BOREHOLE 5 CONSTRUCTION AND TEST PUMPING REPORT

DECANTAE NATURAL MINERAL WATER

For

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Ref: P19-247 Cott DC Lic \TP Report
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Revision	Details	Completed by	Date	Checked by	Date
REV01	Draft	EV	23/10/19	PH	25/10/19
REV02	Draft	EV	05/11/19	PH / TM	06/11/19
REV03	Client Issue	PH	18/12/19	TM	18/12/19
REV04					

BOREHOLE 5 CONSTRUCTION AND TEST PUMPING REPORT

DECANTAE NATURAL MINERAL WATER

1 INTRODUCTION

Envireau Water has been appointed by Decantae Natural Mineral Ltd ("Decantae") to oversee the construction and test pumping of a new borehole (BH5), analyse test pumping data, and the production of a borehole construction and test pumping report to support an application to Natural Resources Wales (NRW) for a new abstraction licence.

1.1 Background

Decantae bottle natural mineral water from a spring and two active production boreholes (BH1 & BH4) at their site at Trofarth Farm, Conwy, North Wales ('the Site'), which were previously geographically exempt from abstraction licensing until 1st January 2018.

The existing borehole sources at the Site are all constructed to depths between 30 – 40m into Carboniferous bedrock (Elwy Formation). The boreholes all yield low volumes of water, which reflects the low permeability of the Elwy Formation. Most of the water obtained is likely to be from the weathered top of the formation or where fractures are present within the bedrock.

To improve the long-term security of supply and support further growth of the business, a new production borehole (BH5) was constructed at the Site in April 2018. The borehole was subsequently test pumped under Groundwater Investigation Consent (GIC) Ref. PPN-00266 issued by NRW in December 2018.

1.2 Report Objectives

This report presents the findings from the groundwater investigation carried out at BH5 and will be used to support an application to NRW for a new abstraction licence. The application will be considered in parallel with the application recently submitted by Envireau Water as part of the New Authorisations process [Ref. PAN-007278, validated 16/10/2019] to licence the existing sources.

The report includes:

- A review of the site setting and water sources in close proximity to the new borehole (BH5).
- A review of the geology and hydrogeology at BH5 based on mapping data from the British Geological Survey (BGS) together with borehole construction records and the results of geophysical logging.
- A summary of findings from groundwater investigations; including the analysis of test pumping data from BH5.
- Development of a hydrogeological conceptual model of the proposed abstraction, based on all the above and the implications for abstraction licensing.

2 BOREHOLE CONSTRUCTION

BH5 was constructed by WB and AD Morgan Ltd, with Envireau Water providing technical support during the process. Construction of BH5 commenced on 9th April 2018 and was completed on 18th April 2018. The borehole construction details are summarised in Table 1.

The location of BH5 is shown on Figure 1. A schematic diagram showing the 'as-built' borehole construction is presented on Figure 2 and the driller's construction log is presented in Appendix A.

The borehole was sited based on the results of a surface geophysical survey, which identified areas of more conductive, weathered bedrock at the Site that would be likely to be water bearing.

Table 1 Summary of Production Borehole Construction

Construction Element	Details
Location	NGR SH 85863 70523
Surface Elevation	243 mAOD (handheld GPS)
Completion Date	18/04/2018
Completion Depth	41m
Drilled Diameter*	380mm to 12m, 250mm to 41m
Casing Depth & Diameter*	Grouted 275mm stainless steel casing from surface to 12mbgl
Screen Depth & Diameter*	150mm uPVC casing from 0 to 41m bgl; plain casing from 0 to 11m bgl; slotted casing (1mm slots) from 11 to 36m bgl; plain casing from 36 to 41m bgl
Target Aquifer	Elwy Formation

**Nominal diameters*

The screen and casing depths were chosen based on the results of a geophysical logging exercise after the borehole was drilled. The results of the logging exercise are presented in Appendix B and show that:

- There is very limited inflow in the top ~20m of the borehole.
- The reduction in the natural gamma log and concomitant increase in resistivity at ~23m suggests a sandier horizon at this depth and corresponds with inflow to the borehole recorded on the fluid logs; and the drillers observation of a water strike at this depth. This is considered to be the principal inflow horizon to the borehole.
- There are some similar (but less pronounced) responses observable between 30 – 33m bgl and little, if any, flow contribution beneath this depth.

