Mining Remediation Authority

Gateshead Mine Water Heat Living Lab: CCTV & geophysical survey report

July 2025

Disclaimer

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Making a better future for people and the environment in mining areas

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Executive summary

The Gateshead Mine Water Heat Living Lab, developed by the Mining Remediation Authority, is a pioneering initiative aimed at advancing the understanding and optimisation of mine water as a sustainable, low-carbon heat source. Situated near three operational mine water heat schemes in a single mine water block, the Living Lab provides open-access data to support research into the thermal and hydrogeological behaviour of interconnected mine systems.

The Living Lab consists of four boreholes across two sites – Bede and Stadium. In January 2025 a suite of CCTV and geophysical surveys was conducted by European Geophysical Services (EGS) to provide further information and data on the physical properties of the mine workings to help develop the conceptual understanding of heat flow within mines.

Key findings include:

- **Borehole Magnetic Resonance (BMR) logging**, used for the first time in a Mining Remediation Authority borehole, provided valuable insights into the physical properties of mined seams. Fractured areas, generally associated with worked horizons, are highly conductive and allow free water movement

- **The calculated density and specific yield** of the open hole sections are similar to those for sands and sandstones, between 1.7 and 2.5 g/cm^3 and 15 and 30% respectively. Worked sections recorded specific yield values up to 80%.

- **Fractured zones** in the open section of the boreholes were consistently identified as primary flow paths, with the highest flow rates (up to 3.5 mm/s) observed at the Bede site.

- **Temperature profiles** confirmed elevated geothermal gradients, >0.05°C/m and highlighted potential inflow zones, particularly at Stadium – High Main and Stadium – Hutton.

- **Electrical conductivity profiles** show that the mine water electrical conductivity increases with workings depth 3300 µS/cm in the shallowest (Bede – High Main) to 17,600 µS/cm in the deepest (Stadium – Hutton).

The data collected assists in the establishment of a strong baseline for ongoing monitoring and research. It underscores the importance of detailed subsurface characterisation to inform future licensing, management and wider adoption of mine water heat schemes. Further work will be undertaken to understand some questions raised by this work for example the cause of variable geothermal gradients.

All geophysical data are available under the Open Government Licence via data.gov.uk, with CCTV footage available upon request.

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1 Overview

1.1 Gateshead Mine Water Heat Living Lab

The Mining Remediation Authority's Mine Water Heat Living Lab in Gateshead is a flagship project that embodies our mission to protect and enhance the environment while delivering long-term value for communities and minimising costs to the taxpayer. It is designed to explore the thermal and hydrogeological behaviour between operational mine water heat schemes in the same mine water block. The facility was launched in January 2025 and is located in the vicinity of three mine water heat schemes and provides open access data that will help optimise the use of mine water as a secure, low carbon heat source.

1.2 CCTV and geophysical surveys

CCTV and geophysical surveys were undertaken by European Geophysical Services (EGS) at the Gateshead Living Lab between 14/01/25 and 17/01/25 to provide further information on the boreholes post-construction to help development of a baseline. This note provides a summary of the key information.

The following logs were undertaken at each of the four boreholes:

- **CCTV survey**: a visual representation of the borehole condition
- **Temperature & electrical conductivity**: a continuous log of temperature and indication of water chemistry
- **Caliper**: a log of the borehole diameter, used to confirm any gaps, collapses
- **Natural gamma**: measures naturally occurring gamma radiation in rocks and sediments, usually used to detect clays
- **Density (short space and long space):** measures apparent density of formation surrounding borehole
- **Heat pulse flow meter**: designed to measure low fluid velocities in boreholes,
- **Borehole magnetic resonance (BMR)**: used to provide estimates of hydrogeological properties

Usually, CCTV surveys are undertaken first to check the condition of the borehole and to prevent the effects of disturbance of the water from other survey tools, which can make it difficult to see through the water. Due to logistical reasons the CCTV surveys at Stadium were undertaken following the other logs which means that it is difficult to see during parts of the survey.

This is the first time a Borehole Magnetic Resonance survey has been carried out in a Mining Remediation Authority borehole. This tool is widely used in the petroleum industry to provide direct estimates of formation water content and pore structures. Empirical

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relationships can also be used to provide estimates of porosity, permeability and hydraulic conductivity (US EPA 2025).

This note summarises the results and provides a high-level interpretation of the data. The interpretative reports provided by EGS are included as **Appendix A**. The profile data are available under open government licence (OGL v3) on the data.gov.uk repository: https://www.data.gov.uk/dataset/0aab938a-07b5-4c95-9c11-1b09ac4e82da/gateshead-mine-water-heat-living-laboratory

The CCTV videos are available on request at MineWaterHeat@MiningRemediation.gov.uk.

2 Summary

2.1 Borehole details

The Gateshead Living Lab consists of four boreholes at two sites, Bede (two boreholes) and Stadium (two boreholes). Full borehole construction details can be found in MRA 2025, online on the data.gov.uk repository, and summary logs are shown in **Appendix B**. The strata description from the driller's logs are included as **Appendix C**. Key depths are given in **Table** 1, these have been converted from the geophysical reports to metres below ground level (m bgl), see MRA 2025 for details.

In general, the boreholes are open hole in the mine workings with 102 mm (4 inch) casing above to surface, grouted in place. The boreholes at Bede and Stadium have 24 m and 27 m of surface casing respectively. Stadium – Hutton has additional steel casing at several depths to keep the formation stable during the construction process. Following drilling and prior to casing installation the boreholes were cleaned and developed.

Table 1: Summary borehole details (in mbgl)

	Bede High Main	Bede Brass Thill	Stadium High Main	Stadium Hutton
Datum	Top of casing	Top of casing	Top of casing	Top of casing
Depth	55.4	134.3	71.3	183.6
Casing depth	50.1	122.1	60.7	170.9
Water level	26.9	22.6	21.0	17.1
Drilled depth	55.6	135.6	82.1	189.0

2.2 Report structure

This report summarises the key findings from the geophysical logging undertaken in January 2025. It summaries the logs for each borehole followed by focussed sections on temperature and electrical conductivity profiling and the open hole section as this is of the most interest for the rock properties of the mine workings.

3 Borehole summaries

3.1 Bede –High Main

The CCTV survey at Bede – High Main showed a large vertical fracture in the sandstone from the base of the casing (50 m) to around 53 mbgl (**Figure 1**). The highest flow rate, of approximately 3.2 mm/s, was recorded in this area. Below this there are large horizontal fractures and thin beds which is confirmed by the caliper data. This is presumably a change from the more competent sandstone to the workings.

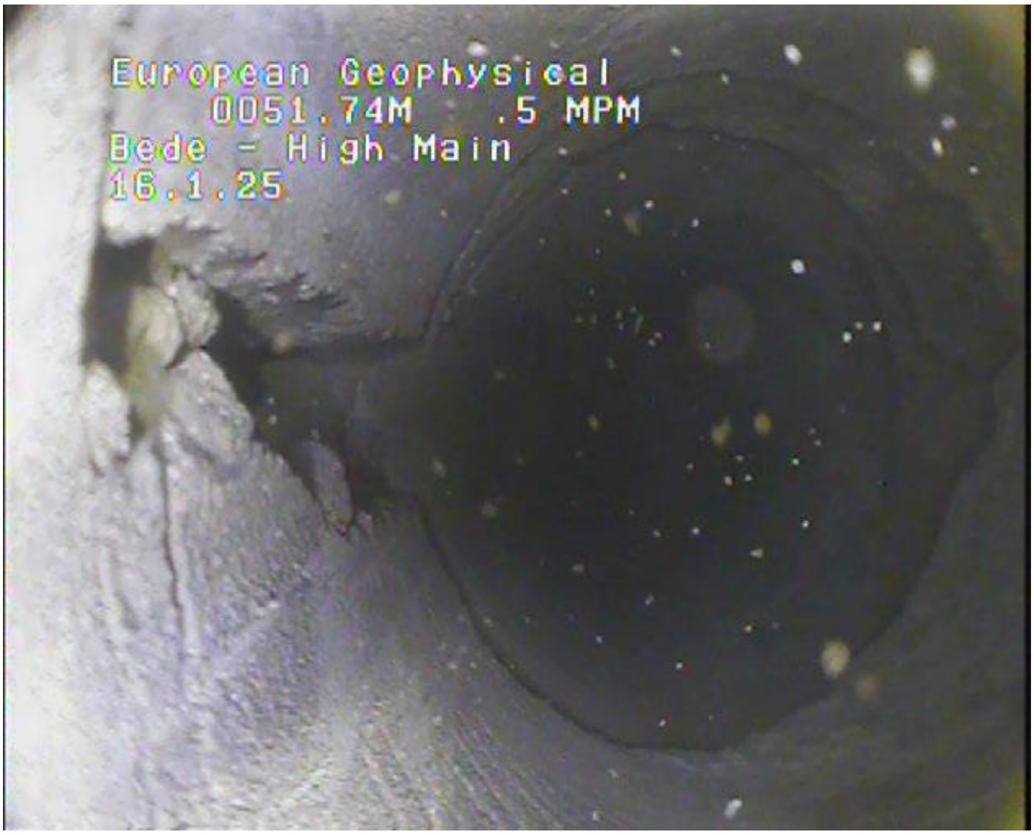

Figure 1: Large vertical fracture in the sandstone in the Bede- High Main borehole.

In the higher flow zone below the casing there is a reduction in electrical conductivity from 2500 µS/cm in the casing to around 1780 µS/cm. This rises again towards the base of the casing as the flow rate reduces. At around 52 mbgl, in the higher flow zone, the total porosity increases to around 34% from an average of 16%, and density also reaches a peak of 2.3 g/cm^3. The density reduces to 1.8 g/cm^3 towards the base of the borehole, correlating with the more fractured zone. The porosity also increases in this zone, as would be expected.

In the cased section of the borehole there is a zone with high porosity peaks. These are areas with low capillary bound water which means that the water here is flowing easily. This is likely to correspond to a fracture zone in the High Main Post aquifer above the High Main workings.

The summary logs are shown in **Figure 3.**

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3.2 Bede – Brass Thill

The CCTV survey and caliper log show that the unlined borehole below the casing is competent and stable sandstone. There is a sub-vertical fracture between 125.5 and 125.9 mbgl and below approximately 132 mbgl there are further break outs observed. This fracture is assumed to be the top of a flow zone with upwards flow measured around 2.5 to 2.8 mm/s between here and the base of the borehole. This is also corroborated with the clarity of the CCTV improving around 124.5 mbgl. Above this there is a lot of black flaky sediment floating in the water and encrusted onto the casing.

The electrical conductivity is fairly constant within the casing between 190 and 220 μS/cm before increasing to 8000 μS/cm at 125 mbgl (just below the casing) and then gradually increasing to 9000 μS/cm at the borehole base. This is likely related to the flow zone with stagnant water in the casing and the true mine water in the flow zone.

The porosity in the lined section is much more variable (generally ranging between <10 to 20% with some much higher peaks >60%) than in the open hole section which is predominantly competent sandstone. As with Bede – High Main, the water in the open section of the borehole is mainly free flowing water, i.e. not capillary bound.

The summary logs are shown in **Figure 4**.

3.3 Stadium – High Main

It is difficult to see the casing in the top part of this CCTV survey due to murky water. At the base of the casing some of the "grout basket" is seen indicating it had slipped during installation (**Figure 2).** This is a holder made of rubber strips that was attached to the base of the plastic casing during installation to keep the grout behind the casing and stop it pouring into the open hole section below. A couple of the rubber strips seem to have slipped down during installation. The density tool was not run below the casing due to the risk of getting the radioactive source stuck on these protruding strips.

The temperature and electrical conductivity logs suggest there is some vertical fluid flow within the casing. There is a clear inflection point in the temperature log at approximately 49 mgl where it drops by 0.6°C before increasing by 0.9°C. At the same depth the electrical conductivity reduces from 7900 μS/cm to 5800 μS/cm. The electrical conductivity rises again at the base of the casing and there is a similar small increase in temperature. This wasn't picked up in the flow meter perhaps because the flow rate was very low. As the water clarity was low it is unclear if there is a casing joint at the top of this flow zone (49 mbgl).

In the open section, minor up flow of 1.7 mm/s was recorded from 60 to 66 mbgl and again at 71.5 mbgl (bottom of the borehole) at a rate of 1.4 mm/s. This flow zone correlates with a region of high porosity, up to 40%.

The summary logs are shown in **Figure 5**.

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Figure 2: Slipped 'grout basket' at the base of the casing at Stadium High Main borehole.

3.4 Stadium – Hutton

The main difference in the construction of Stadium – Hutton compared to the other boreholes is that additional steel casing had to be installed to keep the formation stable during drilling (from ground level to 90 mbgl and another string from152.4 to 167.4 mbgl). This impacted some of the logging tools, such as natural gamma which showed attenuation due to the casing and the borehole magnetic resonance (BMR) which cannot be run within steel casing.

The CCTV survey showed oscillating flow, where particles in the water moved upwards for a few seconds and then moved downwards in a repeating pattern. This is seen best at around 21.7 mbgl. The cause for this is unknown but it could be due to pumping in the wider mine water system.

A horizontal fracture is seen towards the base of the borehole which corresponds to caliper log. This is likely to be an inflow point as the flow meter shows a small upward flow of 2 mm/s which also corresponds to this zone. No downward flow was seen in the borehole.

The summary logs are shown in **Figure 6**.

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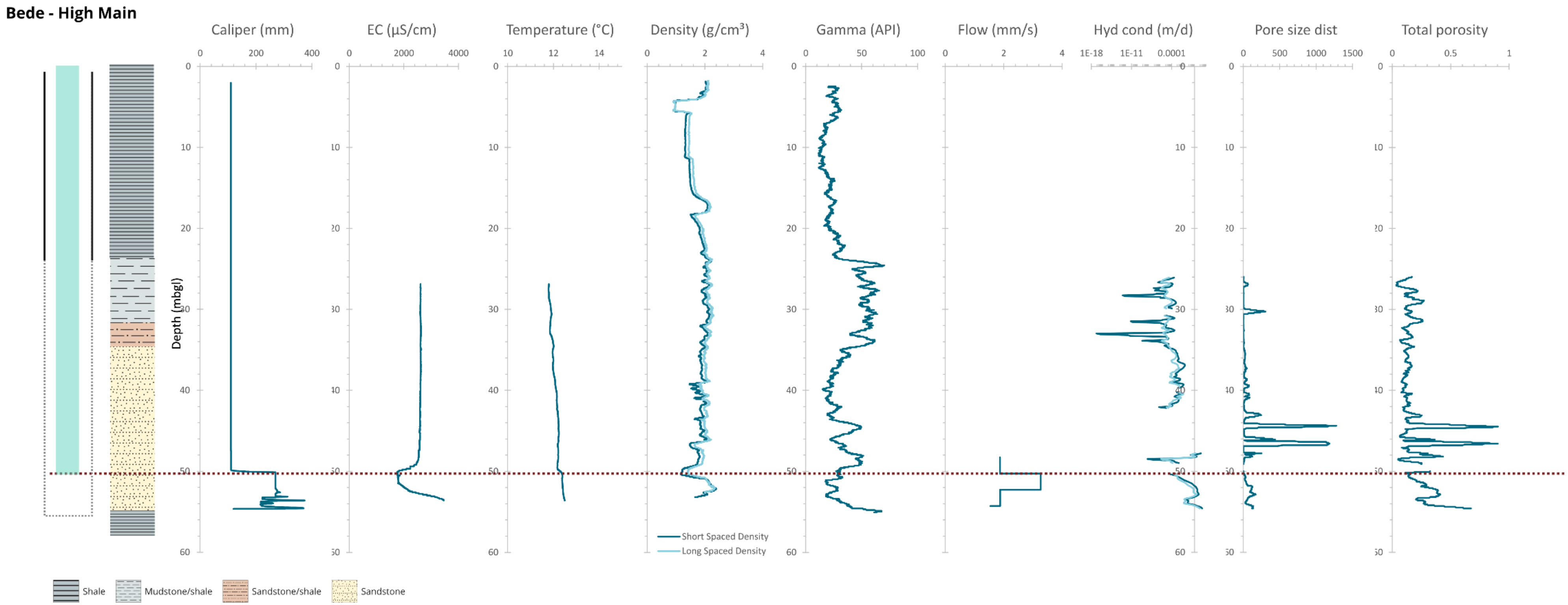

Figure 3: Summary geophysical profiles for Bede – High Main

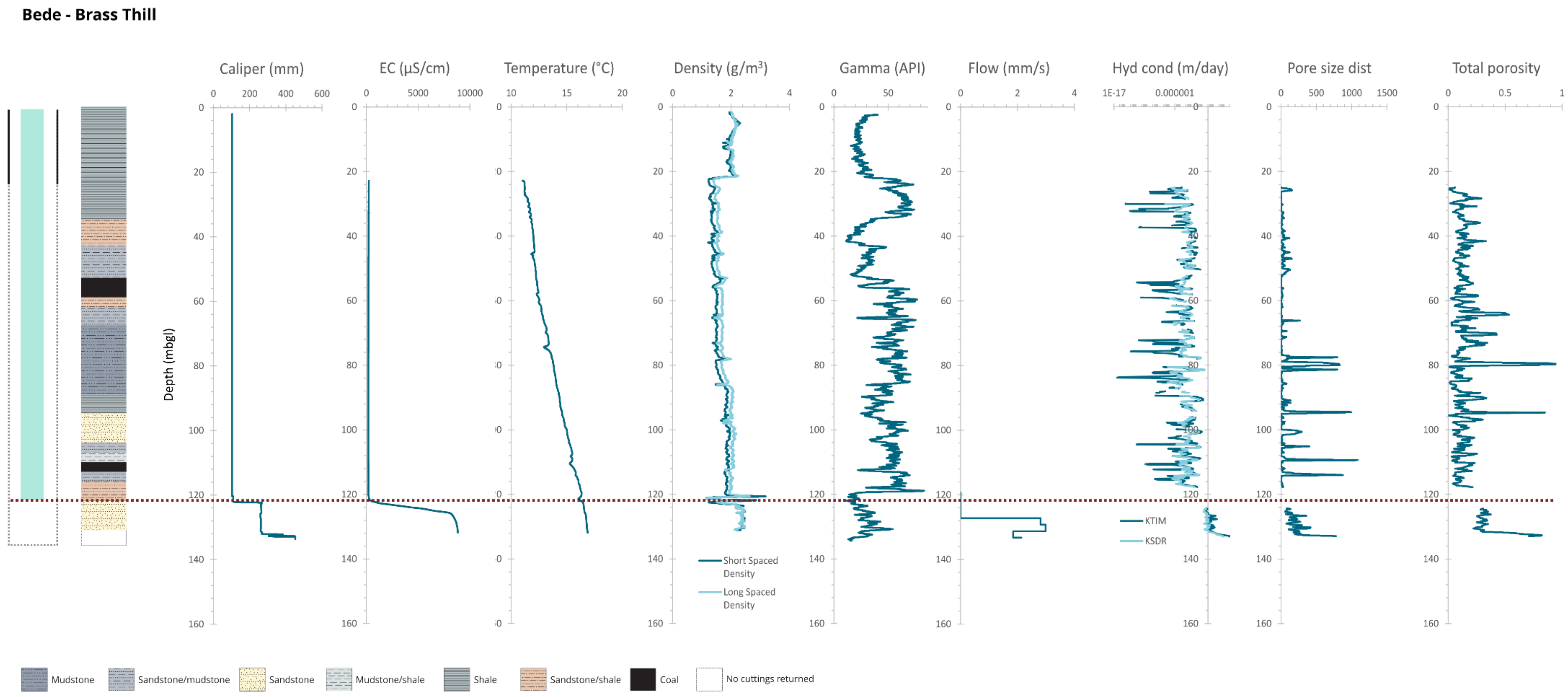

Figure 4: Summary geophysical profiles for Bede – Brass Thill

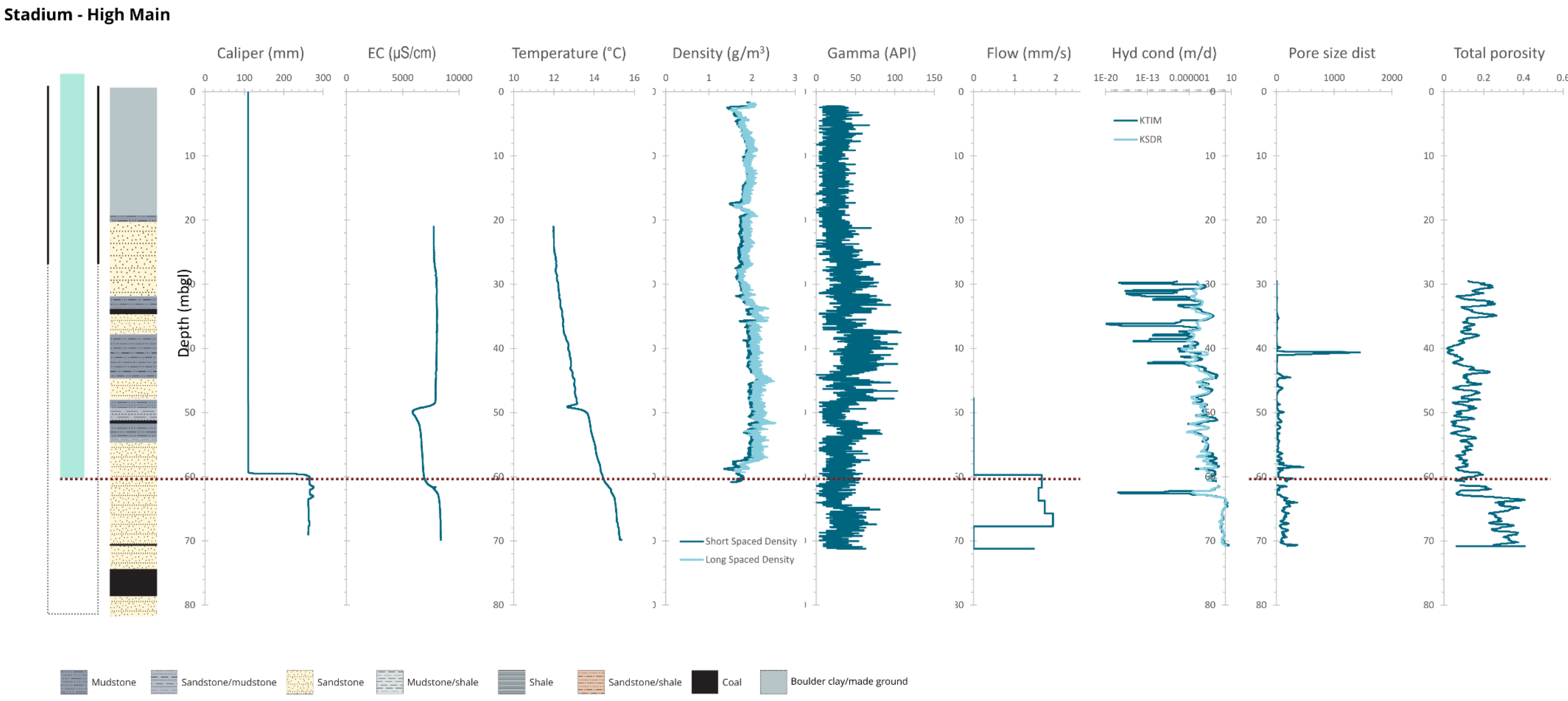

Figure 5: Summary geophysical profiles for Stadium – High Main

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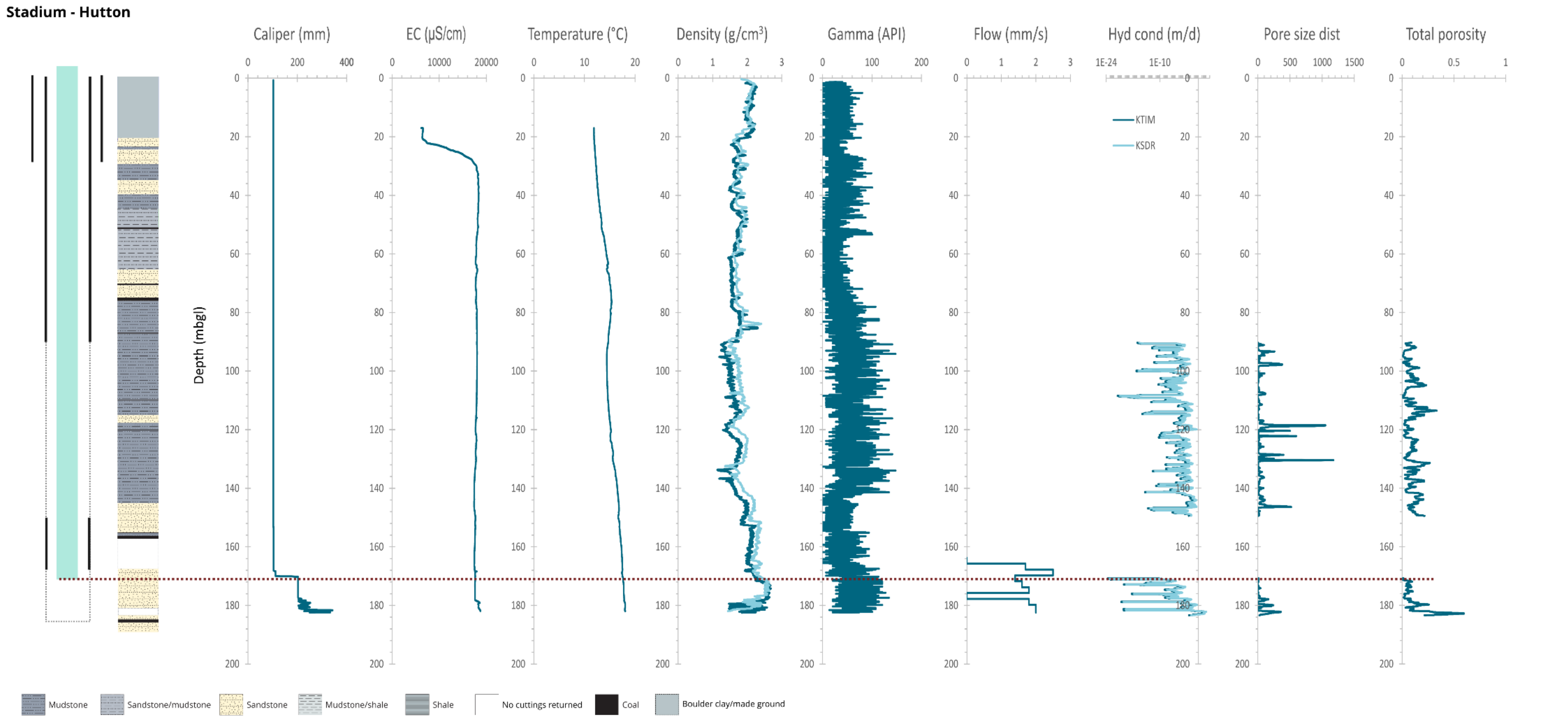

Figure 6: Summary geophysical profiles for Stadium – Hutton

4 Profile comparison

4.1 Temperature

We have undertaken several manual temperature and electrical conductivity profiles of the boreholes since construction, and these have been compared to the profiles obtained during the geophysical logging.

In general, the temperature profiles from the geophysical surveys are lower temperature, by <1°C than those collected to date manually. The geothermal gradients recorded are very similar to the manual mostly showing a geothermal gradient >0.05°C/m. These are higher than the 0.034°C/m estimated for the Northeast Coalfield (Farr et al 2020). The exception to this is Bede – High main which has a lower gradient of 0.02°C/m.

