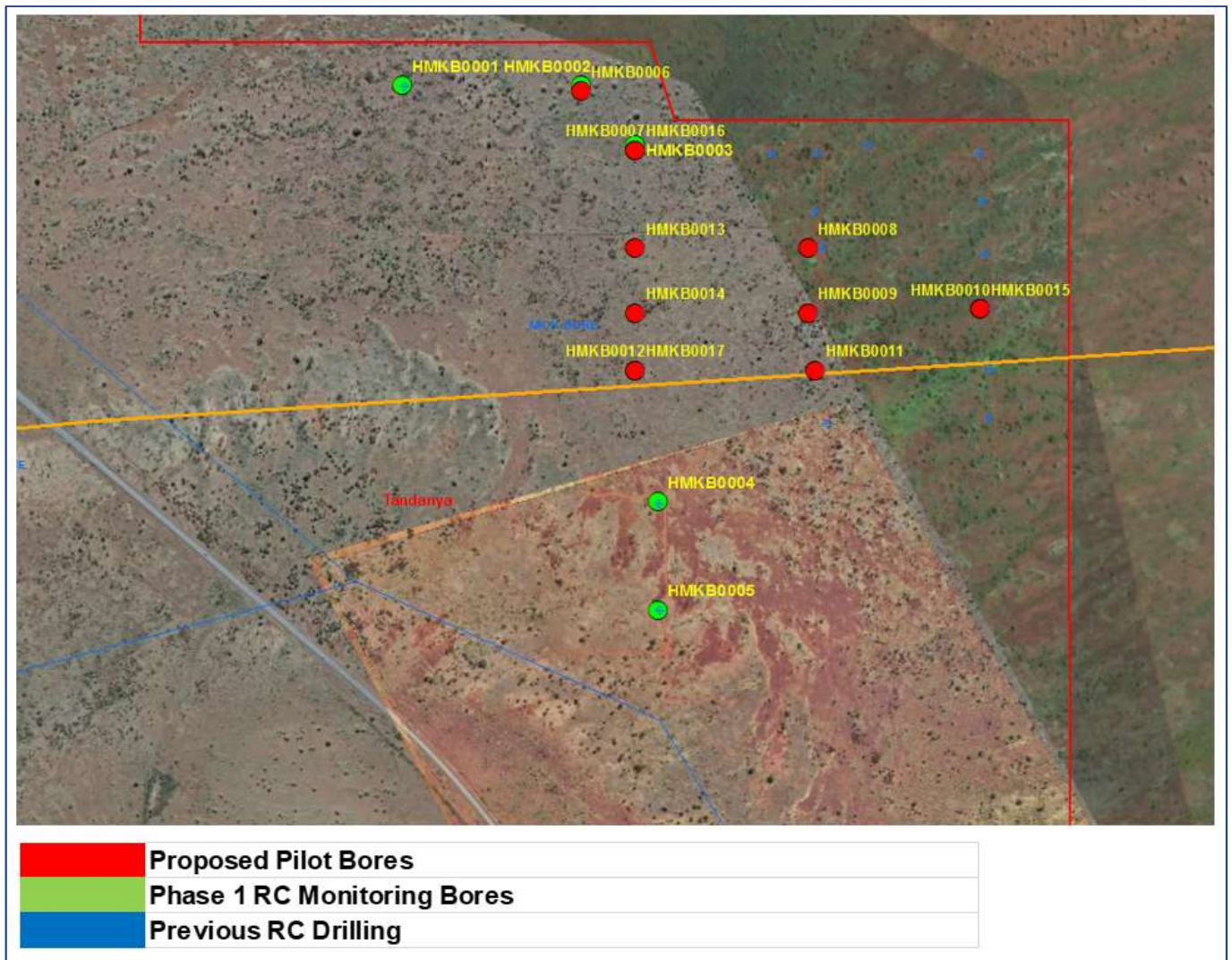


Figure 2: Planned Bore Location Map

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2 Geological and Hydrogeological Setting

INTRODUCTION

The investigation area resides within the eastern corner of the Tandanya Tenement, which consists of Brockman Formation and Marra Mamba Formation ridges separated by alluvial valleys. The Northern RAV area is one of these alluvial valleys bounded by ridges in the east, north and south. To date there is no preliminary resource estimate at Mick's Bore and it is likely that mineralisation is more prominent in the Brockman ridges of Floodplain and The Noose to the west.

GEOLOGY AND GEOMORPHOLOGY

The Northern RAV investigation area is a detrital valley within a series of Brockman ridges to the east, north and south. This valley is oriented E-W though the investigation area with an outlet to north (Marillana Creek) and west (Floodplain deposit) and ultimately Karijini National park on the western tenure boundary. The Brockman Ranges to the north, south and east consist of Joffre Member and Dales Gorge Member BIF units which are mineralised along fault and fold structures, and McRae/Mt Silvia Formations shale which has been brought closer to surface in areas that have been folded.

The detrital valley within the investigation area is formed by erosion and deposition of sediments from the surrounding ridgelines. The main E-W floodplain area is fed by a number of smaller creek lines from the south that cut through the topographical low point in the ranges and ultimately report to the valley fill that forms the investigation area. As a result of the valley fill accumulating at the bottom of the ridgelines, the detrital sequence is thickest through the centre of the valley with the detrital cover ranging from 10-50 m.

The detrital package contains some mineralisation; however, this is not deemed economical as it is below Fe cut-off grade (Hough 2015). The regional structures that crosscut the bedrock continue through the detrital valley. The two main structures are a large E-W oriented syncline that has brought the McRae and Mt Sylvia shale sequence close to the surface in the southern ridgeline, and an E-W thrust fault that runs parallel to the fold hinge which likely formed at a similar time to the folding event.

A series of RC exploration campaigns were conducted between 2011 and 2016 across in the Northern RAV area by BHP, with a total of 14 holes drilled. The drilling focused mainly on the Brockman orebody in the eastern edge of the tenement.

The holes drilled into the detrital and underlying Brockman sequence have provided initial information on potential viability of an infiltration scheme in the area with evidence of some prospective ground to install infiltration ponds. These lines of evidence include:

- Mineralisation in the Tertiary sequence that could have high infiltration rates, groundwater recharge and also transmit flow toward the larger valley further west. In addition, the tertiary sequence has a relatively low clay content which should allow for effective infiltration.
- Large scale regional faults and folding beneath the valley sediments which could improve infiltration rates once water infiltrates down into the detrital/bedrock transition zone. These could also be conduits into the regional aquifer and create higher rates of loss than the detrital package alone. If depth to bedrock, hydraulic gradients, aquifer parameters and the thickness of the unsaturated zone are found favourable, locations within the valley may also be selected for injection (MAR).

CONCEPTUAL HYDROGEOLOGY

The detrital valley that forms the Northern RAV investigation area is quite similar to the geological setting seen across WAIO with detrital valleys weaving in amongst Brockman Formation and Marra Mamba Formation ridges (topographic highs). The shallow alluvium and the tertiary detrital sequences (primarily TD3 and TD2) are being

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investigated as the main receptor for infiltration, as opposed to the dolomites and ore body aquifers being investigated for other MAR options. MAR could become a viable option here, once further investigation into the bedrock has been completed to determine the viability.

The available drill data shows there is inconsistent mineralisation through the Brockman sequence with minor mineralisation in the detrital sequence.

The water level data collected to date shows a regional gradient from west to east through the main valley which is largely controlled by dykes that have formed aquifer compartments throughout the Tandanya project area. This results in the regional water table ranging from ~693 mRL (~20-25 mbgl) in the west to 682 mRL (~42-47 mbgl) in the east where the North RAV investigation area resides (**Figure 3**).

Data collected from monitoring bores and RC drilling in the Northern RAV Investigation area suggest that the base of the detrital sequence (10-15 m) is saturated and therefore, it is inferred that the groundwater gradient within the detrital sequence is not influenced by any nearby dykes and that groundwater flow can flow freely through the detrital sequence.

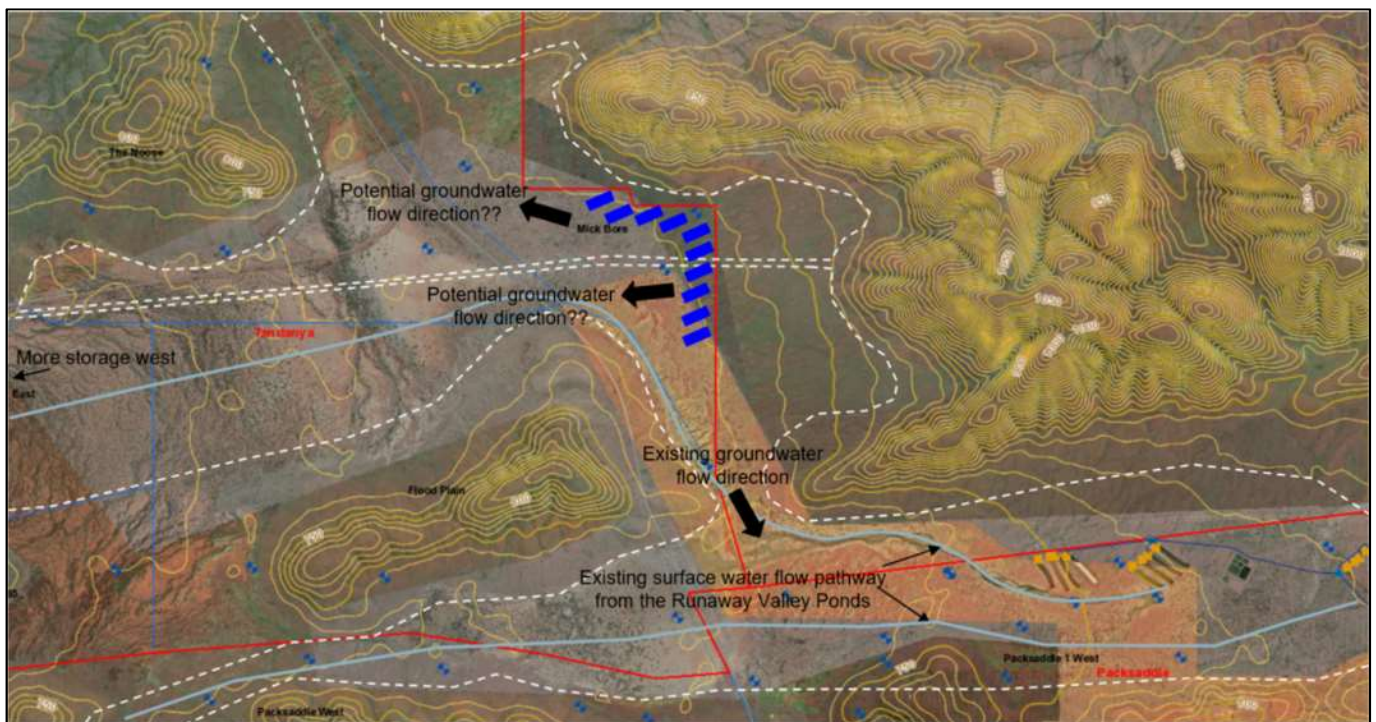


Figure 3: North of RAV Infiltration Basin Option – Location and Inferred Flow Directions

No recent water level data has been recorded in the western end of the investigation area where the valley extends towards the Karijini National Park boundary. This will be a focus for future investigations to ensure an even distribution of water levels is collected to inform future modelling and conceptualisation. Water levels will be collected as a part of the Phase 2 hydrogeological investigation and telemetry deployed to assess how the regional water table changes over time and in preparation for future infiltration trials.

SURFACE WATER

The surface drainage in the Northern RAV area is an extension of the drainage line that the current RAV scheme overflow discharges into. This drainage line essentially fans out into the floodplain that makes up the majority of the low-lying areas of Tandanya. The Northern RAV investigation area is on the eastern extent of this floodplain system and sits at the base of the Brockman ridges that form the eastern boundary of the Tandanya valley. Minor tributaries flow into the centre of the valley from the ridgelines throughout the investigation area and ultimately report to the centre of the Tandanya valley.

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INTERPRETED GEOPHYSICAL DATA

Inverted Airborne Electromagnetic (AEM) data (**Figure 4**) suggests oxidation and thus higher porosity in Mick's Bore area. BIF are ideal injection targets, especially when highly fractured and oxidized. High flow rates are expected during the drilling investigation (Tabain, 2023).

AEM survey executed in 2019 – 2022 has and is continuing to be used to build higher confidence hydrogeological models, reducing the quantity of required exploration holes and PB's (Tabain, 2023).

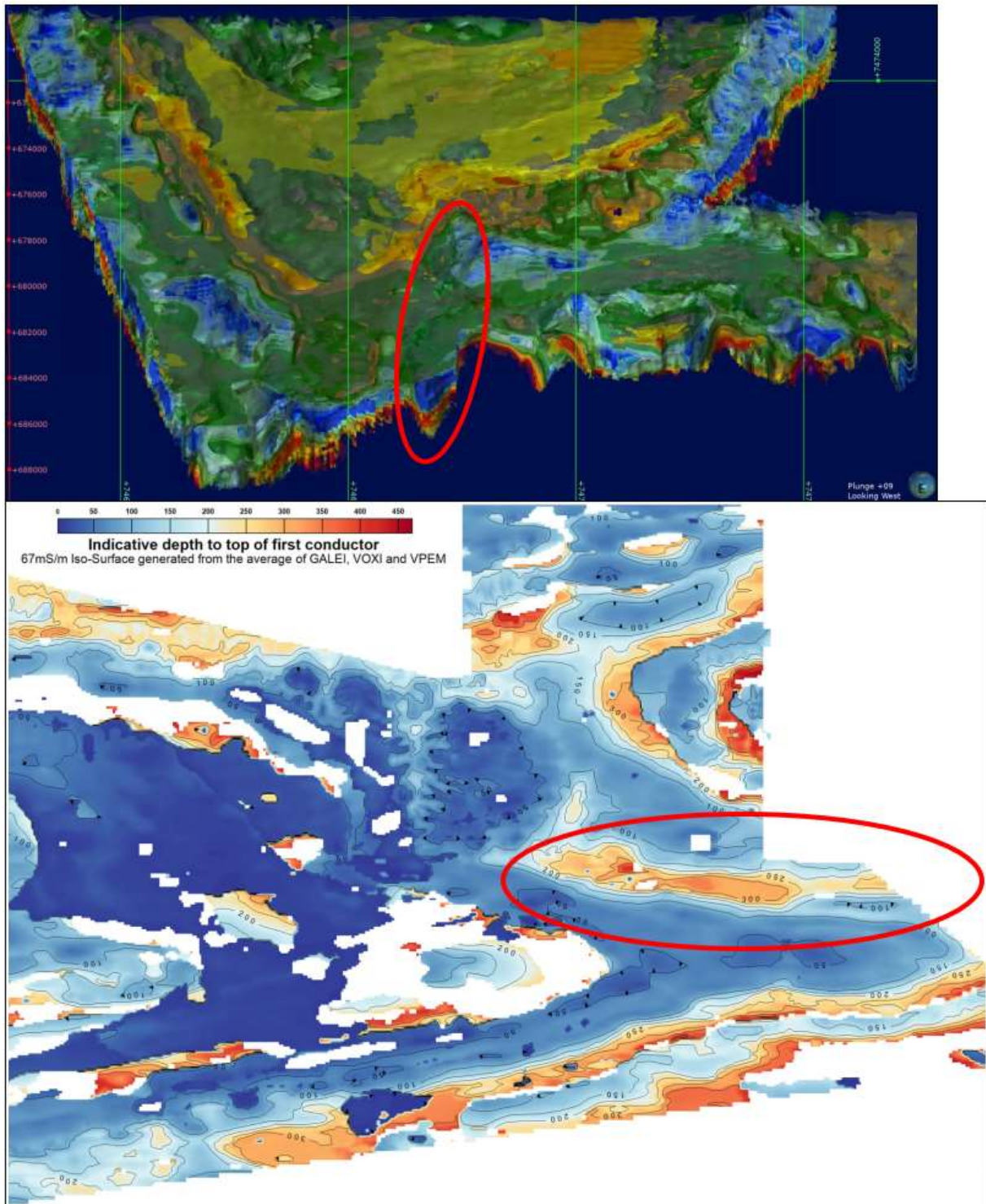


Figure 4: Airborne Electromagnetic (AEM) image (Tabain, 2023)

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3 Field Program

3.1 Health Safety and Environment

All work undertaken during hydrogeological drill program was in accordance with existing WAIO Geoscience and Water Planning safety procedures and requirements. The work was executed under PEHR number 202111172 (expire the 3rd of August 2023).

During the planning phase, technical risks and challenges were highlighted before the execution and appropriate controls were put in place for the duration of the program.

Table 3 lists the risks and constraints that were identified before the commencement of the drilling program.

Table 3: Risk and constraints for drilling program

	Activity
Fibrous Material	<ul style="list-style-type: none"> No fibrous material anticipated (Brockman sequence).
Reactive geology	<ul style="list-style-type: none"> Potential for intersecting McRae Shale at the base of a couple of holes, discharge will need to be contained if fresh pyritic shale encountered. Captured in hole tracking.
Ground condition	<ul style="list-style-type: none"> Broken ground through the mineralised Dales Gorge member observed in Phase 1 RC drilling.
Discharge management whilst drilling	<ul style="list-style-type: none"> Potential for high flows in the mineralised and fractured dales gorge.
Discharge management whilst test pumping	<ul style="list-style-type: none"> As per the DMP guidelines. Holes that encounter black shale will need to contain discharge.
Proximity collars	<ul style="list-style-type: none"> Proximity collars are within 25m for some targets. Some Proxy holes are cased with PVC. RC proxy holes that have been drilled recently so all holes should be identified before drilling.

No fibrous material was intersected during drilling at Mick's Bore SUR Phase 2. However, **reactive ground was encountered** in most of the bores and water quality EC/pH values were within acceptable limits for safe discharge.