3 SITE SETTING

3.1 Location

Decantae is located in an upland, rural setting in North Wales, approximately 8km east of Llanfair Talhaiarn. The Site covers an area of approximately 13Ha and varies in elevation between ~240mAOD in the southeast of the Site to a high of ~330mAOD towards the northwest of the Site. BH5 is located at NGR SH 85863 70523. Figure 1 shows the location of the Site and the sources.

3.2 Water Sources

The source of water supply at the Site currently varies between a spring and two production boreholes (BH1 & BH4). The existing sources target groundwater at very shallow depths and all yield low volumes of water ranging between approximately 1 m^3/hour to 4 m^3/hour.

Table 2 summarises the details of the existing sources at the Site. The spring and active production borehole sources combine to form a single water supply used for bottling at the factory.

The shallow nature of the groundwater system has led to concerns about the potential impacts between the surface water and groundwater system, and risks to water quality. BH5 has been designed and constructed to address these potential issues and provide Decantae with long term security of supply.

Table 2 Summary Details of Existing Sources at the Site

Source ID	Spring	BH1	BH2	BH3	BH4
NGR	285425, 370704	285448, 370634	285674, 370627	285480, 370510	285877, 370477
Estimated Ground Elevation (mAOD)	295	294	281	288	245
Distance from BH5 (m)	474	428	208	384	65
Year Drilled	Unknown (predates 2004)	Unknown (predates 2004)	Unknown (predates 2004)	2003	2004
Drilled Depth (m)	N/A	30	Unknown	Unknown	39
Casing Diameter*	N/A	100mm	Unknown	Unknown	150mm
Approx. Rest Water Level (mAOD)	295	293-294	N/A	N/A	242
Installation Summary	Underground collection system.	Constructed with a plastic casing/screen.	Construction details unknown to Envireau Water.	Construction details unknown to Envireau Water.	Plain plastic casing to a depth of ~6m bgl; slotted plastic well screen 6-38m bgl; plain plastic casing at bottom ~1m.
Notes	Active and original source of supply that emerges to the northwest of the Site.	Active production borehole. Known to overflow during periods of high rainfall.	Abandoned due to insufficient yield during summer months and no longer accessible.	Abandoned due to insufficient yield.	Active production borehole.

**Nominal diameter*

BH5 was constructed with a surface casing to a depth of 12m bgl, which was grouted to form a sanitary seal. The depth of the sanitary seal means that BH5 targets groundwater at deeper depths than the existing sources.

3.3 Land Use and Soils

The land at Decantae is actively managed and is used to grow grass as a crop for silage.

The soil at the Site is comprised of acid loamy soils over rock [Ref. 1]. Surface runoff over the area mostly drains to local groundwater and the river network.

3.4 Hydrology

The local hydrological base is the River Elwy, which is located approximately 2.5m southeast of the Site and flows in a north-easterly direction. A multitude of small streams drain from the upland areas into the Elwy Valley.

The catchment descriptors at the Site and surrounding area indicate that surface runoff accounts for approximately 30% of discharge within the river network [Ref. 2], which is a low to moderate value.

There are two mapped streams at the Decantae site. The first flows in a south easterly direction from high land in the northwest of the Site passing very close to the spring, BH1 and BH3. The second flows in a southerly direction from high land to the northeast of the site and passes very close to BH4. The streams are likely to be in hydraulic continuity with a shallow groundwater system present within the weathered bedrock.