Due to the higher resolution of the geophysical temperature logging additional inflection points are seen recorded compared to the manual profiles. The most pronounced is seen in Stadium – High Main at approximately 49.4 mbgl which as described in section 3.3 is indicative of inflow into the borehole. Further investigation will be undertaken into this during future profiling. Smaller inflections seen at Bede – Brass Thill and Stadium – Hutton broadly align with casing joints and are therefore, thought to be due to small leakages.

A larger zone of temperature change is seen in all profiles taken in Stadium Hutton where the temperature drops (usually >1°C) at 80 mbgl before returning to the geothermal gradient. The causes for this are unknown and will be investigated further.

4.2 Electrical conductivity

The electrical conductivity profiles are also generally similar to those collected manually. Bede – High Main and Bede – Brass Thill both show stable profiles in the casing with increases in the open hole section, as expected due to the flow rates seen in these zones. Stadium – Hutton generally shows high electrical conductivity (approximately 17,600 µS/cm) from very close to the top of the casing with an additional slight increase at the base. Elevated electrical conductivity can occur at shallow depths due to air lifting etc. post drilling as part of the borehole completion works. The values in the cased sections are therefore not necessarily representative of the mine water. Further details of the mine water electrical conductivity are given in section 5.

The Stadium – High Main profiles don't show consistency in any of the profiles collected (manually and during geophysical logging) the causes of this will be investigated further.

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5 Open hole summary

The open hole section is of most interest to understand the properties of the mine workings. **Figure 7** shows the logs of the open sections only, with depth converted to metres below base of casing. This is to allow a comparison of the logs. Where appropriate the values have been compared to standard values for rocks, taken from Banks (2008) and Sharma (1997) for density values.

There is a direct relationship between temperature and depth with the lowest temperature recorded in the shallowest mine workings. The temperatures are 12.4 °C, 14.9 °C, 16.5 °C and 17.7 °C for Bede – High Main, Stadium – High Main, Bede – Brass Thill and Stadium – Hutton respectively.

A similar pattern is generally seen in the electrical conductivity results, with increasing electrical conductivity with depth, 3300 µS/cm in the shallowest (Bede – High Main) to 17,600 µS/cm in the deepest (Stadium – Hutton). Interestingly the electrical conductivity at Bede – Brass Thill starts lower than Stadium – High Main, around 700 µS/cm before rising to the same level, 8300 µS/cm. This could be due to the fact that the majority of flow in the Bede – Brass Thill is towards the bottom of the borehole causing an increase in electrical conductivity.

The density values in Bede – High Main are between 1.7 and 2.4 g/cm^3, slightly higher in Bede – Brass Thill between 2.3 and 2.5 g/cm^3. The density profile in Stadium – Hutton shows values around 2.6 g/cm3 before becoming erratic in the fractured zone. Density wasn’t run in Stadium – High Main. These values are generally within the shales and sandstone bands, towards the lower end for crystalline rocks and upper end for chalk.

The highest flow is seen at the Bede site: the High Main borehole has rates up to 3.5 mm/s and Brass Thill up to 3 mm/s. The flows at Stadium are slightly lower, generally between 1.5 and 2 mm/s although Hutton does record up to 2.5 mm/s in the open section. Vertical flow is recorded within the casing at Stadium – Hutton.

The porosity in the open sections of most of the boreholes is between 20% and 40% which is similar to gravel and chalk and at the lower end of values in clay, silt and sand (from Banks 2008). There are high peaks, up to 70-80% in the highly fractured areas, some of which correlate with mine voids. Stadium – Hutton generally has a lower porosity than the others, although it still peaks up to 60%.

The calculated specific yield (a measure of the amount of water a rock will release by gravity) is generally 15 to 30% which is the top end of silts/sands/gravel and sandstone (Banks 2008). There are higher values, around 50 – 80% in the broken/worked sections of the boreholes. As for porosity, the specific yield values in Stadium – Hutton are lower.

Two empirical equations are used to predict hydraulic conductivity from borehole magnetic logging data: the Schlumberger Doll Research equation (KSDR) and the Timur-Coates equation (KTIM) (Dlubac et al 2013). Both of these have been plotted as a comparison and mostly give comparable results. Generally hydraulic conductivity values are similar to sands

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and sandstones, perhaps at higher end of silt, crystalline rocks and chalk and the lower end. Several of the peaks, representing the fractured/worked areas go into high values for gravels. As for the previous results the Stadium Hutton has much lower values with some really low points. This is likely to be an artefact of the tool in the broken section of the formation.

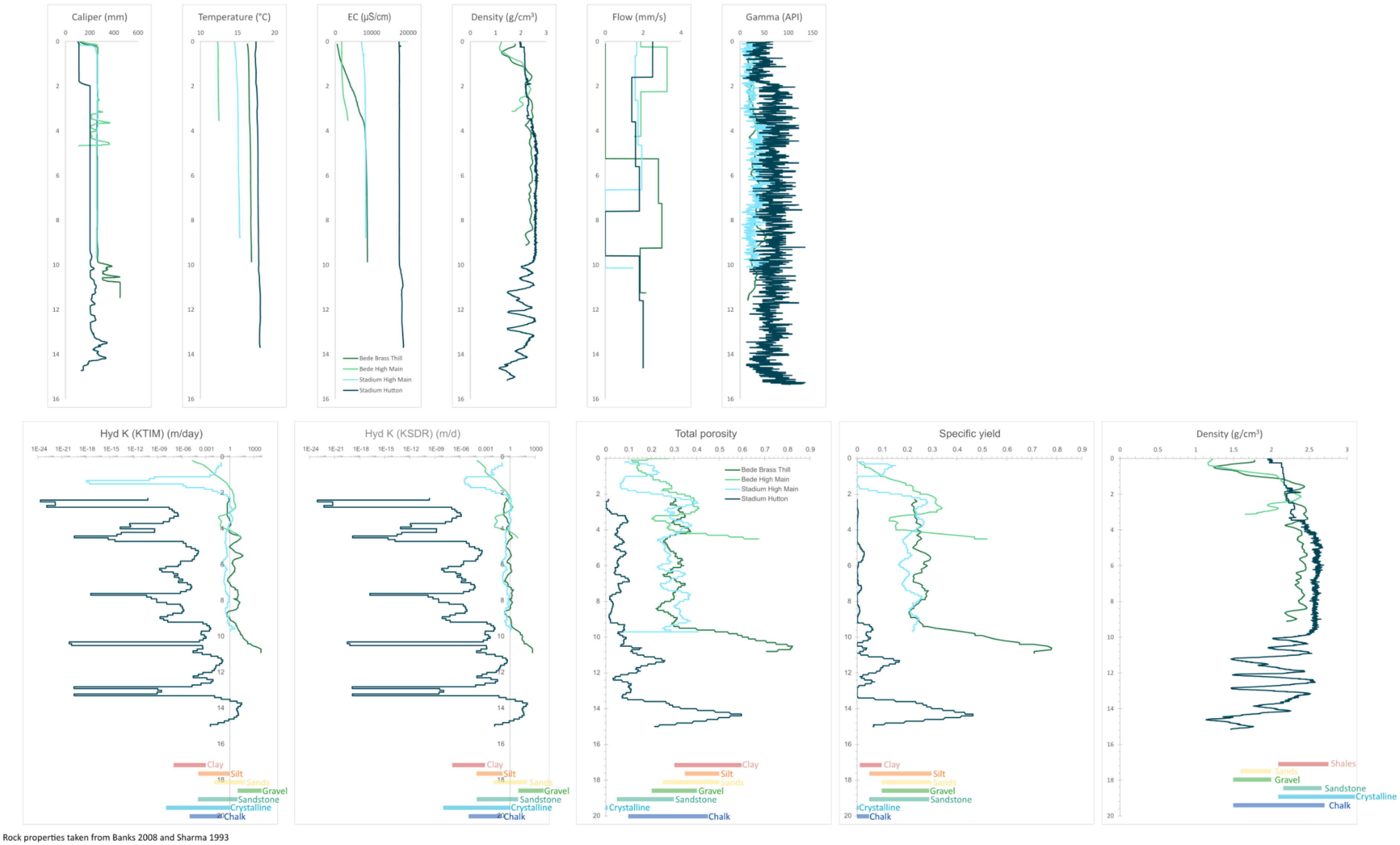

Figure 7: Summary logs of open hole sections. Depths in m below base of casing

6 Conclusions

The CCTV and geophysical logging that was undertaken at the Gateshead Living Lab boreholes in January 2025 provides a baseline for current conditions within the mine workings. The data collected allows further development of the conceptual understanding of the thermal and hydrogeological interactions between multiple mine water heat schemes. This is essential to support operators, regulators, developers, researchers and academics make evidence-based decisions on the development of mine water heat schemes.

The results show that in all of the boreholes flow zones are associated with fractured rocks, which is as to be expected. Generally, the flows at Stadium were lower than at Bede, which was up towards 3.5 mm/s. The elevated geothermal gradient at most of the boreholes that was previously identified during manual profiling has been confirmed with these results. The large inflection in temperature at Stadium – Hutton between 60 and 100 mbgl has been seen and this will be investigated further.

A small reduction in temperature has been identified in Stadium – High Main at around 49 mbgl and this corresponds to a change in electrical conductivity suggesting a potential inflow point. Further work will be undertaken to clarify this further.

The density of the open hole sections are between 1.7 and 2.5 g/cm^3 similar to those for shales and sandstones. The specific yield of the open hole sections, between 15 and 30%, are also predominantly in the silts, sands and sandstones but the worked sections recorded values up to 80%. Generally hydraulic conductivity values are similar to sands and sandstones whereas several of the peaks, representing the fractured/worked areas go into high values for gravels. The fractured areas also provided high levels of porosity, 70 to 80%, which is higher than most other rock types. These are predominantly free water, i.e. the water isn't bound by capillary forces.

This suggests that, as expected, the worked areas are highly conductive and allow free water movement. These zones are focussed on particular bands in the open hole sections and surrounding these the lithology is predominantly similar to sedimentary rocks.

The results for Stadium – Hutton are lower for most of the derived values from the borehole magnetic resonance tool (porosity, specific yield and hydraulic conductivity). It is unclear whether this is real or an artefact of the logging tool and further work will be undertaken to review this.

These results provide an improved understanding of the thermal and hydrogeological properties of the mine workings. We hope that improved understanding of the thermal and hydrogeological properties of the mine workings can be used to inform future licensing, management and wider adoption of mine water heat schemes. Further work will be undertaken to investigate some of the questions raised by this work including the oscillating flow and the large temperature inflection identified in Stadium – Hutton. The causes of inconsistencies e.g. in the Stadium – High Main electrical conductivity profiles, will be investigated through further profiling.

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Appendix A – Geophysical survey reports

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EUROPEAN GEOPHYSICAL SERVICES

REPORT ON THE VIDEO SURVEY

AND

GEOPHYSICAL LOGGING

OF

BOREHOLE BRASS THILL

AT

BEDE

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Report by:	K. Pearson	11.03.25
Checked by:	R. Powell	24.04.25

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1.0 INTRODUCTION

At the request of the Mining Remediation Authority, a video survey, and geophysical logging were carried out in Brass Thill at Bede as part of the Living Lab project, near Gateshead.

The aim of the survey was to check the physical condition of the borehole, and some associated geophysical parameters.

The work was carried out by European Geophysical Services Ltd on 16th January 2025

The following logs were run:

Tool / Log (unit)		Log Depths (m)	
Borehole Video Camera	Dual View	1.0	133.1
Static Fluid Temperature / Conductivity	T (°C) / EC25 (μS/cm)	22.4	133.1
Natural Gamma	Gam (API)	2.6	133.1
Three Arm Caliper	Cal (mm)	2.6	133.1
Dual Densities (Long / Short spaced)	LSD / SSD (Apparent g/cm³)	2.0	131.0
Heat Pulse Flow Meter	HPFM (mm/s)	119	133.0
Borehole Magnetic Resonance	BMR	25.0	133.0

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2.0 THE GEOPHYSICAL LOGGING METHODS

The Equipment and Field Procedure

A fully digital logging system with a 600m capacity motorised winch mounted in a 4x4 van was used.

All logging data was recorded digitally for reprocessing and archiving purposes.

The video camera survey was carried out first to avoid the disturbance of the fluid by geophysical logs which may affect water clarity.

Borehole Video Camera (DTV)

This borehole camera offers a twin view set up allowing the operator to switch between either a forward or side view camera. The side view camera has an infinite 360° rotation

The results of the survey are recorded digitally along with the date, borehole identity and depth information.

Fluid Temperature (T)

There is a natural geothermal gradient of increasing temperature with depth. This gradient varies with the thermal conductivity of the geological formation and is modified by water flowing in, out or vertically though the borehole.

This log is used to determine flow patterns within the borehole and to identify flow zones.

Differential logs are produced over a one metre spacing, these are an interpretative aid to detect gradient changes.

Fluid Conductivity (EC or EC25)

The electrical conductivity (EC) of the water is related to its salinity and dissolved solids and is therefore a measure of the quality of the borehole water. The shape of the log trace can indicate zones of inflow.

Using data from the temperature log the electrical conductivity is corrected to 25°C (EC25).

This log is used to identify different zones of water quality.

Differential logs are produced over a one metre spacing, these are an interpretative aid to detect gradient changes.

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2.0 THE GEOPHYSICAL LOGGING METHODS

Heat Pulse Flowmeter (HPF)

The Heat Pulse Flowmeter consists of two very sensitive temperature sensors which are positioned 5cm above and 5cm below a small heating element. The tool is positioned at a particular depth and left for a few minutes for the temperature sensors to stabilise. A heat pulse is then generated and then the temperature sensors monitor for its movement. The distance from the heating element to the sensors is (5cm). The time taken for the heat pulse to reach the sensor is recorded and is used to calculate the velocity of the fluid movement.

Caliper (Cal)

This tool measures the mean diameter of the borehole. It is used to check the integrity of the borehole lining, and where the borehole is unlined to identify zones of washout, breakout or fissures.

Natural Gamma (Gam)

The tool measures the naturally occurring gamma radiation found in rocks and sediments. It is mainly used to detect the clays that contain potassium K^{40}, though the U^{238} and the Th^{232} series of elements present in certain rocks also emit gamma radiation.

The higher the concentration of these clay minerals the greater the responses on the natural gamma log.

Dual - Density (LSD / HRD)

The density tool has two detectors at different spacing's from a source of gamma radiation. The logs from each detector indicate the apparent bulk density of the material surrounding the tool at a radius of investigation related to the spacing's. The Long Spaced Density (LSD) has a spacing of 48cm and the High Resolution Density (HRD) has a spacing of 24cm.

The High Resolution Density has the smaller radius of investigation, up to around 10cm under average/medium range of densities, and its response is also more affected by the quality of the borehole lining. The Long Spaced Density has the greater radius of investigation, up to 15 - 20cms under average conditions, but least resolution.

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2.0 THE GEOPHYSICAL LOGGING METHODS

Borehole Magnetic Resonance (BMR)

BMR is a quantitative geophysical method that can be used to make in situ assessments of porosity, water content, mobile and immobile water fraction, and estimates of permeability. Also known as NMR; it stands for Nuclear Magnetic Resonance. The term Nuclear refers to the fact that we are measuring a quantum mechanical state of the proton, called Spin. The Spin can be a + or – spin and we look at transitions between to the two levels. 'Magnetic' refers to the fact that we use external magnets to align the spins in one direction. Once we have the spins aligned up, we can then conduct experiments to obtain information about the spins. These transitions in spin states only occur at a particular Resonance frequency. The value of which is determined by the gyromagnetic ratio multiplied by our magnet field strength. This can then be converted to a value in kHz. The tool has an antenna that pulses at this frequency. Typically, for borehole NMR tools this frequency is in the RF range and hence we often call it a RF antenna.

The tool will send a series of pulses in what we call a pulse sequence. The duration and number of the sequences affects the amount of data and quality of data that is obtained. The shorter the echo spacing (time between RF pulses) the more accurate the measurement.

The raw data collected in the CPMG (pulse sequence name) is then inverted to obtain a T2 distribution. T2 is the relaxation time of the spins after they are perturbed by the RF pulse. This decay data is actually a sum of exponentials that is related to the pore size distribution.

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3.0 BOREHOLE DETAILS

Bede Brass Thill

OS Grid Ref: NZ 26806 62678
Post Code: NE10 0DJ

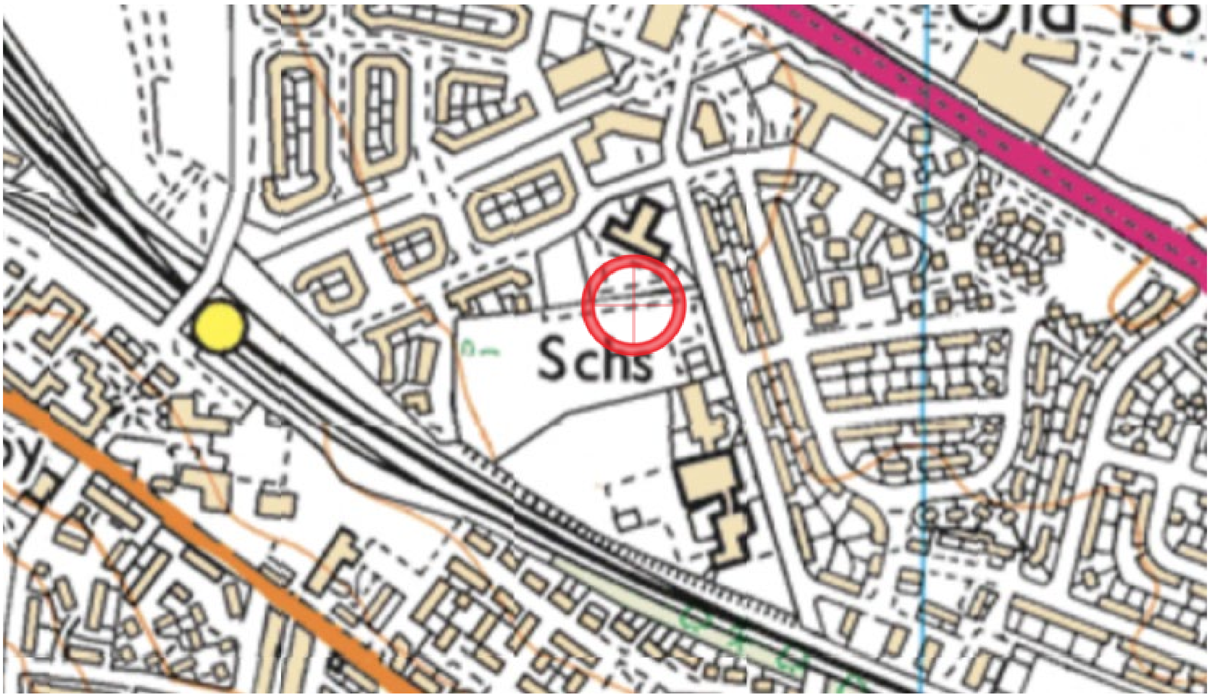

Figure 3.1 Location map showing Bede approximate location. © Crown copyright 2025 OS100057099.

Figure 3.2 Aerial image showing Bede Brass Thill approximate location. © Google 2025.

3.0 BOREHOLE DETAILS

The Bede site is accessed from the Old Fold Rd. The date of sinking of the bore was in 2024. The Brass Thill Borehole is one of 2 boreholes known to occupy the Bede locality. Bede High Main is located to the East, some 20m away.

Figure 3.3 Bede entrance looking from Old Fold Rd. © Google 2025.

Figure 3.4 Bede Brass Thill wellhead with logging tripod and wireline in position.

3.0 BOREHOLE DETAILS

Figure 3.5 View of logging vehicle in position during wireline operations at Bede Brass Thill

Bede Brass Thill		
Date Logged:	**16.01.2025**	
Datum:	Top of uPVC lining	
Drilled Depth	135.6 m*	
Logged Depth:	133.1 m	
	Internal Diameters	*Depths*
Plain Steel Lining:	254 mm	0 – 23.8 m*
MDPE Lining:	103 mm	0.2 – 121.9m
Unlined Borehole:	244 mm	121.9 – 135.6m*
Water Level:	22.4 m	*Rest water level*
Logged By:	C. Clinton	

Figure 3.6 Table of the borehole construction from data obtained during the survey. *Based on information provided by the Mining Remediation Authority.

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4.0 BOREHOLE LOGGING CONSTRAINTS

- **Vehicle access constraints**

  None

- **Tool access constraints**

  None

- **Borehole quality constraints**

  None

- **Sonde risk**

  None

- **Lack of fluid filled column**

  None

- **Time constraints**

  None

- **Construction constraints**

  None

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5.0 RESULTS

5.1 Presentation of Results

A composite geophysical log with associated CCTV observations and construction log has been presented as an A4 colour plot and is shown in Figure 5.1. A composite Magnetic Resonance and geophysical log has been presented as an A4 colour plot and is shown in Figure 5.2.

5.2 Photographs

Photographs of key features have been taken from the digital recording and are shown as Figures 5.3 and 5.4

5.3 Discussion

The records provided by the Mining Remediation Authority show a surface steel casing of 10 inches diameter down to a depth of 23.8m, with an inner uPVC lining of 4 inches diameter to a depth of 121.9m. Above 23.8m the Natural Gamma appears dampened and Density values increase, which are in keeping with a steel casing being behind the uPVC lining. The bottom of the uPVC lining was found at 121.9m on CCTV and Caliper.

The bottom joint of lining at 120.9m shows some separation on the CCTV, with some threads visible, and does appear to be slightly different in nature to the lining above, appearing to be plain steel with a marginally increased internal diameter measurement on the caliper reading of 116mm instead of the 103mm in the lining above.

The density measurements over this section (between 121.9 and 120.1m) are also quite different, again suggesting that this section has a lower density in the middle but higher over the joins. The Mining Remediation Authority have indicated that an inflatable packer was used during casing cementation, so these density values probably reflect the position of this apparatus.

In addition, below 120.1m the temperature gradient begins to cool, going from 16.3 °C at 120m to 16.0°C, with a negative inflection point at 121.2m, before returning to a typical temperature gradient for this well at around 122.6m, below the bottom of the lining. This may be due to the change of surrounding material, although may also indicate a cross flow occurring.

The temperature gradient of ~1.6 °C per 30m is higher than a UK geothermal gradient of ~1 °C per 30m, which is likely due to water movement and local mine workings. There are also some small temperature inflections within the uPVC lining at depths of 30.6, 32.2, 33.9, 45.3, 46.3, 57.7, 60.5, 69.7, 99.1, 108.0 and 113.9m, with more major infections occurring at 74.1, 110.3 and 121.2m

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5.0 RESULTS

5.3 Discussion

The Electrical Conductivity measurements are low within the uPVC lining with an average value of around 200 μs/cm to a depth of 121.9m before raising rapidly in open hole and reaching a gently increasing gradient with values between 8000 – 9000 μs/cm between 125.5m and the total depth logged. There is a small negative inflection at around 125.0m.

These Conductivity measurements tie in nicely with the Heat Pulse Flow Meter measurements which show a small upwards flow of around 2.5 – 2.8 mm/s in the fluid column between the base of the borehole and 125m. Suggesting that fluid is entering the borehole at the base and then leaving the borehole at around 125m.

There is a small decrease in density at around 125.5m, which correlated with a Natural Gamma peak and may indicate a fracture, and a sub vertical fracture was observed on the CCTV between 125.5 - 125.9m, however the caliper log is fairly flat over the area indicating there is minimal breakout.

The CCTV showed some flaky black sediment in the fluid column, which appears to have sat on the inside of the lining and on the borehole wall in places.

Water level was observed on CCTV and located by the Fluid Tools at a depth of 22.4m, with some minor fluctuations in water level of ±5cm over the different runs.

At a depth of 131.7m to the total surveyable depth of 133.1m there is a significant breaking out of the borehole, with horizontal fracturing observed on both CCTV and the caliper data.

The BMR was run from 132.8 – 124.1m and 117.6 – 24.7m. Gaps in BMR data are due to the presence of plain steel casing in the borehole.

Based upon the other logs and the data provided by The Mining Remediation Authority, the borehole is comprised of Clastic lithology. Therefore, the subject BMR data was processed using global cutoffs for a clastic (clay (3 ms) and capillary (33 ms) bound water) lithology and standard co-efficients for permeability equations. It should be noted that in unsaturated media, TPOR reports only moisture content and Water Volume, Hydraulic Conductivity and Transmissivity outputs are invalid. If present, minor Noise, Magnetics and Formation Effects in the borehole have been flagged throughout the log. When the effects are above tolerances, the data has additionally been labelled as formation corrupted and should not be used unless validated with other logs/information. Thus, at the corrupted sections, the hydraulic conductivities, SR and SY have been removed for clarity. A Borehole/Washout flag has been applied as a late T2 porosity response that seems to coincide with caliper changes suggests the BMR tool is not centered in the openhole section resulting in a small portion of the diameter of investigation to be in the borehole. This could be a result of a slightly deviated borehole causing the BMR tool to lean against one side of the borehole in this lower section. At the bottom of the section, the same flag is for the enlarged diameter measured by the caliper indicating washout.

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The average total porosity in the sandstone section of the unlined borehole was measured at around 0.3 (30%; with 1 being 100%).

The total porosity values in the upper section are more variable, with higher signal noise, which is to be expected when run inside uPVC casing. We see formation effects on the data quality occurring at 94.7m where the formation changes between sandstone and shale, and again at 79.7m inside the mudstones. It should be noted that where the cementing behind the uPVC lining is inconsistent, the BMR data will not be representative of the formation, due to the higher quantity of water.