3.1.1 Safety Events

During the drilling program two incidents were reported:

1. A Human Safety Event (#1000519014 – Pinched L Index finger between flange and truck tray) was recorded during the drilling of HMKB0009M on the 1st of October. Whilst loading a circle flange disc (approx. 15kg) on to the tray of the light truck, IP pinched left index finger between flange and lip of tray. IP instantly pulled their finger out. Immediate actions were put in place after the incident: IP reported the incident to supervisor, job was stopped, and IP was taken to the medical centre for reviews. The event was also reported to BHP supervisor and IP was placed on PRD's for follow up review the day after the incident.
2. A Near Miss Event (#1000636981 – Gravitational - Dropped Air Swivel Components) was reported during the drilling of HMKB0017P on the 5th of March 2023. While cleaning a hydro drill hole after drilling approximately 1.5m, the air swivel failed resulting in the cap (2 kg), circlip and retention bar dropping from five metres to the ground. The swivel cap landed approximately 1.5 m from the driller who was standing on the driller step which had Falling Objects Protection System (FOPS) in place. Immediate actions were put in

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place after the incident: Drill rig was shut down and area made safe. Scene was frozen and event was reported to supervisor and compliance. Also, other hydro rigs with the same air swivel set up were shut down and Investigation commenced

There were no other incidents requiring investigation or first aid treatment during the program.

3.2 Drilling and Installation

The drilling and completion of the groundwater monitoring bores was carried out in accordance with the WAIO Geoscience Drilling Standards, WAIO Hydrogeology Bore Completion Criteria, and followed a detailed design and specification compliant with the National Uniform Drillers Licencing Committee (NUDLC) 2020, Minimum Construction Requirements for Water Bores in Australia, 4th Edition.

The drilling and installation of the monitoring bores was undertaken by Welldrill Water Well Drilling (Rig 05) commencing the 24th of September 2022 and completed on the 31st of October 2022. Welldrill used Fraste FS500 conventional (air rotary) drilling rig for this drilling program. However, HMBK0011M was drilled and constructed by Ventia DR04 from the 24th to the 27th of July 2022. No more monitoring bores were drilled by DR04 because this program was set up in the contract system for Welldrill (ST11). However, the execution of the production bores was done by Ventia (DR04) from the 19th of February 2023 to the to the 31st of March 2023 due to the poor ground condition encountered while drilling monitoring bores.

The target depth of the boreholes was confirmed by the Field Hydrogeologist as guided by the Target and Termination Criteria (**Table 2**) in the Draft Bore Plans for each planned bore pre-defined by the planning team. The target depths specified on the Draft Bore Plans were based on the anticipated geology and adjusted accordingly by the Field Hydrogeologist based on the actual geology encountered during drilling.

Drill cuttings samples were collected every two metres for detailed geological logging of the lithology, and air lift yields were estimated and recorded at the end of each drill rod (every 6 m). Water quality field parameters including temperature, electrical conductivity (EC) and pH were measured using a calibrated Hanna Instruments HI991301 multi-parameter water quality meter. These parameters are shown on the hydrogeological bore logs in **Appendix I**.

Bore casing (screen and blanks) was installed to the depths specified in the Final Bore Plans (for Monitoring bores and Production bores) or sufficiently close to the design depth such that the technical objectives of the bore were achieved.

Gravel pack and low permeability seals were installed at the depths and tolerance as specified in the Final Bore Plan or sufficiently close to the design such that the technical objectives of the bore were achieved. Standard methods of gravel pack and low permeability seal installation were followed by the drilling contractors, including:

1. Pouring from the surface using a hopper for shallow installations, or
2. Tremie to required depth.

Bore construction details and initial standing water levels (SWLs) measured following bore installation are presented in **Appendix II**.

EPIROC geophysics contractors were able to perform an in-Rod gamma survey in most of the monitoring bores, except for the abandoned bores HMKB0006 and HMKB0010, for HMKB0012M (survey not available during night shift) and HMKB0021M due to the gamma being already available for the historical piezo HMKB0002 drilled on the same pad. No in-rod gamma survey was completed for production bores.

Monitoring bores were constructed using Class 18 50 mm NB slotted (1 mm aperture) and blank PVC casing using solvent weld joints and screws. A medium specification gravel (size range 3.2 – 6.4 mm) was inserted in the hole annulus to provide a filter pack, and five metres of cement surface seal was placed at surface. Headworks consisted of concrete plinth and steel monument cover (**Figure 5, 6 and 7**). Due to unconsolidated and loose Tertiary Detrital

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material (TD3 and TD2) that caused the collapse of surface detritals zone in HMKB0006 and HMKB0010 and heavy sample contamination in HMKB0010 and HMK0014M, it was decided to install and cement six metres of 12" steel blank surface casing and 60 m of 8" steel blank conductor casing to stabilise the unconsolidated zone.



Figure 5, 6 and 7: Monitoring bore completion with vented lid

All the production bores were constructed using 12" (304.8 mm) blank steel and wire-wound stainless steel screens (2 mm aperture) as planned in the Final Bore Plan. All the bores were gravel-packed up to a certain depth (generally around 55 mbgl) and an interval of bentonite seal (between two and three metres) was placed above the gravel. Then a surface grout seal as installed above the bentonite interval up to surface.

A large amount of grout was used at HMBK0015 due to a suspected void at depth, do the decision was made to grout "only" to 28 mbgl and then gravel to 6 mbgl. Six metres of cement seal was placed above the gravel up to surface. Steel surface casing (20", 500 mm diameter) was also cemented in all the bores; 12 m in HMKB0015P, 8 m in HMKB0016M and 11 m in HMBK0017P. The headwork completion has a concrete plinth and lockable steel cover (~0.30 m, **Figure 8 and 9**).



Figure 8 and 9: Production bore completion

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Airlifting development of the production bores was carried out until the discharge water was clear and with minimal or no coarse sediment in a 20 L sample. The development required 25.5 hours for HMKB0015P, 15 hours for HMKB0016P and 46.25 hours for HMKB0017P. Water samples were collected from each production bore at the end of development and submitted to SGS Laboratory for Comprehensive Suite analysis.

The production bores were checked for verticality during the bore development stage, with the drilling contractor attaching a pump dummy (4 m length, 10" diameter) to the drill string as part of the developing tool.

EPIROC conducted downhole survey (ATV/OTV) within two weeks of the production bore completion.

HMKB0006 was proposed to be a pilot hole on the northernmost pad of the project area. The pilot hole was designed to determine the yield profile in the area. However, due to cavities encountered at 28 mbgl and 54 mbgl circulation was lost and two rods were drilled without sample return. The nightshift drilling activity was suspended to allow for escalation of the issue in the morning, as per protocol. Consultations between the drilling supervisors, Geoscience, Program Designer and Field Hydro resulted in the hole being abandoned and decommissioned per minimum construction requirements. HMKB0021M was drilled on the other side of the pad with six m of 12" blank steel casing and 60 m of 8" blank steel casing installed.

Due to 94 m of fallback (from 56 mbgl to 150 mbgl) caused by the collapse of surface detritals zone below the surface casing, HMKB0010 was abandoned and fully decommissioned as required by the Minimum Construction Requirements for Water bores in Australia, 4th edition. The bore was gravel packed up to within 5 metres of surface and sealed with concrete from 0 to 5 mbgl. The surface casing was also removed from the ground. The collapse of shallow detritals resulted in contamination of all the samples below 102 mbgl (**Figure 10, 11 and 12**). A surface casing could have been installed to deeper levels to prevent this happening.



Figure 10: (Left) HMBK0010 Chip Trays.

Figure 11 and 12: (Right) HMBK0010 Sample Farm and Sump.

All bores were surveyed by BHP Surveyors to Map Grid Australia (MGA), a grid coordinate system based on the Universal Transverse Mercator projection and the Geocentric Datum of Australia 1994. The bores were also surveyed for surface elevation and top of casing to mAHD.

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3.2.1 Pads, Sumps and Access

- The program was located in a non-active mining area so access in and out of the pads didn't require any escorts. The pads were prepared to 50 m x 50 m size to accommodate either Welldrill or Ventia DR rigs. This allowed adequate space to accommodate Welldrill Rig 5 and Ventia DR 04, their support trucks, other rig equipment's and enough space for supervising Field Hydrogeologist to park and log.
- **Most of the sumps built were large enough for the monitoring bores.** However, due to high water flows (25+ L/s) during the drilling of HMKB0007M the sump filled in a short amount of time and at depth of 132 mbgl the drilling was stopped for safety reason still achieving the technical objective of drilling to McRae shale.
- **The sumps built were not large enough for the production bores.** Due to high water flows (30 – 50 L/s) during the drilling and development of the production bores, the sumps filled in a short amount of time. To continue drilling, a controlled breach was made in the sump to allow discharge under the WAIO Discharge Management Standard. First water quality measurements were taken on the same day from the sump discharge as required by the WAIO Discharge Management Standard (#0072882 in Controlled Documents). All the readings were within Water Quality Criteria for Discharge as per the Standard (4 < pH > 10, TDS < 5000 mg/L). The sump was opened at HMKB0016P during drilling, so all the measurements were recorded in the Water Quality measurements sheet (data saved in Geobank), while for HMKB0015P and HMKB0017P the sump was breached during developing. All the readings were also within Discharge parameters.

3.3 Field Data Collection

During drilling, the following were collected by the driller and the field hydrogeologist for each bore drilled except HMKB0021M:

- First water strike (FWS) and all subsequent significant increases in yield.
- Changes in drilling conditions i.e. harder/softer ground/ lost circulation/fractures/voids etc.
- Airlift yield estimates and field water quality measurements (EC, pH and temperature) every six metres and at the end of the hole when readings have stabilised.

Following the completion of each bore (after 24 hrs), the groundwater static water level (SWL) was measured by the field hydrogeologist and recorded in the Geobank log.

4 Field Observations and Results

The following sections present the field observations and descriptions of the site geology and hydrogeology.

A summary of field Water Level (WL), Static Water Level (SWL) and airlift yield values data is shown in **Figure 13**.

The site geology encountered is displayed in the Cross Sections in **Figure 14** and **Figure 15**. These figures were prepared by entering the As-Built hole details and in-Rod gamma survey results into the Leapfrog model for Mick's Bore.

All the holes were drilled through the Brockman Iron Formation, targeting the Mt McRae Shale Formation (RU) to understand the thickness of the Dales Gorge Member (D).

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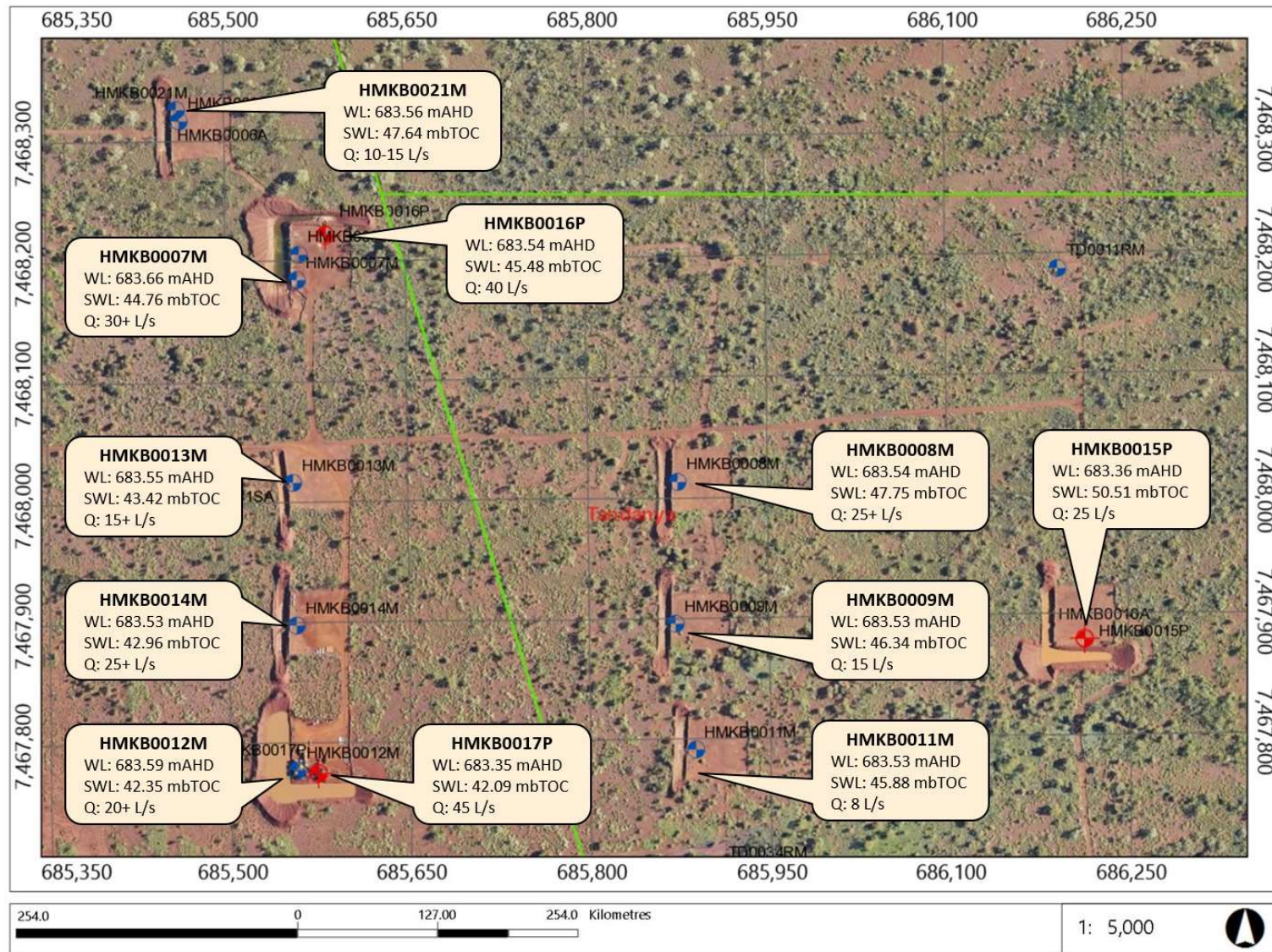


Figure 13: Summary of Field Observations

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Surface cover (SZ) consisted of loose scree at surface, generally 0 to 12 m deep, but up to 58 – 60 m of transported material was encountered above the Dales Gorge Member. In particular, TD3 was logged to 30 – 38 mbgl (Gravelly siltstone GS3) and TD2 to 54 – 60 mbgl.

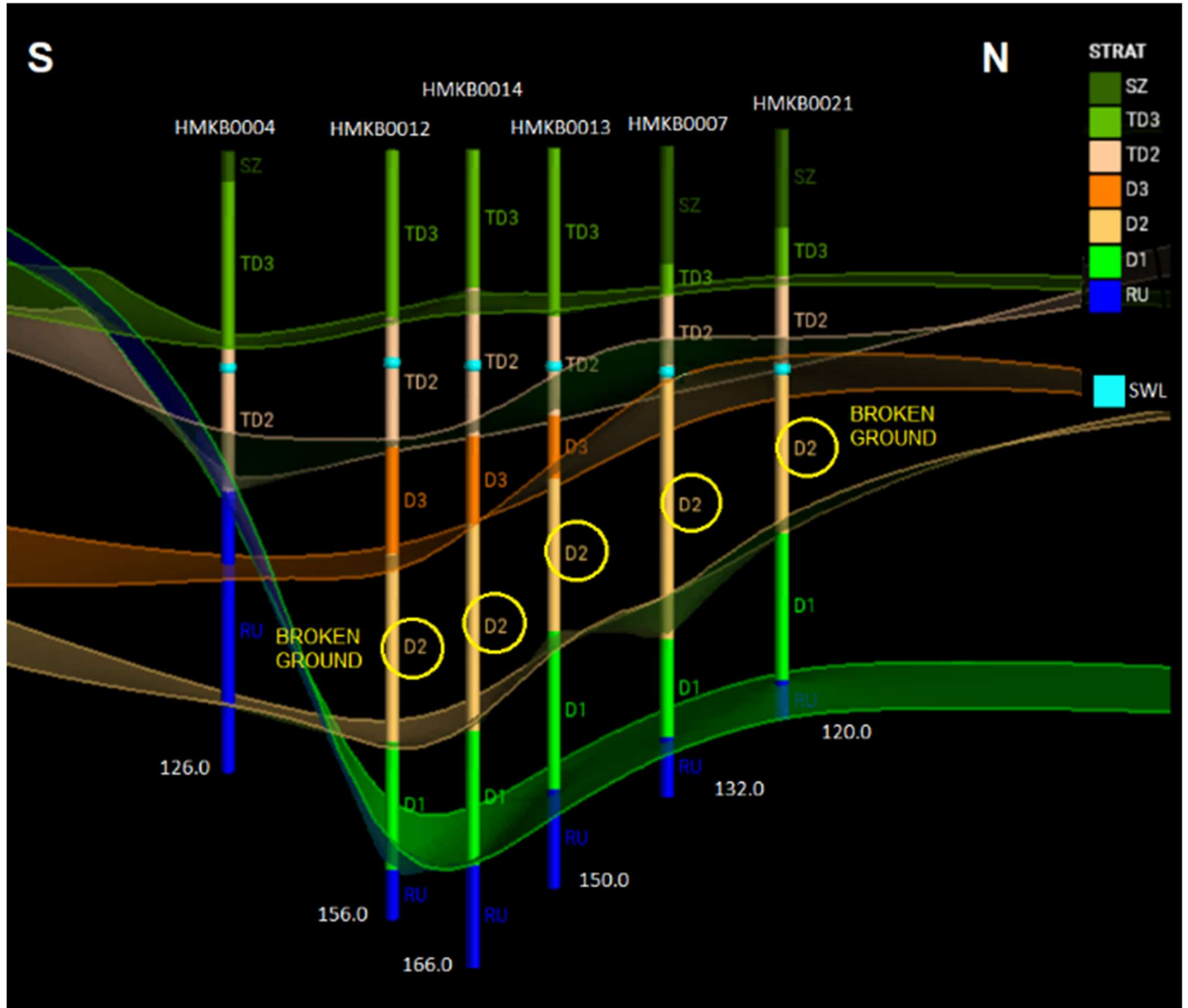


Figure 14: Cross Section 1

In **Figure 14** the Static Water Level (SWL) is shown with a light blue mark. The SWL was encountered in all the bores in the Tertiary Detrital TD2.

Calcrete (CA2) and Vuggy Breccia (VB2) was found in the area as part of TD2.

A broken interval was discovered in most bores around 68 – 104 mbgl in D2 Member (HMKB0007M, HMKB0012M and HMKB0014M) associated with an increase in chips size (10 – 55 mm) and in yield (25+ L/s).