3.5 Geology

The geology at the Site and surrounding area has been characterised using the BGS 1:50,000 scale sheet 107 (Denbigh) [Ref.3]; borehole construction and geophysical records; and data from the BGS online GeoIndex database. An excerpt from the geological map is represented on Figure 3.

3.5.1 Superficial Deposits

The geological map shows that there are limited superficial deposits overlying the bedrock geology at the Site. Glacial Till is however shown to be present in the area around BH4 and BH5 and is more prevalent in the lower lying areas within the Elwy Valley to the south of the Site. Small areas of alluvial deposits are shown to be present in the surrounding area and are associated with local surface water features.

The presence of superficial deposits is confirmed in the construction record for BH5 [Appendix A], which shows that ~2m of Glacial Till and weathered bedrock were encountered above competent bedrock.

3.5.2 Bedrock Geology

The bedrock geology consists of a sequence of silty mudstones and thin sandstones of the Carboniferous age Elwy Formation, which extends to a thickness of up to 1,750m [Ref. 3]. The bedrock formation is extensively faulted and dips at a steep angle (up to 80 degrees) to the south. There are several mapped faults present at the Site and it is worth noting that all the existing sources are located close to faults.

The construction record for BH5 [Appendix A] and geophysical logging exercise [Appendix B] shows layers of strata up to 14m in thickness consisting of medium-hard to hard fractured mudstone and black shale, which is consistent with the geological description of the Elwy Formation.

3.6 Hydrogeology

The hydrogeology at the Site is dominated by the Elwy Formation, which is classified as a Secondary A aquifer.

The strata comprises a sequence of silty mudstones that, overall, are likely to be poorly permeable. The majority of groundwater flow occurs towards the weathered top of the formation or where fractures are present within the rock matrix. Groundwater flow direction is likely to be predominantly to the northeast, consistent with the surface water system.

The yield of boreholes is dependent on targeting groundwater stored within productive fractures and joint systems, which are likely to diminish with depth. Enhanced fracturing may be present around fault structures. Ref. 4 discusses the variations in transmissivity of mudstones within the Elwy Formations and suggests that shallow mudstones to a depth of ~40m with thin sandstone layers can exhibit transmissivity values ranging from <0.1 m^2/day to >1 m^2/day.

Recharge to the formation is dependent on direct infiltration where the formation outcrops at surface, and infiltration particularly along bedding planes and through fracture networks. Recharge is likely to be limited where the bedrock is overlain by a thick sequence of low permeability Glacial Till.

3.7 Water Dependent Features

A Water Feature Survey (WFS) [Ref. PPN-00266] was undertaken and submitted to NRW in October 2018. The WFS radius was 250m and details of the identified features are summarised in Table 3. Based on the findings of the WFS, no private water supplies were identified and it was proposed that BH4 would be monitored during the test pumping programme to establish the potential impacts from the new abstraction at BH5.

NRW issued a GIC in December 2018 that confirmed monitoring would be required at the existing boreholes BH1, BH3 and BH4. BH3 has been abandoned and is no longer accessible therefore, monitoring could not be undertaken at this location. Monitoring data for BH1 and BH4 are described in the following sections of this report.

NRW also requested confirmation of whether private water supplies were present at two nearby residential properties (Swn yr Afon and Trofarth Isa) located beyond the WFS radius. Decantae contacted the owners of the two properties and both confirmed they are connected to mains and do not have private water supplies.

Table 3 Summary Details of Identified Water Features

Water Feature	Type	National Grid Reference	Use	Distance from source (m)	Notes
BH4	Borehole	285877, 370477	Active production borehole	65	BH4 was constructed in 2004 and is being used by Decantae as a production borehole. This will be monitored during the test pumping programme.
Field Drain	Field Drain	285891, 370547	N/A	29	The field drain conveys surface water runoff to the south following local topography. Flows are dependent on rainfall.
Pond	Fishing Pond	286050, 370618	N/A	203	The pond is a man-made private fishing pond, constructed at an elevation above BH4 and BH5.
BH2	Borehole	285674, 370627	Abandoned/ disused	208	BH2 is a historic borehole at the Decantae site but has been abandoned. The borehole is inaccessible during the period of proposed test pumping.