The base of the borehole was covered with a fine sediment, and the total observable depth was 133.1m

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Figure 5.1

Composite Geophysical Log

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Client: **Mining Remediation Authority**

Borehole: **Bede - Brass Thill**

Log Type: ***Composite***

Location: **Gateshead** Area: **Newcastle** Grid Ref: **NZ26** Elevation:

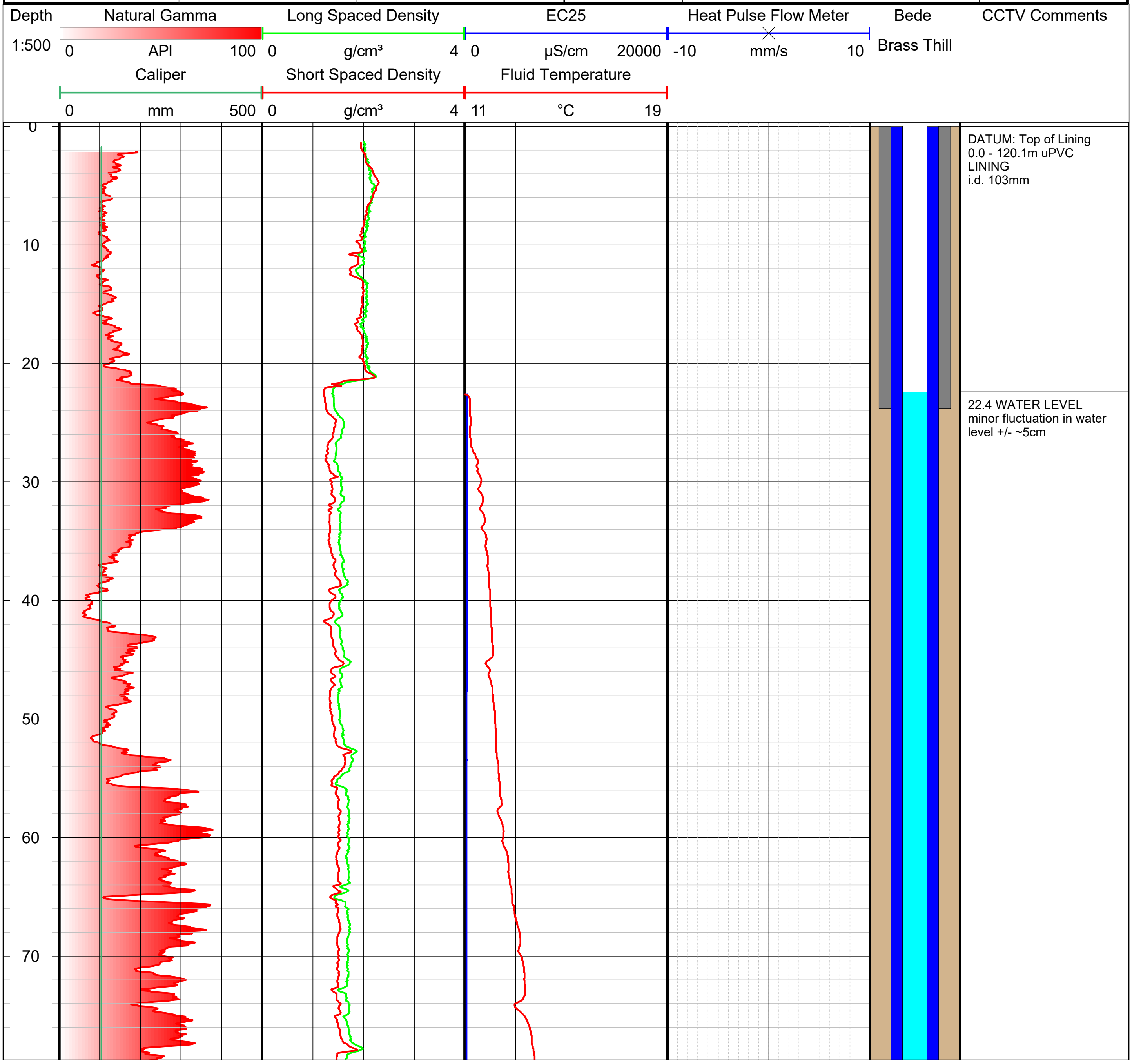
Drilled Depth: (m)	**135.6 (BGL)**	Date:	**16.01.25 & 17.01.25**
Logged Depth: (m)	**133.1**	Recorded By:	**C. Clinton**
Logging Datum:	**Top of uPVC**	Remarks:	
Logged Interval: (m)	**0.0 - 133.1**		
Fluid Level: (m)	**22.4**		

BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)
375	**0.0**	**23.8**
245	**23.8**	**135.6**

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
Steel	**254**	**0.0**	**22.0**
uPVC	**103 (id)**	**0.0**	**120.1**
Steel	**111 (id)**	**120.1**	**121.9**




80
90
100
110
120
130
140
120.1 - 121.9m PLAIN STEEL LINING i.d. 111mm
121.9 - 133.1m - UNLINED BOREHOLE
133.1m FINAL SURVEYABLE DEPTH

Figure 5.2

Borehole Magnetic Resonance Log

© European Geophysical Services Ltd

EUROPEAN GEOPHYSICAL SERVICES LTD

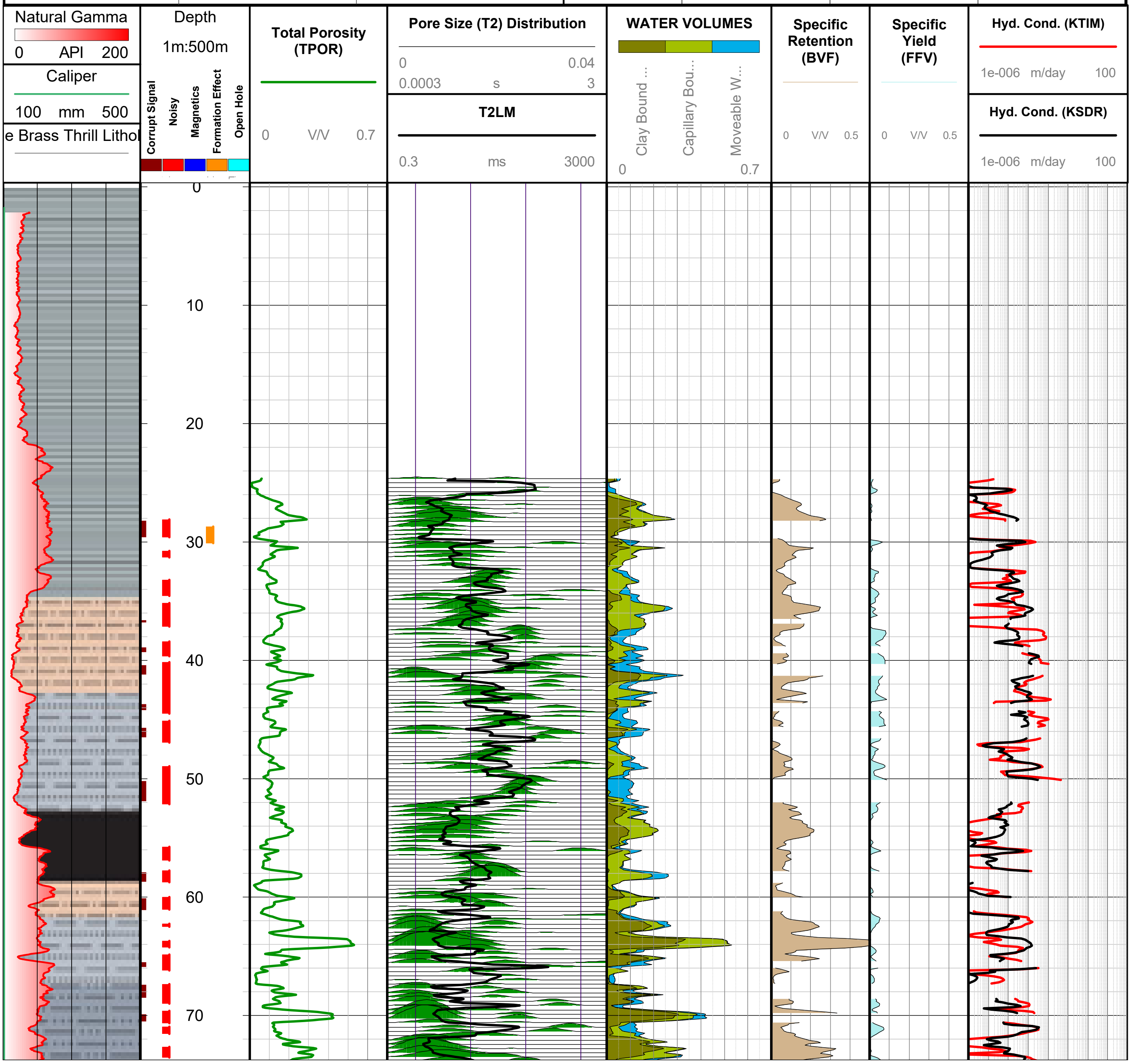
Client:	**Mining Remediation Authority**	Log Type:	
Borehole:	**Bede - Brass Thill**		***Composite***

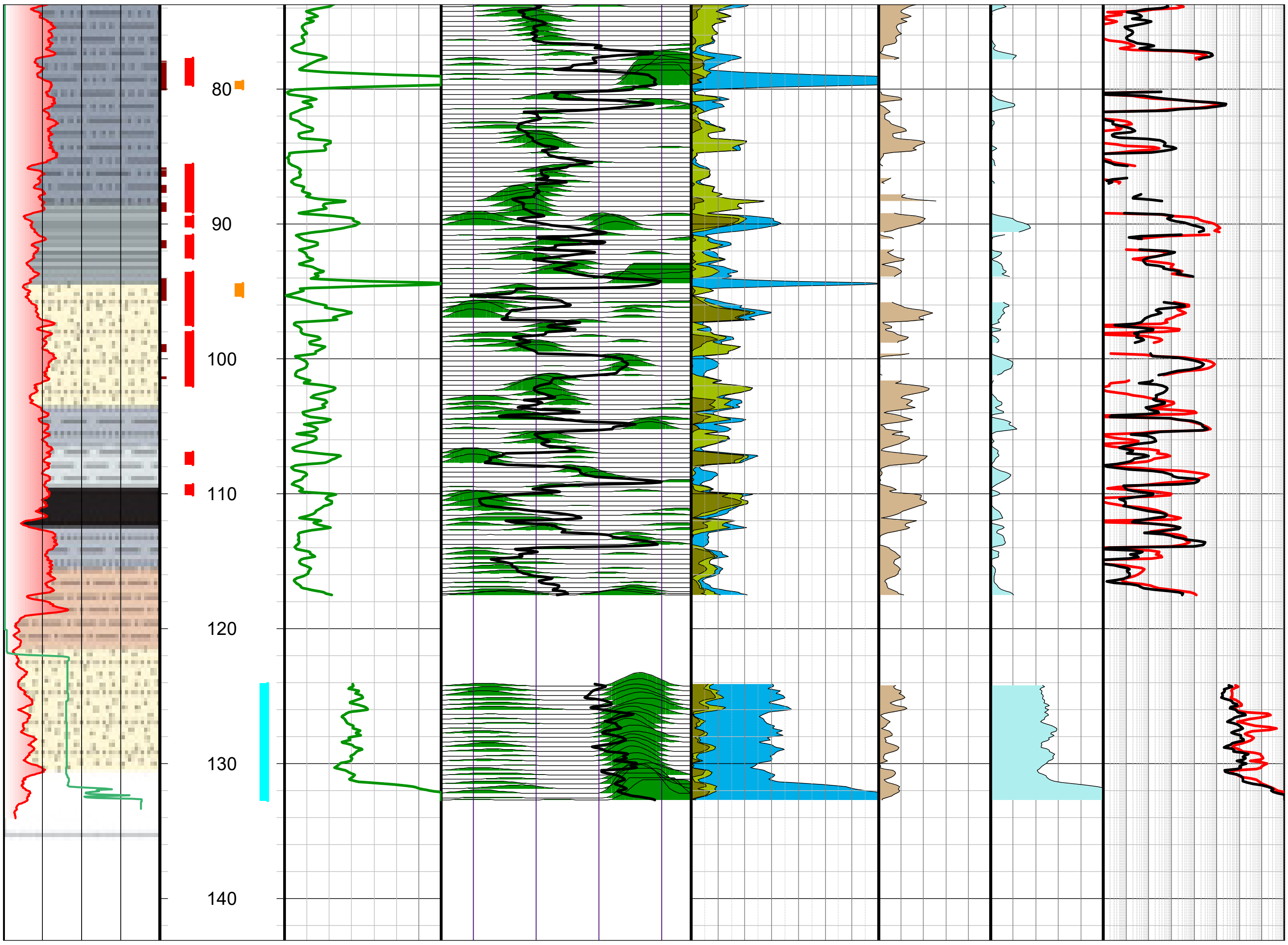
Location: **Gateshead** Area: **Newcastle** Grid Ref: **NZ26** Elevation:

Drilled Depth: (m)	**135.6 (BGL)**	Date:	**16.01.25 & 17.01.25**
Logged Depth: (m)	**133.1**	Recorded By:	**C. Clinton**
Logging Datum:	**Top of uPVC**	Remarks:	
Logged Interval: (m)	**0.0 - 133.1**		
Fluid Level: (m)	**22.4**		

BOREHOLE RECORD		
Bit: (mm)	From: (m)	To: (m)
375	**0.0**	**23.8**
245	**23.8**	**135.6**

CASING RECORD			
Type	Size: (mm)	From: (m)	To: (m)
Steel	**254**	**0.0**	**22.0**
uPVC	**103 (id)**	**0.0**	**120.1**
Steel	**111 (id)**	**120.1**	**121.9**





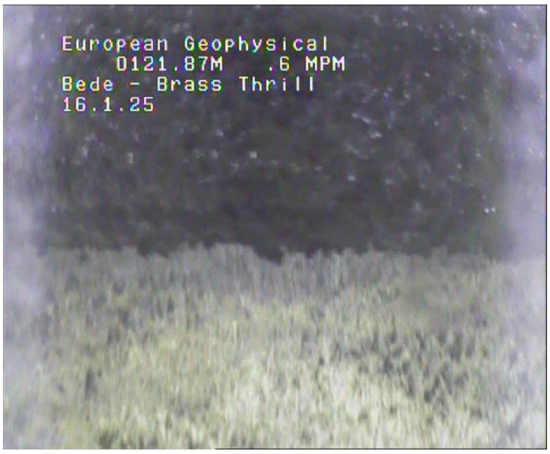
80
90
100
110
120
130
140

5.0 RESULTS

PHOTOGRAPHS FROM THE CCTV SURVEY

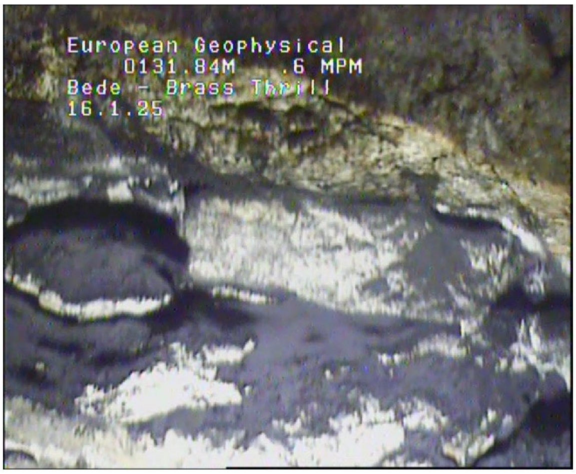
Borehole Brass Thill **Date: 16.01.25**

Bottom of casing



Black sediment sitting on borehole wall

Down hole view of breakout at base of borehole



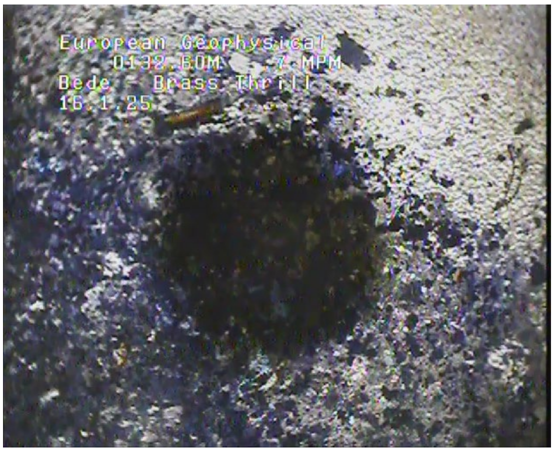
Breakout at 131.8m

Figure 5.3

5.0 RESULTS

PHOTOGRAPHS FROM THE CCTV SURVEY

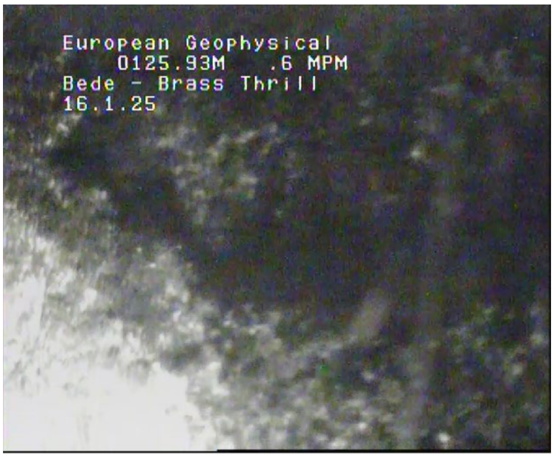
Borehole Brass Thill **Date: 16.01.25**



Base of borehole covered in fine sediment

View of fracturing at base of borehole

Top of sub vertical fracture



Bottom of sub vertical fracture

Figure 5.4

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6.0 CONCLUSIONS

6.1 The final surveyable depth of the borehole was recorded at 133.1m and was covered in fine sediment.

6.2 The borehole was lined with 254mm diameter plain steel casing between datum and 23.8m. A second string of uPVC lining with 103mm i.d. is within this going from datum to 121.9m.

6.3 A change in lining was evident between 120.1 – 121.9m, with density changes suggesting that there the packer used during casing cementing is at this depth.

6.4 The unlined borehole was competent and stable sandstone, with some break outs observed below 131.7m and a sub vertical fracture observed at 125.5 – 125.9m on CCTV which is assumed to be the top of the flow system.

6.5 The unlined borehole was +/-270mm in diameter.

6.6 The rest water level was 22.4m with around a +/-5cm fluctuation. Some black flaky suspended sediment was observed in the fluid column and settling onto surfaces.

6.7 There was vertical fluid movement between the base of the borehole and 125.0m, with flow rates on the Heat Pulse Flow Meter being measured at around 2.5-2.8mm/s. this correlated with the Conductivity measurements.

6.8 Changes to water quality were primarily associated with this flow with EC25 values remaining near constant in the lining at around 200 µS/cm before increasing rapidly to the top of the flow horizon at 125m, and then stabilising between 8000 – 9000 µS/cm within the flow horizon.

6.9 Some minor inflections in temperature were observed across the uPVC lining, at depths of 30.6m 32.2m 33.9m 45.3m 46.3m 57.7m 60.5m 69.7m 99.1m 108.0m and 113.9m, suggesting some minor cross flows present.

6.10 Major inflections in temperature were observed at 74.1m 110.3m and 121.2m. and an inflection in Conductivity was observed at 125.0m.

6.11 The average total porosity in the sandstone section of the unlined borehole is around 30%. The total porosity values in the upper section are more variable, with higher signal noise, which is to be expected when run inside uPVC casing.

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EUROPEAN GEOPHYSICAL SERVICES

REPORT ON THE VIDEO SURVEY

AND

GEOPHYSICAL LOGGING

OF

Bede High Main

AT

Gateshead Living Lab

Prepared For:

Mining Remediation Authority

Mining Remediation Authority
200 Lichfield Lane
Mansfield
Nottinghamshire
NG18 4RG
United Kingdom

JAN_2025/COA2422A_Bede_High_Main_rpt/NZ26

	Name	Date
Logged by:	C. Clinton	16.01.25 17.01.25
Report by:	K. Pearson	11.03.25
Checked by:	R. Powell	24.04.25

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LIST OF FIGURES

1.0 INTRODUCTION

At the request of the Mining Remediation Authority, a video survey, and geophysical logging were carried out in High Main at Bede as part of the Living Lab project, near Gateshead.

The aim of the survey was to check the physical condition of the borehole, and some associated geophysical parameters.

The work was carried out by European Geophysical Services Ltd on 16th and 17th January 2025

The following logs were run:

Tool / Log (unit)		Log Depths (m)	
Borehole Video Camera	Dual View	1.0	55.0
Static Fluid Temperature / Conductivity	T (°C) / EC25 (µS/cm)	26.5	55.0
Natural Gamma	Gam (API)	2.6	55.0
Three Arm Caliper	Cal (mm)	2.6	55.0
Dual Densities (Long / Short spaced)	LSD / SSD (Apparent g/cm³)	2.0	53.0
Heat Pulse Flow Meter	HPFM (mm/s)	48.0	54.0
Borehole Magnetic Resonance	BMR	26.0	55.0

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2.0 THE GEOPHYSICAL LOGGING METHODS

The Equipment and Field Procedure

A fully digital logging system with a 600m capacity motorised winch mounted in a 4x4 van was used.

All logging data was recorded digitally for reprocessing and archiving purposes.

The video camera survey was carried out first to avoid the disturbance of the fluid by geophysical logs which may affect water clarity.

Borehole Video Camera (DTV)

This borehole camera offers a twin view set up allowing the operator to switch between either a forward or side view camera. The side view camera has an infinite 360° rotation

The results of the survey are recorded digitally along with the date, borehole identity and depth information.

Fluid Temperature (T)

There is a natural geothermal gradient of increasing temperature with depth. This gradient varies with the thermal conductivity of the geological formation and is modified by water flowing in, out or vertically though the borehole.

This log is used to determine flow patterns within the borehole and to identify flow zones.

Differential logs are produced over a one metre spacing, these are an interpretative aid to detect gradient changes.

Fluid Conductivity (EC or EC25)

The electrical conductivity (EC) of the water is related to its salinity and dissolved solids and is therefore a measure of the quality of the borehole water. The shape of the log trace can indicate zones of inflow.

Using data from the temperature log the electrical conductivity is corrected to 25°C (EC25).

This log is used to identify different zones of water quality.

Differential logs are produced over a one metre spacing, these are an interpretative aid to detect gradient changes.

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2.0 THE GEOPHYSICAL LOGGING METHODS

Heat Pulse Flowmeter (HPF)

The Heat Pulse Flowmeter consists of two very sensitive temperature sensors which are positioned 5cm above and 5cm below a small heating element. The tool is positioned at a particular depth and left for a few minutes for the temperature sensors to stabilise. A heat pulse is then generated and then the temperature sensors monitor for its movement. The distance from the heating element to the sensors is (5cm). The time taken for the heat pulse to reach the sensor is recorded and is used to calculate the velocity of the fluid movement.

Caliper (Cal)

This tool measures the mean diameter of the borehole. It is used to check the integrity of the borehole lining, and where the borehole is unlined to identify zones of washout, breakout or fissures.

Natural Gamma (Gam)

The tool measures the naturally occurring gamma radiation found in rocks and sediments. It is mainly used to detect the clays that contain potassium K^{40}, though the U^{238} and the Th^{232} series of elements present in certain rocks also emit gamma radiation.

The higher the concentration of these clay minerals the greater the responses on the natural gamma log.

Dual - Density (LSD / HRD)

The density tool has two detectors at different spacing's from a source of gamma radiation. The logs from each detector indicate the apparent bulk density of the material surrounding the tool at a radius of investigation related to the spacing's. The Long Spaced Density (LSD) has a spacing of 48cm and the High Resolution Density (HRD) has a spacing of 24cm.

The High Resolution Density has the smaller radius of investigation, up to around 10cm under average/medium range of densities, and its response is also more affected by the quality of the borehole lining. The Long Spaced Density has the greater radius of investigation, up to 15 - 20cms under average conditions, but least resolution.

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2.0 THE GEOPHYSICAL LOGGING METHODS

Borehole Magnetic Resonance (BMR)

BMR is a quantitative geophysical method that can be used to make in situ assessments of porosity, water content, mobile and immobile water fraction, and estimates of permeability. Also known as NMR; it stands for Nuclear Magnetic Resonance. The term Nuclear refers to the fact that we are measuring a quantum mechanical state of the proton, called Spin. The Spin can be a + or – spin and we look at transitions between to the two levels. ‘Magnetic’ refers to the fact that we use external magnets to align the spins in one direction. Once we have the spins aligned up, we can then conduct experiments to obtain information about the spins. These transitions in spin states only occur at a particular Resonance frequency. The value of which is determined by the gyromagnetic ratio multiplied by our magnet field strength. This can then be converted to a value in kHz. The tool has an antenna that pulses at this frequency. Typically, for borehole NMR tools this frequency is in the RF range and hence we often call it a RF antenna.

The tool will send a series of pulses in what we call a pulse sequence. The duration and number of the sequences affects the amount of data and quality of data that is obtained. The shorter the echo spacing (time between RF pulses) the more accurate the measurement.

The raw data collected in the CPMG (pulse sequence name) is then inverted to obtain a T2 distribution. T2 is the relaxation time of the spins after they are perturbed by the RF pulse. This decay data is actually a sum of exponentials that is related to the pore size distribution.

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3.0 BOREHOLE DETAILS

Bede High Main **OS Grid Ref:** NZ 26806 62678
Post Code: NE10 0DJ

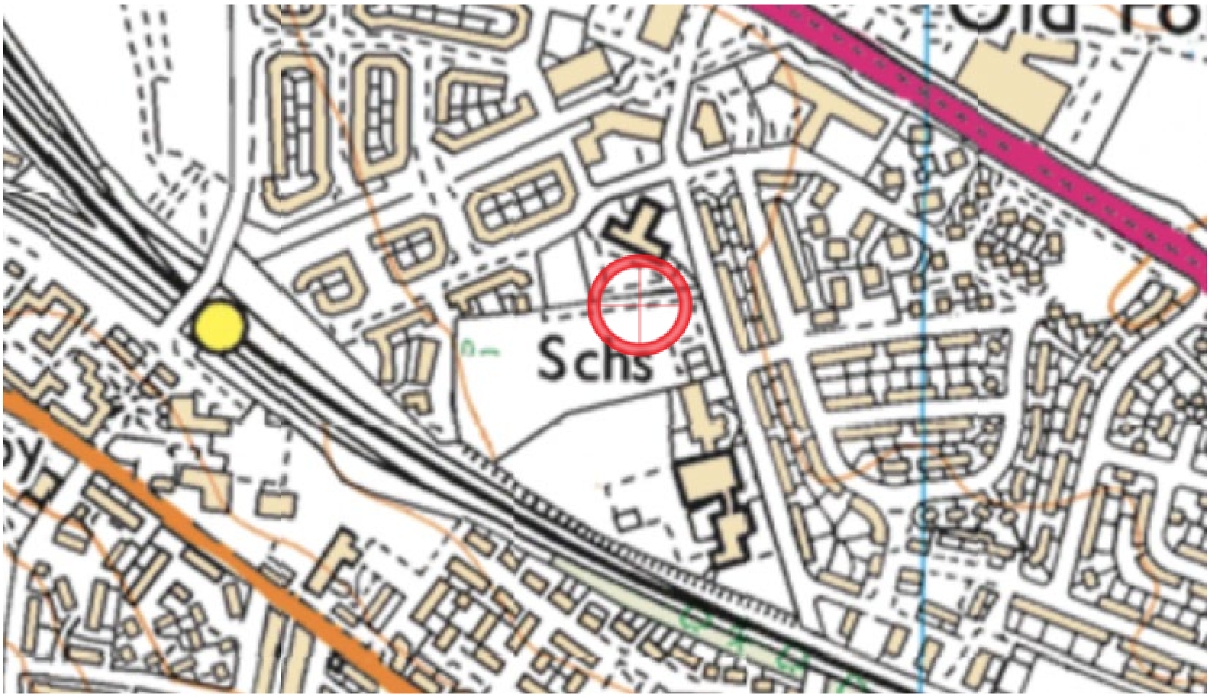

Figure 3.1 Location map showing Bede approximate location. © Crown copyright 2022 OS100057099.

Figure 3.2 Aerial image showing Bede High Main approximate location. © Google 2022.

3.0 BOREHOLE DETAILS

The Bede site is accessed from the Old Fold Rd. The date of sinking of the bore was in 2024. The High Main Borehole is one of 2 boreholes known to occupy the Bede locality. Bede Brass Thill is located to the West, some 20m away.

Figure 3.3 Bede entrance looking from Old Fold Rd. © Google 2022.

Figure 3.4 Bede High Main wellhead with logging tripod and wireline in position.

3.0 BOREHOLE DETAILS

Figure 3.5 View of logging vehicle in position during wireline operations at Bede High Main

Bede High Main		
Date Logged:	**16.01.2025 & 17.01.2025**	
Datum:	Top of uPVC lining	
Drilled Depth	171 m*	
Logged Depth:	55 m	
	Internal Diameters	*Depths*
Plain Steel Lining:	254 mm	0 – 23.8 m*
UPVC Lining:	102 mm	0.2 – 49.8 m
Unlined Borehole:	244 mm	49.8 – 55.0 m
Water Level:	26.6 m	*Rest water level*
Logged By:	C. Clinton	

Figure 3.6 Table of the borehole construction from data obtained during the survey. *Based on information from the Mining Remediation Authority.