On the basis of hydrogeological proprieties, BIF are ideal injection targets, especially when highly fractured and oxidized, causing an increase of porosity (Tabain, 2023).

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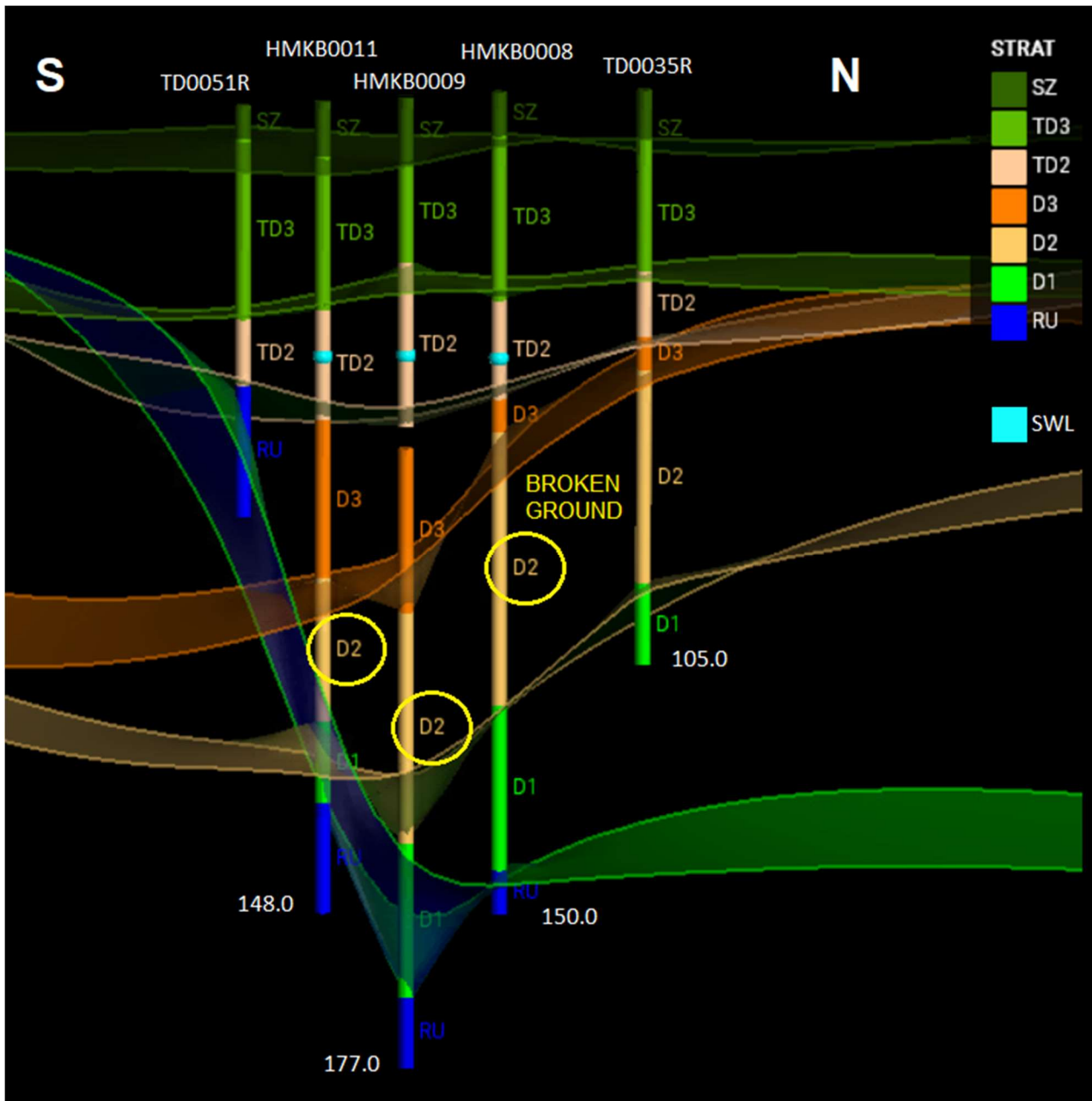


Figure 15: Cross Section 2

During the drilling of the monitoring bores a broken interval was discovered in most bores around 68 – 102 mbgl in D3- D2 Member (HMKB0008M and HMKB0009M) associated with an increase in chips size (10 – 40 mm) and yield (25+ L/s).

4.1 Site Hydrogeology and Drilling Conditions

First water strike (FWS) was recorded at depths ranging between 46 – 62 mbgl. The standing water levels measured in the bores after construction range of 41 – 47 mbgl.

Airlift yields varied between the drilled holes with variations from 8 L/s to 45 L/s based on visual estimation (**Appendix II**).

The occurrences are summarised in **Table 4**.

Table 4: Description of Yield Intersections and Ground Conditions

Hole Name	Yield (Max)	Description of Yield Intersections and Ground Conditions
HMKB0006 Abandoned	-	<ul style="list-style-type: none"> Hole abandoned due to loss of circulation from 54m in TD3. No FWS had been recorded at that stage
HMKB0021	10-15 L/s	<ul style="list-style-type: none"> FWS @ 54 mbgl in D2. No water quality measurement and Yield was taken during the drilling. Unstable and loose ground from 0 – 30 mbgl in TD3 BROKEN GROUND recorded from 72 – 102 m in D2 and D1. Black and pyritic shale from 112 – 120 mbgl (RU). Estimated Yield of 10 – 15 L/s at the EOH (120 mbgl).
HMKB0007	30+ L/s	<ul style="list-style-type: none"> FWS @ 54 mbgl in unmineralised and cherty D2. Increase Yield to 3 L/s at 66 mbgl. 68 – 100 mbgl (Unmineralised D2): Extremely BROKEN ZONE associated with large chips (10 – 55 mm) and Yield increased from 12 L/s at 72 mbgl to 20+ L/s at 78 mbgl (Figure 16). Further big increase to 25 L/s at 84 mbgl in D2. Driller noted broken ground from 68 – 100 mbgl (unmineralised D2). Minor Back shale and trace of pyrite from 120 – 132 mbgl (RU). Steady 25 – 30+ L/s from 84 mbgl to the EOH (132 mbgl).
HMKB0016P Pilot hole HMKB0007	40 L/s	<ul style="list-style-type: none"> FWS at 50 mbgl in D2. Yield increased from 5 to 25+ L/s between 65 – 86 mbgl, associated with broken ground at same interval. Yield increased from 25 to 40 L/s at 113 mbgl, associated with BROKEN GROUND from 92 to 113 mbgl. Black shale intersected at 113 – 119 mbgl. Final estimated yield of 40 L/s after 15 hours of airlifting.
HMKB0008	25+ L/s	<ul style="list-style-type: none"> FWS @ 54 mbgl in VB2. Yield of 7 L/s at 66 mbgl in unmineralised D2. Cavities noted between 66-78 mbgl in unmineralised D2. 88 – 102 mbgl (Unmineralised D2): BROKEN ZONE associated with large chips (10 – 40mm) and Yield increased from 7 L/s at 90 mbgl to 20 L/s at 102 mbgl (Figure 17). Flow of 15 L/s from 114 – 126 mbgl in D1. Broken ground also noted from 120 – 126 mbgl in D2. Steady yield of 20 L/s from 132 mbgl to 138 mbgl in unmineralised D1. Increase in flow to 25 L/s at 144 mbgl in RU. Estimated Yield of 25+ L/s at the EOH (150 mbgl) in RU.
HMKB0009	15 L/s	<ul style="list-style-type: none"> FWS @ 60 mbgl with 4 L/s at the contact TD2 (Silicified Calcrete: Figure 18) – D4. 68 – 84 mbgl (Mineralised D3): BROKEN ZONE associated with large chips (4 – 27 mm) and trace of Qtz chips at 70 – 72 mbgl. Yield increased to 6 L/s at 66 mbgl and to 10 L/s at 78 mbgl. Further increase to 12 L/s at 84 mbgl and to 15 L/s at 108 mbgl in mineralised D2. Steady yield of 15 L/s to the EOH (177 mbgl). From 170 mbgl: minor manganiferous shale with manganese nodules (Figure 19). Looks more of the bottom of D1 than the top of RU (McRae Shale).

Hole Name	Yield (Max)	Description of Yield Intersections and Ground Conditions
<p>HMKB0010 Abandoned</p>	<p>8.5 L/s</p>	<ul style="list-style-type: none"> Slightly broken ground from 54 mbgl to the EOH (150 mbgl). Driller recorded more like "Honeycomb" texture than broken ground. FWS @ 60 mbgl in Mineralised Dale Gorge unit (D4?) with Yield of less than 1 L/s. Yield increased to 3 L/s at 72 mbgl at the potential contact D4/D3, due to an increase in shale. Slightly Flows increased to 5 L/s at 78 mbgl and to 7 L/s at 90 mbgl in potential D3. Yield increased to 8 L/s at 102 mbgl in D2? and to 8.5 – 9 L/s at 132 mbgl in D1?. Steady 8.5 L/s from 132 mbgl to the EOH (150 mbgl). RU from 147 mbgl, on the basis of TD0030R (hole drilled on the same pad). Visible Detrital contamination in samples from 102 mbgl and samples fully contaminated from 132 mbgl. At the end of the drilling hole collapsed to 30 mbgl. 1st fallback from 130 mbgl and 2nd and last fallback from 56 mbgl at the contact Detrital – Bedrock. Driller suggested to case all the Detrital section in the next hole.
<p>HMKB0015P Pilot hole HMKB0010</p>	<p>25 L/s</p>	<ul style="list-style-type: none"> FWS at 68 mbgl with yield of 0.5 L/s Extremely BROKEN GROUND between 68 – 100 mbgl, 108 – 118 mbgl and then 128 – 151 mbgl, all associated with chips up to 40 mm and an increase in groundwater yield from 1 L/s at 68 mbgl to 10 L/s at 98 mbgl. Further increase to 15 L/s at 110 mbgl and then to 25 L/s in broken ground between 110 – 118 mbgl. Yield visually estimated to be 25+ L/s at EOH. Final estimated yield of 25 L/s after 25.5 hours of airlifting.
<p>HMKB0011</p>	<p>8 L/s</p>	<ul style="list-style-type: none"> FWS at 62 mbgl in mineralised D3 with a yield of 2 L/s. Yield increased to 4 L/s at 68 mbgl and to 6 L/s at 80 mbgl in mineralised D3. Steady flows of 7 L/s from 98 (D2) – 140 mbgl (RU) Estimated final yield of 8 L/s from 146 mbgl to the EOH (148 mbgl). BROKEN GROUND from 62 – 110 mbgl (mineralised D3 & D2) and highly broken grounds was recorded from 128 – 146 mbgl in R.
<p>HMKB0012</p>	<p>20+ L/s</p>	<ul style="list-style-type: none"> FWS @ 48 mbgl in TD2. Incomplete yield data from 48 – 96 mbgl, but driller reported broken ground throughout interval, confirmed by chip samples brought up. Yield estimated at 5 L/s at 102 mbgl in mineralised D2, but is likely conservative Heavily BROKEN INTERVAL from 98 – 104 mbgl (mineralised D2), with chips up to 70 mm contributing significantly to yield. Competent ground to 104 – 134 mbgl (mineralised D2 & unmineralised D1) with only gradual increase in yield to 8 L/s, then a doubling of yield to 20+ L/s over broken ground between 134 – 156 mbgl (EOH) in unmineralised D1 (120 – 146 mbgl) and RU (146 – 156 mbgl).
<p>HMKB0017P Pilot hole HMKB0012</p>	<p>45 L/s</p>	<ul style="list-style-type: none"> FWS @ 56 mbgl at the contact TD2-D3 with Yield 0.5 L/s. Slightly flow increase to 2 L/s at 68 mbgl and to 5 L/s at 74 mbgl. Yield increase to 10 L/s at 86 mbgl in D2 and to 15 L/s at 98 mbgl in D2. 20 L/s at 128 mbgl in D1 and Yield of 25 L/s at 134 mbgl. Yield of 25+ L/s in D1 from 140 to the EOH (152 mbgl) at the end of drilling. Final estimated yield for 45 L/s after 46.25 hours of airlifting. No broken ground or cavities recorded during DR drilling. Soft material in the Detrital unit and Medium hard ground noted in the Dales Gorge units.

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Hole Name	Yield (Max)	Description of Yield Intersections and Ground Conditions
HMKB0013	15+ L/s	<ul style="list-style-type: none"> FWS @ 54 mbgl at the contact TD2 – D3 with Yield 1 L/s. Slightly flow increase to 2 L/s at 72 mbgl to 4 L/s at 90 mbgl in D2 and to 5 L/s at 114 mbgl in D1. BROKEN GROUND between 48 – 72 mbgl (unmineralised D3 & D2) and consolidated from 72 – 115 mbgl, where a saturated broken ground was reported. Yield increase to 10 L/s at 120 mbgl in D1. Steady 10 L/s to 144 mbgl in R. Final estimated yield of 15+ L/s in R.
HMKB0014	25+ L/s	<ul style="list-style-type: none"> FWS at 46 mbgl in TD2 (CA2) with Yield of 2 L/s. Yield increased gradually to 4 L/s at 54 mbgl (TD2) and to 8 L/s at 66 mbgl in Mineralised D3. BROKEN GROUND noted from 66 – 84 mbgl in D3/D2. Flow increase to 12 L/s at 96 mbgl in unmineralised D2 and to 17 L/s at 102 mbgl in unmineralised D2. Further increase to 20 L/s at 108 mbgl (D2) and steady 20 L/s to 138 mbgl in D1, associated with broken ground recorded by driller (126 – 132 mbgl). Increase in flow to 22 L/s at 144 mbgl in D1. Cavity noted from 133 – 144 mbgl in unmineralised D1. Yield of 25 at 150 mbgl (RU). Estimated Final Yield of 25+ L/s from 150 to 166 mbgl (EOH). Black shale from 146 mbgl. Heavy Detrital contamination in samples from 106 to the EOH (166 mbgl). No 8" surface casing was installed in this bore.

During the drilling of the monitoring bores a broken interval was discovered in most bores around 68 – 104 mbgl in D2 Member (HMKB0007M, HMKB0008M and HMKB0014M) and D3 Member (HMKB0009M). These broken zones (Figure 16 and Figure 17) were associated with yield increases and larger chips size (20 – 55 mm).

HMKB0007M provided the best broken ground condition. The bore was drilled to 132 mbgl and constructed only to 92 mbgl due to 40 metres of fallback caused by extremely broken ground and high volume of water (30+ L/s). Accordingly with this outcome, one production bore was constructed on the same pad (HMKB0016P). According to the outcomes from the Monitoring bores it was decided to drill the other two production bores on pad 05 (HMKB0015P – HMKB0010) and pad 07 (HMKB0017P – HMKB0012M).



Figure 16: HMKB0007M: Broken Ground

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Figure 17: HMKB0008M: Broken Ground

Examples of silicified calcrete and manganese nodules from HMKB0009M are shown in Figure 18 and 19 below.



Figure 18 and 19: HMBK0009M: Silicified Calcrete or Silcrete (CA2) and black Manganese Nodules (N).

4.2 Field Groundwater Quality and Water Level Measurements

Water quality and water level measurements taken in the field are summarised in Table 5 below.

- Tested groundwater is fresh with EC between 670 $\mu\text{S}/\text{cm}$ and 1,240 $\mu\text{S}/\text{cm}$.
- Temperature ranged between 22.8° and 30.4°.
- The pH levels recorded were relatively consistent and ranged from 7.76 to 8.50.

Table 5: Summary of Groundwater Quality and Water Level Field Measurements

Hole Name	Last EC ($\mu\text{S}/\text{cm}$)	Last pH	Last Temp ($^{\circ}\text{C}$)	TOC RL (mAHD)	Water Level (mAHD)	Stick up (m)	SWL (mbgl)	FWS (mbgl)
HMKB0007	920	7.83	26.8	728.42	683.66	1.00	43.76	52
HMKB0008	910	8.31	24.0	731.29	683.54	0.98	46.77	54
HMKB0009	1,140	7.97	25.6	729.87	683.53	0.80	45.54	60
HMKB0011	895	8.50	26.5	729.42	683.54	0.89	44.99	62
HMKB0012	880	8.30	27.0	725.942	683.59	0.95	41.40	48

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Hole Name	Last EC (µS/cm)	Last pH	Last Temp (°C)	TOC RL (mAHD)	Water Level (mAHD)	Stick up (m)	SWL (mbgl)	FWS (mbgl)
HMKB0013	670	8.02	22.8	726.97	683.55	0.73	42.69	54
HMKB0014	950	8.30	28.0	726.49	683.53	0.90	42.06	46
HMKB0015P	1240	8.27	28.9	733.87	683.36	0.34	50.17	68
HMKB0016P	1040	7.99	30.1	729.05	683.54	0.36	45.12	50
HMKB0017P	960	7.76	30.4	725.44	683.35	0.39	41.70	56
HMKB0021	-	-	-	731.20	683.56	1.08	46.56	54

5 Hydrochemistry Analysis

Groundwater samples were collected from the production bores at the end of the development process and were submitted to SGS Laboratory for comprehensive suite analysis. The SGS test certificates are available in ioWater.

- Tested groundwater is fresh with EC between 930 and 1200 µS/cm;
- Temperature ranged between 28.9° and 30.4°;
- The pH levels recorded were also relatively consistent throughout the program and ranged from 8.3 to 8.4;
- No laboratory samples were taken from monitoring bores.

Laboratory analysis results for the three Mick Bore production bores are summarised in **Table 6** below:

Table 6: Laboratory Analysis Results

Sample ID	CATIONS					ANIONS			WQ DATA		
	Na	K	Ca	Mg	Fe	HCO ₃	SO ₄	Cl	pH	EC	TDS
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pH units	µS/cm	mg/L
HMKB0015P Screened in D3, D2, D1	74	11	78	60	<0.005	390	110	150	8.3	1200	670
HMKB0016P Screened in D2, D1	52	9.2	64	46	<0.005	330	84	96	8.4	960	610
HMKB0017P Screened in D3, D2, D1	56	9.5	62	45	0.010	290	87	95	8.3	930	550

Since the MAC and South Flank operations could be utilising a future MAR scheme at Mick's Bore, the water sample chemistry from two production bores in Dead End (HGF0044P and HGF0045P), two bores in West Packsaddle (HNPIAC0001P and HNPIAC0002P), and two production bores in South Flank (HSF0102P and HSF5570P) have been included for comparison with the Mick's Bore samples.