3.8 Preliminary Conceptual Model

Based on the above, the preliminary hydrogeological conceptual model at the Site is summarised as follows:

- BH5 targets bedrock of the Elwy Formation, which consists of a sequence of silty mudstones and thin sandstones. The aquifer is classified as a Secondary A aquifer.
- The strata is likely to be poorly permeable; therefore, the majority of groundwater flow occurs towards the weathered top of the formation or where fractures are present within the bedrock.
- BH5 has been purposely constructed with a sanitary seal to a depth of 12m bgl and the majority of groundwater inflow occurs at a depth of around 23m bgl. BH5 is likely to be targeting a deeper groundwater system than the existing production boreholes at the Site.
- The poorly permeable nature of the Elwy Formation means that there may be limited interaction between the deep groundwater system targeted by BH5 and the shallow system targeted by the existing production boreholes.

The conceptual model is illustrated on Figure 4 and has been tested through test pumping of BH5, as described in the following sections of this report.

4 GROUNDWATER INVESTIGATIONS

4.1 Test Pumping Summary

A test pumping programme was carried out to determine the yield and impact of abstraction from BH5. The programme was carried out over 7 days from 13/06/2019 to 19/06/2019 to investigate the yield of BH5 and any potential impacts on BH4. The data was collected by Decantae and is presented electronically in Appendix C.

Water level and abstraction data was collected at BH4 and BH5 using dataloggers. Manual water level readings were obtained once a day at BH1, BH4 and BH5. The Spring, BH1 and BH4 were all in continuous production during the test pumping period and the abstraction data from those sources is also presented in Appendix C.

Hydrographs showing the logged and manual data are presented on Figures 5a and 5b. Table 4 summarises the details of the test pumping programme.

During test pumping, all the water abstracted was piped and discharged downstream of BH4 to prevent recirculation back to the aquifer (see Figure 1). A visual inspection of the field drain was carried out during testing to ensure the discharge was carried out in a controlled manner, without causing any flood risk complication downstream.

Table 4 Test Pumping Programme

Event	Date / Period	Duration	Description
Start of water level monitoring	13/06/2019 – 14/06/2019	2 days	Rest water level prior to the test pumping observed as 0.77mgbl.
BH5 CRT	15/06/2019 – 16/06/2019	2 days	Test pumped at average rate of 1.59 m^3/hr. Maximum drawdown of 22.73m observed in BH5 and 0.20m in BH4.
Recovery test End of monitoring	17/06/2019 – 19/06/2019	3 days	Water levels recovered to pre-pumped levels. Data downloaded from all dataloggers.

4.2 Constant Rate Test

A hydrograph for the constant rate test (CRT) is shown on Figure 6. A hydrograph showing the CRT recovery period is presented separately on Figure 7. Daily rainfall plotted against the water levels in BH4 is shown on Figure 8.

The CRT commenced on 15/06/2019 at an average abstraction rate of 1.59 m^3/hr. Steady-state conditions were reached after approximately 5 hours of pumping. The observed maximum drawdown after 2 days was 22.73m in BH5 and approximately 0.20m in BH4. Pumping ceased on 17/06/2019 and the recovery period ended after 3 days.

The hydrograph shows the water level in BH5 drops sharply at the start of the CRT from 0.77mbgl to 23.5mbgl and recovered to within 0.2m of the starting water level after 4 hours of the cessation of pumping. The water level in BH4 drops by approximately 0.2m and recovers after 4 hours of the end of the test.

Figure 5a shows a small overall increase in observed water levels at BH4, which most likely indicates that the borehole is responding to recharge from rainfall. Indeed, Figure 8 presents rainfall data which shows significant rainfall in the days prior to the start of the test.