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4.0 BOREHOLE LOGGING CONSTRAINTS

- **Vehicle access constraints**

  None

- **Tool access constraints**

  None

- **Borehole quality constraints**

  None

- **Sonde risk**

  None

- **Lack of fluid filled column**

  None

- **Time constraints**

  None

- **Construction constraints**

  Borehole backfilled to 55m

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5.0 RESULTS

5.1 Presentation of Results

A composite geophysical log with associated CCTV observations and construction log has been presented as an A4 colour plot and is shown in Figure 5.1. A composite Magnetic Resonance and geophysical log has been presented as an A4 colour plot and is shown in Figure 5.2.

5.2 Photographs

Photographs of key features have been taken from the digital recording and are shown as Figures 5.3, 5.4 and 5.5

5.3 Discussion

The records provided by the Mining Remediation Authority show a surface steel casing of 10 inches diameter down to a depth of 23.8m, with an inner uPVC lining of 4 inches diameter to a depth of 50.1m.

Above 23.8m the Natural Gamma does appear attenuated potentially indicating the presence of the steel casing behind the uPVC however the Density values are actually lower than in the section below with 1.3-1.5 g/cm3 in the steel cased section as opposed to around 2 g/cm3 in section below with no steel casing behind. Apart from between 16-18m where it increases to around 2.0 g/cm3, suggesting the presence of material behind the uPVC in this section. After ~18m values slowly increase again to around 2.0 g/cm3 again at around 20m. This all suggests that the distribution/quantity of material between the steel casing and the uPVC pipe is not evenly distributed.

In Bede Brass Thill, a distinctive response on the Density logs highlighted the presence of potential metal work behind the casing used while cementing the pipe in place. Information provided by the Mining Remediation Authority suggests that a grout basket was used during cementing in this well, so it is likely that this is what the density log is recording.

The bottom of the uPVC lining was found at 49.8m below datum on CCTV and Caliper.

The uPVC lining appears in generally good condition throughout on the CCTV log, with an i.d. of around 103mm from the Caliper measurements throughout.

The Density measurements show a few small changes from ~2.0g/cm3 to 1.5-1.8 g/cm3 between 38.7m and 41.0m and again between 46-47m. Density values in the open-hole section were measured at 2.1-2.3g/cm3.

The temperature gradient measured between 28m and 44m of 0.79 °C per 30m, was slightly cooler than the typical UK of 1 °C per 30m, and there was a negative inflection point at 45.5m, with temperatures remaining stable until 49.4m, just above the casing shoe, values begin to increase and returns to the typical temperature gradient for this borehole at around 50m. This may be due to a small change in the surrounding material, or possible flow occurring.

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The Fluid Electrical Conductivity measurements were fairly stable within the uPVC lining, with values ranging from 2600 μs/cm at the top of the water level to 2500 μs/cm at around 48.0m. Values then decreased to ~1800 μs/cm at the casing shoe to ~51.0m, before slowly increasing from ~2320 μs/cm to ~3450 μs/cm in the open-hole section.

These Temperature and Conductivity measurements tie in nicely with the Heat Pulse Flow Meter measurements which show a small upwards flow of around 1.5 mm/s in the fluid column, with a small increase over the bottom of the lining. Suggesting that fluid is entering the borehole at the base and exiting above.

Water level was observed on CCTV and temperature/conductivity sonde at a depth of 26.6m, with some minor fluctuations in water level of ±5cm over the different runs.

From MRA records, the drilled diameter in the open hole was 9.625”, or 245mm. The Caliper shows the diameter from the lining down to 52.8m to be around 270mm, and Below 52.8m to the observable depth of 55.0m there are a series of larger horizontal fractures and breakouts visible on the CCTV and the Caliper measurements. Notably the caliper shows the diameter in between breakouts in this area to ~225mm, which is very slightly narrower than expected.

Density values dropped sharply towards the base of the casing to 1.2g/cm3, before increasing in the open-hole to 2.3g/cm3 at 52.2m. From this point, values then decreased to 1.8g/cm3 towards the base, which correlates well with the fractured zone seen on the CCTV and caliper log.

Based on the other logs and the information provided by The Mining Remediation Authority, the borehole is comprised of Clastic lithology. Therefore, the subject BMR data was processed using global cutoffs for a clastic (clay (3 ms) and capillary (33 ms) bound water) lithology and standard co-efficients for permeability equations. It should be noted that in unsaturated media, TPOR reports only moisture content and Water Volume, Hydraulic Conductivity and Transmissivity outputs are invalid. If present, minor Noise, Magnetics and Formation Effects in the borehole have been flagged throughout the log. When the effects are above tolerances, the data has additionally been labelled as formation corrupted and should not be used unless validated with other logs/information. Thus, at the corrupted sections, the hydraulic conductivities, SR and SY have been removed for clarity.
Although no mention of steel present at the bottom of the installed UPVC Lining, data quality was affected from circa 48 to 42 m and it was not apparent what caused this response at the time of this processing.

The average total porosity in the sandstone section of the unlined borehole is around 0.2 – 0.4 or 20-40% (with 1 being 100%).

The total porosity values in the upper section were around 0.1 – 0.2, with higher signal noise, which is to be expected when run inside uPVC casing. It should be noted that where the cementing behind the uPVC lining is inconsistent, the BMR data will not be representative of the formation, due to the higher quantity of water.

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The base of the borehole was covered with a fine sediment and the total observable depth was 55.0m.

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Figure 5.1

Composite Geophysical Log

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Client:	**Mining Remediation Authority**	Log Type:
Borehole:	**Bede - High Main**	***Composite***

Location: **Gateshead** Area: **Newcastle** Grid Ref: **NZ26** Elevation:

Drilled Depth: (m)	**55.6 (BGL)**	Date:	**17.01.25**
Logged Depth: (m)	**55.0**	Recorded By:	**C. Clinton**
Logging Datum:	**Top of uPVC**	Remarks:	Borehole backfilled to 55.6m
Logged Interval: (m)	**0.0 - 55.0**		
Fluid Level: (m)	**26.6**		

BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)
375	**0.0**	**23.8**
245	**23.8**	**171.0**

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
Steel	**254**	**0.0**	**23.8**
uPVC	**103 (id)**	**0.0**	**49.8**

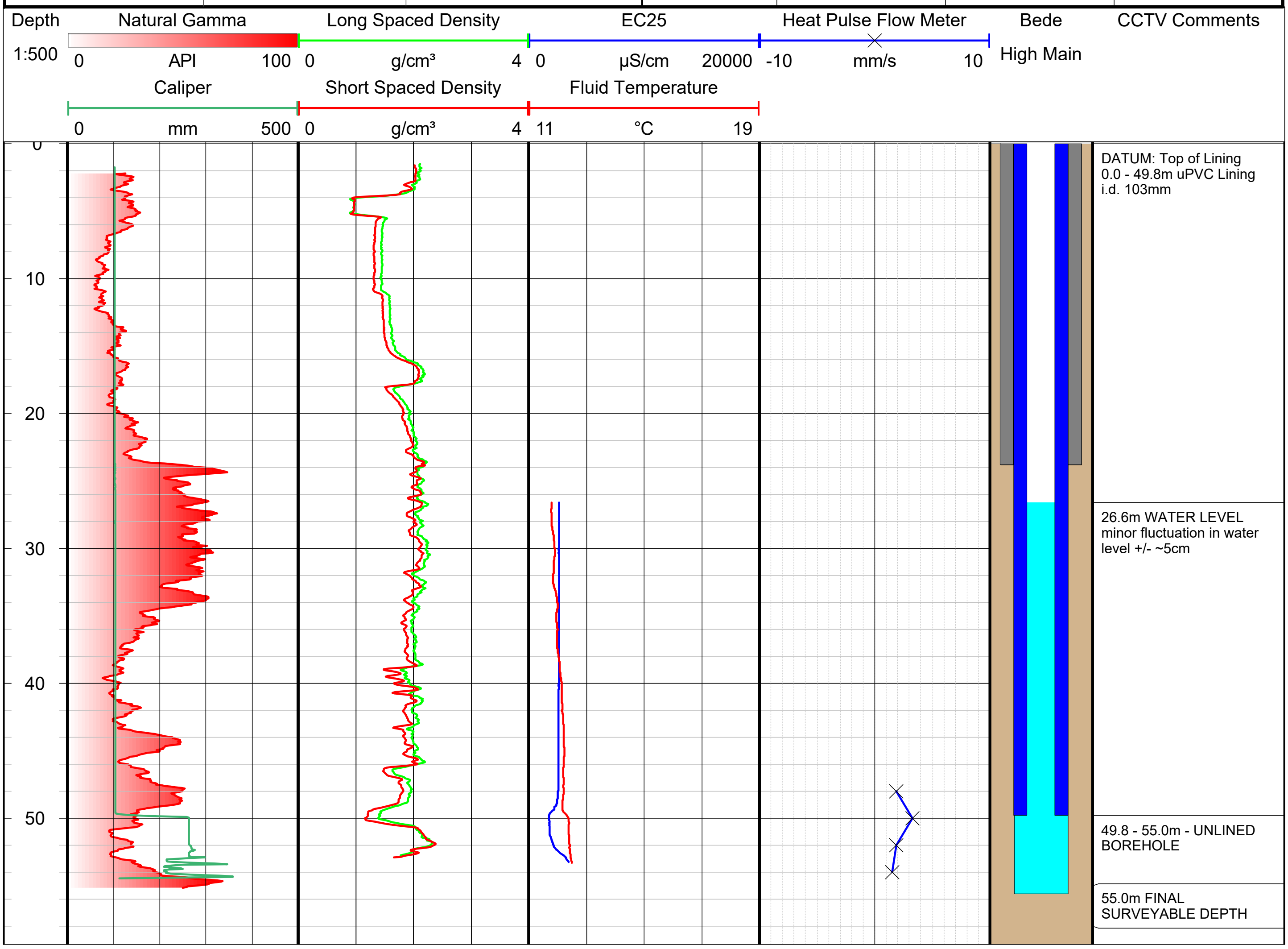

Figure 5.2

Borehole Magnetic Resonance Log

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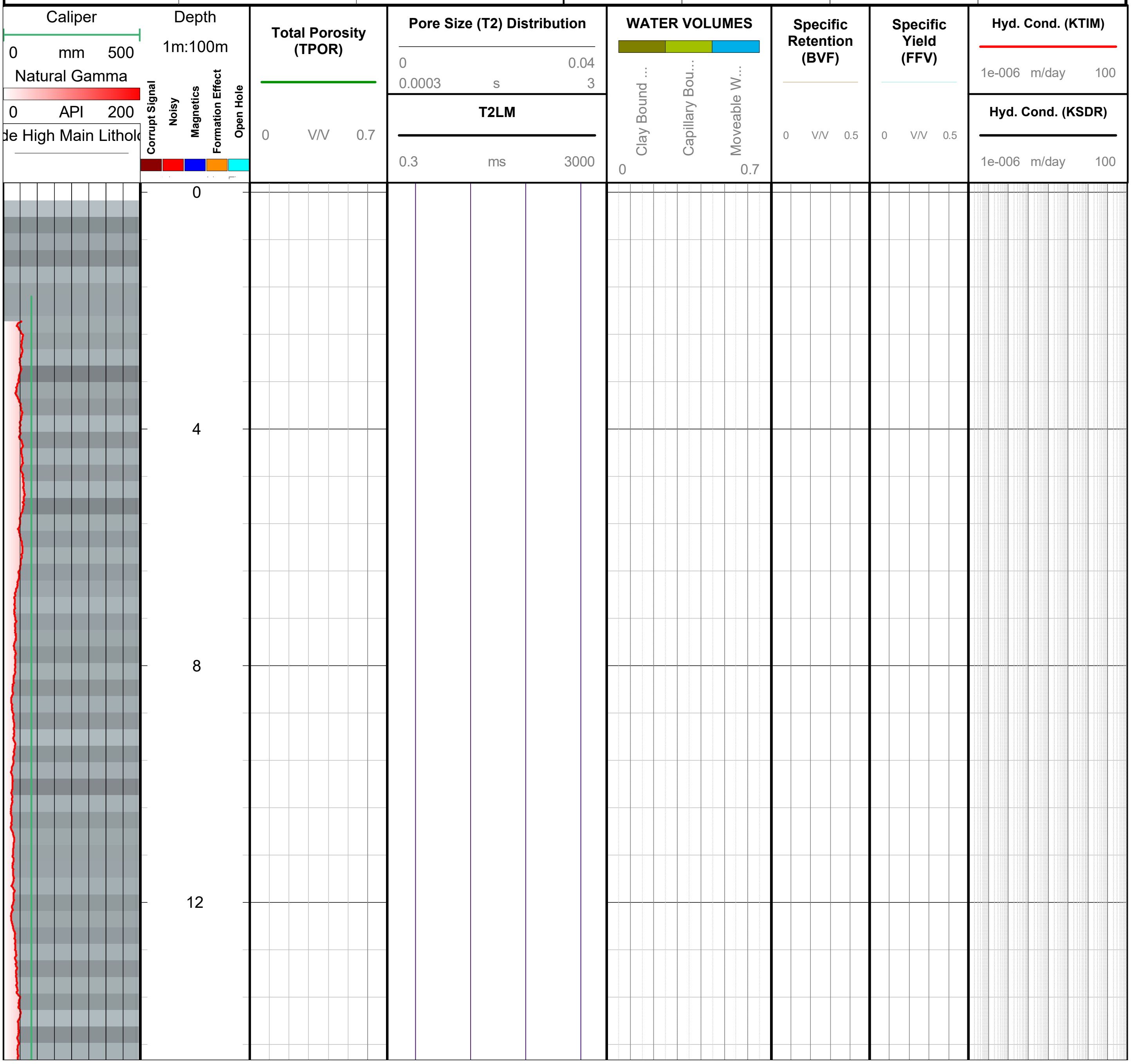
EUROPEAN GEOPHYSICAL SERVICES LTD

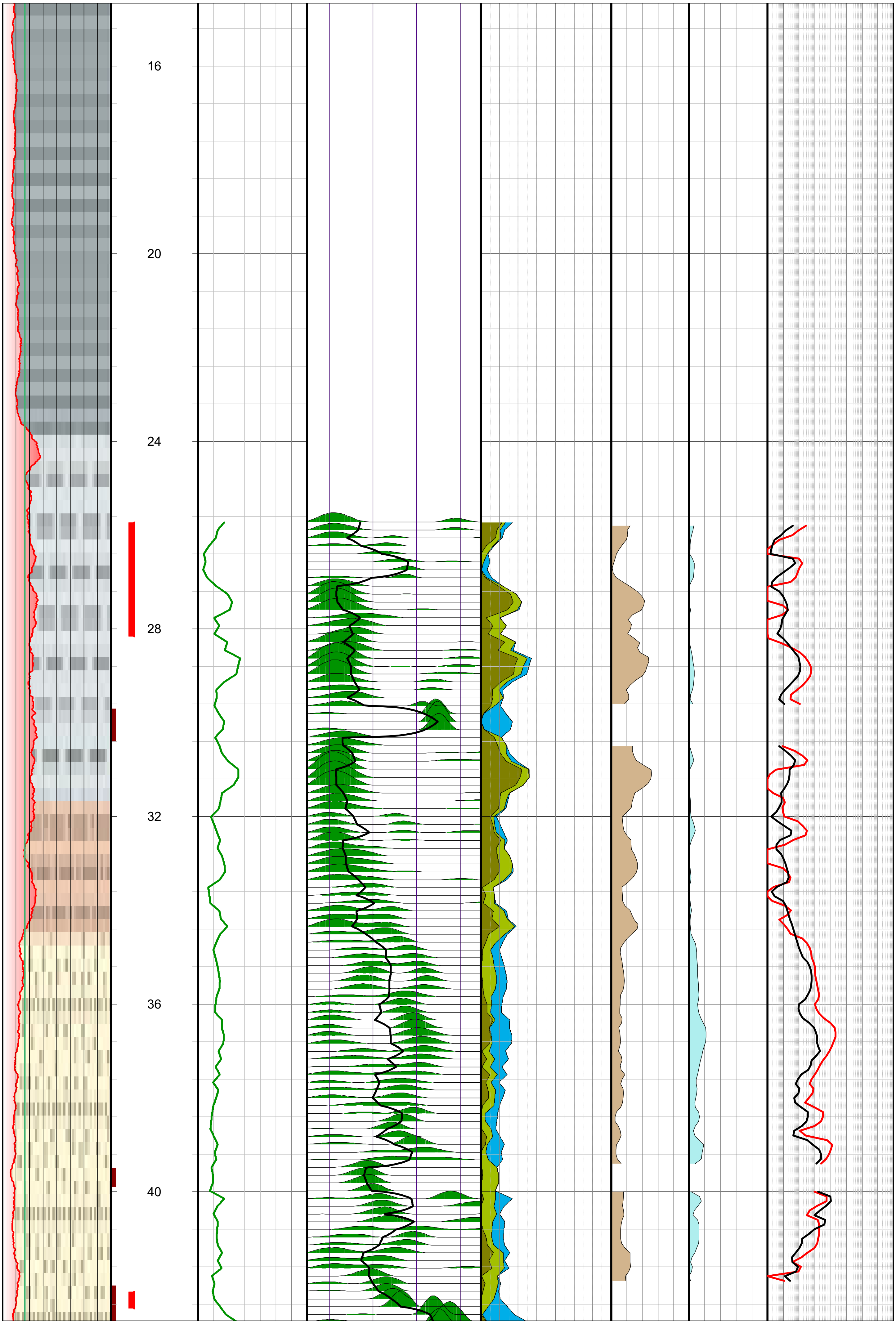
Client:	**Mining Remediation Authority**	Log Type: ***BMR***
Borehole:	**Bede - High Main**	

Location: **Gateshead**	Area: **Newcastle**	Grid Ref: **NZ26**	Elevation:

Drilled Depth: (m)	**55.6 (BGL)**	Date:	**17.01.25**
Logged Depth: (m)	**55.0**	Recorded By:	**C. Clinton**
Logging Datum:	**Top of uPVC**	Remarks:	Borehole backfilled to 55.6m
Logged Interval: (m)	**25.6 - 55.0**		
Fluid Level: (m)	**26.6**		

BOREHOLE RECORD			CASING RECORD			
Bit: (mm)	From: (m)	To: (m)	Type	Size: (mm)	From: (m)	To: (m)
375	**0.0**	**23.8**	**Steel**	**254**	**0.0**	**23.8**
245	**23.8**	**171.0**	**uPVC**	**103 (id)**	**0.0**	**49.8**

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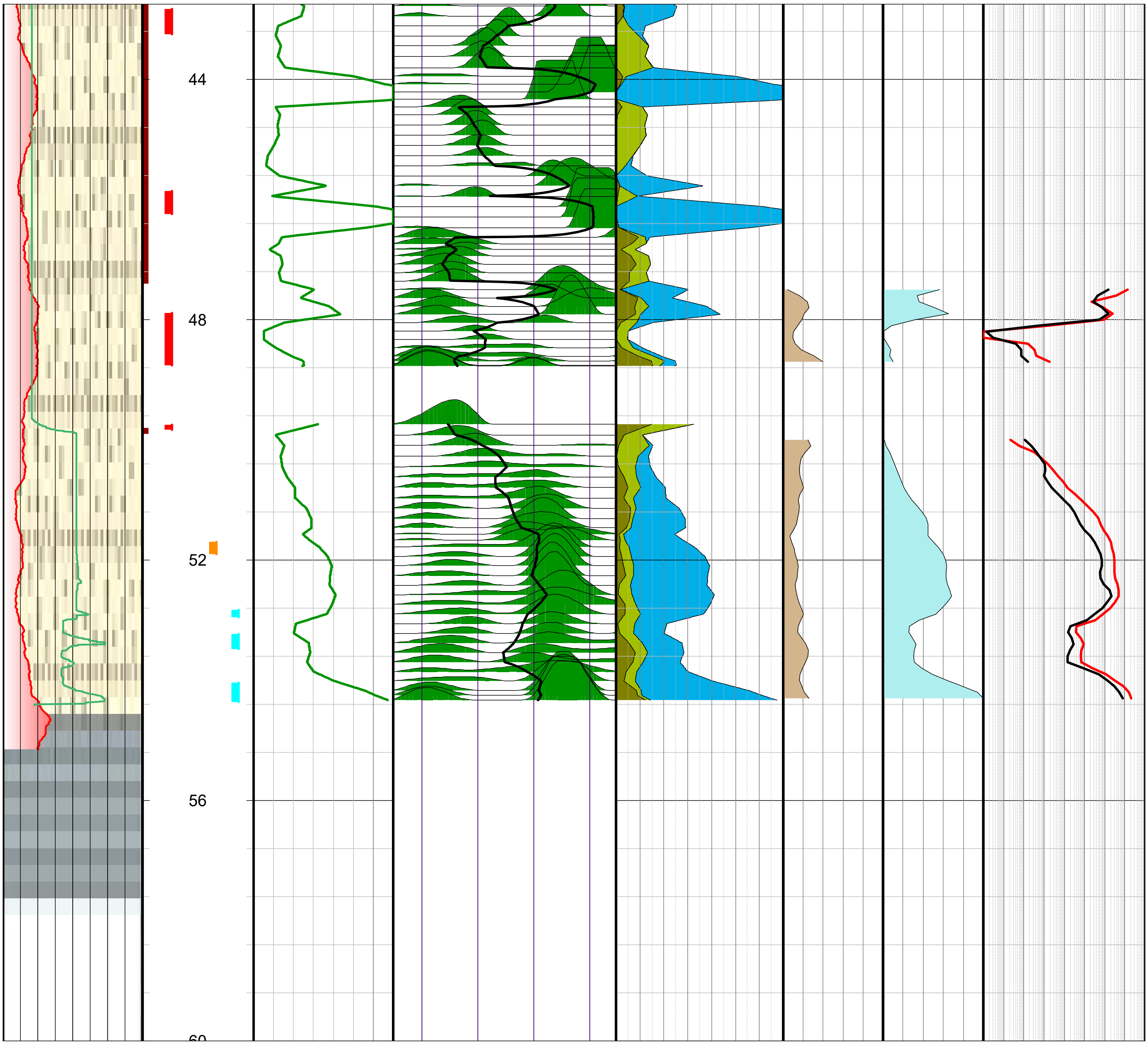


44
48
52
56
60

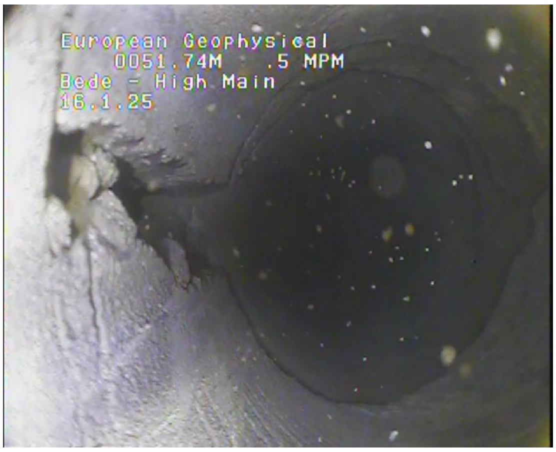
5.0 RESULTS

PHOTOGRAPHS FROM THE CCTV SURVEY

Borehole High Main **Date: 16.01.25**

Water Level

Bottom of casing



Vertical Fissure

Vertical Fissure

Figure 5.3

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5.0 RESULTS

PHOTOGRAPHS FROM THE CCTV SURVEY

Borehole High Main **Date: 16.01.25**

Sub vertical fissure extending beneath the vertical fissure

View of fracturing at base of borehole

Sub vertical fissure extending beneath the vertical fissure

Sub vertical fracture

Figure 5.4

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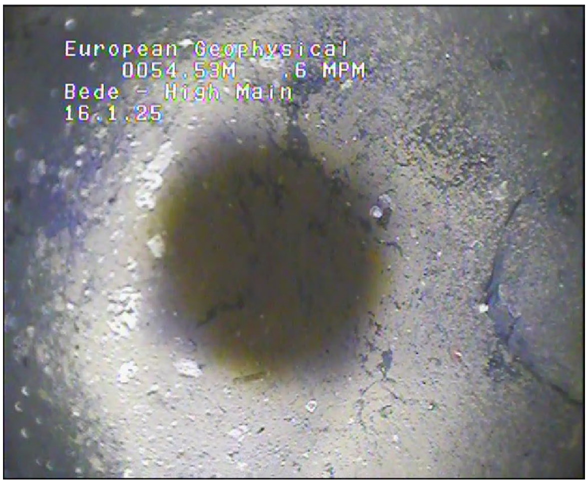
5.0 RESULTS

PHOTOGRAPHS FROM THE CCTV SURVEY

Borehole High Main **Date: 16.01.25**



Base of borehole covered in fine sediment

Figure 5.5

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6.0 CONCLUSIONS

6.1 The final surveyable depth of the borehole was recorded at 55.0m and was covered in fine sediment.

6.2 The borehole was lined with 254mm diameter plain steel casing between datum and 23.8m. A second string of uPVC lining with 103mm i.d. is within this going from datum to 49.8m.

6.3 Lower and fluctuating density values are observed in the section with steel casing present behind the uPVC lining, suggesting that the distribution/quantity of material between the steel casing and the uPVC pipe is not consistent.

6.4 A response on the density log between 3.8 and 5.6m, suggests that maybe a cementing structure was possibly utilised in this borehole. There was no change in caliper data over this section.

6.5 The unlined borehole was competent and stable sandstone above 52.8m, with a large vertical fracture running from the lining downwards. Below 52.8m it appears to change in nature, with large horizontal fractures appearing, with thin beds apparent within.

6.6 The unlined borehole above 52.8m was +/-270mm, below this was +/-225mm

6.7 The rest water level was 26.6m with around a 5cm fluctuation.

6.8 There was vertical fluid movement between the base of the borehole and inside the bottom of the lining, with flow rates on the Heat Pulse Flow Meter being measured at around 1.5 mm/s. this correlated with the Temperature and Conductivity measurements.

6.9 Changes to water quality appear to be primarily associated with this flow, with EC25 values remaining stable at ~2550 μs/cm down to 48m, before decreasing slightly to 1800 μs/cm at the bottom of the lining, remaining stable until 51.0m, when they begin to slowly increase to ~2320 μs/cm. Between 51 – 53 m it increases slightly more rapidly from ~2320 μs/cm to ~3450 μs/cm. These values are markedly different from those at Bede Brass Thill.

6.10 The average total porosity in the sandstone section of the unlined borehole is around 0.2 – 0.4 (with 1 being 100%). The total porosity values in the upper uPVC lined section were around 0.1 – 0.2, with higher signal noise.

6.11 The temperature gradient was slightly lower than the UK average, at 0.79 °C per 30m rather than 1 °C per 30m. Aside from a small inflection between 45.5-49.5m, this gradient is consistent throughout.

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REPORT ON THE VIDEO SURVEY

AND

GEOPHYSICAL LOGGING

OF

Stadium High Main

AT

Gateshead Living Lab

Prepared For:

Mining Remediation Authority

Mining Remediation Authority
200 Lichfield Lane
Mansfield
Nottinghamshire
NG18 4RG
United Kingdom

JAN_2025/COA2422A_Stadium_High_Main_rpt/NZ26

	Name	Date
Logged by:	C. Clinton	15.01.25
Report by:	K. Pearson	25.03.25
Checked by:	R. Powell	24.04.25

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CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

At the request of the Mining Remediation Authority, a video survey, and geophysical logging were carried out in Stadium High Main as part of the Gateshead Living Lab project.