Laboratory analysis results for these comparison six bores are summarised in **Table 7** below:

Table 7: Laboratory Analysis Results for comparison

Sample ID	CATIONS					ANIONS			WQ DATA		
	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	Fe mg/L	HCO3 mg/L	SO4 mg/L	Cl mg/L	pH pH units	EC µS/cm	TDS mg/L
HGF0044P* <i>Screened in N1, MM</i>	25	8.2	43	26	<0.005	260	35	33	8.0	640	390
HGF0045P* <i>Screened in N3</i>	27	8.6	49	31	<0.005	290	36	36	8.0	630	360
HNPIAC0001P** <i>Screened in OB</i>	25	8	60	36	0.008	317	45	44	7.9	710	430
HNPIAC0002P** <i>Screened in OC, OB</i>	27	8.2	60	37	0.024	317	47	46	8.0	720	430
HSF0102P*** <i>Screened in WA1, N3, N2, N1</i>	28	13	49	27	<0.005	290	30	27	7.9	590	340
HSF5570P*** <i>Screened in WA1, N3, N2, N1</i>	33	9.2	40	31	<0.005	260	47	40	8.2	580	330

* Production bores in Dead End, ** Production bores located in West Packsaddle, *** Production bores situated in South Flank.

See **Figure 20** below for the production bores locations.

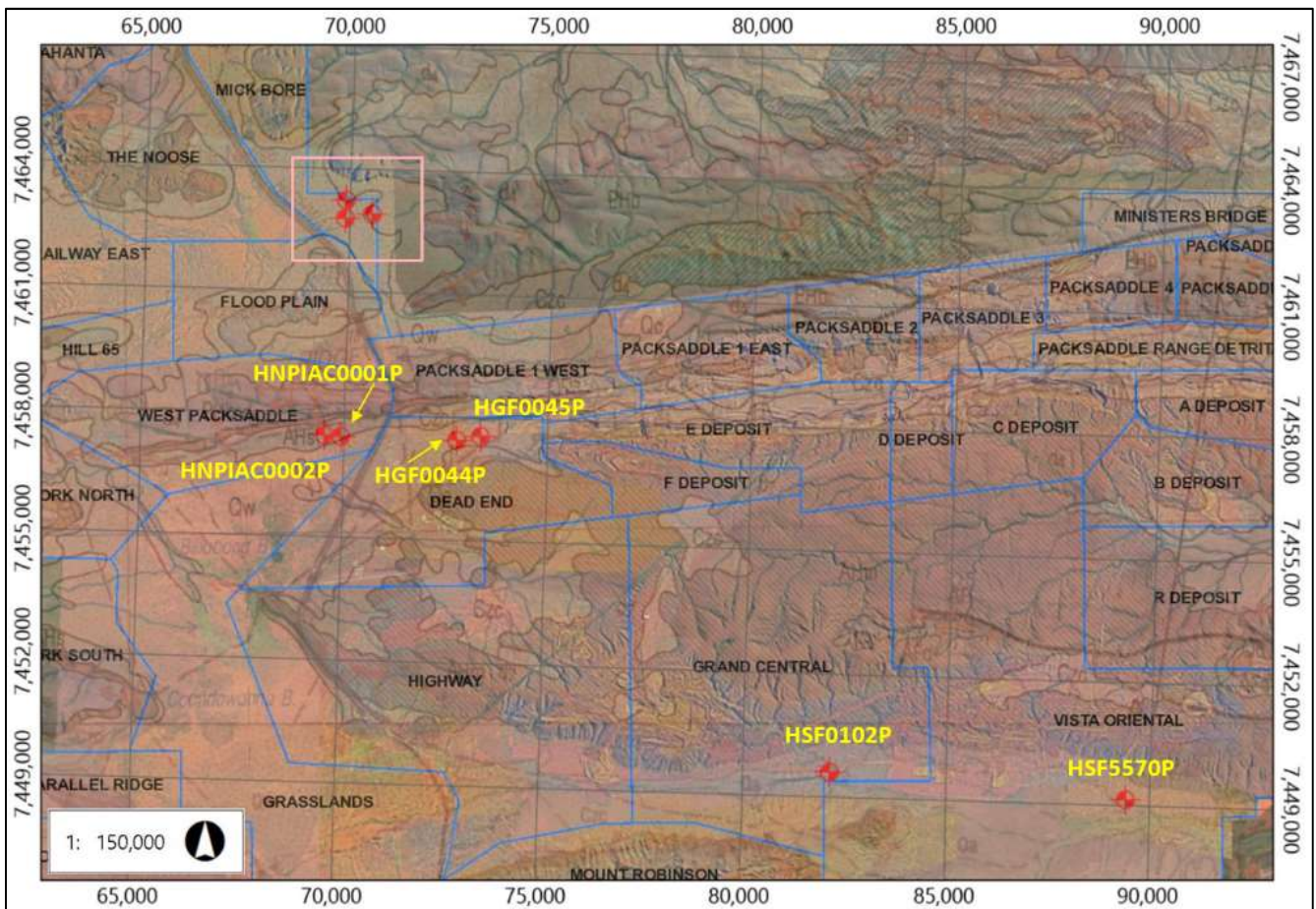


Figure 20: PBs Location for evaluation

These sample points were plotted onto a Piper and Expanded Durov Plots (Figure 21 and Figure 22) to assess the water type category and water type sub fields for the analysed samples.

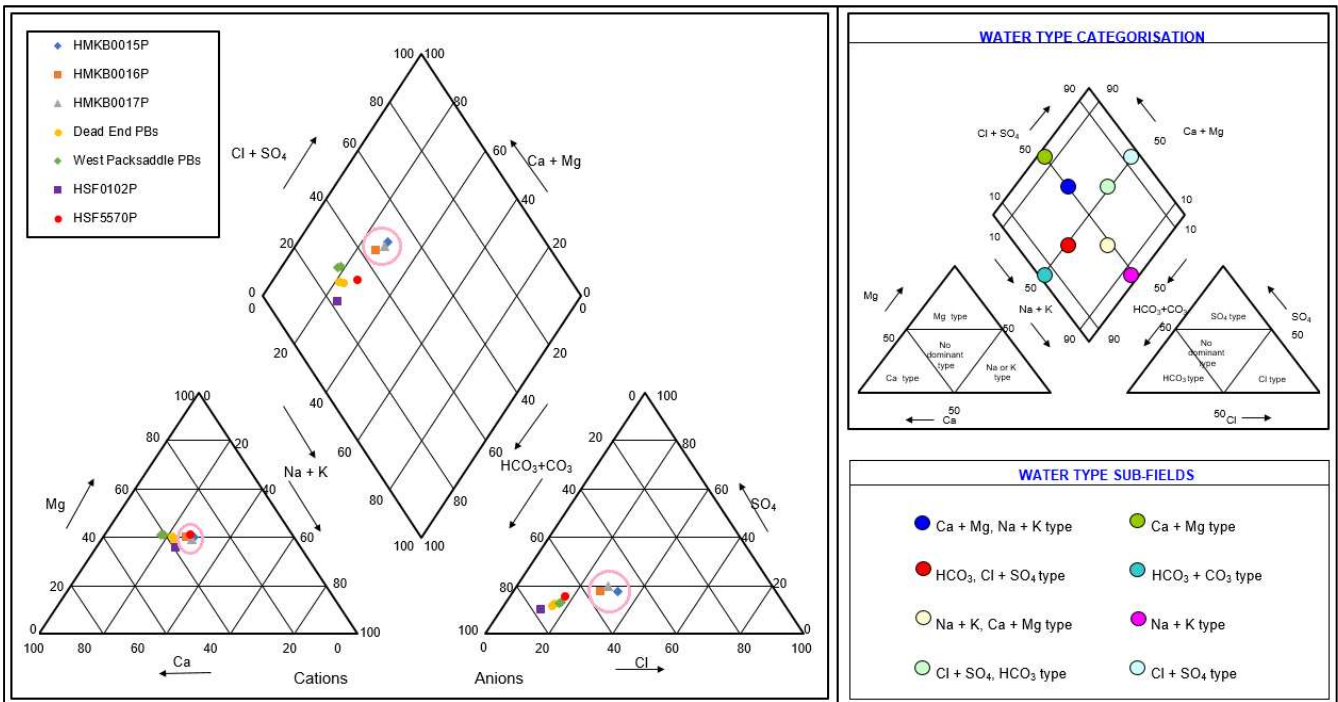


Figure 21: Piper Diagram for all the Production Bore Water Samples

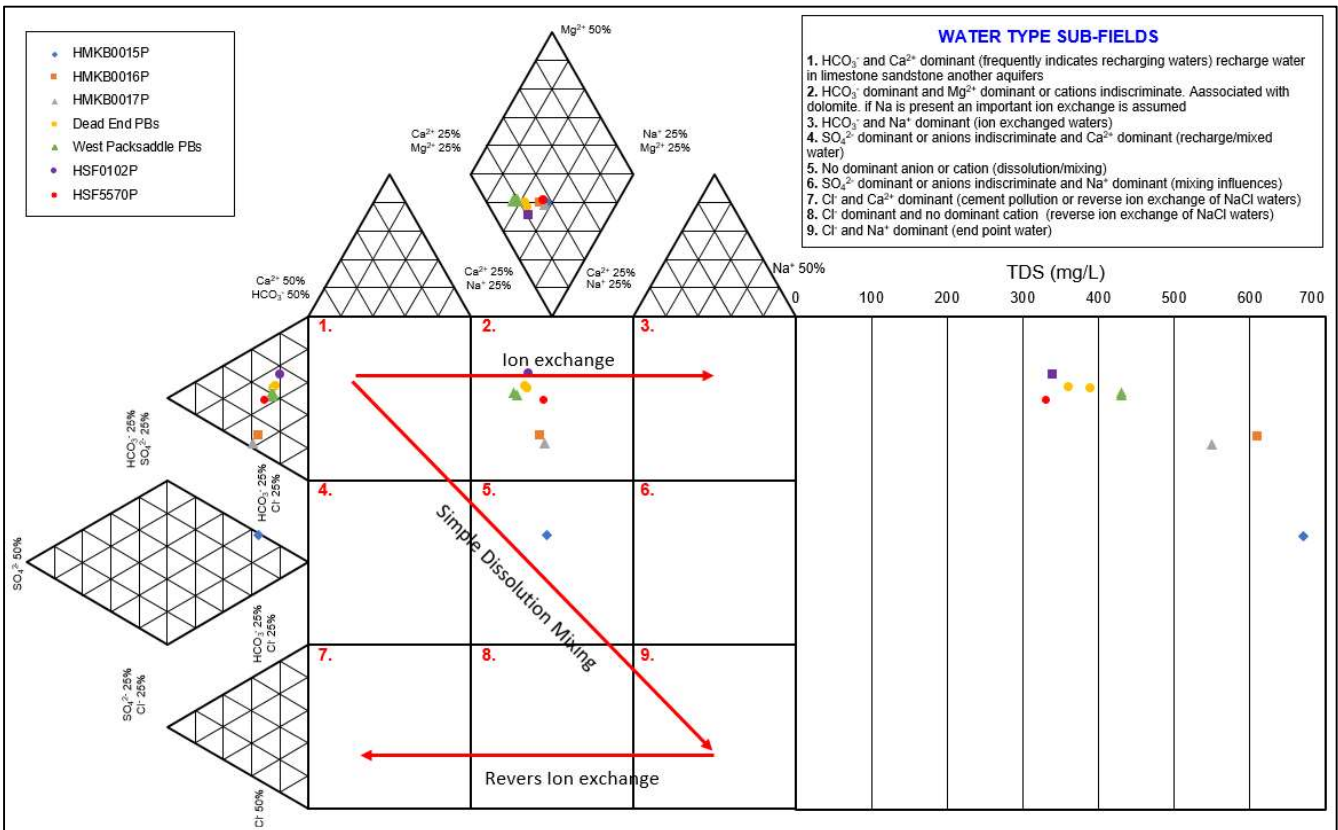


Figure 22: Expanded Durov Diagram for all the Production Bore Water Samples

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The following observations can be made from the groundwater chemistry data shown in **Table 6** and **Table 7**, and from the Piper and Expanded Durov plots with future MAR re-injection taken into consideration:

- On average the groundwater Total Dissolved Solids values for the aquifers at Mick's Bore are higher than the groundwater at Dead End, West Packsaddle and South Flank. This is a positive factor for re-injection because a fresher source will be introduced into the Mick's Bore aquifer. This is also a positive factor for screen longevity and well efficiency behaviour as lower Total Dissolved Solids injection water will have a lower rate of causing encrustation of screens or clogging of the filter pack and surrounding formation.
- Essentially all anion and cation concentrations in the likely re-injection source water (from Dead End, West Packsaddle and South Flank) are lower than in the Mick's Bore aquifers. Positive factor.
- Higher dissolved iron (Fe) concentrations are however present in the likely source water compared with the Mick's Bore aquifer, and this may present some cause for concern for future re-injection. There may be a need to treat re-injection water to reduce the dissolved iron concentration.
- The slight differences in hydrochemistry shown in the Piper and Expanded Durov plots between the West Packsaddle and Mick's Bore samples suggests that these two aquifers are not directly connected.
- Additional examination of the comprehensive analysis suite for the bores shows that the source water bores in Mick's Bore is slightly higher in Barium, Boron and Chromium compared with Dead End and South Flank aquifer. Trace Metals (Dissolved) in Water data for all nine production bores are presented in **Appendix III**.

6 DRILLING PERFORMANCE ASSESSMENT

6.1 Drilling Execution Risks

HMBK0011M was drilled with the DR method with no drilling issue. The hole was drilled to 148 mbgl but the installation was completed only to 142.5 mbgl due to 5.5 m of fallback.

All the other monitoring bores were drilled with the CH Conventional Drilling Method. The ground encountered was quite loose and unstable in the Pisolitic interval (TD3). For this reason, in most of the bores, a deeper surface casing was installed to case the Detrital zone.

The Percussion drilling method was probably not the best option for the purpose of this program. Considering the difficulties faced with then poor ground condition in the detrital zone and especially in the Tertiary Detrital sequence (TD3) the Mud or DR drilling would have been a better choice.

A deeper surface casing was not installed during the drilling of HMKB0006 and HMKB0010 that were abandoned due to the collapse of surface detritals zone. To prevent this failure a surface casing could have been installed to deeper levels.

HMKB0014M was drilled to 166 mbgl without drilling difficulties and no deep surface casing was installed in this monitoring bore. However, heavy detrital contamination was noted in the samples from 106 – 166 mbgl (EOH). Due to this contamination it was quite hard to describe the hydrogeological characteristics of the material encountered. Fortunately, the logging was confirmed by the gamma survey.

During the drilling of HMKB0007M, 32 meters of broken zone was noted between 68 – 100 mbgl causing slow drilling and high water flow. Due to this high rate (25+ L/s) the sump filled in a short amount of time and at depth of 132 mbgl the drilling was stopped for safety reason.

The three production bores were drilled with DR Drilling method with no major issue encountered during drilling.

The DR drilling method was the best option for the purpose of this program.

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6.2 Drilling Completion Performance

An average of eight shifts was required to drill and construct a single monitoring bore, a slightly higher value than expected for a typical monitoring bore. This was caused by the installation of the double steel surface casing (8" and 12") that was cemented to avoid the collapse of the detrital zone. The mixing and grouting operation (**Figure 23, 24, 25 and 26**) required at least four shifts for the grout to set.

An average of 24 shifts was required to drill and construct a single production bore. This number of shifts was due to the installation of a thick surface grout seal (from 0 to 50 – 55 mbgl) and one or two metres of bentonite seal below that to meet Minimum Construction Requirements for reinjection bore propose. The grouting operation required at least five shifts for each bore.



Figure 23, 24, 25 and 26: Grouting and Mixing Operation

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7 CONCLUSIONS

The drilling program resulted in the successful construction of a total of eight monitoring bores and three production bores. The primary objectives of this program to build upon the data collected in the Phase 1 program and drill a series of pilot and production bores to determine the viability for a MAR scheme at Mick's Bore, was achieved.

Due to the poor ground condition and the thickness of the Tertiary Detritals, it was not possible to install all monitoring bores; two bores were abandoned and fully decommissioned (HMKB0006 and HMKB0010).

Despite this, the hydrogeological information obtained from the program improved the knowledge of prospective aquifers and provided a better understanding of the aquifer setting. Broken ground and high airlift yields were recorded at almost all of the pilot holes and these outcomes suggest a potential viability for a MAR in the area.

This investigation into the hydrogeology at Mick's Bore has shown it to have the following aquifer conditions that may be suitable for a future MAR injection scheme:

- The thickness and extent of the inferred high permeability fractured bedrock aquifer (Unmineralised Dales Gorge Member BIF) is likely to provide high transmissivity to allow for injected water to be efficiently distributed in the aquifer.
- A Yield of 20+ L/s was estimated in most of the monitoring bores and high yields (40 – 45 L/s) were estimated in the production bores.
- On average the groundwater Total Dissolved Solids values for the aquifers at Mick's Bore are higher than the groundwater at Dead End, West Packsaddle and South Flank. This is a positive factor for re-injection because a fresher source will be introduced into the Mick's Bore aquifer. This is also a positive factor for screen longevity and well efficiency behaviour as lower Total Dissolved Solids injection water will have a lower rate of causing encrustation of screens or clogging of the filter pack and surrounding formation.
- A further positive factor is that all anion and cation concentrations in the likely re-injection source water (from Dead End, West Packsaddle and South Flank) are lower than in the Mick's Bore aquifers.

Table 8 presents a summary of the various components that require consideration when planning a MAR scheme, with a rating for each aspect based on the current data obtained during the Phase 2 Mick's Bore hydrogeological investigation.