The same trend is not observable in BH5, which suggests that BH4 and BH5 are likely targeting two different groundwater systems. This is consistent with the differences in borehole construction and that BH5 is targeting a deeper groundwater system than BH4. The impact of the preceding rainfall event on the water levels in BH4 suggests (as would be expected) that the shallow system responds more readily to recharge than at BH5 (see Figure 8).

The data shows that abstraction from BH5 has a small impact on the water levels in BH4; however, the extent of the impact is minimal.

A small decrease in water levels is also observed in BH1 over the test period and water levels continue to decrease after the end of the testing period. Given the relative elevation of BH1 to BH5, it is not possible for the changes in water level to be impacted by pumping at BH5. The observed changes are more likely related to operational pumping at BH1.

4.3 Aquifer Properties

The data collected from test pumping have been analysed using standard analytical techniques to calculate values for aquifer transmissivity and storage. Storage values cannot be calculated using the data from the production borehole (BH5) and can only be calculated using observation borehole data from BH4. Table 5 summarises the calculated aquifer properties.

Table 5 Aquifer Properties Derived from CRT Analysis

Borehole	Analysis	Transmissivity (m^2/day)	Storage (-)
BH5	Cooper-Jacob	0.63	-
BH5	Theis Recovery	0.37	-
BH4	Cooper-Jacob	73.98	0.6
BH4	Theis Recovery	175.7	-

The transmissivity values derived for BH5 reflect the very low yielding nature of the deep aquifer system and are consistent with literature values [Ref. 4]. Conversely, the estimated values for BH4 are much higher and reflect the more transmissive, shallow groundwater system that is present within the weathered bedrock.

4.4 Summary

The test pumping data for BH5 validates the preliminary conceptual model and suggests that BH4 and BH5 are targeting two separate groundwater systems that are poorly connected. The aquifer properties derived from BH5 data is reflective of the deeper formation whilst the data from BH4 is reflective of the shallow, weathered system.

Test pumping at BH5 was carried out at the same time as operational pumping from the existing sources (Spring, BH1, BH4). The test pumping data shows that abstraction from BH5 has no impact on BH1 and minimal impact on the shallow groundwater system targeted by BH4. Subsequently, there is also minimal impact on the nearby surface water system.

5 CONCLUSIONS

BH5 has been constructed to provide Decantae with a reliable long-term source of supply to sustain the Site's production needs and to support further growth of the business.

The new borehole targets low permeability mudstones of the Elwy Formation that is present at the Site and has been constructed to target a 'deep' groundwater system. Test pumping shows there is minimal interaction between the deep groundwater system and the shallow groundwater systems targeted by the existing sources.

Test pumping at BH5 was carried out at the same time as operational pumping from the existing sources (Spring, BH1, BH4). Analysis of the test pumping data demonstrates that BH5 can support an abstraction rate of 1.6m^3/hour without adversely impacting the local groundwater or surface water environment.

It is therefore appropriate for an abstraction licence to be issued based on the following maximum abstraction rates:

- Hourly: 1.6m^3
- Daily: 38.4 m^3
- Annual: 14,016 m^3

Envireau Water
18/12/19

REFERENCES

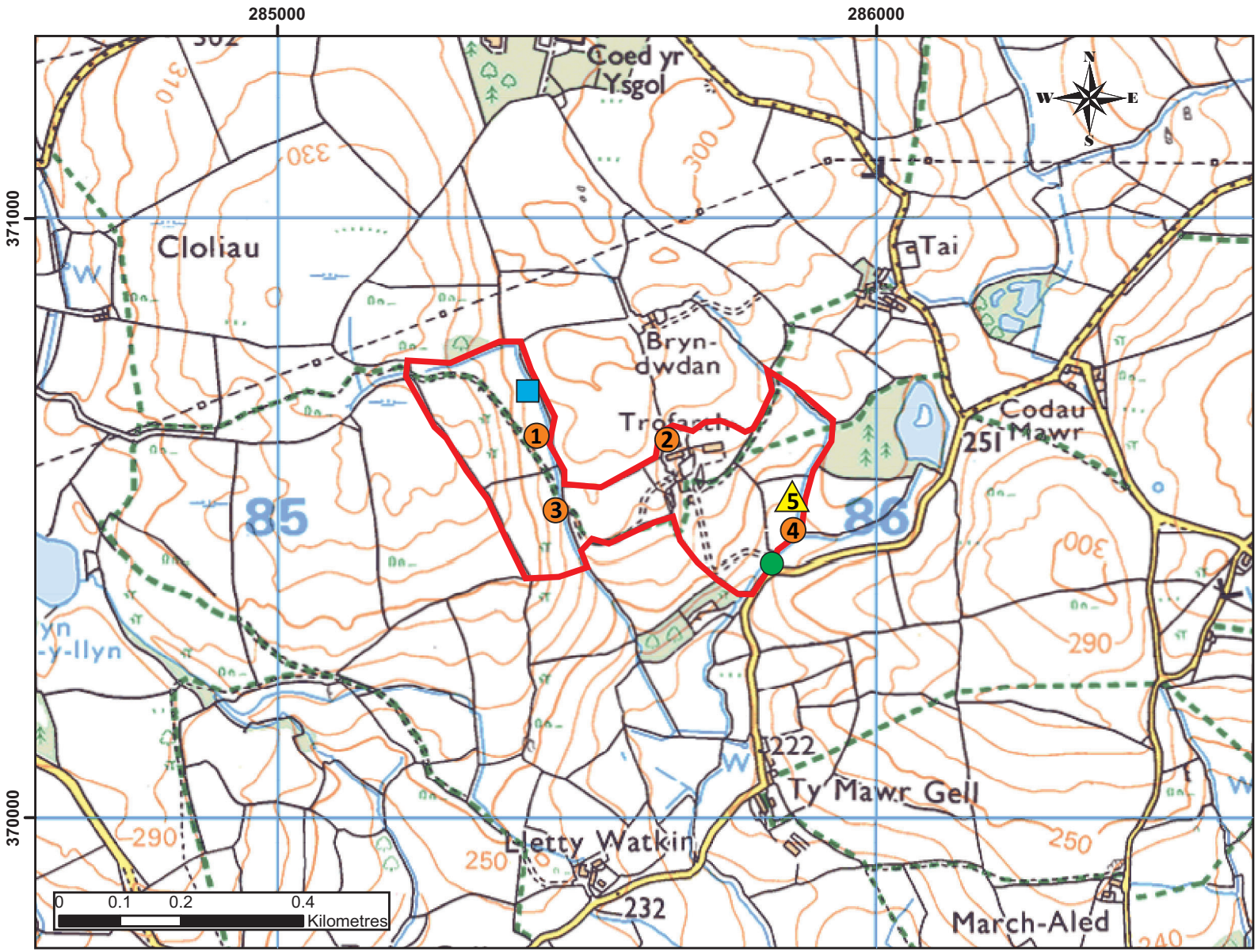
Ref.1 Cranfield University (2019). *The Soils Guide*. Available at: www.landis.org.uk [Accessed: 23 October 2019].

Ref.2 Centre for Ecology & Hydrology (2019). *FEH Catchment Descriptors*. Available at: https://nrfa.ceh.ac.uk/feh-catchment-descriptors [Accessed: 24 October 2019].

Ref.3 British Geological Survey (1985). *Geological map sheet 107, Denbigh, 1:50,000*. Solid and Drift.

Ref.4 MacDonald, AM., Kemp, SJ., Davies, J. (2005). Transmissivity variations in mudstones. *Ground Water*, 43(2), pp. 259-269.