The aim of the survey was to check the physical condition of the borehole, and some associated geophysical parameters.

The work was carried out by European Geophysical Services Ltd on 15th January 2025

The following logs were run:

Tool / Log (unit)		Log Depths (m)	
Borehole Video Camera	Dual View	1.0	71.6
Static Fluid Temperature / Conductivity	T (°C) / EC25 (µS/cm)	21.3	70.1
Natural Gamma	Gam (API)	2.3	71.6
Three Arm Caliper	Cal (mm)	1.9	71.1
Dual Densities (Long / Short spaced)	LSD / SSD (Apparent g/cm^3)	1.9	61.1
Heat Pulse Flow Meter	HPFM (mm/s)	48.0	71.5
Borehole Magnetic Resonance	BMR	29.8	71.1

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2.0 THE GEOPHYSICAL LOGGING METHODS

The Equipment and Field Procedure

A fully digital logging system with a 600m capacity motorised winch mounted in a 4x4 van was used.

All logging data was recorded digitally for reprocessing and archiving purposes.

The video camera survey was carried out first to avoid the disturbance of the fluid by geophysical logs which may affect water clarity.

Borehole Video Camera (DTV)

This borehole camera offers a twin view set up allowing the operator to switch between either a forward or side view camera. The side view camera has an infinite 360° rotation

The results of the survey are recorded digitally along with the date, borehole identity and depth information.

Fluid Temperature (T)

There is a natural geothermal gradient of increasing temperature with depth. This gradient varies with the thermal conductivity of the geological formation and is modified by water flowing in, out or vertically though the borehole.

This log is used to determine flow patterns within the borehole and to identify flow zones.

Differential logs are produced over a one metre spacing, these are an interpretative aid to detect gradient changes.

Fluid Conductivity (EC or EC25)

The electrical conductivity (EC) of the water is related to its salinity and dissolved solids and is therefore a measure of the quality of the borehole water. The shape of the log trace can indicate zones of inflow.

Using data from the temperature log the electrical conductivity is corrected to 25°C (EC25).

This log is used to identify different zones of water quality.

Differential logs are produced over a one metre spacing, these are an interpretative aid to detect gradient changes.

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2.0 THE GEOPHYSICAL LOGGING METHODS

Heat Pulse Flowmeter (HPF)

The Heat Pulse Flowmeter consists of two very sensitive temperature sensors which are positioned 5cm above and 5cm below a small heating element. The tool is positioned at a particular depth and left for a few minutes for the temperature sensors to stabilise. A heat pulse is then generated and then the temperature sensors monitor for its movement. The distance from the heating element to the sensors is (5cm). The time taken for the heat pulse to reach the sensor is recorded and is used to calculate the velocity of the fluid movement.

Caliper (Cal)

This tool measures the mean diameter of the borehole. It is used to check the integrity of the borehole lining, and where the borehole is unlined to identify zones of washout, breakout or fissures.

Natural Gamma (Gam)

The tool measures the naturally occurring gamma radiation found in rocks and sediments. It is mainly used to detect the clays that contain potassium K^{40}, though the U^{238} and the Th^{232} series of elements present in certain rocks also emit gamma radiation.

The higher the concentration of these clay minerals the greater the responses on the natural gamma log.

Dual - Density (LSD / HRD)

The density tool has two detectors at different spacing's from a source of gamma radiation. The logs from each detector indicate the apparent bulk density of the material surrounding the tool at a radius of investigation related to the spacing's. The Long Spaced Density (LSD) has a spacing of 48cm and the High Resolution Density (HRD) has a spacing of 24cm.

The High Resolution Density has the smaller radius of investigation, up to around 10cm under average/medium range of densities, and its response is also more affected by the quality of the borehole lining. The Long Spaced Density has the greater radius of investigation, up to 15 - 20cms under average conditions, but least resolution.

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2.0 THE GEOPHYSICAL LOGGING METHODS

Borehole Magnetic Resonance (BMR)

BMR is a quantitative geophysical method that can be used to make in situ assessments of porosity, water content, mobile and immobile water fraction, and estimates of permeability. Also known as NMR; it stands for Nuclear Magnetic Resonance. The term Nuclear refers to the fact that we are measuring a quantum mechanical state of the proton, called Spin. The Spin can be a + or – spin and we look at transitions between to the two levels. ‘Magnetic’ refers to the fact that we use external magnets to align the spins in one direction. Once we have the spins aligned up, we can then conduct experiments to obtain information about the spins. These transitions in spin states only occur at a particular Resonance frequency. The value of which is determined by the gyromagnetic ratio multiplied by our magnet field strength. This can then be converted to a value in kHz. The tool has an antenna that pulses at this frequency. Typically, for borehole NMR tools this frequency is in the RF range and hence we often call it a RF antenna.

The tool will send a series of pulses in what we call a pulse sequence. The duration and number of the sequences affects the amount of data and quality of data that is obtained. The shorter the echo spacing (time between RF pulses) the more accurate the measurement.

The raw data collected in the CPMG (pulse sequence name) is then inverted to obtain a T2 distribution. T2 is the relaxation time of the spins after they are perturbed by the RF pulse. This decay data is actually a sum of exponentials that is related to the pore size distribution.

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3.0 BOREHOLE DETAILS

Gateshead Living Lab		**OS Grid Ref:**	NZ 27129 62788
Stadium High Main		**Post Code:**	NE10 0DZ

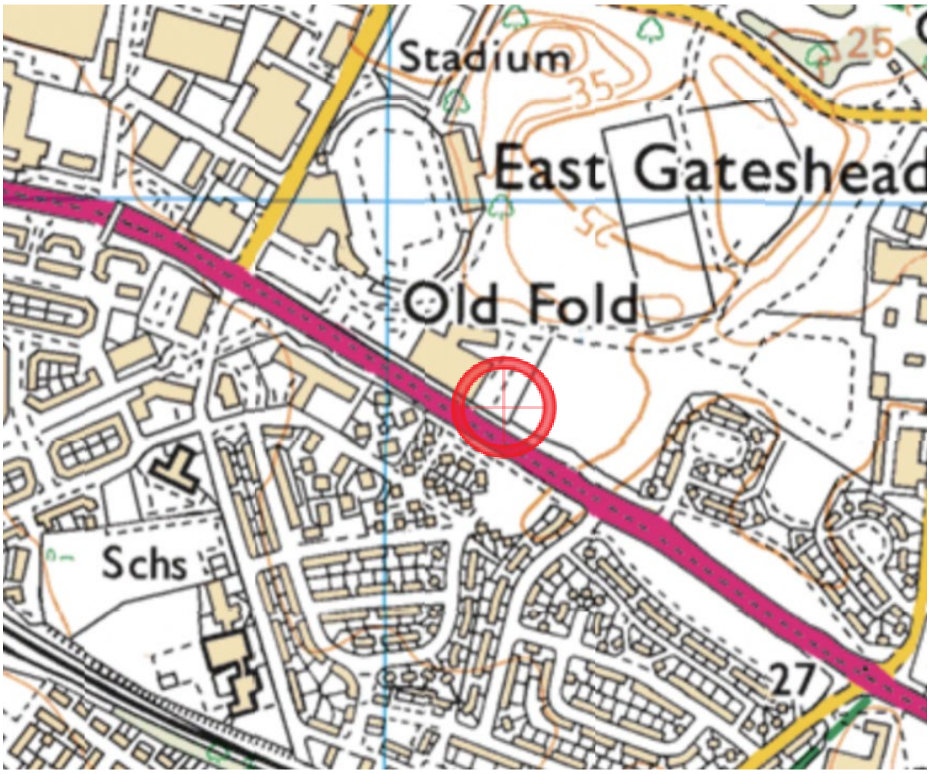

Figure 3.1 Location map showing Stadium High Main approximate location. © Crown copyright 2025 OS100057099.

Figure 3.2 Aerial image showing Stadium High Main approximate location. © Google 2025.

3.0 BOREHOLE DETAILS

The Stadium site is accessed from Loverose Wynd. The date of sinking of the bore was in 2024. The High Main Borehole is one of 2 boreholes known to occupy the Stadium locality of the Gateshead Living Lab project. Stadium Hutton is located to the West, some 4m away.

Figure 3.3 Stadium entrance looking from Loverose Wynd. © Google 2025.

Figure 3.4 Stadium High Main wellhead with logging tripod and wireline in position.

Stadium High Main		
Date Logged:	**15.01.25**	
Datum:	Top of uPVC lining	
Drilled Depth	82.0 m*	
Logged Depth:	71.6 m	
	Internal Diameters	*Depths*
Plain Steel Lining:	254 mm	0.0 – 27.0 m*
uPVC Lining:	102 mm	0.0 – 61.4 m
Unlined Borehole:	244 mm	61.4 – 71.6 m
Water Level:	21.3 m	*Rest water level*
Logged By:	C. Clinton	

Figure 3.5 Table of the borehole construction from data obtained during the survey. *Based on information from the Mining Remediation Authority.

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4.0 BOREHOLE LOGGING CONSTRAINTS

- **Vehicle access constraints**

  None

- **Tool access constraints**

  None

- **Borehole quality constraints**

  None

- **Sonde risk**

  None

- **Lack of fluid filled column**

  None

- **Time constraints**

  None

- **Construction constraints**

  Material protruding below the uPVC lining for 0.1m, preventing the Density tool from being run in open hole so as not to risk the radioactive source.

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5.0 RESULTS

5.1 Presentation of Results

A composite geophysical log with associated CCTV observations and construction log has been presented as an A4 colour plot and is shown in Figure 5.1. A composite Magnetic Resonance and geophysical log has been presented as an A4 colour plot and is shown in Figure 5.2.

5.2 Photographs

Photographs of key features have been taken from the digital recording and are shown as Figures 5.3 and 5.4.

5.3 Discussion

The records provided by the Mining Remediation Authority show a surface steel casing of 10 inches diameter down to a depth of 27.0m, with an inner uPVC lining of 4 inches diameter to a depth of 60.9m.

The bottom of the uPVC lining was observed at 61.4m on the CCTV, with 2 ‘teeth’ like features protruding on opposite sides of the borehole, down to a depth of 61.5m. These may be part of the grout catching structure behind the lining having dropped slightly.

The Natural Gamma log shows attenuated values from surface to 27m, which corroborates with the presence of the steel casing behind. Measurements below this are consistent with a predominantly sandstone lithology with some interbedded mudstone horizons such as 32-35m and 38-45m. The logged open-hole section was entirely composed of sandstone.

The density log shows a fairly distinctive feature between 2.3 – 4.9m which is potentially a structure designed to assist in cementing the liner into place. We see this feature in the Bede High Main borehole also. Below this the average density is around 1.9 g/cm3. There is then another slightly similar but less distinct feature between 17.4 – 19.8m, after which the average density drops slightly to around 1.75 g/cm3 down to 27m, which is the provided depth of the external casing.

From 32.0m to 57.0m the density increased to around 2.1 g/cm3, before a notable drop towards the base of casing, which may be caused by a lack of cement in the annular space. Because of the rubber grout basket ‘teeth’ protruding below the lining, the density tool was not run in open hole due to the risk to the radioactive source contained within.

The bottom of the uPVC lining was found at 61.4m on both the CCTV and the caliper, although the caliper does also register the presence of the grout basket teeth protruding from behind the casing to 61.5m.

The uPVC lining appears in generally good condition throughout on the CCTV footage, with an i.d. of around 103mm from the Caliper measurements throughout.

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5.0 RESULTS

5.3 Discussion

The rest water level was found at 21.3m on both the CCTV and the Temperature and Conductivity logs.

From the water level to 27m the temperature gradient is quite low, at around 0.02 °C/m, below this the temperature gradient increases to around 0.05. The average UK geothermal gradient is around 0.033 °C/m. Conductivity values sit around 7750 μs/cm from the rest water level down to 27m, where is shows a zone of increase between 27 – 30m to ~8020 μs/cm, where it then stabilises.

This correlates nicely with the presence of the steel outer casing behind the uPVC lining, which is believed to be at a depth of around 27m.

Between 48.5 and 52.0m some changes in the temperature and the conductivity logs are apparent. The temperature log shows a sharp decrease between 48.9 – 49.3m, with temperatures dropping by around 0.5 °C. They then increase sharply between 49.3 – 50.2m by 0.9 °C. At 50.2m there is an inflection point and the gradient changes to be stable at around 0.75 °C/m. The conductivity log shows a similar sharp decrease in conductivity values occurring at 48.5 - 49.5m of around 2000 μs/cm. Between 49.5 – 52.0m the measurements increase again by ~600 μs/cm. They then stabilise at ~6500 μs/cm. These inflections do suggest that there was some fluid movement within the cased section, however, visibility in the CCTV footage could not confirm this.

A significant inflection was observed in both the fluid temperature and conductivity logs at the base of the casing at 61.5m. Temperature increased to ~15°C and electrical conductivity increased to ~8300μs/cm

The Heat Pulse Flow Meter did not measure any flow between 48.0 – 52.0m, where significant changes on the temperature and conductivity logs were observed. Some minor up flow of around 1.7mm/s from 60.0 – 66.0m was observed, and again at 71.5m at the bottom of the borehole at a rate of 1.4mm/s. It is likely that there is minor inflow at the base of the borehole and outflow around the base of casing.

The drilled diameter in the open hole was 9.625”, or 245mm. The caliper showed that the diameter from the lining down to be around 255mm and the CCTV the shows the borehole to be quite competent. The CCTV showed some breakout at the bottom of the borehole and appeared somewhat blocky in appearance, as shown in the CCTV photos. The caliper did not show any significant breakout, however its possible this may have been just below the maximum depth of that tool and so not picked up.

Based on the other logs and the information provided by The Mining Remediation Authority, the borehole is comprised of Clastic lithology. Therefore, the subject BMR data was processed using global cutoffs for a clastic (clay (3 ms) and capillary (33 ms) bound water) lithology and standard co-efficients for permeability equations. It should be noted that in unsaturated media, TPOR reports only moisture content and Water Volume, Hydraulic Conductivity and Transmissivity outputs are invalid. If present, minor Noise, Magnetics and Formation Effects in the borehole have been flagged

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throughout the log. When the effects are above tolerances,the data has additionally been labelled as formation corrupted and should not be used unless validated with other logs/information. An Openhole flag has been applied as a late T2 porosity response that seems to coincide with caliper changes suggests the BMR tool is not centered in the openhole section resulting in a small portion of the diameter of investigation to be in the openhole. This could be a result of a slightly deviated borehole causing the BMR tool to lean against one side of the borehole in this lower section.

The average total porosity in the sandstone section of the unlined borehole was around 0.3, or 30% (with 1 being 100%).

The average total porosity values in the upper section were around 0.1 – 0.2, with some sections in the mudstone going down to as low as 0.05. It should be noted that where the cementing behind the uPVC lining is inconsistent, the BMR data will not be representative of the formation, due to the higher quantity of water.

The base of the borehole was covered with a fine sediment and the total observable depth was 71.6m.

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Figure 5.1

Composite Geophysical Log

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EUROPEAN GEOPHYSICAL SERVICES LTD

Client:	**Mining Remediation Authority**	Log Type: ***Composite***
Borehole:	**Stadium - High Main**	

Location: **Gateshead** Area: **Newcastle** Grid Ref: **NZ26** Elevation:

Drilled Depth: (m)	**82.0 (BGL)**	Date:	**15.01.25**
Logged Depth: (m)	**71.6**	Recorded By:	**C. Clinton**
Logging Datum:	**Top of uPVC**	Remarks:	No density below the casing due to grout basket tassels presenting a trapping risk
Logged Interval: (m)	**0.0 - 71.6**		
Fluid Level: (m)	**21.3**		

BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)
375	**0.0**	**27.0**
245	**27.0**	**82.0**

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
Steel	**254**	**0.0**	**27**
uPVC	**103 (id)**	**0.0**	**60.9**

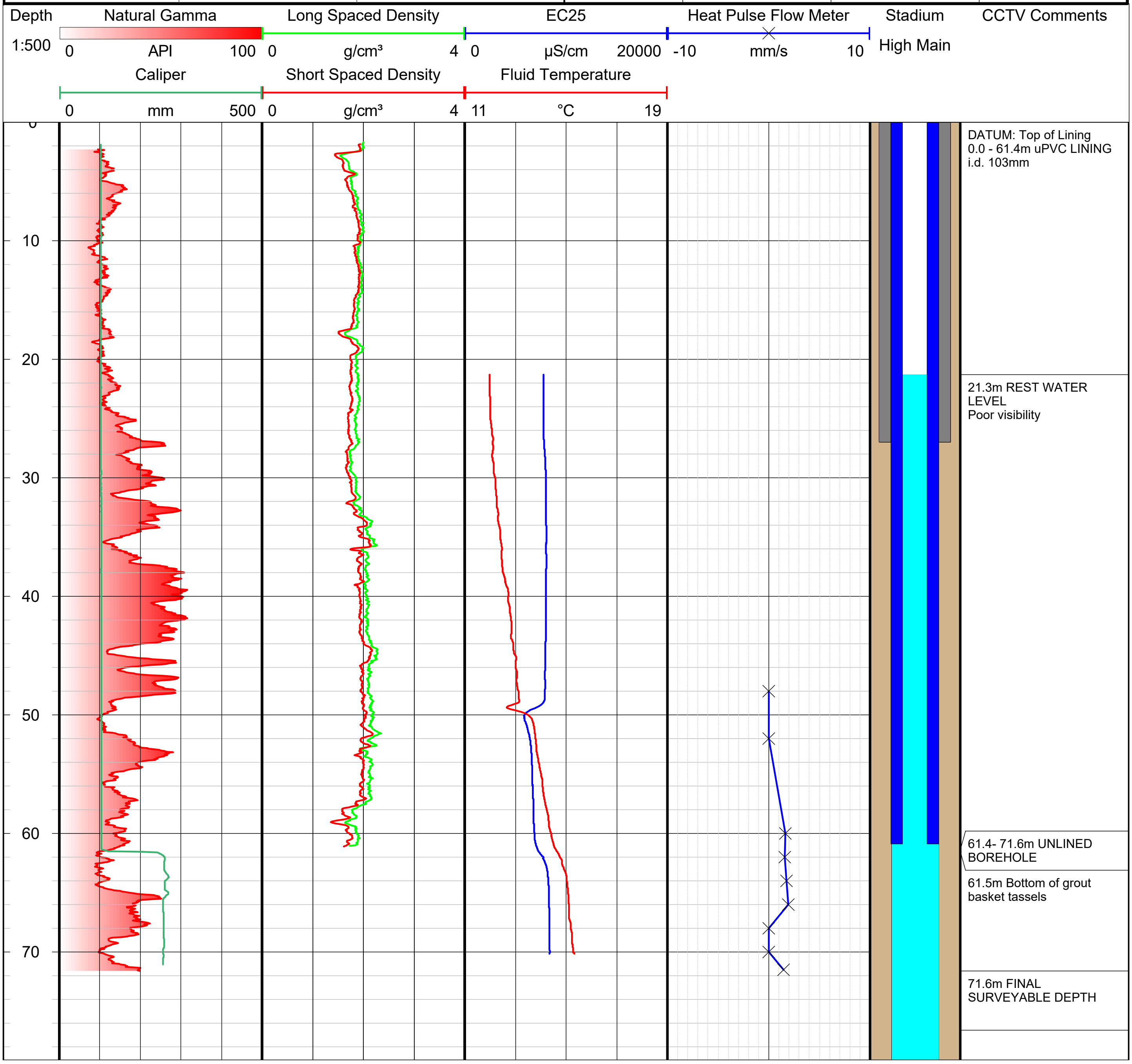

Figure 5.2

Borehole Magnetic Resonance Log

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EUROPEAN GEOPHYSICAL SERVICES LTD

Client:	**Mining Remediation Authority**	Log Type: ***BMR***
Borehole:	**Stadium - High Main**	

Location: **Gateshead** Area: **Newcastle** Grid Ref: **NZ26** Elevation:

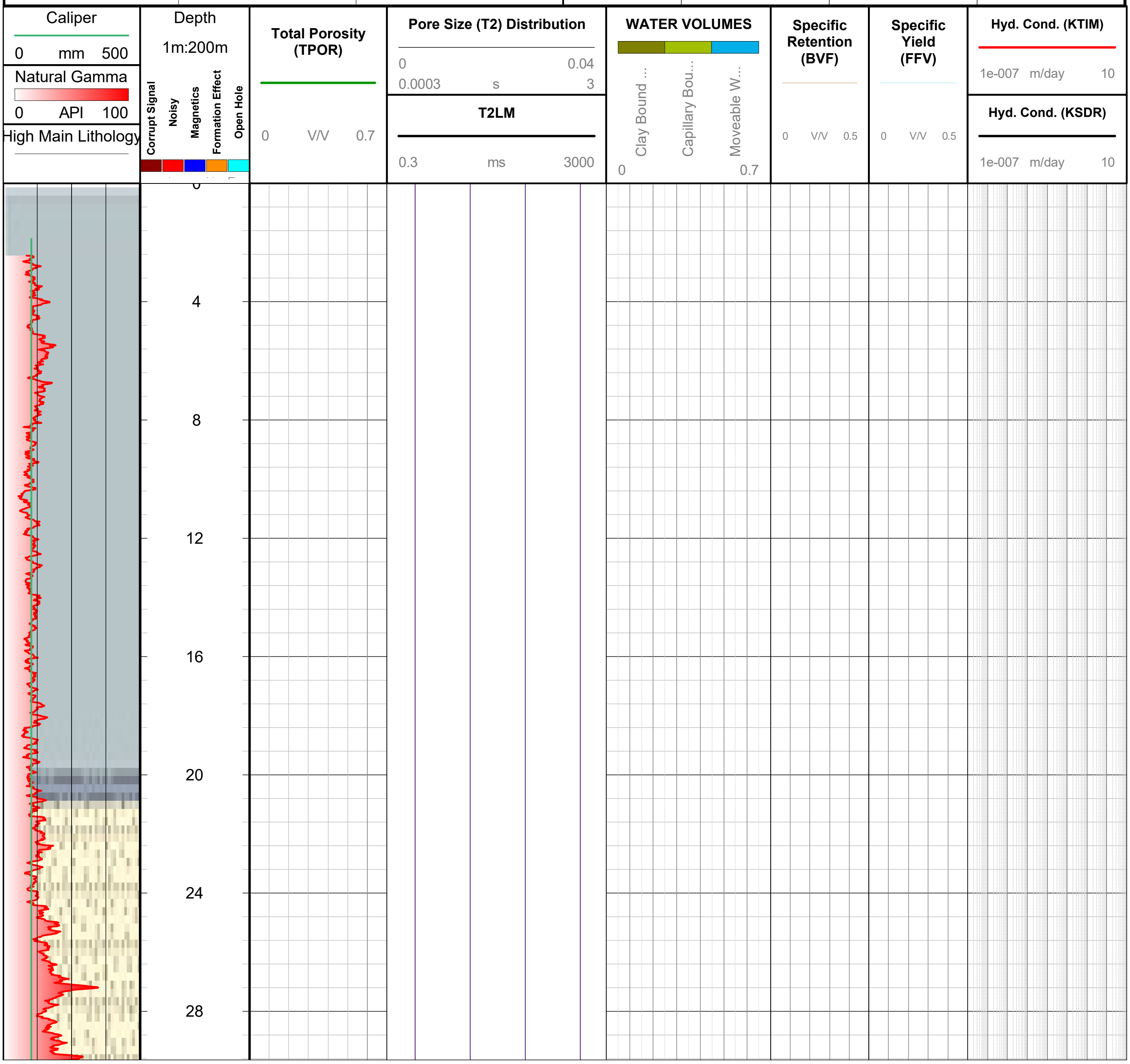
Drilled Depth: (m)	**82.0 (BGL)**	Date:	**15.01.25**
Logged Depth: (m)	**71.6**	Recorded By:	**C. Clinton**
Logging Datum:	**Top of uPVC**	Remarks:	No density below the casing due to grout basket tassels presenting a trapping risk
Logged Interval: (m)	**0.0 - 71.6**		
Fluid Level: (m)	**21.3**		

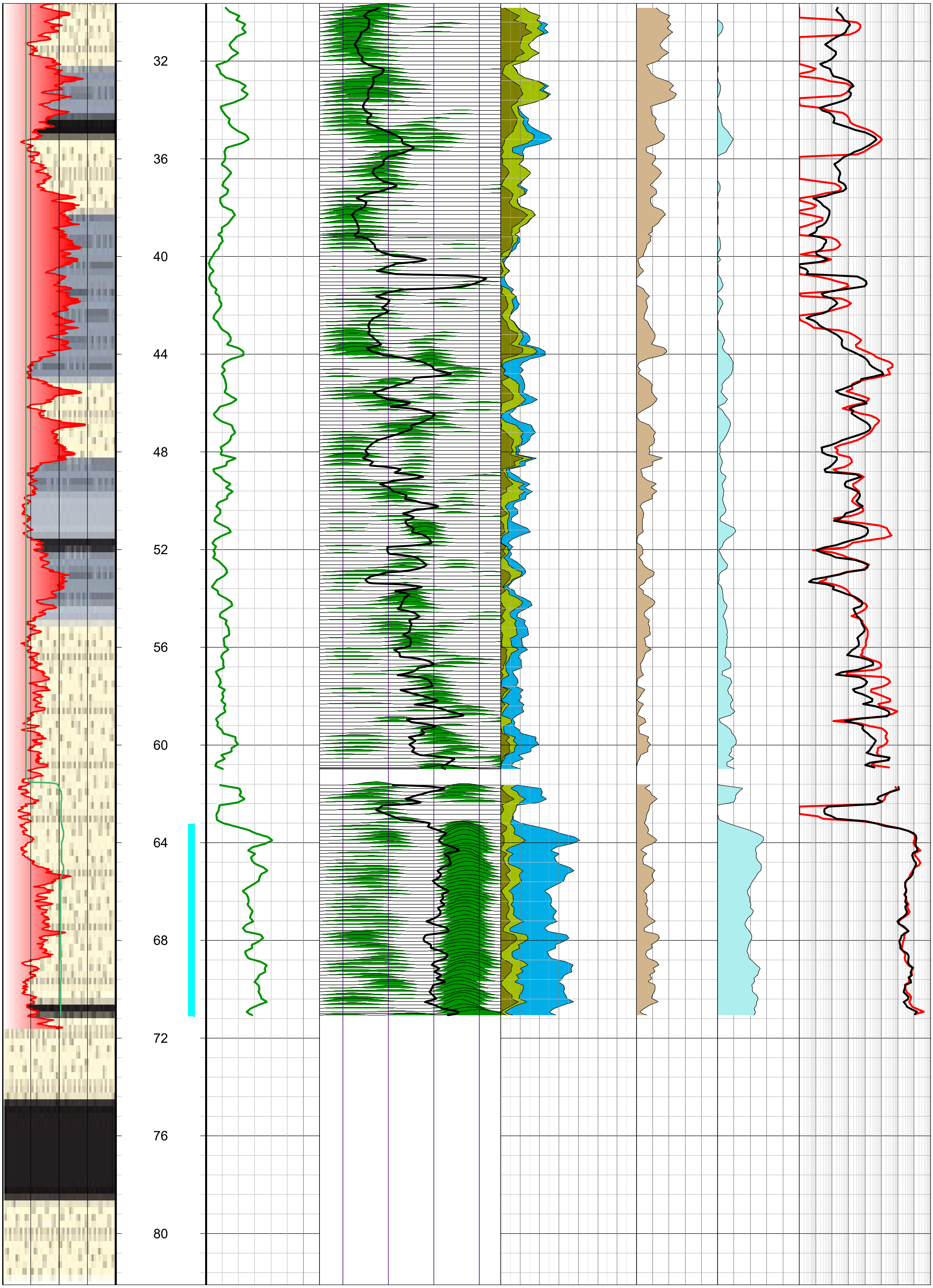
BOREHOLE RECORD

Bit: (mm)	From: (m)	To: (m)
375	**0.0**	**27.0**
245	**27.0**	**82.0**

CASING RECORD

Type	Size: (mm)	From: (m)	To: (m)
Steel	**254**	**0.0**	**27.3**
uPVC	**103 (id)**	**0.0**	**60.9**