Table 8: Managed Aquifer Recharge prospectively assessment (Managed Recharge, 2020)

Prospective Injection Bore Site	High potential	Moderate potential	Low potential
Proximal to mining operations		Approximately 20 km to the northwest of the MAC/South Flank mining hub.	
Aquifer Thickness	Thickness of saturated Dales Gorge Member between 74 – 87 m (from bottom of TD2 to the contact with Mt. McRea Shale). Thickness of saturated TD2 between 1.5 – 16 m (from the SWL to the bottom of TD2).		
High transmissivity and storativity	Additional Pump Testing program required, however the ground condition encountered during drilling indicates potentially high transmissivity.		
Structurally enhanced permeability	Broken ground and cavities/voids noted.		

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Prospective Injection Bore Site	High potential	Moderate potential	Low potential
Compatible GW salinity / chemistry	Salinity slightly higher in receiving aquifer, geochemical modelling required.		
Compatible GW trace metal /hydrochemistry	Barium, Boron and Chromium content slightly higher in receiving aquifer.		
Significant depth to GW (Unsaturated zone)	41 – 47 mbgl.		
Proximity to receptors	No GDEs or surface hydro features supported by GW.		

Another important factor to consider when dealing with MAR, it is the redox state of the receiving groundwater compared to the injection water. If receiving water is highly anoxic (high Fe, high Mn, no NO₃, no O₂) and the injection water is oxygenated, than precipitation of iron or manganese oxides it may be possible. Also, an additional precipitates could be CaCO₃. The precipitation of these minerals could lead to severe clogging of boreholes.

8 RECOMMENDATIONS

For the next drilling programs, there a few recommendations that can be highlighted:

- Due to the high volume of water encountered, it would be beneficial to build bigger sumps, especially in the production bore locations.
- Future bores should be drilled with mud rotary drilling or DR methods, considering the difficulties faced with then poor ground condition in the detrital zone and especially in the Tertiary Detrital sequence (TD3).
- Pumping tests should be performed to ascertain potential bore yields/injection capacity and to determine aquifer characteristics at each site location. Particularly, CRT's should be conducted at each injection bore to generate pumping drawdown curves for each bore and to obtain transmissivity and storativity data for each site. Such hydraulic testing may also identify any hydraulic boundaries that may have long-term detrimental effects on an injection scheme.
- All injection bores should have annulus seals from surface down to the top of the productive zone to ensure water injected under pressure cannot leave the bore via the annulus. This can improve efficiency and enable higher injection rates in addition to meeting Minimum Construction Requirements.

For the potential MAR scheme the following aspects require consideration and additional assessment and review:

- The source water hydrochemistry that may be sent for re-injection at Mick's Bore requires detailed assessment in order to ensure that Department of Water and Environmental Regulation (DWER) approval to inject can be obtained.
- Similarly, the source water hydrochemistry requires assessment to decide whether any pre-treatment may be required before re-injection takes place. (e.g. to reduce dissolved iron concentrations).
- The calcrete unit and TD3 gravels may require assessment for stygofauna and troglafauna populations as these would be affected by mounding of the water table.
- It would be beneficial to carry out a field sampling and testing exercise at selected monitoring bores or production bores to assess the aquifer REDOX conditions as part of the design planning for any future MAR scheme. Furthermore, it would be relevant to run a mixing model with Phreeqc to get a first rough idea of compatibility and potential over/undersaturation in respect to common minerals.

BHP

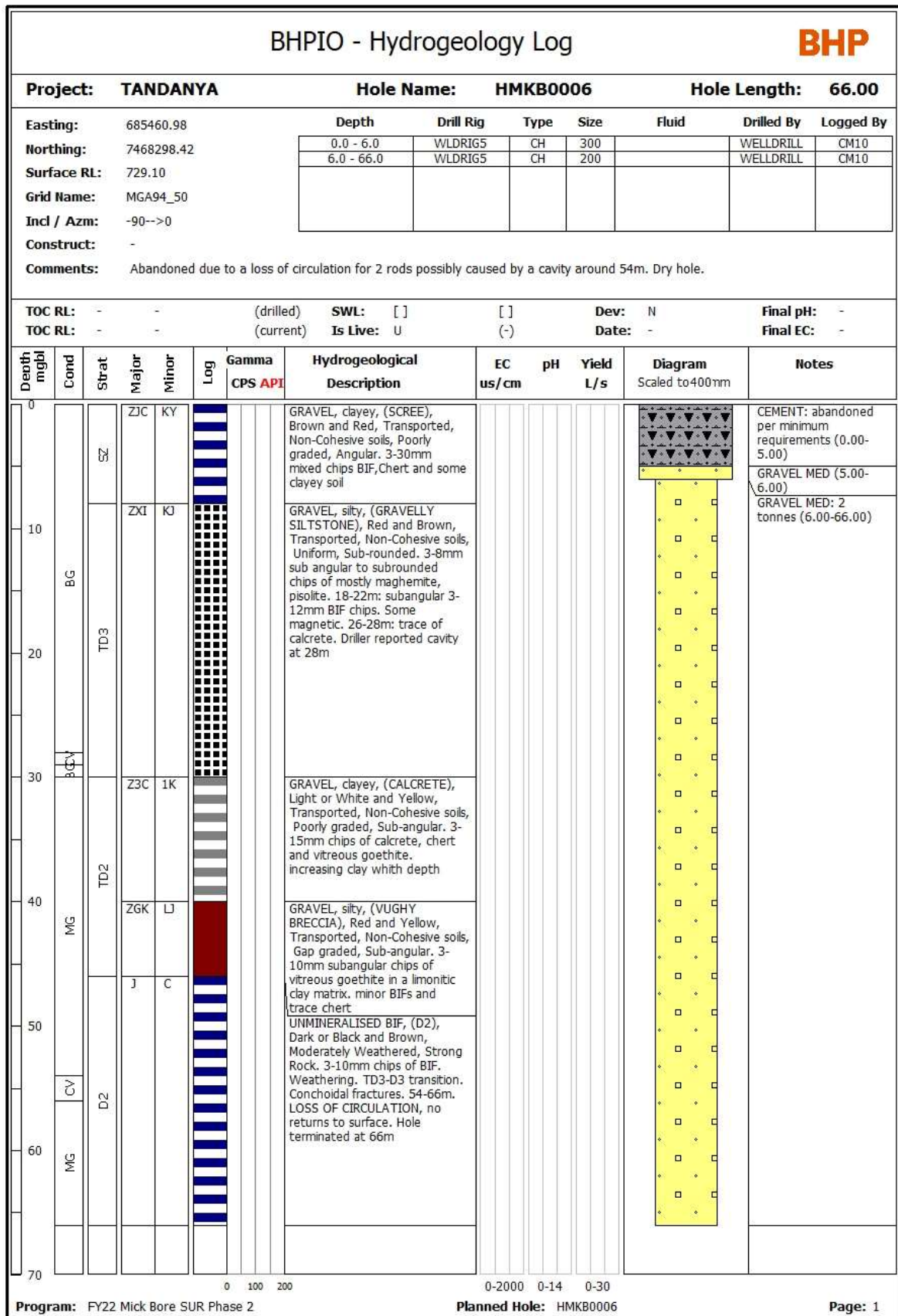
9 LOGGING REFERENCE MATERIAL

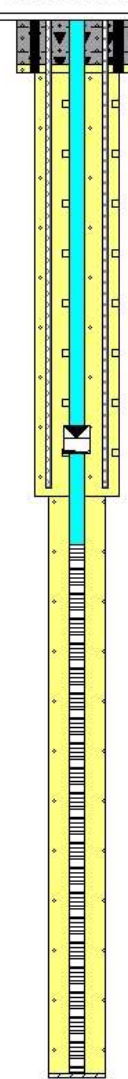
A reference sheet containing descriptions of the various geological and hydrogeological data presented on the bore logs is provided in **Appendix IV**.

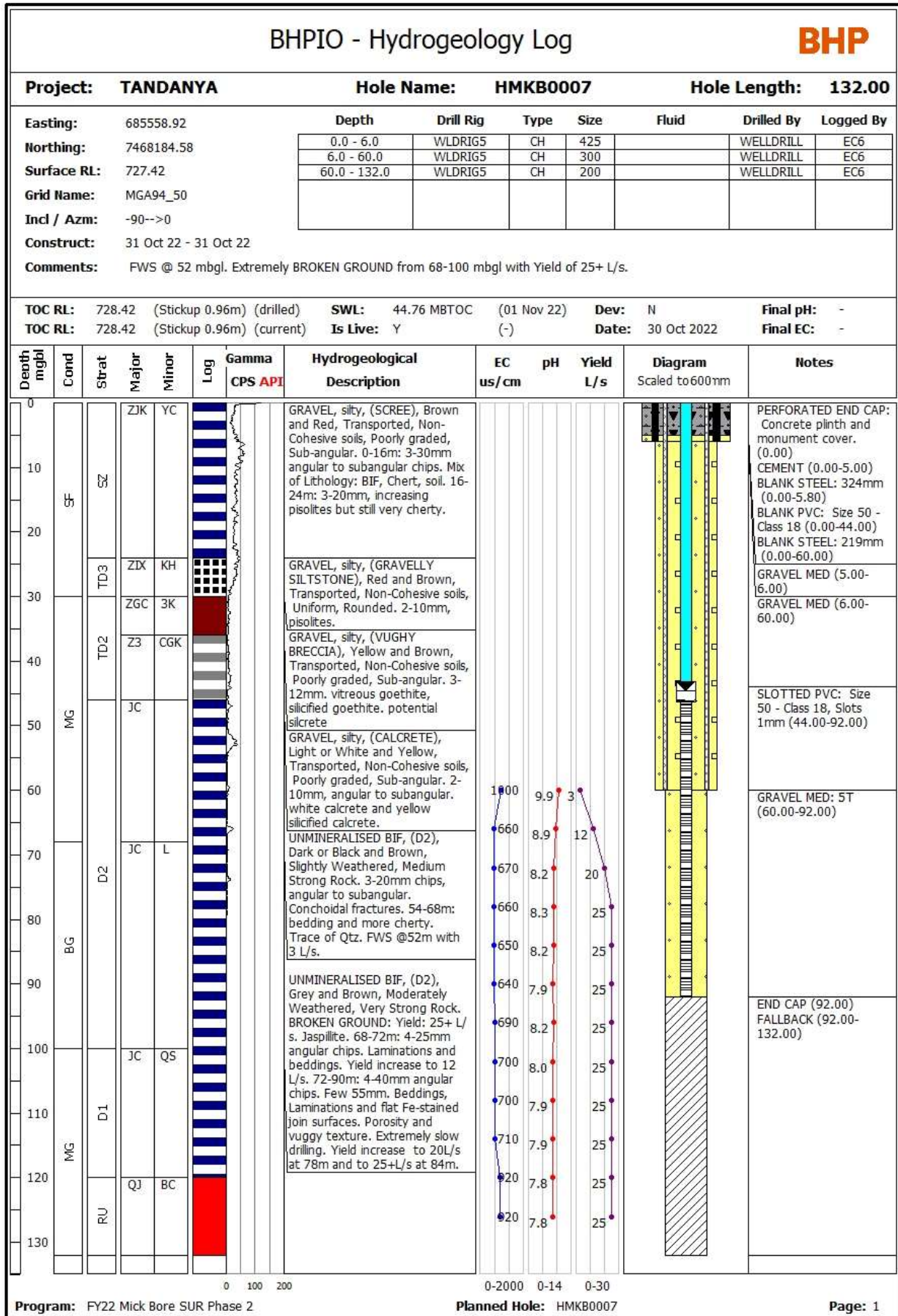
10 REFERENCE

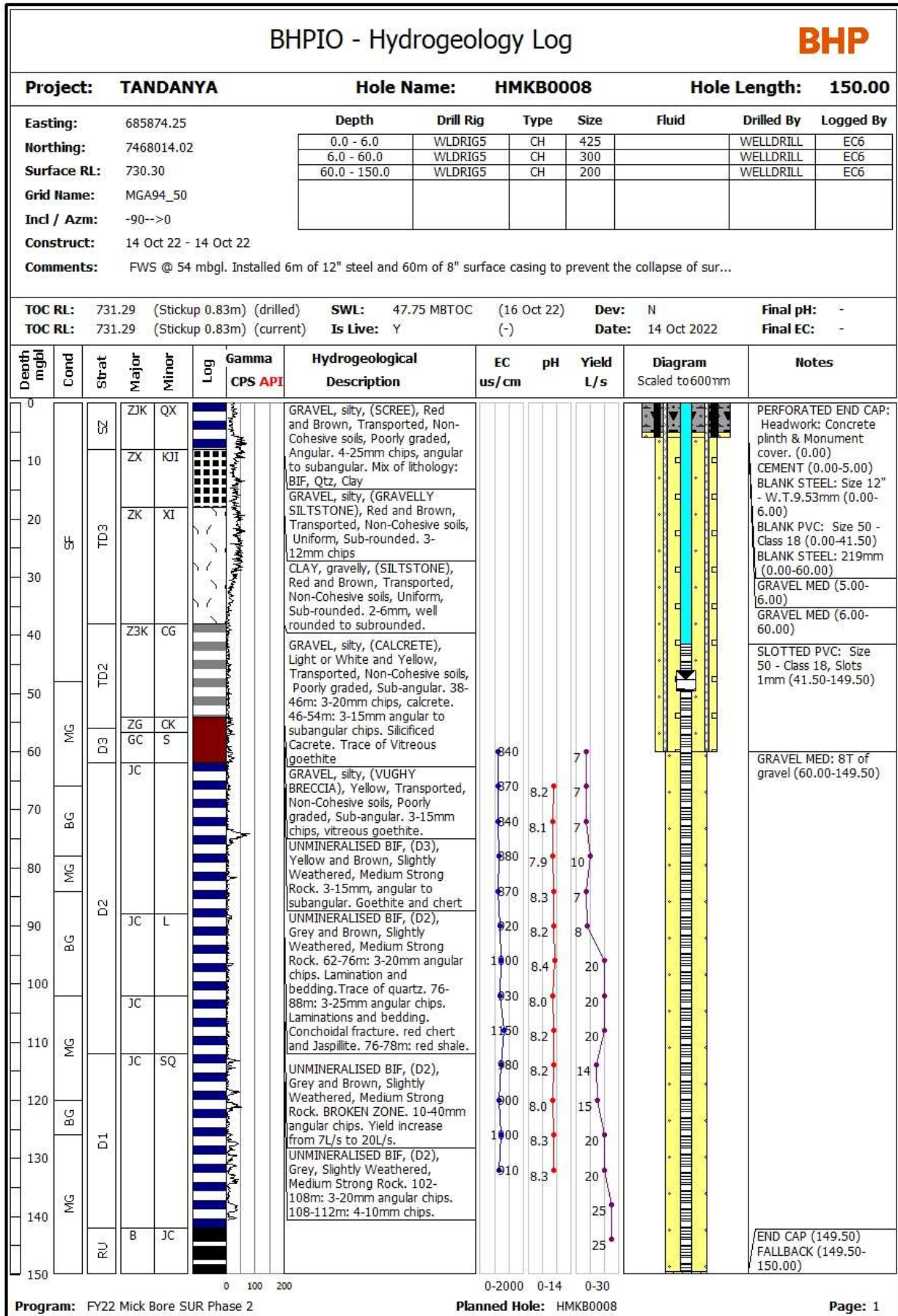
Tabain. N. (2023) AEM For Hydrogeology. WAIO Share to Coal