FIGURES



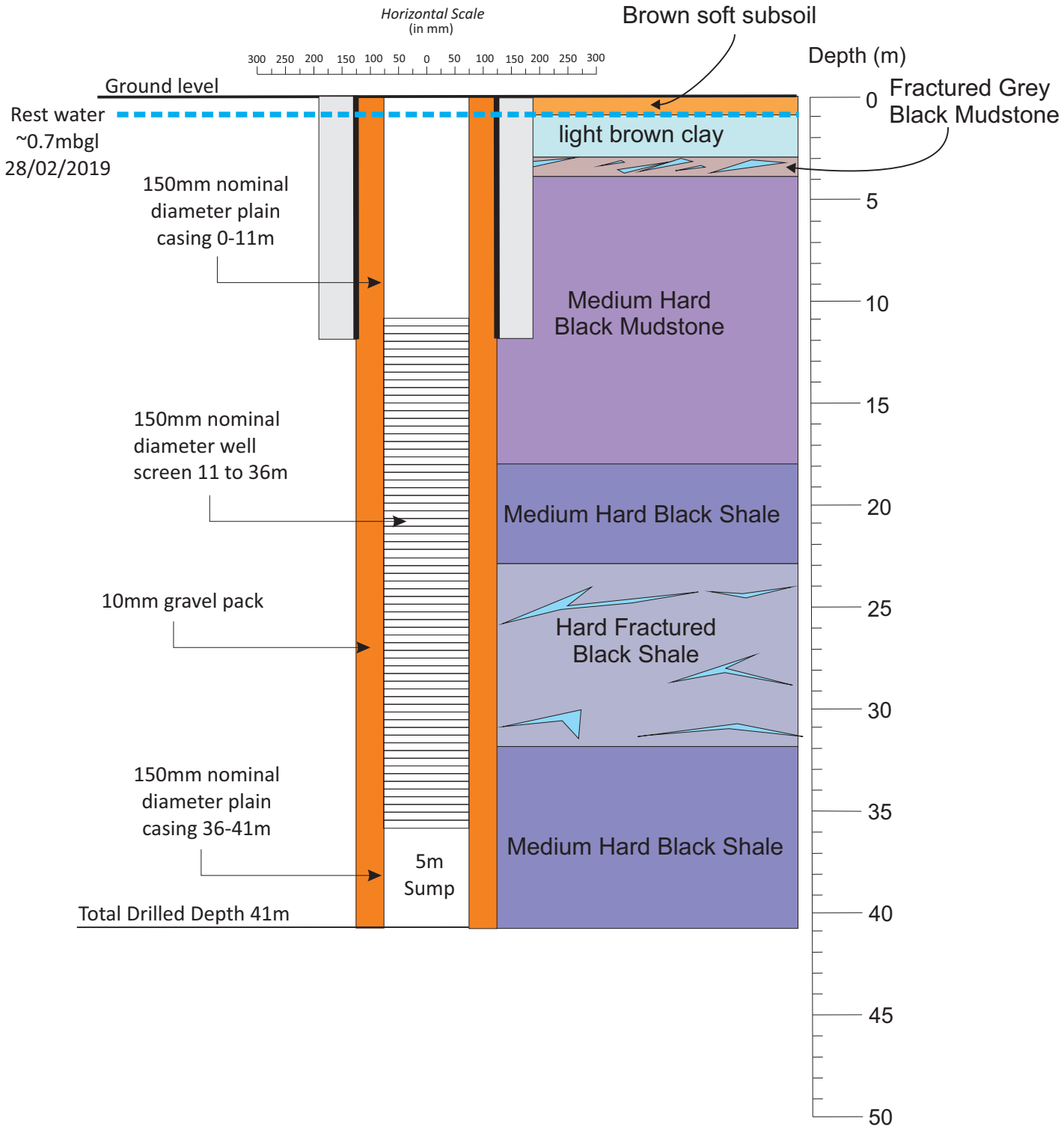
KEY

- Site boundary
- Spring
- Pre-existing boreholes