32
36
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52
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68
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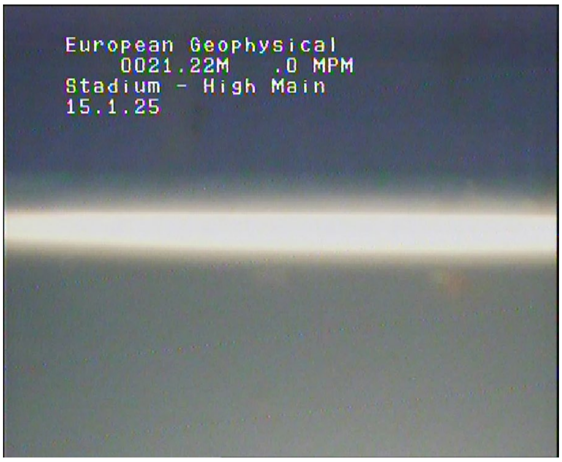
76
80

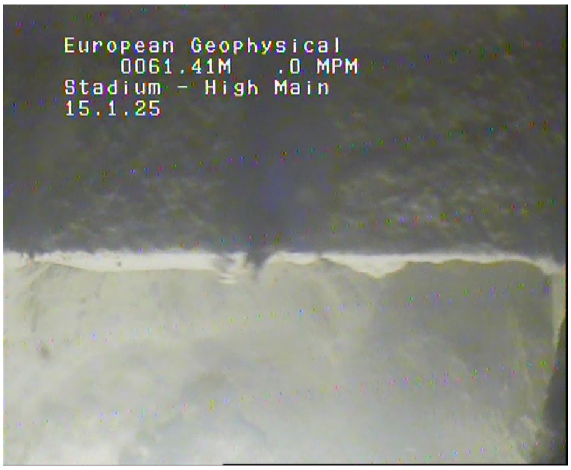
5.0 RESULTS

PHOTOGRAPHS FROM THE CCTV SURVEY

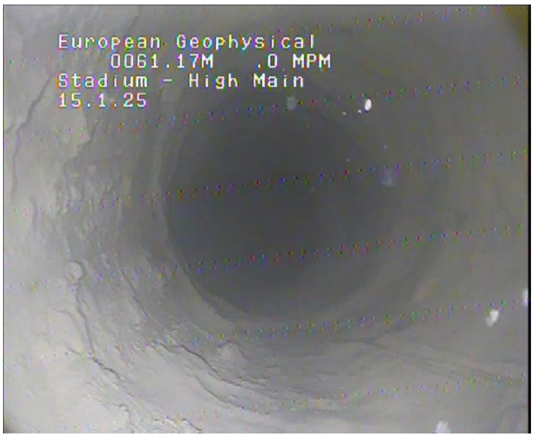
Borehole High Main **Date: 16.01.25**



Water Level



Bottom of casing



Down hole view

Regular ‘teeth’ protruding below bottom of lining

Figure 5.3

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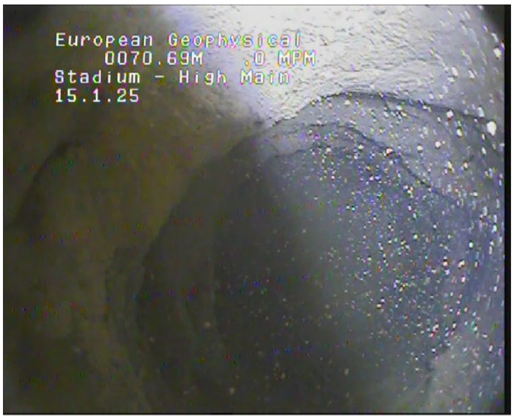
5.0 RESULTS

PHOTOGRAPHS FROM THE CCTV SURVEY

Borehole High Main **Date: 16.01.25**

Down hole view of ‘teeth’ protruding below bottom of lining

Fine sediment at base of borehole.



Possible horizontal bedding features at base of borehole.

Figure 5.4

6.0 CONCLUSIONS

6.1 The final surveyable depth of the borehole was recorded at 71.6m and was covered in fine sediment.

6.2 The CCTV shows some ‘teeth’ protruding 0.1m below the base of the lining, likely remaining from grouting operations.

6.3 The borehole was lined with 254mm diameter plain steel casing between datum and 27m. A second string of uPVC lining with 103mm i.d. is within this going from datum to 61.4m .

6.4 Density values of around 1.9g/cm3 were observed in the section of the lining with steel casing behind. In the lining beneath this the values down to 32m are marginally lower at ~1.8g/cm3. Below 32m it increases to around 2g/cm3 down to 57.5m. This suggests that there is a difference in the quantity of material sitting behind the uPVC lining with depth, with more consistent quantities below 32m.

6.5 The unlined borehole appeared competent on both the CCTV and the caliper with an average diameter measurement of around 245mm. Although the CCTV does show what appears to be some blocky natured breakout in the base of the borehole, which may have been below the maximum depth reached by the caliper.

6.6 The rest water level was 21.3m.

6.7 There appears to be some vertical fluid movement between the base of the borehole and inside the lining to ~49m, with flow horizons being visible in the temperature and conductivity logs, however the heat flow pulse meter measurements show some low upward flow but are not as consistent, which may be due to the very low flow rates.

6.8 The temperature gradient is slightly higher than the UK average, at between 0.5 and 0. 7 °C/m rather than 0.03 °C/m.

6.9 The average total porosity in the sandstone section of the unlined borehole is around 0.3 (with 1 being 100%). The average total porosity values in the upper section were around 0.1 – 0.2, with some sections in the mudstone going down to as low as 0.05.

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EUROPEAN GEOPHYSICAL SERVICES

REPORT ON THE VIDEO SURVEY

AND

GEOPHYSICAL LOGGING

OF

Stadium Hutton

AT

Gateshead Living Lab

Prepared For:

Mining Remediation Authority

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Mansfield
Nottinghamshire
NG18 4RG
United Kingdom

JAN_2025/COA2422A_Stadium_Hutton_rpt/NZ26

	Name	Date
Logged by:	C. Clinton	14.01.25 15.01.25
Report by:	K. Pearson	25.03.25
Checked by:	R. Powell	25.04.25

CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

At the request of the Mining Remediation Authority, a video survey, and geophysical logging were carried out in Hutton at Stadium as part of the Living Lab project, near Gateshead.

The aim of the survey was to check the physical condition of the borehole, and some associated geophysical parameters.

The work was carried out by European Geophysical Services Ltd on the 14th and 15th of January 2025

The following logs were run:

Tool / Log (unit)		Log Depths (m)	
Borehole Video Camera	Dual View	1.0	183.8
Static Fluid Temperature / Conductivity	T (°C) / EC25 (μS/cm)	17.4	182.1
Natural Gamma	Gam (API)	1.4	183.8
Three Arm Caliper	Cal (mm)	0.9	183.1
Dual Densities (Long / Short spaced)	LSD / SSD (Apparent g/cm³)	1.8	183.6
Heat Pulse Flow Meter	HPFM (mm/s)	164.0	183.0
Borehole Magnetic Resonance	BMR	90.3	183.4

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2.0 THE GEOPHYSICAL LOGGING METHODS

The Equipment and Field Procedure

A fully digital logging system with a 600m capacity motorised winch mounted in a 4x4 van was used.

All logging data was recorded digitally for reprocessing and archiving purposes.

The video camera survey was carried out first to avoid the disturbance of the fluid by geophysical logs which may affect water clarity.

Borehole Video Camera (DTV)

This borehole camera offers a twin view set up allowing the operator to switch between either a forward or side view camera. The side view camera has an infinite 360° rotation

The results of the survey are recorded digitally along with the date, borehole identity and depth information.

Fluid Temperature (T)

There is a natural geothermal gradient of increasing temperature with depth. This gradient varies with the thermal conductivity of the geological formation and is modified by water flowing in, out or vertically though the borehole.

This log is used to determine flow patterns within the borehole and to identify flow zones.

Differential logs are produced over a one metre spacing, these are an interpretative aid to detect gradient changes.

Fluid Conductivity (EC or EC25)

The electrical conductivity (EC) of the water is related to its salinity and dissolved solids and is therefore a measure of the quality of the borehole water. The shape of the log trace can indicate zones of inflow.

Using data from the temperature log the electrical conductivity is corrected to 25°C (EC25).

This log is used to identify different zones of water quality.

Differential logs are produced over a one metre spacing, these are an interpretative aid to detect gradient changes.

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2.0 THE GEOPHYSICAL LOGGING METHODS

Heat Pulse Flowmeter (HPF)

The Heat Pulse Flowmeter consists of two very sensitive temperature sensors which are positioned 5cm above and 5cm below a small heating element. The tool is positioned at a particular depth and left for a few minutes for the temperature sensors to stabilise. A heat pulse is then generated and then the temperature sensors monitor for its movement. The distance from the heating element to the sensors is (5cm). The time taken for the heat pulse to reach the sensor is recorded and is used to calculate the velocity of the fluid movement.

Caliper (Cal)

This tool measures the mean diameter of the borehole. It is used to check the integrity of the borehole lining, and where the borehole is unlined to identify zones of washout, breakout or fissures.

Natural Gamma (Gam)

The tool measures the naturally occurring gamma radiation found in rocks and sediments. It is mainly used to detect the clays that contain potassium K^{40}, though the U^{238} and the Th^{232} series of elements present in certain rocks also emit gamma radiation.

The higher the concentration of these clay minerals the greater the responses on the natural gamma log.

Dual - Density (LSD / HRD)

The density tool has two detectors at different spacing’s from a source of gamma radiation. The logs from each detector indicate the apparent bulk density of the material surrounding the tool at a radius of investigation related to the spacing’s. The Long Spaced Density (LSD) has a spacing of 48cm and the High Resolution Density (HRD) has a spacing of 24cm.

The High Resolution Density has the smaller radius of investigation, up to around 10cm under average/medium range of densities, and its response is also more affected by the quality of the borehole lining. The Long Spaced Density has the greater radius of investigation, up to 15 - 20cms under average conditions, but least resolution.

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2.0 THE GEOPHYSICAL LOGGING METHODS

Borehole Magnetic Resonance (BMR)

BMR is a quantitative geophysical method that can be used to make in situ assessments of porosity, water content, mobile and immobile water fraction, and estimates of permeability. Also known as NMR; it stands for Nuclear Magnetic Resonance. The term Nuclear refers to the fact that we are measuring a quantum mechanical state of the proton, called Spin. The Spin can be a + or – spin and we look at transitions between to the two levels. 'Magnetic' refers to the fact that we use external magnets to align the spins in one direction. Once we have the spins aligned up, we can then conduct experiments to obtain information about the spins. These transitions in spin states only occur at a particular Resonance frequency. The value of which is determined by the gyromagnetic ratio multiplied by our magnet field strength. This can then be converted to a value in kHz. The tool has an antenna that pulses at this frequency. Typically, for borehole NMR tools this frequency is in the RF range and hence we often call it a RF antenna.

The tool will send a series of pulses in what we call a pulse sequence. The duration and number of the sequences affects the amount of data and quality of data that is obtained. The shorter the echo spacing (time between RF pulses) the more accurate the measurement.

The raw data collected in the CPMG (pulse sequence name) is then inverted to obtain a T2 distribution. T2 is the relaxation time of the spins after they are perturbed by the RF pulse. This decay data is actually a sum of exponentials that is related to the pore size distribution.

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3.0 BOREHOLE DETAILS

Gateshead Living Lab
Stadium Hutton

OS Grid Ref: NZ 27127 62788
Post Code: NE10 0DZ

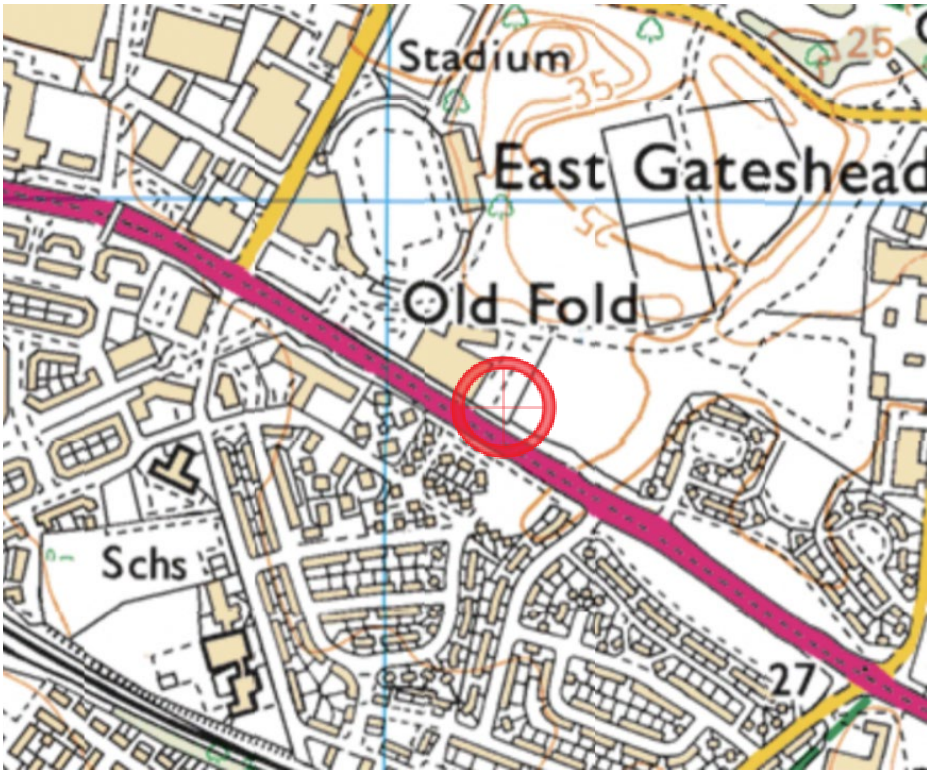

Figure 3.1 Location map showing Stadium Hutton approximate location. © Crown copyright 2025 OS100057099.

Figure 3.2 Aerial image showing Stadium Hutton approximate location. © Google 2025.

3.0 BOREHOLE DETAILS

The Stadium site is accessed from Loverose Wynd. The date of sinking of the bore was in 2024. The Hutton Borehole is one of 2 boreholes known to occupy the Stadium locality of the Gateshead Living Lab project. Stadium High Main is located to the East, some 4m away.

Figure 3.3 Stadium entrance looking from Loverose Wynd. © Google 2025.

Figure 3.4 Stadium Hutton wellhead with logging tripod and wireline in position.

3.0 BOREHOLE DETAILS

Stadium Hutton		
Date Logged:	**14.01.2025 & 15.01.2025**	
Datum:	Top of uPVC lining	
Drilled Depth	189.0 m*	
Logged Depth:	183.8 m	
	Internal Diameters	*Depths*
Plain Steel Lining:	254 mm	0.0 – 27.0 m*
Plain Steel Lining	203 mm	0.0 – 89.9 m*
Plain Steel Lining	203 mm	152.4 – 167.4 m*
uPVC Lining:	102 mm	0.0 – 171.1 m
Unlined Borehole:	194 mm	171.1 – 183.8
Water Level:	17.4 m	*Rest water level*
Logged By:	C. Clinton	

Figure 3.5 Table of the borehole construction from data obtained during the survey. *Based on information provided by the Mining Remediation Authority.

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4.0 BOREHOLE LOGGING CONSTRAINTS

- **Vehicle access constraints**

  None

- **Tool access constraints**

  None

- **Borehole quality constraints**

  None

- **Sonde risk**

  None

- **Lack of fluid filled column**

  None

- **Time constraints**

  None

- **Construction constraints**

  None

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5.0 RESULTS

5.1 Presentation of Results

A composite geophysical log with associated CCTV observations and construction log has been presented as an A4 colour plot and is shown in Figure 5.1. A composite Magnetic Resonance and geophysical log has been presented as an A4 colour plot and is shown in Figure 5.2.

5.2 Photographs

Photographs of key features have been taken from the digital recording and are shown as Figures 5.3 and 5.4

5.3 Discussion

The records provided by the Mining Remediation Authority show a surface steel casing of 10 inches diameter down to a depth of 27m, with 8 inch steel casing from 0.0 – 89.9m and 152.4 – 167.4m and an inner uPVC lining of 4 inches diameter from 0.2m – 170.0m

The CCTV and the caliper log located the bottom of the uPVC lining at a depth of 169.4m with a small section of what appeared on the CCTV to be steel below from 169.4 – 171.1m which appeared to be slightly larger diameter (111mm) than the uPVC lining above. Subsequent information obtained from the Mining Remediation Authority suggests that this was in fact the inflatable packer used for containing cement during grouting operations. The caliper log recorded the uPVC lining to be 103mm in diameter, and the open-hole at 202mm to 178m, where notable fracturing was apparent to the final surveyable depth at 183.8m.

Between 167.4 and 170m uPVC lining was anticipated, with no steel casing behind. However, the CCTV showed the grouting packer before entering open hole at 171.1m. This change is confirmed by the caliper which shows an I.D. of around 111mm. This was also observed at Bede Brass Thill.

From 0.0 – 27.0m, the Natural Gamma response was strongly attenuated due to the multiple casing strings. From 27.0 – 89.9m the records showed the presence of 8 inch steel casing behind the uPVC lining and there was an attenuation of the Natural Gamma response, due to increased density of material behind the uPVC lining. Between 89.9m and 152.4m there is a single uPVC lining. The Natural Gamma response was higher which is in keeping with having less dense material behind the lining. Based on the provided records, between 152.4 – 167.4m there was a length of 8 inch steel casing behind the uPVC lining. The Natural Gamma response in this section is attenuated compared to the sections above and below, which supports the location of the casing. The log showed a predominantly mudstone lithology in the cased section, with occasional sandstone horizons, and predominantly sandstone formation in the open-hole.

Density values were highest between 0.0-21m, as expected by the presence of multiple casing strings. Readings decreased at 21m and were consistent other than

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minor peaks representing casing joins to 90m, where a further decrease was observed, corresponding to the base of the steel linings. Throughout the plastic-lined section, values were reasonably consistent, apart from the occasional slight decrease (134m & 138m), most likely representing slight gaps/thinning in the cement. A further increase was noted between 153-168m. This corresponds to the presence of steel again. In the open-hole section of the borehole, values were around 2.6g/cm3, typical of competent sandstone, before becoming slightly erratic at ~178m due to the presence of large fractures.

The rest water level was at 17.4m, and showed some minor fluctuation of ±0.05m. The CCTV observed an oscillating flow when observing the sediment load in the fluid column at 21.7m, showing a repeating pattern of a few seconds of upward flow, and then a few seconds of downward flow. This was an unusual characteristic, and may be a sign of some kind of pumping somewhere in the hydraulic system.

The Fluid Temperature and Conductivity logs also showed the water level at 17.4m and were both fairly stable down to 21m, with temperature around 11.9 °C and conductivity ~6500 µs/cm. Below this the conductivity began to significantly increase towards 18000 µs/cm at 30m where it stabilised, and the temperature gradient increased to 0.05 °C/m from 21m down to ~45m. The conductivity log remained quite constant throughout the borehole at ~18000 µs/cm, with a slight increase observed at 178.8m. This corresponds to the fractured zone and minor flow seen in the Heat-Pulse flowmeter data.

The fluid temperature log showed a positive gradient to ~65m, before a zone of constant temperature gave way to a negative gradient from ~80-100m. The profile then returned to a positive gradient with several small inflections within the cased section. A further inflection at 178.8m corresponds to the possible flow point mentioned above.

The heat pulse flow meter showed a small upward flow of around 2mm/s in the unlined borehole, extending up into the uPVC lining. This zone corresponds with the area of fracturing so it is likely that inflow was occurring here.

The BMR was run from 183.4 – 170.7m and 149.5 – 90.2m. Gaps in BMR data are due to the presence of steel casing in the borehole.

Based on the other logs and the information provided by The Mining Remediation Authority, the borehole is comprised of Clastic lithology. Therefore, the subject BMR data was processed using global cutoffs for a clastic (clay (3 ms) and capillary (33 ms) bound water) lithology and standard co-efficients for permeability equations. It should be noted that in unsaturated media, TPOR reports only moisture content and Water Volume, Hydraulic Conductivity and Transmissivity outputs are invalid. If present, minor Noise, Magnetics and Formation Effects in the borehole have been flagged throughout the log. When the effects are above tolerances,the data has additionally been labelled as formation corrupted and should not be used unless validated with other logs/information. It was observed in the upper section that noise was significantly higher and variable compared to the lower section. Upon review of the borehole completion it was noted that multiple thermistor sensors on fiber optic cable are

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installed in the cemented annulus and are considered the source of the noise effect when comparing to the High Main log noise in the similar cemented section.

The average total porosity in the competent sandstone section of the unlined borehole was around 0.02 – 0.1 (with 1 being 100%). Below this there are breakouts which may effect the porosity measurements.

The total porosity values in the upper section were more variable, with values between 0.02 – 0.3 with higher signal noise. It should be noted that where the cementing behind the uPVC lining is inconsistent, the BMR data will not be representative of the formation, due to the higher quantity of water.

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Figure 5.1

Composite Geophysical Log

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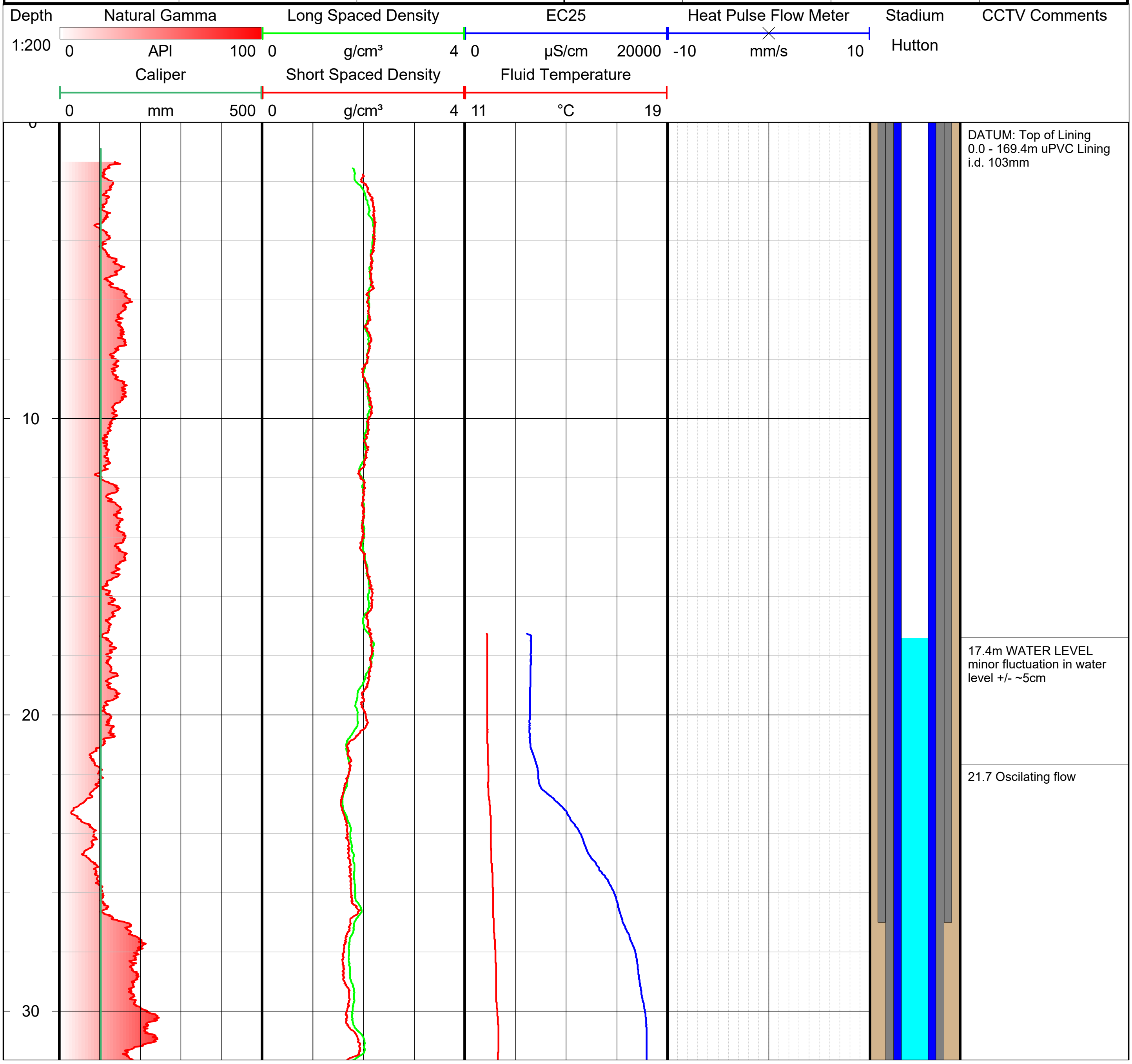
Client:	**Mining Remediation Authority**	Log Type:
Borehole:	**Stadium - Hutton**	***Composite***