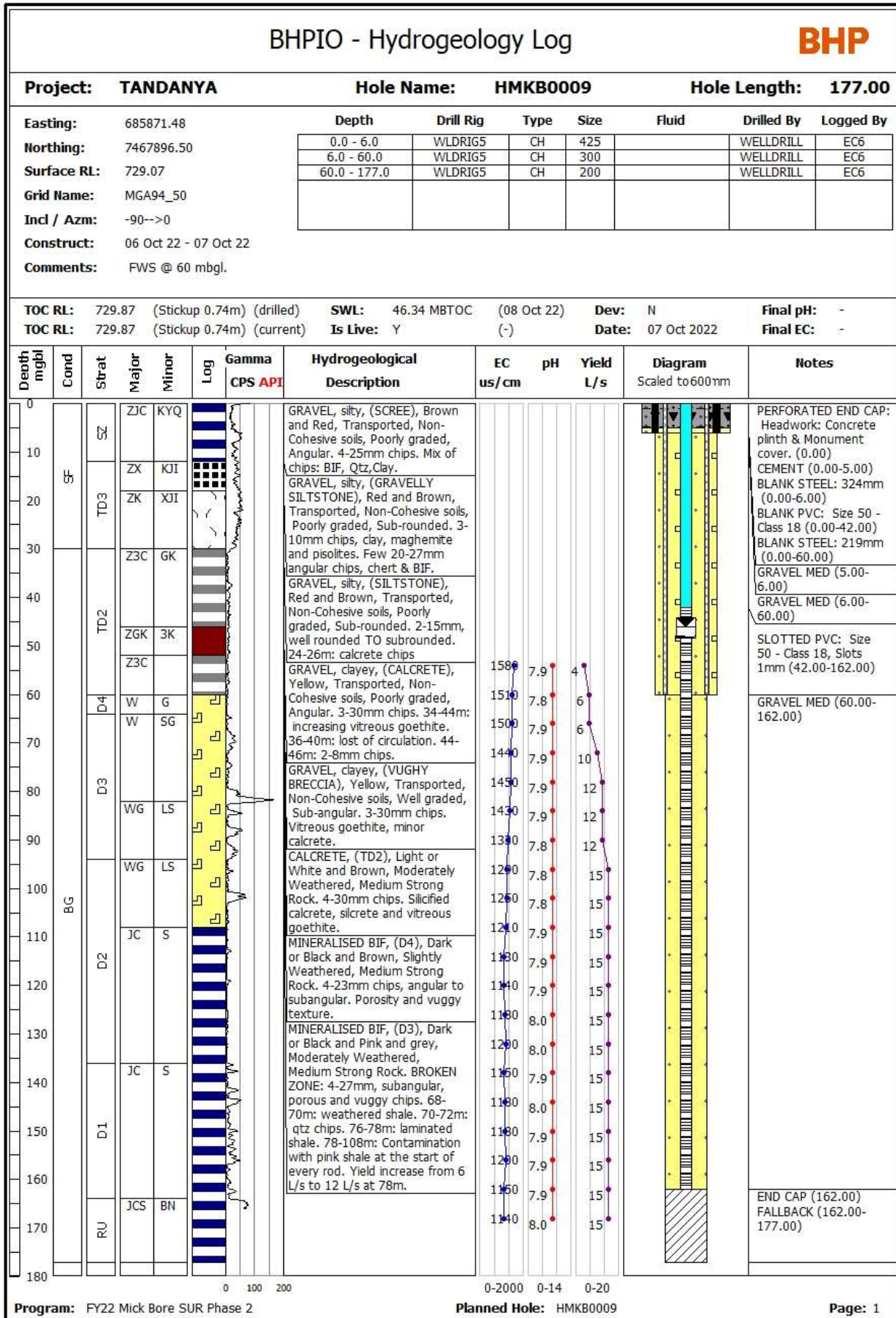
Appendix I Bore Hydrogeology Log

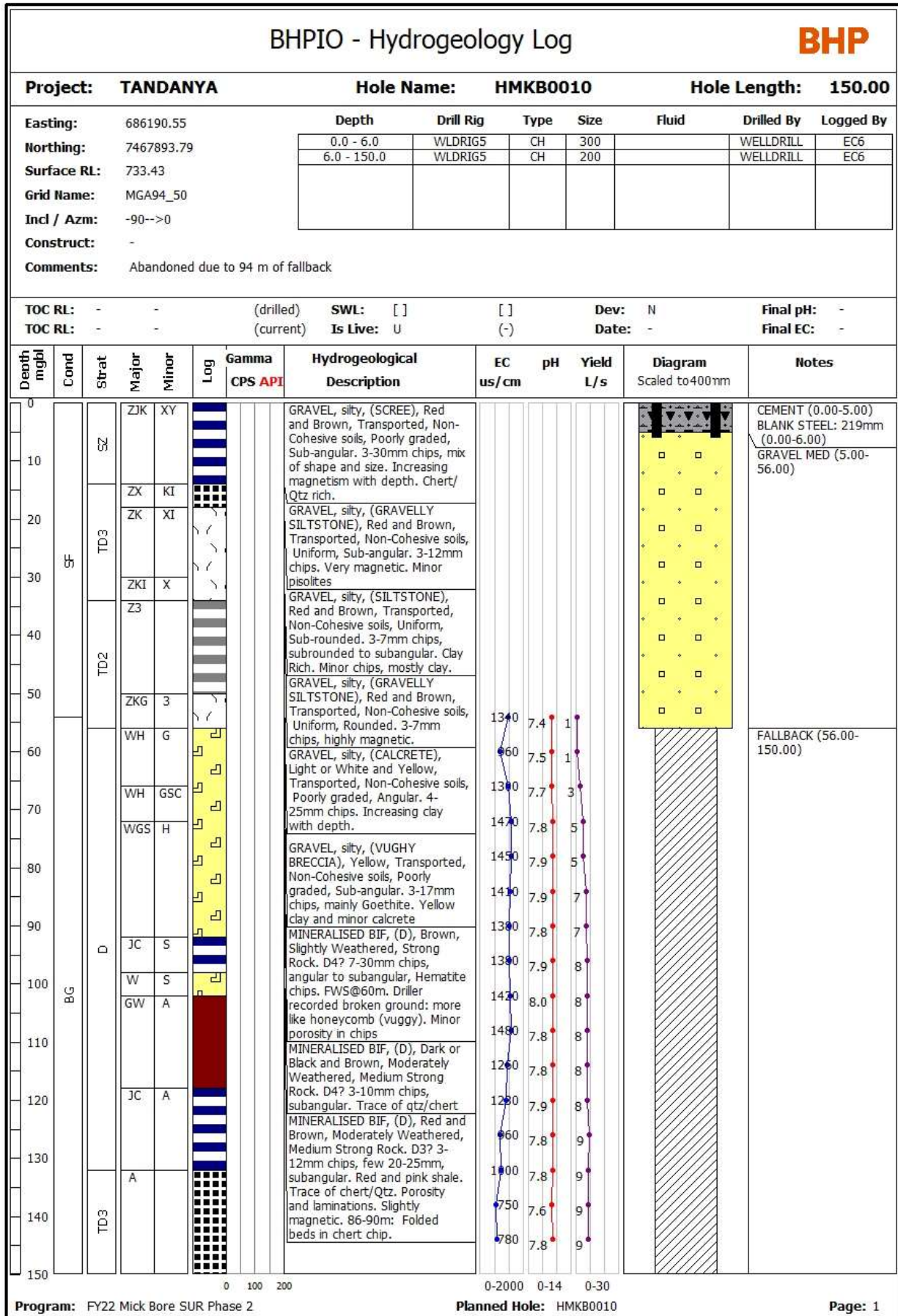


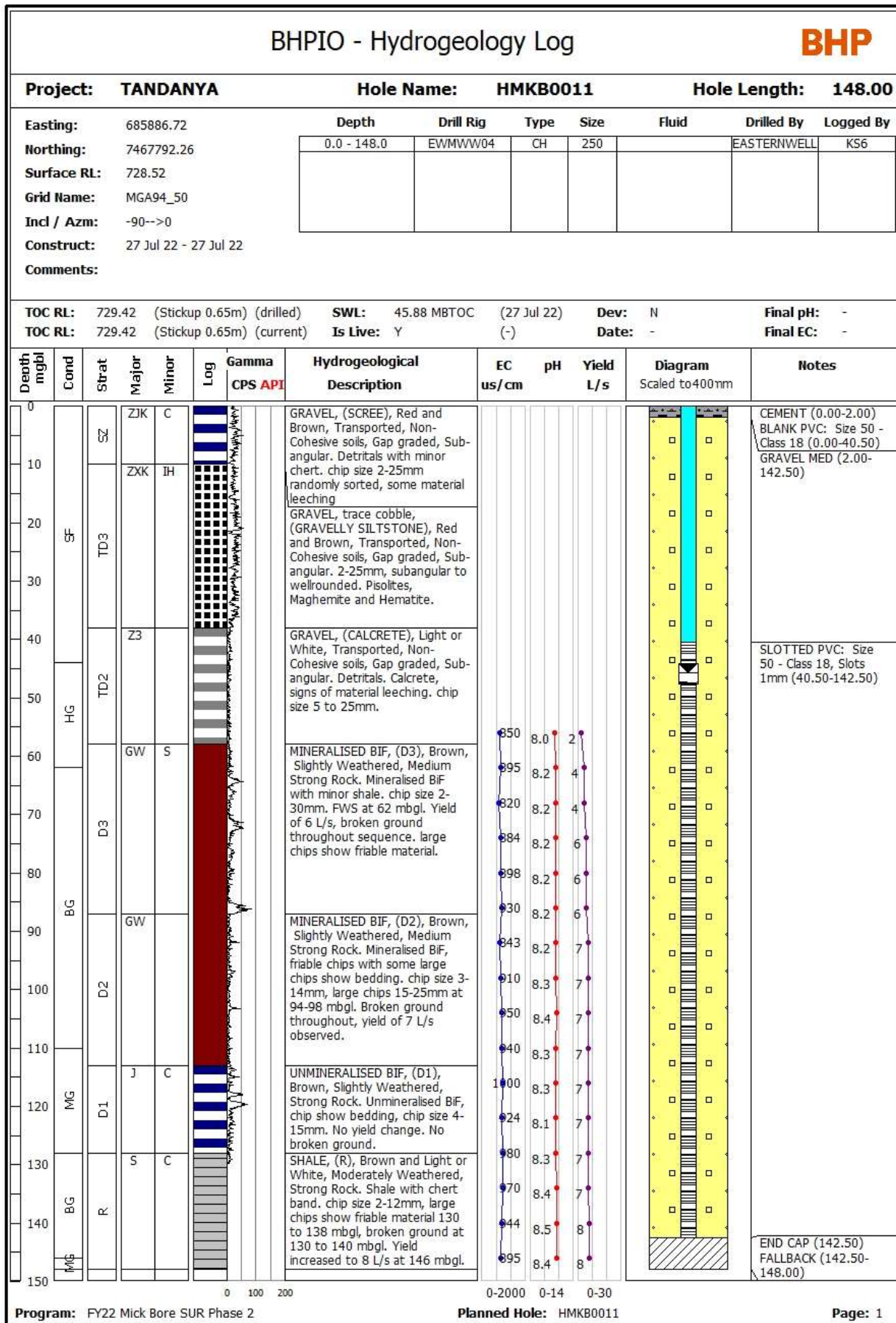
BHPIO - Hydrogeology Log											BHP	
Project: TANDANYA			Hole Name: HMKB0021			Hole Length: 120.00						
Easting:	685460.44		Depth	Drill Rig	Type	Size	Fluid	Drilled By	Logged By			
Northing:	7468326.23		0.0 - 6.0	WLDRIG5	CH	425		WELLDRIILL	EC6			
Surface RL:	730.12		6.0 - 54.0	WLDRIG5	CH	300		WELLDRIILL	EC6			
Grid Name:	MGA94_50		54.0 - 120.0	WLDRIG5	CH	200		WELLDRIILL	EC6			
Incl / Azm:	-90-->0											
Construct:	26 Oct 22 - 27 Oct 22											
Comments:	FWS @ 54 mbgl. No Water Quality Measurements and airlift yield recorded.											
TOC RL:	731.20	(Stickup 1.00m) (drilled)	SWL:	47.64 MBTOC	(28 Oct 22)	Dev:	N	Final pH:	-			
TOC RL:	731.20	(Stickup 1.00m) (current)	Is Live:	Y	(-)	Date:	26 Oct 2022	Final EC:	-			
Depth mgl	Cond	Strat	Major	Minor	Log	Gamma CPS API	Hydrogeological Description	EC us/cm	pH	Yield L/s	Diagram Scaled to 600mm	Notes
0			ZI	KYQ			GRAVEL, silty, (SCREE), Brown and Red, Transported, Non-Cohesive soils, Poorly graded, Angular. 2-30mm chips. Mix of lithology: BIF, Chert, Qtz, Soil and clay					PERFORATED END CAP: Concrete plinth and monument cover. (0.00) CEMENT (0.00-5.00) BLANK STEEL: 324mm (0.00-6.00) BLANK STEEL: 219mm (0.00-53.00) BLANK PVC: Size 50 - Class 18 (0.00-59.50) GRAVEL MED (5.00-6.00) GRAVEL MED (6.00-54.00)
10		UG	ZXI	HK			GRAVEL, silty, (GRAVELLY SILTSTONE), Red and Brown, Transported, Non-Cohesive soils, Poorly graded, Sub-rounded. 20-26m: 2-15mm chips, subangular to subrounded. Magnetite and Pisolites. 26-30m: 1-4mm chips, wellrounded pisolites					GRAVEL MED: 5.2 Tonnes (54.00-119.50)
20			Z3	GKC			GRAVEL, silty, (CALCRETE), Light or White and Brown and yellow, Transported, Non-Cohesive soils, Poorly graded, Sub-angular. 30-36m: 3-15mm, calcrete and silicified calcrete. 36-38m: increasing vitreous goethite. Transition to VB2					SLOTTED PVC: Size 50 - Class 18, Slots 1mm (59.50-119.50)
30			ZGK	3			GRAVEL, silty, (VUGHY BRECCIA), Yellow and Brown, Transported, Non-Cohesive soils, Poorly graded, Sub-angular. 38-40m: transition CA2-VB2. 40-46m: 2-7mm chips, vitreous goethite and clay. Increasing yellow clay with depth. 46-48m: goethite and silcrete					
40		MG	J	C			UNMINERALISED BIF, (D2), Brown and Grey, Slightly Weathered, Medium Strong Rock. 3-15mm, angular to subangular. Beddings. 52-54m: Minor Qtz chips. Increasing chert content with depth. FWS @ 54m. 62-72m: mainly smaller chips 3-8mm.					
50			JC	S			UNMINERALISED BIF, (D2), Brown and Yellow, Slightly Weathered, Medium Strong Rock. 4-20mm chips, angular. Cherty BIF. Laminations and beddings.					
60			CJ	S			UNMINERALISED BIF, (D1), Light or White and Yellow and brown, Moderately Weathered, Medium Strong Rock. 4-20mm chips, angular. Conchoidal fractures. Cherty and minor Qtz. Increasing chips size with depth. Driller noted a steady yield of 10-15 L/s from around 84m.					
70			JC	SQ								
80		BG	B	PQ								
90												
100												
110		HG										
120												END CAP (119.50) FALLBACK (119.50-120.00)
130												