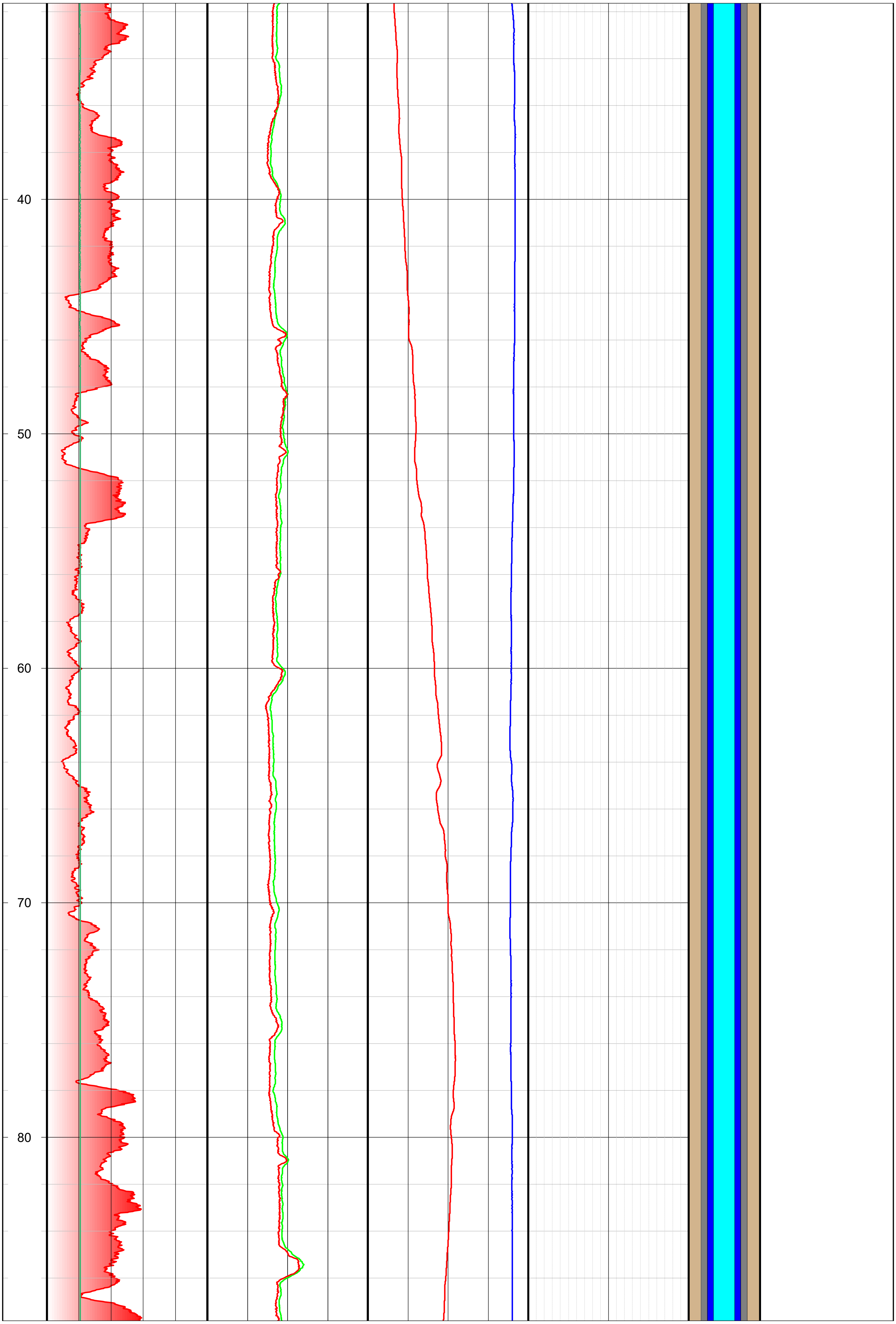
Location: **Gateshead** Area: **Newcastle** Grid Ref: **NZ26** Elevation:

Drilled Depth: (m)	**189.0 (BGL)**	Date:	**14.01.25**
Logged Depth: (m)	**183.8**	Recorded By:	**C. Clinton**
Logging Datum:	**Top of uPVC**	Remarks:	
Logged Interval: (m)	**0.0 - 183.8**		
Fluid Level: (m)	**17.4**		

BOREHOLE RECORD		
Bit: (mm)	From: (m)	To: (m)
375	**0.0**	**27.0**
245	**27.0**	**167.0**
194	**167.0**	**189.0**

CASING RECORD			
Type	Size: (mm)	From: (m)	To: (m)
Steel	**200**	**0.0 and 152.4**	**89.9 and 167.4**
uPVC	**103 (id)**	**0.0**	**169.4**
Steel	**111 (id)**	**169.4**	**171.1**





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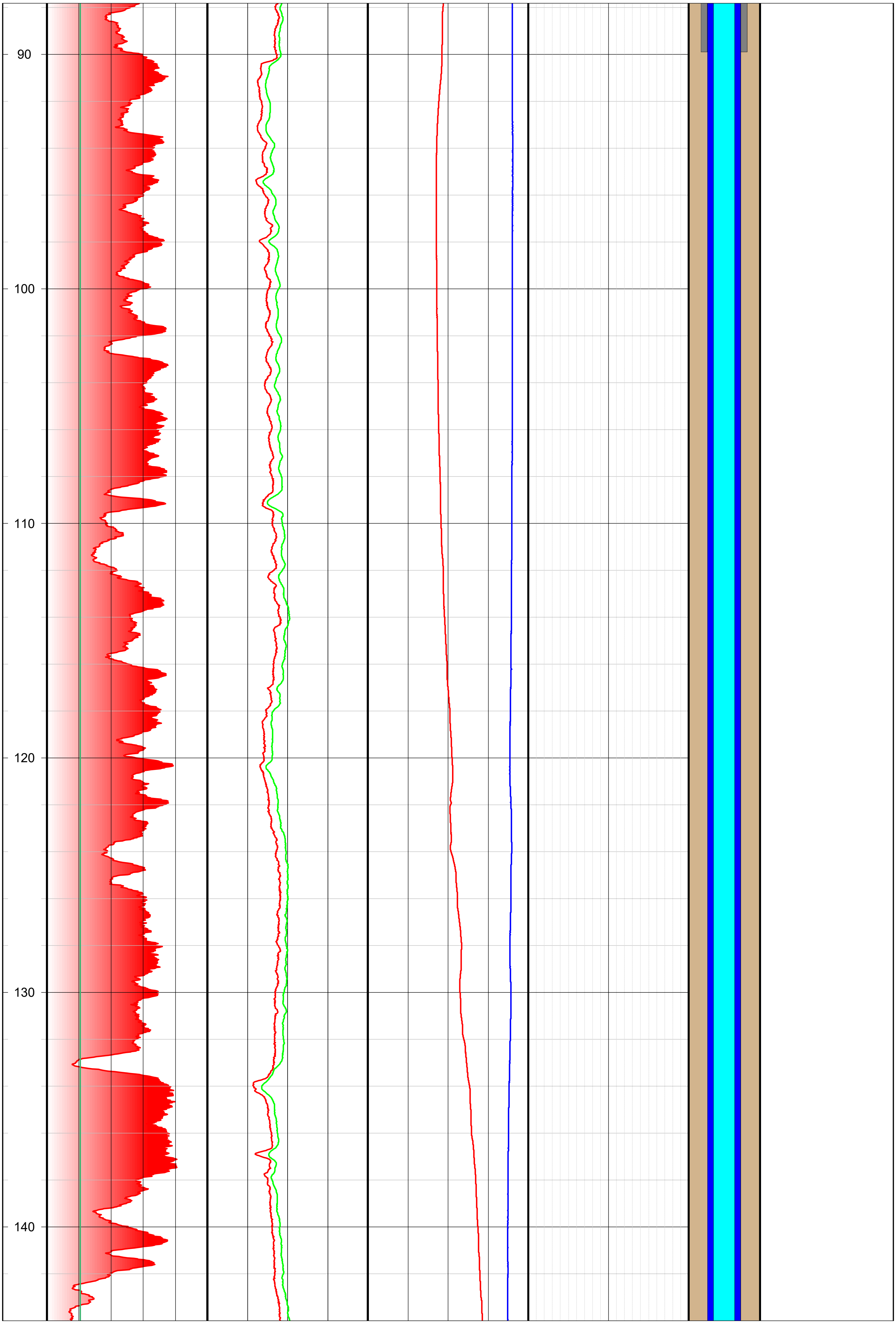
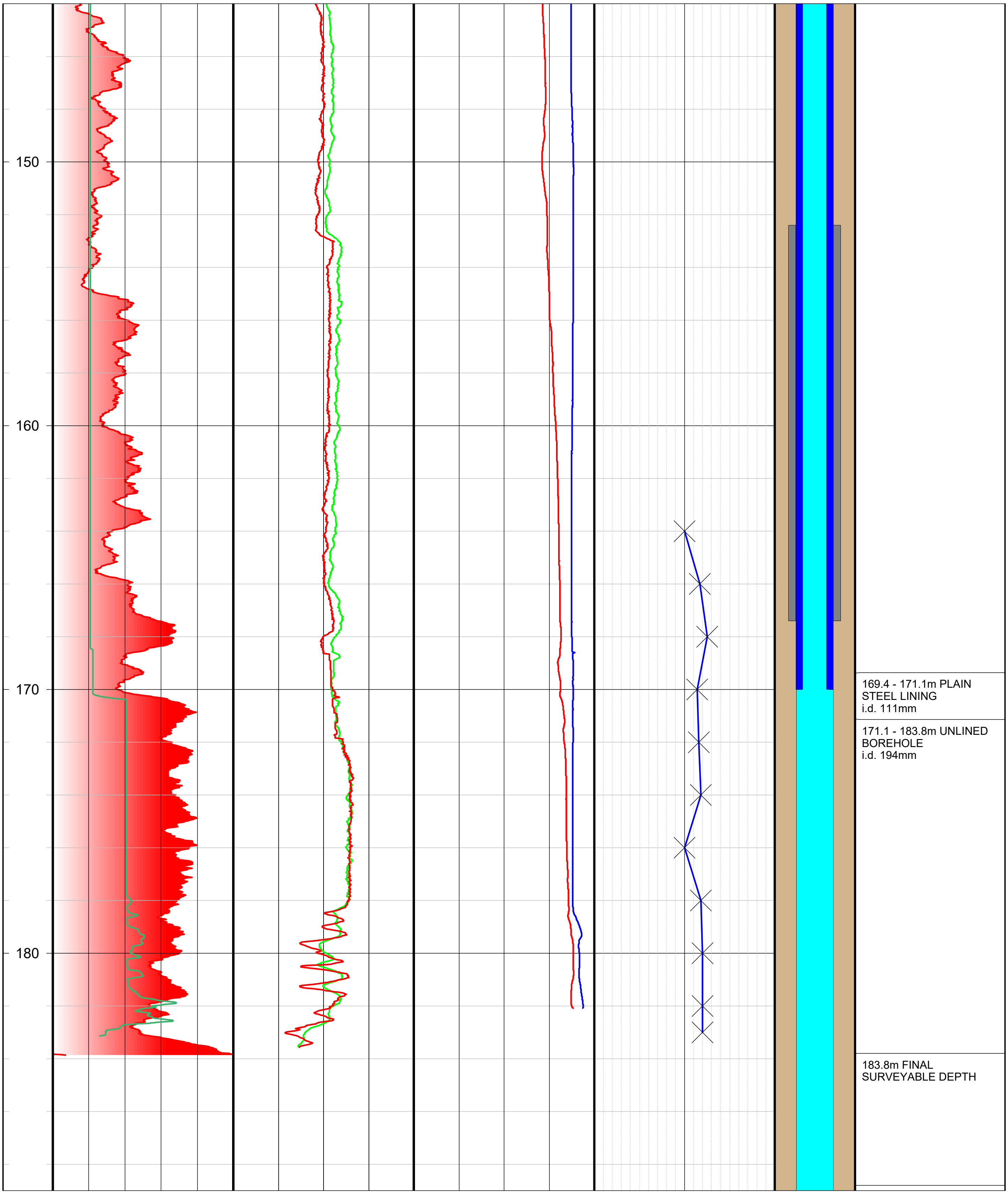
50
60
70
80



90
100
110
120
130
140



150
160
170
180
169.4 - 171.1m PLAIN STEEL LINING i.d. 111mm
171.1 - 183.8m UNLINED BOREHOLE i.d. 194mm
183.8m FINAL SURVEYABLE DEPTH

Figure 5.2

Borehole Magnetic Resonance

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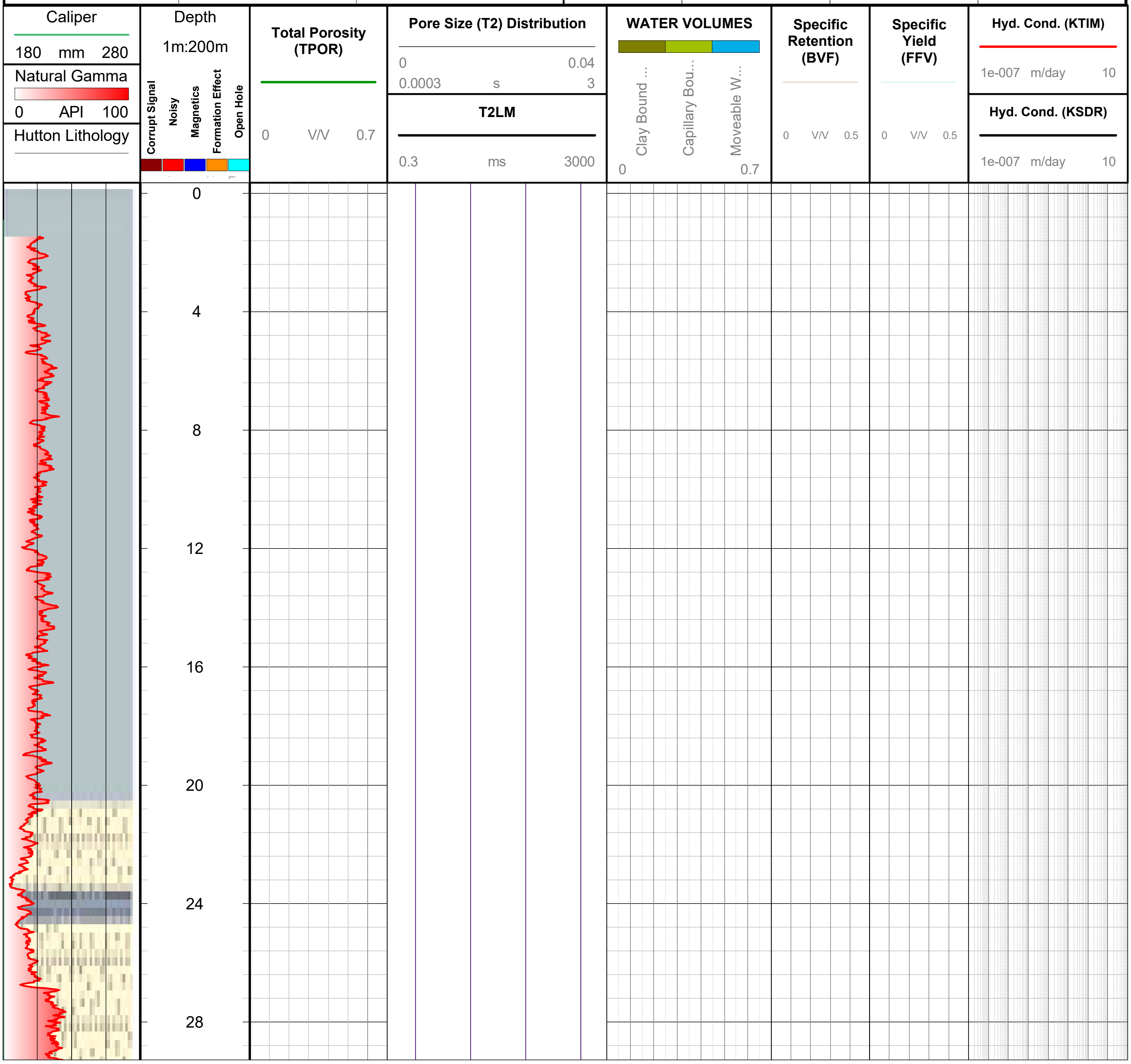
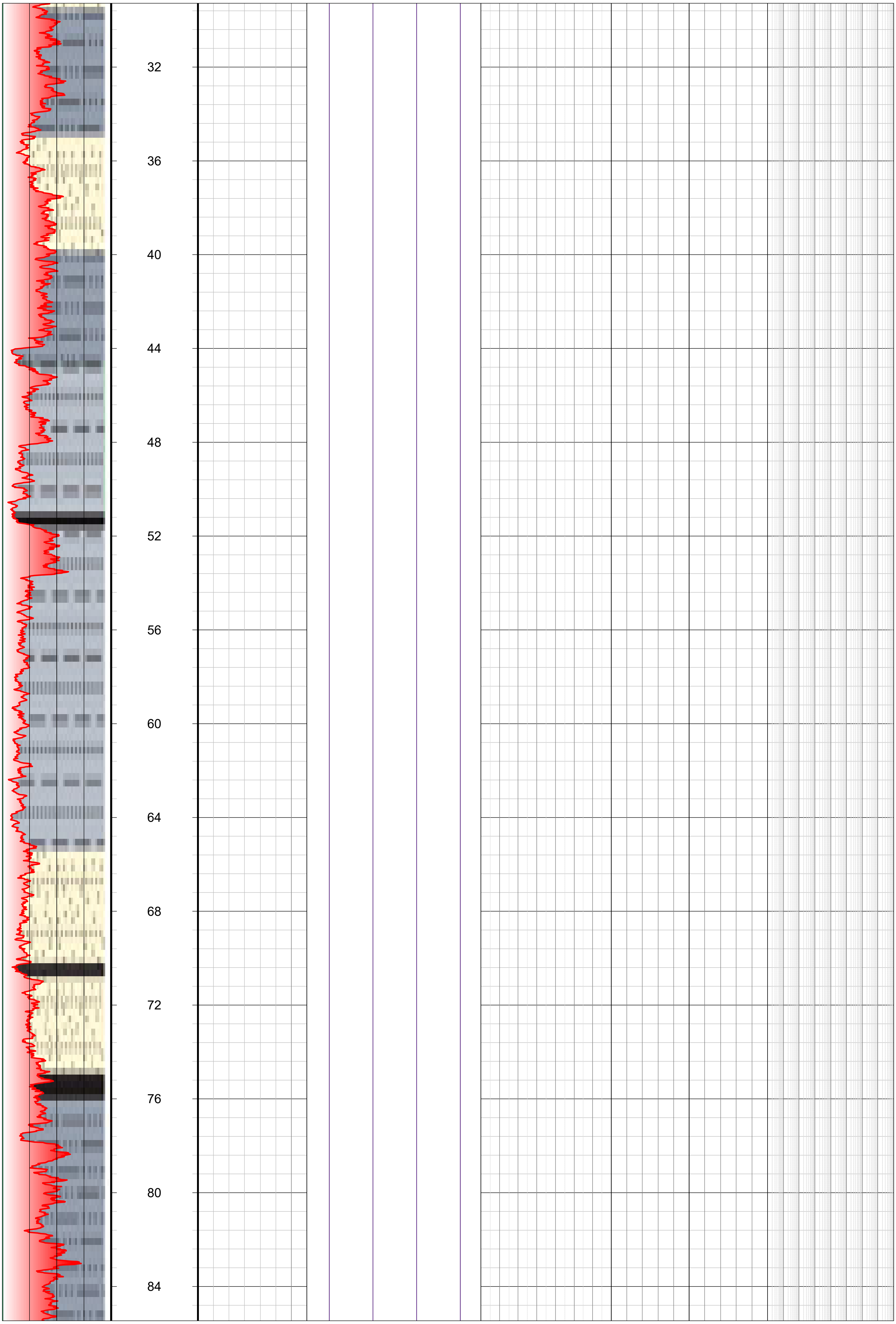
Client:	**Mining Remediation Authority**	Log Type: ***BMR***
Borehole:	**Stadium - Hutton**	

Location: **Gateshead** Area: **Newcastle** Grid Ref: **NZ26** Elevation:

Drilled Depth: (m)	**189.0 (BGL)**	Date:	**14.01.25**
Logged Depth: (m)	**183.8**	Recorded By:	**C. Clinton**
Logging Datum:	**Top of uPVC**	Remarks:	
Logged Interval: (m)	**0.0 - 183.8**		
Fluid Level: (m)	**17.4**		

BOREHOLE RECORD			CASING RECORD			
Bit: (mm)	From: (m)	To: (m)	Type	Size: (mm)	From: (m)	To: (m)
375	**0.0**	**27.0**	**Steel**	**200**	**0.0 and 152.4**	**89.9 - 167.4**
245	**27.0**	**167.0**	**uPVC**	**103 (id)**	**0.0**	**169.4**
194	**167.0**	**189.0**	**Steel**	**111 (id)**	**169.4**	**171.1**

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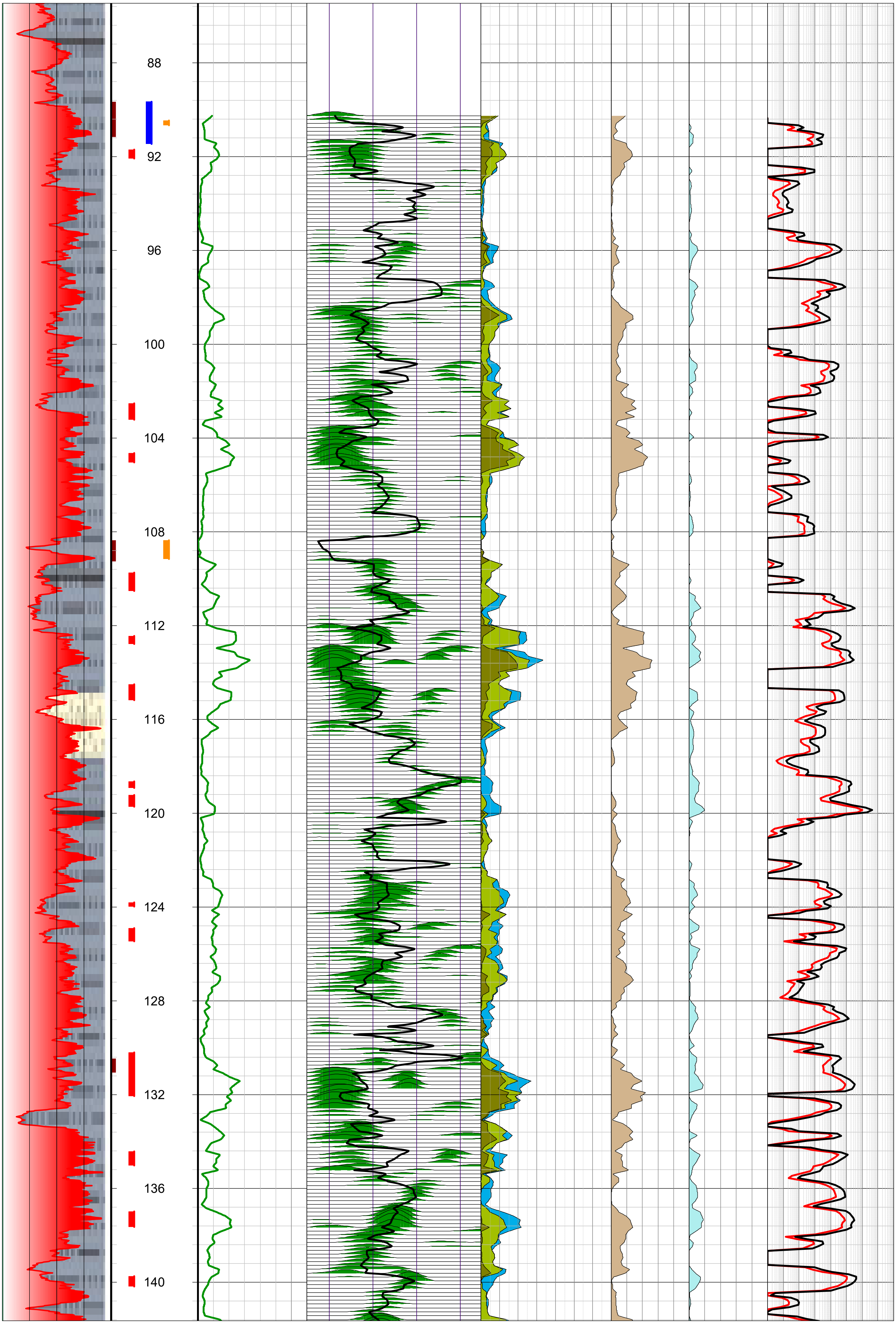

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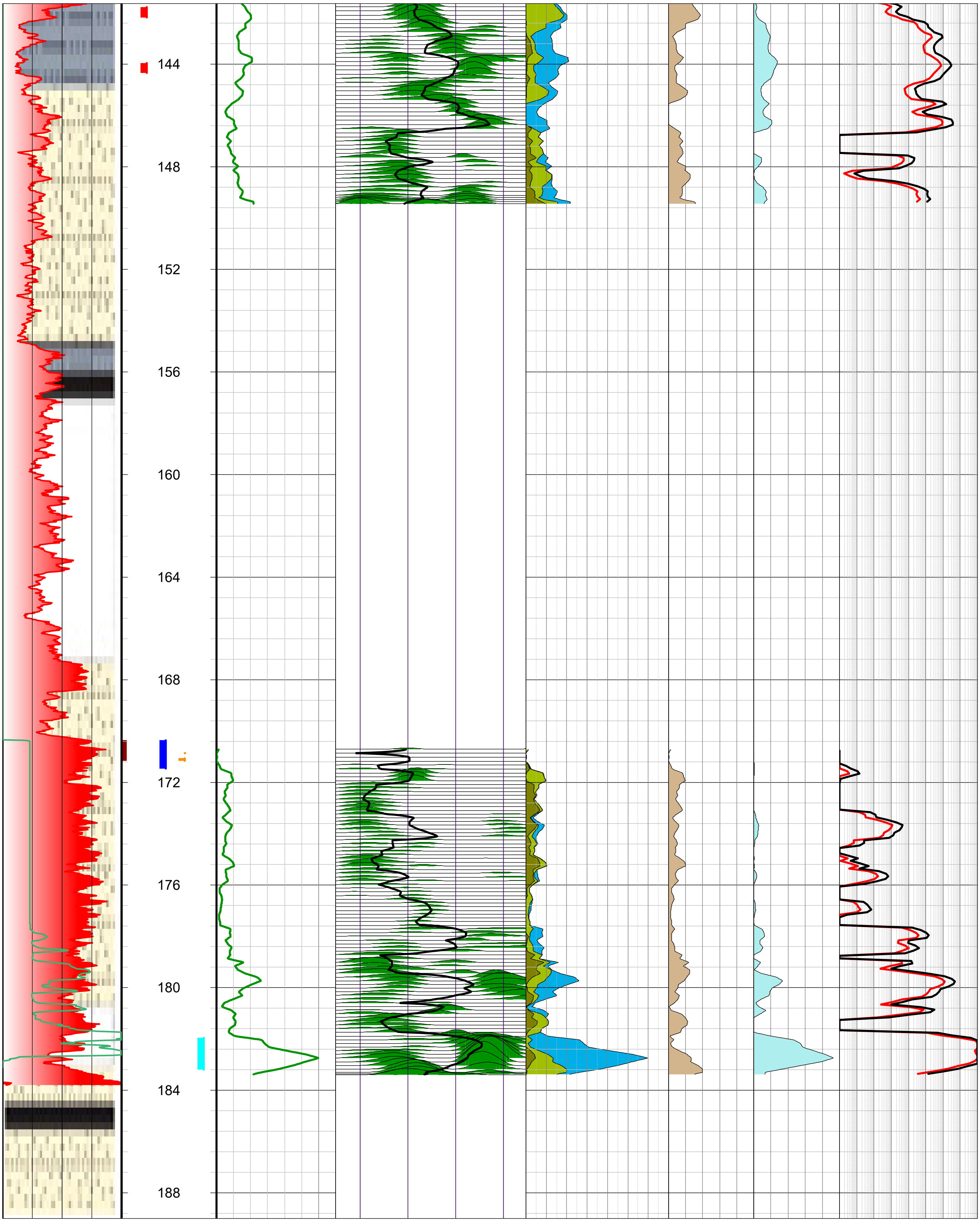
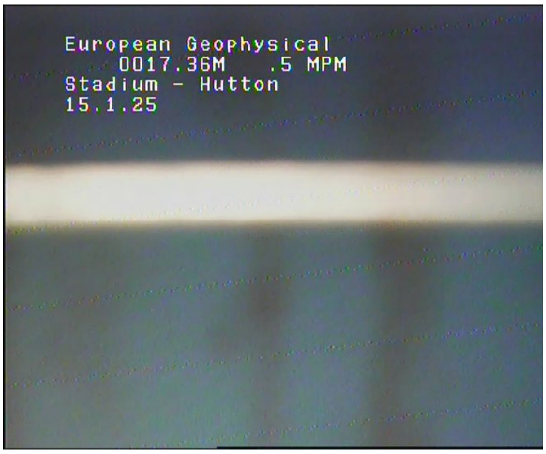

144
148
152
156
160
164
168
172
176
180
184
188

5.0 RESULTS

PHOTOGRAPHS FROM THE CCTV SURVEY

Stadium Hutton **Date: 14.01.25**



Resting Water Level

Change from uPVC lining to plain steel lining

Bottom of steel lining.