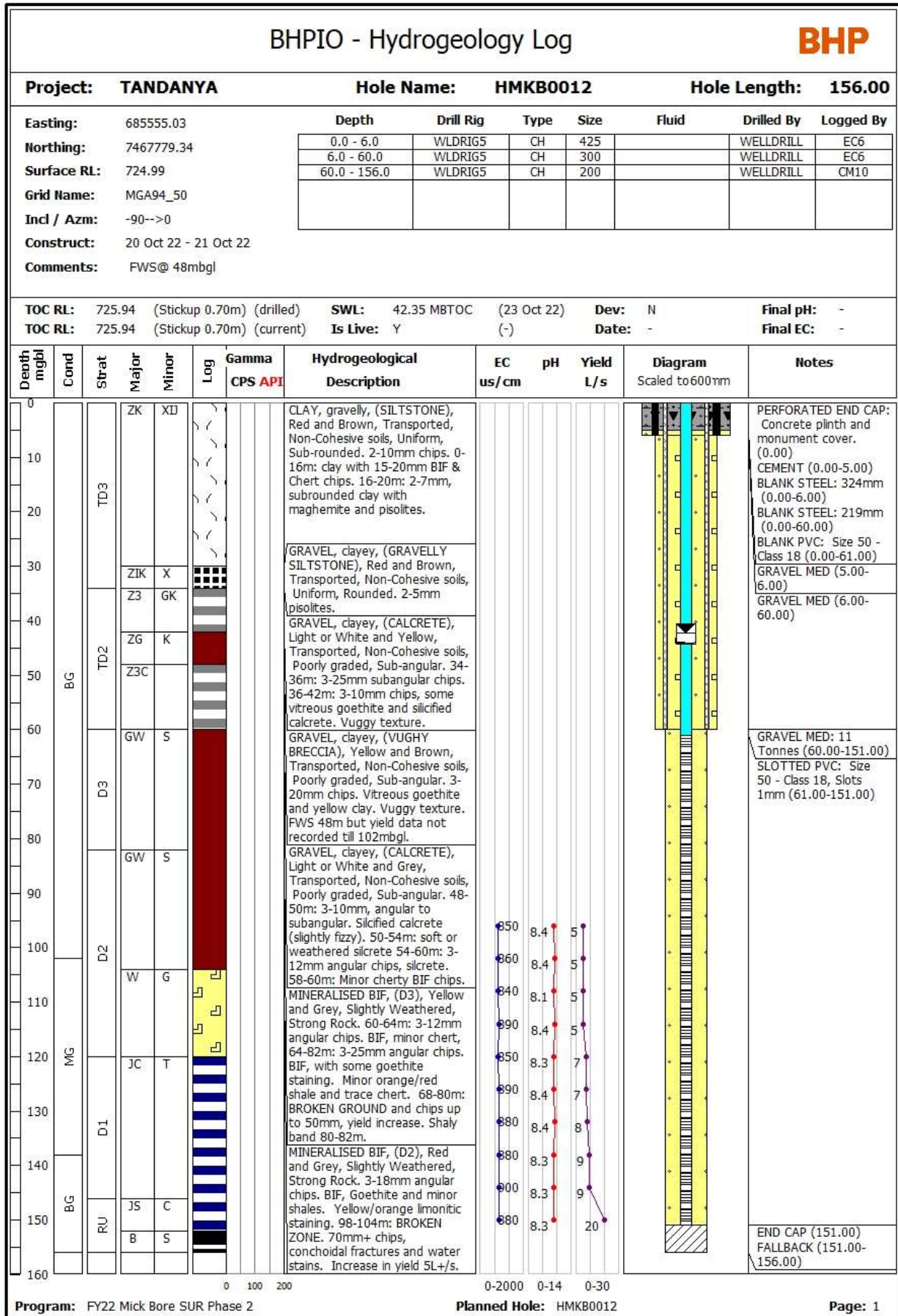


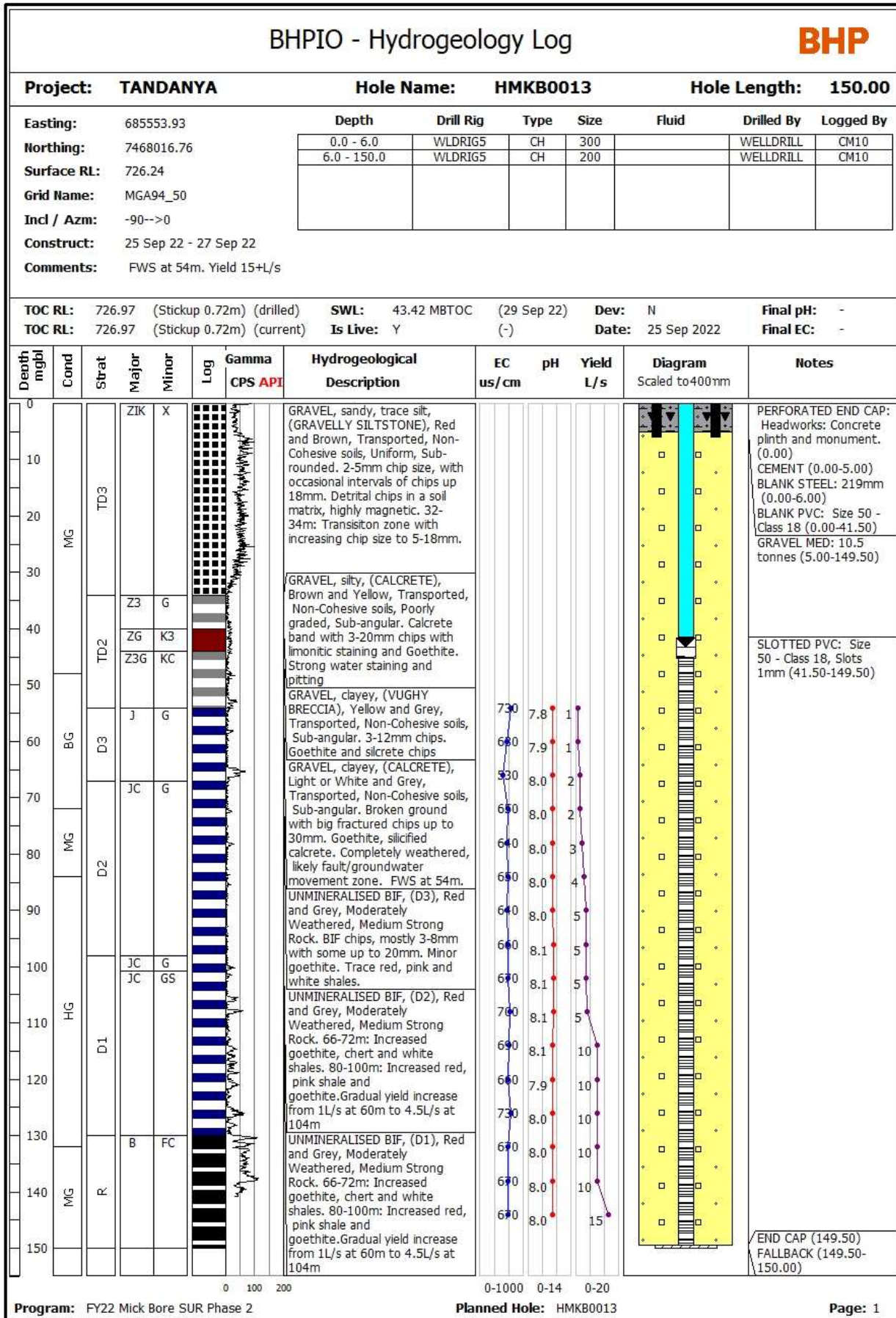


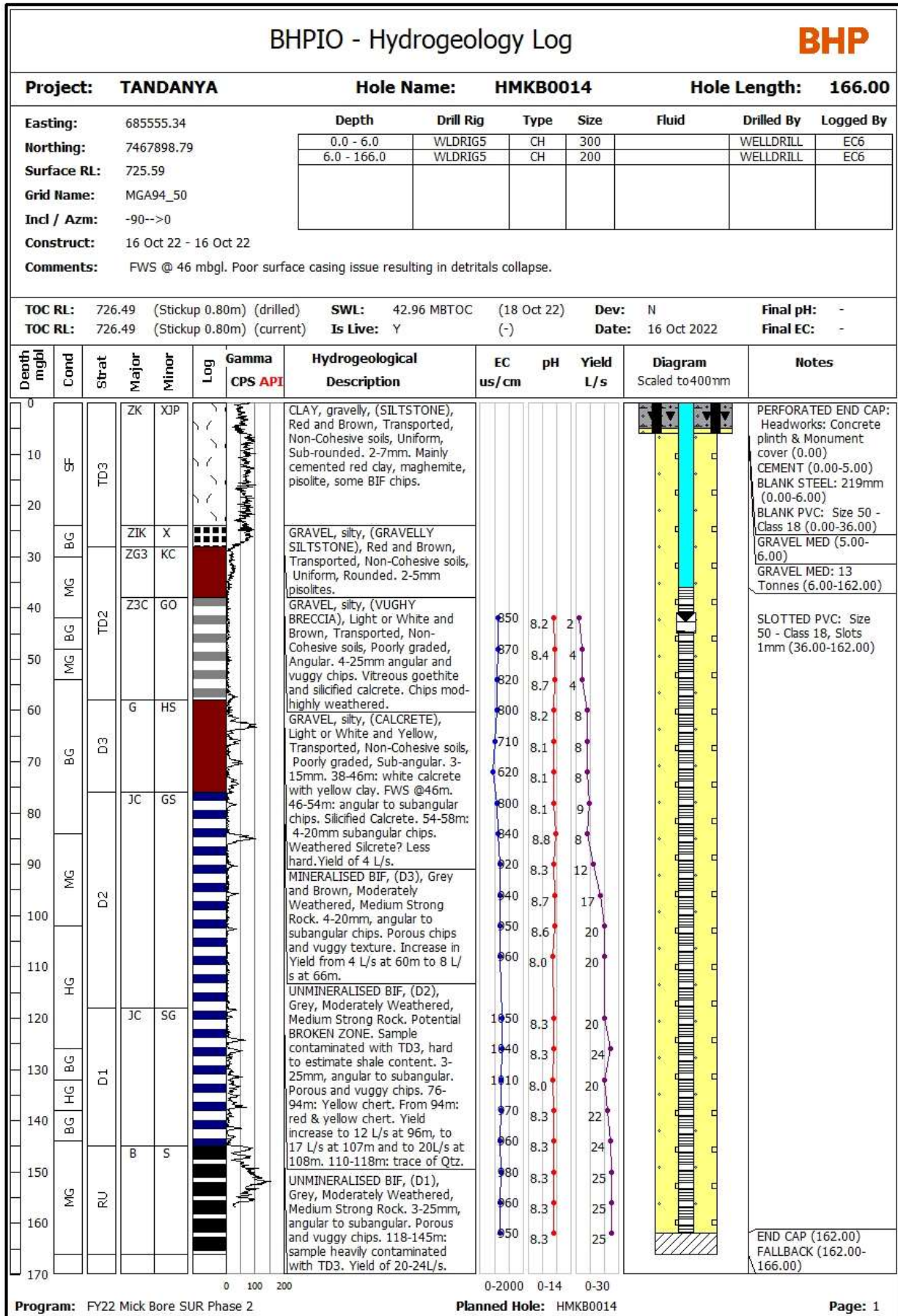


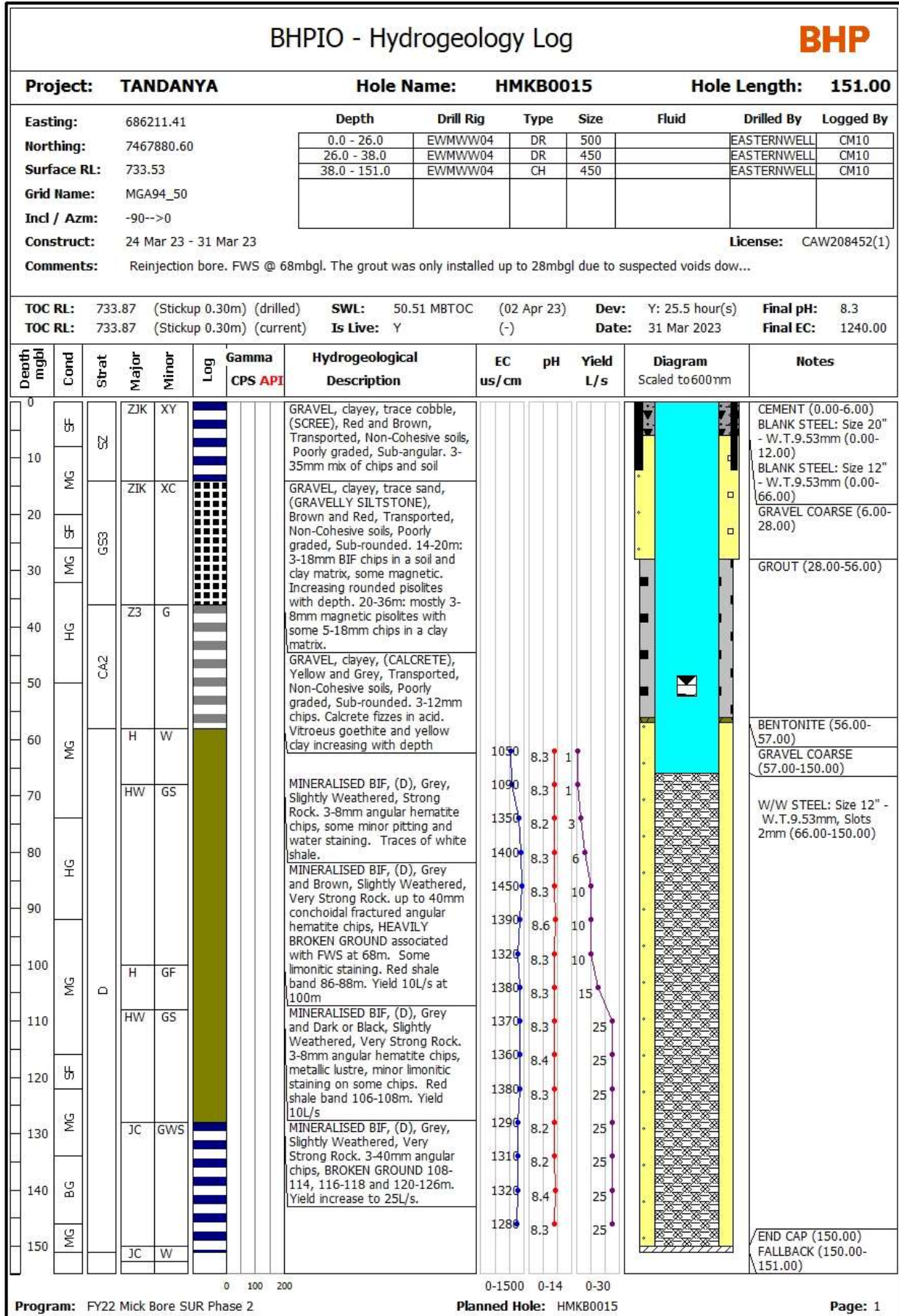


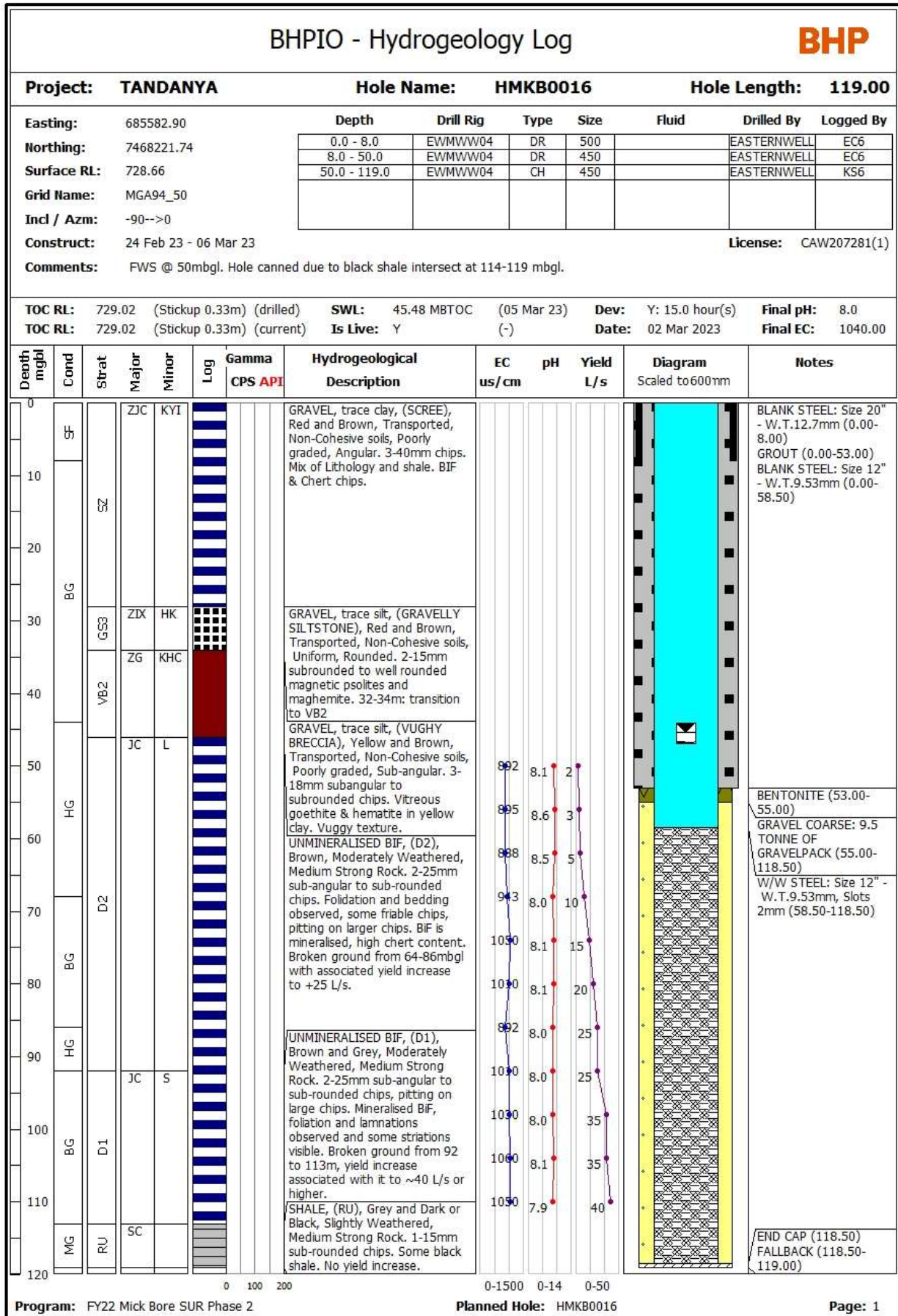


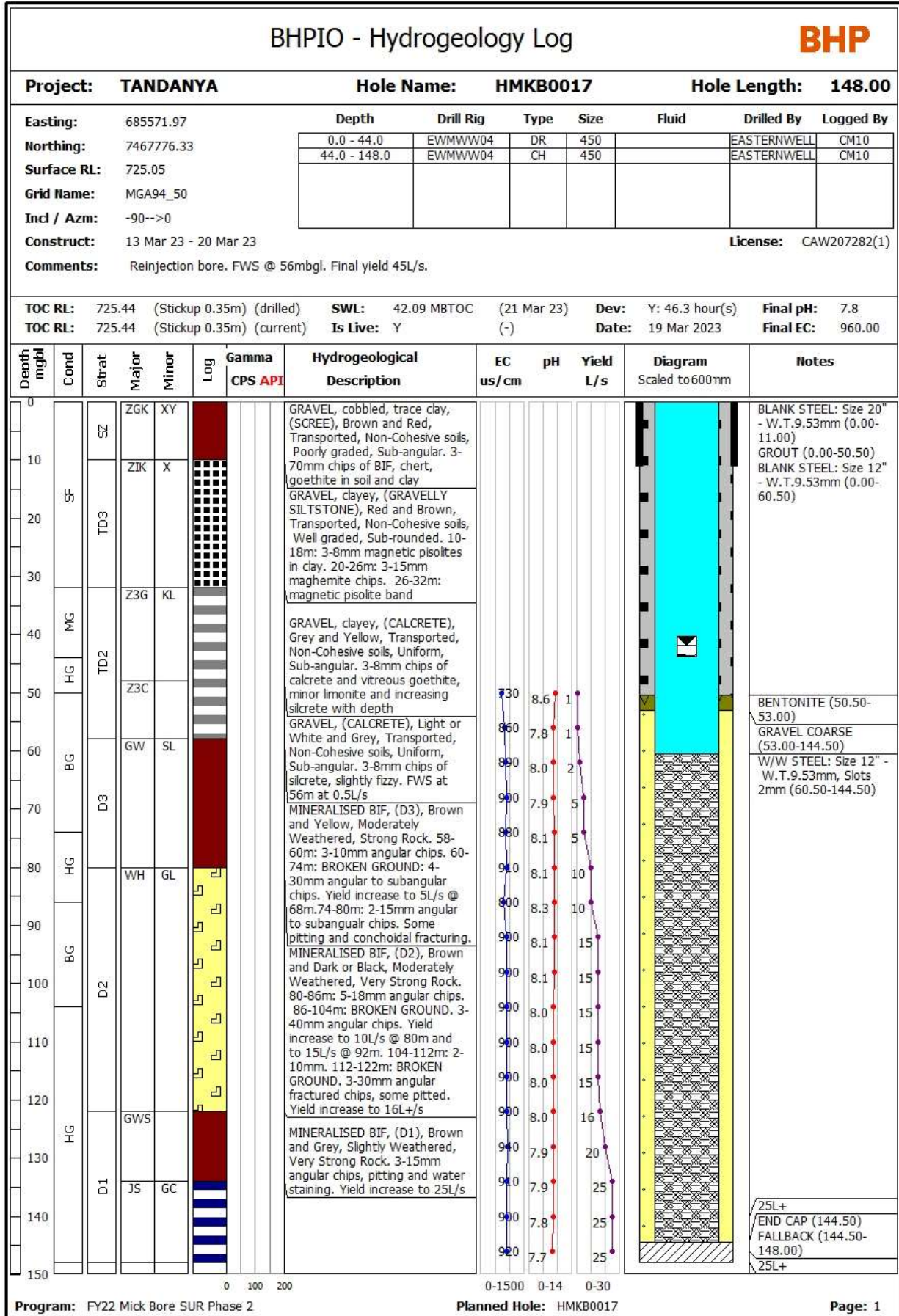












Appendix II Bore construction information

Hole Name	Location (MGA94_51)																		
Final Name	East	North	Ground RL	EOH	Hole Strat	Comments	Detr. Thick.	Fallback	Gravel Pack	Seals	Yield (Max)	Last EC (us/cm)	Last pH	Screened Unit	TOC RL (AHD)	Stick up (m)	SWL mbgl	Slot Min	Slot Max
HMKB0006	685,461.0	7,468,298.4	729.1	66	SZ TD3 TD2 D2	Abandoned due to a loss of circulation for 2 rods possibly caused by a cavity around 54 m.	46		5-66	0-5									
HMKB0021	685,460.4	7,468,326.2	730.1	120	SZ TD3 TD2 D2 D1 RU	FWS @ 54 mbgl. No Water Quality Measurements and airlift yield recorded.	48	119.5-120	5-119.5	0-5	12.5 (120m)			D2 D1 RU	731.199	1.08	46.56	59.50	119.50
HMKB0007	685,558.9	7,468,184.6	727.4	132	SZ TD3 TD2 D2 D1 RU	FWS @ 52 mbgl. Extremely BROKEN GROUND from 68-100 mbgl.	46	92-132	5-92	0-5	25+ (84m)	920	7.8	D2 D1 RU	728.42	1.00	43.76	44.00	92.00
HMKB0008	685,874.2	7,468,014.0	730.3	150	SZ TD3 TD2 D3 D2 D1 RU	FWS @ 54 mbgl. Installed 6m of 12" steel and 60m of 8" surface casing to prevent the collapse of surface detritals zone.	56	149.5-150	5-149.5	0-5	25+ (144m)	910	8.3	TD2 D3 D2 D1 RU	731.286	0.98	46.77	41.50	149.50
HMKB0009	685,871.5	7,467,896.5	729.1	177	SZ TD3 TD2 D4 D3 D2 D1 RU	FWS @ 60 mbgl.	60	162-177	5-162	0-5	15 (102m)	1,140	8.0	TD2 D4 D3 D2 D1 RU	729.87	0.80	45.54	42.00	162.00
HMKB0010	686,190.6	7,467,893.8	733.4	150	SZ TD3 TD2 D TD3	Abandoned due to 94 m of fallback	60	56-150	5-56	0-5	8.5 (132m)	780	7.8						
HMKB0011	685,886.7	7,467,792.3	728.5	148	SZ TD3 TD2 D3 D2 D1 R		58	142.5-148	2-142.5	0-2	8 (146m)	895	8.4	TD2 D4 D3 D2 D1 R	729.418	0.89	44.99	40.50	142.50
HMKB0012	685,555.0	7,467,779.3	725.0	156	TD3 TD2 D3 D2 D1 RU	FWS@ 48mbgl.	60	151-156	5-151	0-5	20+ (156m)	880	8.3	TD2 D3 D2 D1 RU	725.942	0.95	41.40	61.00	151.00
HMKB0013	685,553.9	7,468,016.8	726.2	150	TD3 TD2 D3 D2 D1 R	FWS at 54 mbgl.	58	149.5-150	5-149.5	0-5	15+ (150m)	670	8.0	TD2 D3 D2 D1 R	726.969	0.73	42.69	41.50	149.50
HMKB0014	685,555.3	7,467,898.8	725.6	166	TD3 TD2 D3 D2 D1 RU	FWS @ 46 mbgl. Poor surface casing issue resulting in detritals collapse.	58	162-166	5-162	0-5	25+ (156m)	950	8.3	TD2 D3 D2 D1 RU	726.489	0.90	42.06	36.00	162.00
HMKB0015P	686,211.4	7,467,880.6	733.5	151	SZ GS3 CA2 D	Reinjection bore. FWS @ 68mbgl. The grout was only installed up to 28mbgl due to suspected voids downhole.	58.0	150.0-151.0	6-28 57-150	0-6 28-57	25.0 (116.0m)	1,280	8.3	CA2 D	733.874	0.34	50.17	66.00	150.00
HMKB0016P	685,582.9	7,468,221.7	728.7	119	SZ GS3 VB2 D2 D1 RU	FWS @ 50mbgl. Hole canned due to black shale intersect at 114-119 mbgl.	46.0	118.5-119.0	55-118.5	0-55	40.0 (116.0m)	1,050	7.9	D2 D1 RU	729.025	0.36	45.12	58.50	118.50
HMKB0017P	685,572.0	7,467,776.3	725.1	148	SZ TD3 TD2 D3 D2 D1	Reinjection bore. FWS @ 56mbgl. Final yield 45L/s.	58.0	144.5-148.0	53-144.5	0-53	25.0 (140.0m)	920	7.7	TD2 D3 D2 D1	725.444	0.39	41.70	60.50	144.50

Appendix III Trace Metals (Dissolved) in Water by ICPMS in mg/L

Sample ID	Aluminium (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Zinc (mg/L)
LOR	0.005	0.001	0.001	0.005	0.0001	0.001	0.001	0.005	0.001	0.001	0.00005	0.001	0.001	0.001	0.001	0.005
HMKB0015P	<0.005	<0.001	0.045	0.340	<0.0001	0.002	<0.001	<0.005	<0.001	0.001	<0.00005	<0.001	<0.001	0.002	<0.001	<0.005
HMKB0016P	<0.005	<0.001	0.034	0.3	<0.0001	0.001	<0.001	<0.005	<0.001	0.008	<0.00005	<0.001	<0.001	<0.001	<0.001	0.008
HMKB0017P	<0.005	0.002	0.027	0.31	<0.0001	0.003	<0.001	0.010	<0.001	0.001	<0.00005	0.001	<0.001	<0.001	<0.001	<0.005
HGE0044P	<0.005	<0.001	0.009	0.210	<0.0001	0.002	0.002	<0.005	<0.001	<0.001	<0.00005	<0.001	<0.001	0.001	<0.001	0.016
HGE0045P	<0.005	<0.001	0.029	0.220	<0.0001	0.001	<0.001	<0.005	0.002	<0.001	<0.00005	<0.001	<0.001	0.001	<0.001	0.011
HNPIAC0001P						<0.001		0.008								
HNPIAC0002P						0.001		0.024								
HSF0102P	<0.005	<0.001	0.005	0.210	<0.0001	0.003	<0.001	<0.005	<0.001	<0.001	<0.00005	<0.001	<0.001	<0.001		<0.005
HSF5570P	<0.005	<0.001	0.005	0.190	<0.0001	<0.001	<0.001	<0.005	<0.001	0.007	<0.00005	<0.001	<0.001	<0.001	<0.001	<0.005

The concentration of the trace metals enlightened in red exceed the LOR values. Additional assessment for the MAR it may be required.

Appendix IV Logging Reference Sheet

BHPIO - Reference Codes			BHP	
Data Type	Code	Description	Active	
Drill Conditions	BG	Broken ground	Y	
	CV	Cavity. Hammer drops with no resistance	Y	
	FR	Suspected fracture rather than broken ground or fault	Y	
	FZ	Fault zone	Y	
	HG	Hard Ground. Stable. Slow progress	Y	
	MG	Moderately hard ground. Good progress rates	Y	
	SF	Soft/loose ground. Easy drilling	Y	
	UG	Unstable ground. Drillers report hole collapse / fallback problems	Y	
	Constituent	1	Goethitized Chert	Y
		2	Gypsum	Y
3		Calcrete	Y	
4		Dolomitic Shale	Y	
5		Opaline Silica	Y	
6		Lignite	Y	
7		Granite	Y	
8		Hardcap/Laterite	Y	
9		Chlorite Schist/Saprolite	Y	
A		Cement (Contamination)	Y	
B		Carbonaceous Shale	Y	
C		Chert	Y	
D		Dolomite	Y	
E		Dolerite/Basalt	Y	
F		Ferruginous Shale (20-54% Fe)	Y	
G		Goethite	Y	
H		Hematite	Y	
I		Pisolite	Y	
J		Banded iron-formation (BIF)	Y	
K		Clay	Y	
L		Limonite	Y	
M		Magnetite	Y	
N		Manganese Minerals	Y	
O		Conglomerate/Sandstone/Sand/Siltstone	Y	
P		Pyrite	Y	
Q		Quartz	Y	
R		Siderite	Y	
S		Shale (<20% Fe)	Y	
T		Hematised Shale (>54%)	Y	
U		Siliceous Hematite	Y	
V	Void (Cavity)	Y		
W	Goethitic Hematite	Y		
X	Maghemite	Y		
Y	Silt/Soil	Y		
Z	Debitrals/colluvium/Alluvials	Y		
Strat Code	A	Alluvials	Y	
	ACB	Coonieena Basalt	Y	
	ACS	Cundaline Formation (Formerly AU)	Y	
	AG	Granites	Y	
	AGM	Muccan Granite	Y	
	AGW	Warrwagine Granite	Y	
	ANGq	Intercalated Zone Phyllites/Quartzite	Y	
	ASI	Shay Intrusion (Added 16Aug2013.)	Y	
	AW	Warrawoona Group	Y	
	B	Basement	Y	
	BB1	Wittenoom Formation, Bee Gorge Member OC - BB1 BIF band	Y	
	BB2	Wittenoom Formation, Bee Gorge Member OD - BB2 BIF band	Y	
	BB3	Wittenoom Formation, Bee Gorge Member OD - BB3 BIF band	Y	
	BB4	Wittenoom Formation, Bee Gorge Member OD - BB4 BIF band	Y	
	BD1	Wittenoom Formation, Bee Gorge Member OC - BD1 Dolomite	Y	
	BD2	Wittenoom Formation, Bee Gorge Member OC - BD2 Dolomite	Y	
	BD3	Wittenoom Formation, Bee Gorge Member OC - BD3 Dolomite	Y	
	BD4	Wittenoom Formation, Bee Gorge Member OC - BD4 Dolomite	Y	

BHPIO - Reference Codes			BHP
Data Type	Code	Description	Active
	BD4	Wittenoom Formation, Bee Gorge Member OC - BD4 Dolomite	Y
	BD5	Wittenoom Formation, Bee Gorge Member OC - BD5 Dolomite	Y
	BD6	Wittenoom Formation, Bee Gorge Member OC - BD6 Dolomite	Y
	BD7	Wittenoom Formation, Bee Gorge Member OC - BD7 Dolomite	Y