Down hole view of break out

Figure 5.3

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5.0 RESULTS

PHOTOGRAPHS FROM THE CCTV SURVEY

Stadium Hutton **Date: 14.01.25**

Sub vertical fracture

Breakout with blocky appearance, with possible fracturing.

Fine sediment on base of borehole.

Horizontal fracture

Figure 5.4

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6.0 CONCLUSIONS

6.1 The final surveyable depth of the borehole was recorded at 183.8m and was covered in fine sediment.

6.2 The borehole was lined with uPVC with a 103mm I.D. to a depth of 169.4m with plain steel casing with an id of 111mm to a depth of 171.1m. behind the uPVC lining there was a section of 10 inch plain steel casing from 0 – 27m and 2 sections of 8 inch casing from 0 – 89.9m and 152.4 – 167.4m. This was corroborated by the Natural Gamma, density and caliper measurements.

6.3 The temperature and conductivity logs show a change at the base of the borehole at 178.8m, which suggests the inflow point is located below this zone.

6.4 The CCTV shows a horizontal fracture at the base of the hole, at 183.4m. This may be the inflow point.

6.5 The unlined borehole was comprised of competent and stable sandstone down to ~177.9m, with an average density of around 2.5 – 2.6 g/cm3 and a diameter of ~202mm. Break outs were observed below this on the CCTV and the caliper which have also affected the density logs.

6.6 The oscillating flow at the top of the borehole was unusual and may be related to some kind of pumping in the hydraulic system.

6.7 The rest water level was 17.4m with some small fluctuation of around ±5cm, which is likely related to the oscillating flow observed on the CCTV

6.8 There was vertical fluid movement between the base of the borehole and ~164m measured on the heat pulse flow meter, of around 1.4 mm/s. No downward flow was observed on the heat pulse flow meter, despite the oscillating flow observed at the top of the fluid column on the CCTV.

6.9 The average total porosity in the competent sandstone section of the unlined borehole was around 0.02 – 0.1 (with 1 being 100%). Below this there were breakouts which may effect the porosity measurements. The total porosity values in the upper uPVC lined section were more variable, with values between 0.02 – 0.3 and higher signal noise which may be due to the sensors installed behind the lining.

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Appendix B – Borehole construction details

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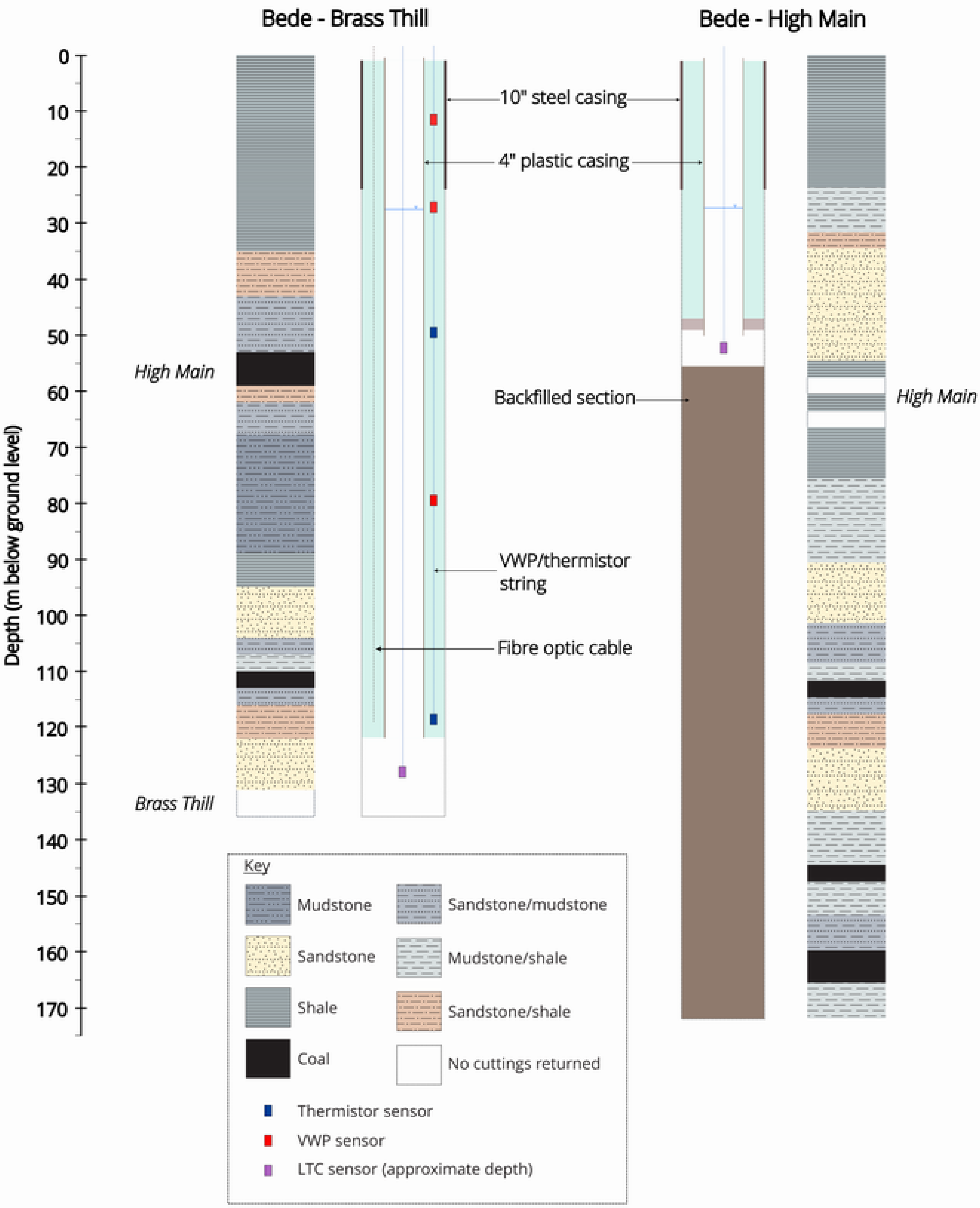
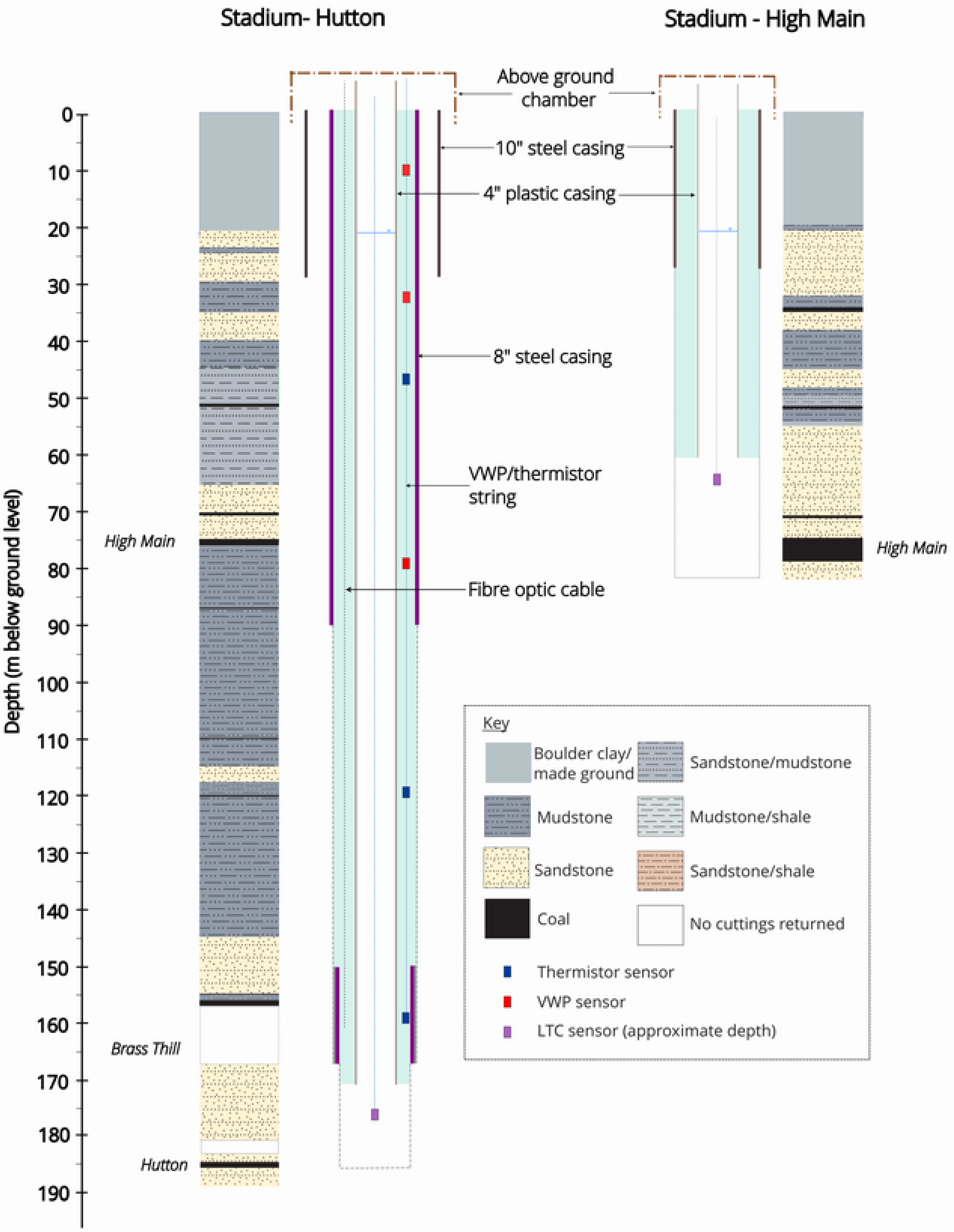

Bede - Brass Thill
Bede - High Main
Depth (m below ground level)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
High Main
Brass Thill
10" steel casing
4" plastic casing
Backfilled section
VWP/thermistor string
Fibre optic cable
High Main
Key
Mudstone
Sandstone/mudstone
Sandstone
Mudstone/shale
Shale
Sandstone/shale
Coal
No cuttings returned
Thermistor sensor
VWP sensor
LTC sensor (approximate depth)


Stadium- Hutton
Stadium - High Main
Above ground chamber
10" steel casing
4" plastic casing
8" steel casing
VWP/thermistor string
Fibre optic cable
Depth (m below ground level)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
High Main
Brass Thill
Hutton
Key
Boulder clay/ made ground
Sandstone/mudstone
Mudstone
Mudstone/shale
Sandstone
Sandstone/shale
Coal
No cuttings returned
Thermistor sensor
VWP sensor
LTC sensor (approximate depth)

Appendix C – Driller's logs strata description

Bede – High Main				
Diameter	From	To	Strata Description	%Flush
14 ¾"	1.2	2.48	Shale / clay	100
14 ¾"	2.48	5.48	Shale / clay	100
14 ¾"	5.48	7.48	Shale	100
14 ¾"	7.48	10.48	Shale	100
14 ¾"	13.48	16.48	Shale	100
14 ¾"	16.48	19.48	Shale	100
14 ¾"	19.48	22.48	Shale	100
14 ¾"	22.48	23.80	Shale	100
9 5/8"	23.80	25.48	Mud stone / shale	100
9 5/8"	25.48	28.48	Grey shale / mudstone	100
9 5/8"	28.48	31.38	Grey shale / mudstone	100
9 5/8"	31.48	34.48	Grey shale / white stone	100
9 5/8"	34.48	37.48	White stone / sand stone	100
9 5/8"	37.48	40.48	White stone / sand stone	100
9 5/8"	40.48	43.48	White stone / sand stone	100
9 5/8"	43.48	46.48	White stone / sand stone	100
9 5/8"	46.48	49.48	White stone / sand stone	100
9 5/8"	49.48	52.48	White stone / sand stone	0
6"	66.61	69.61	SHALE	100
6"	69.61	72.61	SHALE	100
6"	72.61	75.61	SHALE / COAL	100
6"	75.61	78.61	SHALE /MUD STONE	100
6"	78.61	81.61	GREY MUDSTONE / SHALE	100
6"	81.61	84.61	GREY MUDSTONE / SHALE	100
6"	84.61	87.61	GREY MUDSTONE / SHALE	100
6"	87.61	90.61	GREY MUDSTONE / SHALE	100
6"	90.61	93.61	SAND STONE	100
6"	93.61	96.61	SAND STONE	100
6"	96.61	99.61	SAND STONE	100
6"	99.61	101.61	SAND STONE / COAL	100
6"	101.61	102.61	Sand stone / mud stone	100
6"	102.61	105.61	Sand stone / mud stone	100
6"	105.61	108.61	Sand stone / mudstone	100
6"	108.61	111.61	Shale / mudstone	100
6"	111.61	114.61	Coal	100
6"	114.61	117.61	Mud stone / sand stone	100
6"	117.61	120.61	Sand stone / shale	100
6"	120.61	123.61	Sand stone / shale	100
6"	123.61	126.61	White stone / sand stone	100

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Bede – High Main				
Diameter	From	To	Strata Description	%Flush
6”	126.61	129.61	White stone / sand stone	100
6”	129.61	132.61	White stone / sand stone	100
6”	132.61	135.61	White stone / sand stone	100
6”	135.61	138.61	White stone / sand stone	100
6”	138.61	141.61	Shale / mud stone	100
6”	141.61	144.61	Shale / mud stone	100
6”	144.61	147.61	Coal / white sand stone	100
6”	147.61	150.61	Mud stone / shale	100
6”	150.61	153.61	Mud stone / shale	100
6”	153.61	156.61	Sand stone / mud stone	100
6”	156.61	159.61	Sand stone / mud stone	100
6”	159.61	162.61	Coal / white stone	100
6”	162.61	165.61	Coal / mud stone	100
6”	165.61	168.61	Mud stone / shale	100
6”	168.61	171.61	Mud stone / shale	100

Bede – Brass Thill				
Diameter	From	To	Strata Description	%Flush
14 ¾”	G/L	1.2	Clay, coal, brick	100
14 ¾”	1.2	5.14	Shale	0
14 ¾”	5.14	8.14	Shale	100
14 ¾”	8.14	11.14	Shale	100
14 ¾”	11.14	14.14	Shale	100
14 ¾”	14.14	15.14	Shale	100
14 ¾”	15.14	18.14	Shale	100
14 ¾”	18.14	21.14	Shale	100
14 ¾”	21.14	23.80	Shale	100
9 5/8	22	23.14	Shale	100
9 5/8	23.14	25.14	Shale	100
9 5/8	25.14	28.14	Shale	100
9 5/8	28.14	31.14	Shale	100
9 5/8	31.14	34.14	Shale	100
9 5/8	34.14	37.14	Shale	100
9 5/8	37.14	40.14	White sand stone / shale	100
9 5/8	40.14	43.14	White sand stone / shale	100
9 5/8	43.14	47.14	Light grey sand stone / dark grey mud stone	100
9 5/8	47.14	50.14	Light grey sand stone / dark grey mud stone	100
9 5/8	50.14	53.14	Light grey sand stone / dark grey mud stone	90
9 5/8	53.14	56.14	Coal / wood	100
9 5/8	56.14	59.14	Coal / wood /dark grey sand stone	100

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Bede – Brass Thill				
Diameter	From	To	Strata Description	%Flush
9 5/8	59.14	62.27	white sand stone	100
9 5/8	62.27	65.27	black shale mudstone coal	100
9 5/8	65.27	68.27	black shale mudstone	100
9 5/8	68.27	71.27	grey mudstone	100
9 5/8	71.27	74.27	grey mudstone	100
9 5/8	74.27	77.27	grey mudstone	100
9 5/8	80.27	83.27	grey mudstone	100
9 5/8	83.27	86.27	grey mudstone	100
9 5/8	86.27	89.27	grey mudstone	100
9 5/8	89.27	92.27	black shale	100
9 5/8	92.27	95.27	black shale	90
9 5/8	95.27	98.27	white sand stone	100
9 5/8	98.27	101.14	white sand stone	100
9 5/8”	101.27	104.27	white sand stone	100
9 5/8	104.27	107.27	sand stone mud stone	100
9 5/8	107.27	110.27	shale mud stone	100
9 5/8	110.27	113.27	Coal	100
9 5/8	113.27	116.27	mud stone sand stone	100
9 5/8	116.27	119.27	sand stone shale	100
9 5/8	119.27	122.27	sand stone shale	100
9 5/8	122.27	125.27	white stone sand stone	100
9 5/8	125.27	128.27	white stone sand stone	100
9 5/8	128.27	131.27	white stone sand stone	100
9 5/8	131.27	133.27	N/A	0
9 5/8”	99.61	102.61	GROUT	100%
9 5/8”	102.61	105.61	GROUT	100%
9 5/8”	105.61	108.61	GROUT	100%
9 5/8”	108.61	111.61	GROUT	100%
9 5/8”	111.61	114.61	GROUT	100%
9 5/8”	114.61	117.61	GROUT	100%
9 5/8”	117.61	120.61	GROUT	100%
9 5/8”	120.61	123.61	GROUT	100%
9 5/8”	123.61	126.61	GROUT	100%
9 5/8”	126.61	129.61	GROUT	100%
9 5/8”	129.61	131.61	GROUT	100%
9 5/8”	131.61	134.61	N/A	100

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Stadium – High Main				
Diameter	**From**	**To**	**Strata Description**	**%Flush**
14" ¾	1.20	2.10	Made ground	100% / Dark Grey
14" ¾	2.10	7.10	Very stiff grey clay	100% / Dark Grey
14" ¾	7.10	16.0	Stiff grey boulder clay	100% / Dark Grey
14" ¾	16.0	21.50	Sandy grey clay with boulders	100% / Dark Grey
14" ¾	21.50	22.50	Dark grey mudstone	100% / Dark Grey
14" ¾	22.50	27.0	Yellow Sandstone	100% / Light Grey
9" 5/8	27.0	32.10	Yellow sandstone	100% / Dark Grey
9" 5/8	32.10	34.0	Dark Grey mudstone	100% / Dark Grey
9" 5/8	34.0	34.58	Coal	100% / Dark Grey
9" 5/8	34.58	37.58	Yellow sandstone	100% / Dark Grey
9" 5/8	37.58	44.58	Dark Grey mudstone	100% / Dark Grey
9" 5/8	44.58	47.58	Dark Grey sandstone, topping up mud treatment tank throughout drilling ops.	80% / Dark Grey
9" 5/8	47.58	49.58	Light Grey mudstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey
9" 5/8	49.58	50.58	Dark Grey siltstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey
9" 5/8	50.58	51.60	Dark Grey siltstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey
9" 5/8	51.60	52.10	Coal, topping up mud treatment tank throughout drilling ops.	80% / Dark Grey
9" 5/8	52.10	53.58	Black mudstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey
9" 5/8	53.58	54.58	Dark grey siltstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey
9" 5/8	54.58	58.58	Light Grey sandstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey
9" 5/8	58.58	60.58	Light grey sandstone with dark grey mudstone bands, topping up mud treatment tank throughout drilling ops.	80% / Dark Grey
9" 5/8	60.58	63.58	Light Grey sandstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey
9" 5/8	63.58	67.58	Light Grey sandstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey
9" 5/8	67.58	70.78	Light Grey sandstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey
9" 5/8	70.78	70.88	Coal, topping up mud treatment tank throughout drilling ops.	80% / Dark Grey
9" 5/8	70.88	72.58	Light Grey sandstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey
9" 5/8	72.58	75.18	Light Grey sandstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey
9" 5/8	75.18	78.33	Coal, topping up mud treatment tank throughout drilling ops. – Client on site witnessing the amount of coal coming out of the b/h.	80% / Very Dark Grey
9" 5/8	78.33	79.58	Dark Grey sandstone, topping up mud treatment tank throughout drilling ops	80% / Very Dark Grey
9" 5/8	79.58	82.08	Dark Grey sandstone, topping up mud treatment tank throughout drilling ops	80% / Dark Grey

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Stadium – Hutton				
Diameter	**From**	**To**	**Strata Description**	**%Flush**
14" ¾	1.20	3.0	Made ground	Dk Brown / 100%
14" ¾	3.0	4.0	Made ground with clay	Brown / 100%
14" ¾	4.0	11.0	Very stiff light grey boulder clay	Dk Grey / 100%
14" ¾	11.0	14.0	Gravels with dark grey boulder clay.	Dk Grey / 100%
14" ¾	14.0	19.20	Grey boulder clay.	Grey / 100%
14" ¾	19.20	21.0	Grey boulder clay with big boulders throughout.	Grey / 100%
14" ¾	21.0	23.0	Yellow sandstone	Very light grey /100%
14" ¾	23.0	24.0	Black mudstone.	Dk grey / 100%
14" ¾	24.0	27.0	Yellow sandstone	Very light grey / 100%
9" 5/8	27.0	29.62	Yellow sandstone	Light Grey / 100%
9" 5/8	29.62	35.62	Light grey mudstone	Light Grey / 100%
9" 5/8	35.62	39.62	Yellow sandstone – badly broken in places and loosing flush returns	Light Grey / 50%
9" 5/8	39.62	44.62	Dark Grey mudstone	Dark grey / 90%
9" 5/8	44.62	49.62	Light grey Siltstone.	Light grey / 70%
9" 5/8	49.62	51.80	Dark Grey Siltstone	Dark grey / 50%
9" 5/8	51.80		Coal – Out of mud to continue drilling, near end of shift and instructed to pull rods out of b/h , coal cuttings coming over shaker at 51.80m	Dark grey / 50%
9" 5/8	51.80	52.20	Coal	Dark grey / 100&
9" 5/8	52.20	57.62	Light Grey Sandstone	Light grey / 100%
9" 5/8	57.62	59.62	Light Grey Sandstone with dark mudstone bands throughout	Light grey / 100%
9" 5/8	59.62	60.62	Light Grey Sandstone with Mudstone bands	Light grey / 100%
9" 5/8	60.62	64.62	Light Grey Sandstone	Light grey / 100%
9" 5/8	64.62	66.05	Dark Grey Mudstone with Light Grey Sandstone bands throughout.	Dark grey / 100&
9" 5/8	66.05	70.89	Light Grey Sandstone	Light grey / 100%
9" 5/8	70.89	70.99	Coal	Dark grey / 100&
9" 5/8	70.99	72.09	Dark Grey Sandstone	Dark grey / 100&
9" 5/8	72.09	73.09	Light Grey Sandstone	Light grey / 100%
9" 5/8	73.09	74.79	Light Grey Sandstone.	Light Grey / 100%
9" 5/8	74.79	75.09	Possible High Main roof, Coal and mudstone chippings, *loosing flush*	Dark Grey / 60%
9" 5/8	75.09	75.51	Coal – High main	Dark Grey / 80%
9" 5/8	75.51	82.09	Dark Grey and Black mudstone	Dark Grey / 80%
9" 5/8	82.09	86.90	Light Grey mudstone with dark grey mudstone bands.	Dark Grey / 80%
9" 5/8	86.90	87.10	Coal	Dark Grey / 80%
9" 5/8	87.10	89.09	Black mudstone with light grey mudstone bands	Dark Grey / 80%
9" 5/8	89.09	90.09	Light grey mudstone with dark grey mudstone bands.	Dark Grey / 80%
9" 5/8	90.09	97.36	Black mudstone with Ligh Grey mudstone bands. *Topping up mud treatment tank throughout drilling ops*	Dark Grey / 80%

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Stadium – Hutton				
Diameter	**From**	**To**	**Strata Description**	**%Flush**
9” 5/8	97.36	99.36	Black mudstone with light grey mudstone bands	Dark Grey / 80%
9” 5/8	99.36	109.56	Light Grey Mudstone with Dark Grey mudstone bands	Dark Grey / 80%
9” 5/8	109.56	109.76	Coal	Dark Grey / 80%
9” 5/8	109.76	112.36	Dark Grey Mudstone with Light Grey mudstone bands	Dark Grey / 80%
9” 5/8	112.36	115.60	Light Grey Mudstone with Dark Grey mudstone bands	Dark Grey / 80%
9” 5/8	115.60	117.36	Light Grey Sandstone	Dark Grey / 80%
9” 5/8	117.36	118.36	Black mudstone with dark grey mudstone bands	Dark Grey / 80%
9” 5/8	118.36	120.36	Dark Grey Mudstone with Light Grey mudstone bands	Dark Grey / 80%
9” 5/8	120.36	120.60	Coal	Dark Grey / 80%
9” 5/8	120.60	122.36	Dark Grey Mudstone with Light Grey mudstone bands	Dark Grey / 80%
9” 5/8	122.36	133.36	Dark Grey mudstone with Light Grey mudstone bands throughout.	Dark Grey / 80%
9” 5/8	133.36	135.36	Black mudstone with Dark Grey mudstone bands throughout.	Dark Grey / 80%
9” 5/8	135.36	140.36	Dark Grey mudstone with Light Grey mudstone bands throughout.	Dark Grey / 80%
9” 5/8	140.36	142.36	Black mudstone with Dark Grey mudstone bands throughout.	Dark Grey / 80%
9” 5/8	142.36	143.36	Black mudstone with Dark Grey mudstone bands.	Dark Grey / 80%
9” 5/8	143.36	145.36	Dark Grey mudstone with Light Grey mudstone bands.	Dark Grey / 80%
9” 5/8	145.36	155.52	Light Grey sandstone.	Light Grey / 80%
9” 5/8	155.52	155.62	Coal.	Dark Grey / 80%
9” 5/8	155.62	156.36	Light Grey mudstone with Coal chippings.	Dark Grey / 80%
9” 5/8	156.36	157.36	Coal	Dark Grey / 80% then 0%
9” 5/8	157.36	164.16	??? - No flush returns	0%
9” 5/8	164.16	166.26	Void, no resistance on drill head from 164.16m to 166.26m. Resistance on drill head encountered at 166.26m –suspected Brass Thill seam. Gap of void 2.10m	0%
9” 5/8	166.26	167.36	??? – No flush returns	0%
7” 5/8	137.0	167.36	Grout	80% / Light Grey
7” 5/8	167.36	180.87	Dark Grey sandstone	80% / Dark Grey
7” 5/8	180.87	182.87	180.87m to 182.87m, total flush loss, very little resistance on drill head, ¼ turning the drill head every so often whilst pushing the drill string down to get to 182.87m, resistance on drill head at 182.87m. Possible Hutton Seam from 180.87m to 182.87m equalling a 2.0m void with backfill in the workings.	0% / ???
7” 5/8	182.87	184.63	Dark Grey sandstone	80% / Light Grey
7” 5/8	184.63	185.93	Coal – Possible Hutton Seam, not a lot of coal coming over shaker.	80% / Dark Grey

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Stadium – Hutton				
Diameter	**From**	**To**	**Strata Description**	**%Flush**
7” 5/8	185.93	188.97	Dark grey sandstone, Reamed rods up and down twice, lost flush ½ way down the rod at approx 186.52m the 2nd time reaming the rod. Reamed rods back to 188.97m, still no flush returns.	80% / Dark Grey then 0% / ????

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