	BG	Marillana Formation, Munjina Member - Basal Conglomerate	Y
	BK	Marillana Formation, Munjina Member - Basal Clay	Y
	BRD	Black Range Dolerites (Black Range Dolerite Suite intrudes Muccan Granite)+ Dolerites	Y
	BS1	Wittenoom Formation, Bee Gorge Member OC - BS1 shale	Y
	BS10	Wittenoom Formation, Bee Gorge Member OD - BS10 shale band	Y
	BS11	Wittenoom Formation, Bee Gorge Member OD - BS11 shale	Y
	BS12	Wittenoom Formation, Bee Gorge Member OD - BS12 shale	Y
	BS2	Wittenoom Formation, Bee Gorge Member OC - BS2 shale	Y
	BS3	Wittenoom Formation, Bee Gorge Member OC - BS3 shale	Y
	BS4	Wittenoom Formation, Bee Gorge Member OC - BS4 shale	Y
	BS5	Wittenoom Formation, Bee Gorge Member OC - BS5 shale	Y
	BS6	Wittenoom Formation, Bee Gorge Member OC - BS6 shale	Y
	BS7	Wittenoom Formation, Bee Gorge Member OC - BS7 shale	Y
	BS8	Wittenoom Formation, Bee Gorge Member OC - BS8 shale	Y
	BS9	Wittenoom Formation, Bee Gorge Member OC - BS9 shale	Y
	BT1	Wittenoom Formation, Bee Gorge Member OC - BT1 Tuff	Y
	CA2	Calcrete	Y
	CID	non-denatured CID. Updated from undifferentiated to non-denatured 18Feb2013. Approved by Paul White...	Y
	CK	Channel Clay (Added 18Feb2013 sysaid #7129. Approved by Paul Whitehouse)	Y
	CY1	Ferruginous Clay	Y
	CY2	Clay	Y
	CY3	Clay in TD3	Y
	D	Brockman Iron Formation, Dales Gorge Member (PHbd) - Undifferentiated	Y
	D1	Colonial Chert Member (Ahrc), informally the lowest unit of the Dales Gorge Member in the Newman are...	Y
	D2	Brockman Iron Formation, Dales Gorge Member (PHbd) - D2	Y
	D3	Brockman Iron Formation, Dales Gorge Member (PHbd) - D3 - middle shaly	Y
	D4	Brockman Iron Formation, Dales Gorge Member (PHbd) - D4	Y
	DCID	Denatured CID (Added 18Feb2013 sysaid #7129. Approved by Paul Whitehouse)	Y
	EC	Eel Creek Formation - Undifferentiated (Encompassing former E, Eb, EH)	Y
	ECH	Eel Creek Formation - Hematitic Conglomerate (Formerly EH)	Y
	ECS	Eel Creek Formation - Unmineralised Sediment	Y
	ECT	Eel Creek Formation - Hematitic Shale	Y
	EK	Marillana Formation, Iowa Member - Eastern Clay	Y
	F	Fault Zone	Y
	FBU	Upper Mafic Volcanic Unit of the Fortescue Group (Bunjina Formation)	Y
	FLL	Fill	Y
	G	Gorge Creek Group (Includes Nimingarra Formation, Cundaline formation and Coonieena Formation)	Y
	GN	Nimingarra Iron Formation (Formerly G) undifferentiated	Y
	GN1	Nimingarra Iron Formation, Lower Mudstone Member incl basal cong/sst/shale (Formerly G1)	Y
	GN2	Nimingarra Iron Formation, Lower BIF Member (Formerly G2)	Y
	GN3	Nimingarra Iron Formation, Middle Member Footwall Mudstone incl FFW shale (Formerly G3)	Y
	GN34	Nimingarra Iron Formation, Undifferentiated Middle BIF including False Footwall Shale (GN3U+GNFS+GN4...	Y
	GN3L	Nimingarra Iron Formation, Middle Mudstone Member (Formerly G3) (Added 16Aug2013.)	Y
	GN3U	Nimingarra Iron Formation, Middle Footwall Zone BIF Member (Formerly G3) (Added 16Aug2013.)	Y
	GN4	Nimingarra Iron Formation, Middle BIF Member (Formerly G4)	Y
	GN5	Nimingarra Iron Formation, Upper Mudstone Member (Formerly G6)	Y
	GN56	Nimingarra Iron Formation, Combined Upper Mudstone Member & Upper BIF Member (Formerly G6) (Added 16...	Y
	GN6	Nimingarra Iron Formation, Upper BIF Member (Formerly G6) (Added 16Aug2013.)	Y
	GNFS	Nimingarra iron Formation, False Footwall Shale Member (Added 16Aug2013.)	Y
	GS3	Gravelly Siltstone	Y
	H	hardcap	Y
	HB	Brockman Iron Formation	Y
	HC1	Hematite Conglomerate	Y
	HCID	Hardcap CID (Added 18Feb2013 sysaid #7129. Approved by Paul Whitehouse)	Y
	HE	Weeli Wolli Dolerite	Y
	HJ	Weeli Wolli Iron Formation (PHj)	Y
	HO	Boolgeeda Iron Formation (PHo)	Y

Code list printed as at : 31 Mar 2022

Page Number: 2

BHPIO - Reference Codes			BHP
Data Type	Code	Description	Active
	HO	Boolgeeda Iron Formation (PHo)	Y
	HOL	Boolgeeda Iron Formation (PHol) - Lower	Y
	HOM	Boolgeeda Iron Formation (PHom) - Middle	Y
	HOU	Boolgeeda Iron Formation (PHou) - Upper	Y
	HW	Woongarra Volcanics (PHw)	Y
	J	Brockman Iron Formation, Joffre Member (PHbj) - Undifferentiated	Y
	J1	Brockman Iron Formation, Joffre Member - J1 - shaly	Y
	J2	Brockman Iron formation, Joffre Member (PHbj) - J2	Y
	J3	Brockman Iron formation, Joffre Member (PHbj) - J3 - shaly	Y
	J3J5	Brockman Iron formation, Joffre Member (PHbj) J3 - 5 zone undifferentiated (Formerly JC)	Y
	J4	Brockman Iron formation, Joffre Member (PHbj) - J4	Y
	J5	Brockman Iron formation, Joffre Member (PHbj) - J5 - shaly	Y
	J6	Brockman Iron formation, Joffre Member (PHbj) - J6	Y
	JN	Jeerinah Formation (AFj) - Undifferentiated	Y
	JNE	Jeerinah Formation Dolerite (Sill)	Y
	K	Dykes/Sills (K Formerly used for Clay)	Y
	KC	Callawa Formation	Y
	LT2	Lignite Clay	Y
	M	Marra Mamba Iron Formation (Ahm) - Undifferentiated	Y
	M1	Marillana Formation, Barimunya Member - Lower CID	Y
	M2	Marillana Formation, Barimunya Member - Lower CID (denatured zone)	Y
	M3	Marillana Formation, Barimunya Member - Upper CID	Y
	M3MN	Northern Marginal Zone	Y
	M3MS	Southern Marginal zone	Y
	M3S	Upper CID High Silica	Y
	M3SA	Upper CID High Silica High Alumina	Y
	M3W	Upper CID Weathered	Y
	M4	Marillana Formation, Iowa Member - Eastern CID	Y
	M4W	Eastern CID Weathered	Y
	MM	Marra Mamba Iron Formation, MacLeod Member (Ahmm)	Y
	MN	Marra Mamba Iron Formation, Mount Newman Member (Ahmn) - undifferentiated	Y
	MU	Marra Mamba Iron Formation, Nammuldi Member (Ahmu)	Y
	N1	Marra Mamba Iron Formation, Mount Newman Member - N1	Y
	N2	Marra Mamba Iron Formation, Mount Newman Member - N2 (Shaley)	Y
	N3	Marra Mamba Iron Formation, Mount Newman Member - N3	Y
	NA	Jeerinah Formation, Shale A	Y
	NB	Jeerinah Formation, Shale B	Y
	NC	Jeerinah Formation, Shale C	Y
	NM	Marginal Zone in CID North Side of Channel (Added 18Feb2013 sysaid #7129. Approved by Paul Whitehous...	Y
	NX	Jeerinah Formation (AFjr) - Undifferentiated Shale	Y
	NZ	Jeerinah Formation, shale under Shale A	Y
	O	Wittenoom Formation (Ahd) - Undifferentiated (Formerly WD)	Y
	OA	Wittenoom Formation, West Angela Member (Ahd) OA - Undifferentiated (Formerly WA)	Y
	OB	Wittenoom Formation, Paraburdoo Member (Ahd) OB - Undifferentiated (Formerly WP)	Y
	OC	Wittenoom Formation, Bee Gorge Member OC - Undifferentiated (Formerly WB)	Y
	OD	Wittenoom Formation, Shaley Bee Gorge Member OD - Undifferentiated	Y
	OG	Wittenoom Formation, Bee Gorge Member - Undifferentiated	Y
	OK	Marillana Formation - Barimunya Member, Ochreous Clay	Y
	Pdd	Dolorite Dykes	Y
	R	Mt McRae Shale (Ahr) - Undifferentiated	Y
	RC	Mt McRae Shale - Chert	Y
	RL	Mt McRae Shale - Lower	Y
	RN	Mt McRae Shale - Nodule Zone	Y
	RU	Mt McRae Shale - Upper	Y
	S	Mt Sylvia Formation (Ahs) - Undifferentiated	Y
	S1	Mt Sylvia Formation - S1 (BIF1)	Y
	S1S4	S1 to S4	Y
	S2	Mt Sylvia Formation - S2	Y
	S3	Mt Sylvia Formation - S3 (BIF2)	Y
	S4	Mt Sylvia Formation - S4	Y
	S5	Mt Sylvia Formation - S5 (Siltstone)	Y