- Borehole 5
- Discharge Point

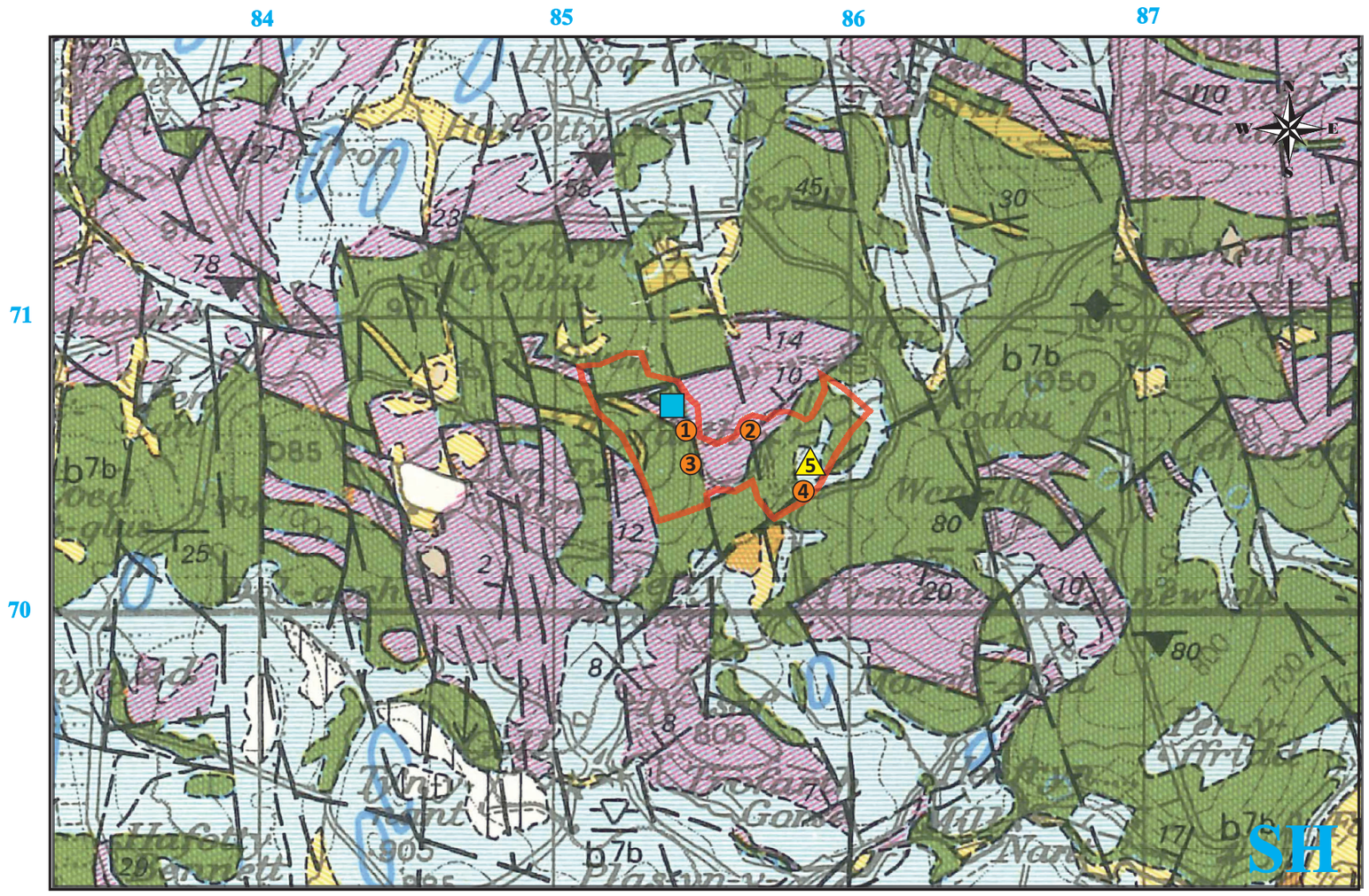
Scale 1 : 10,000 at A4

envireau WATER

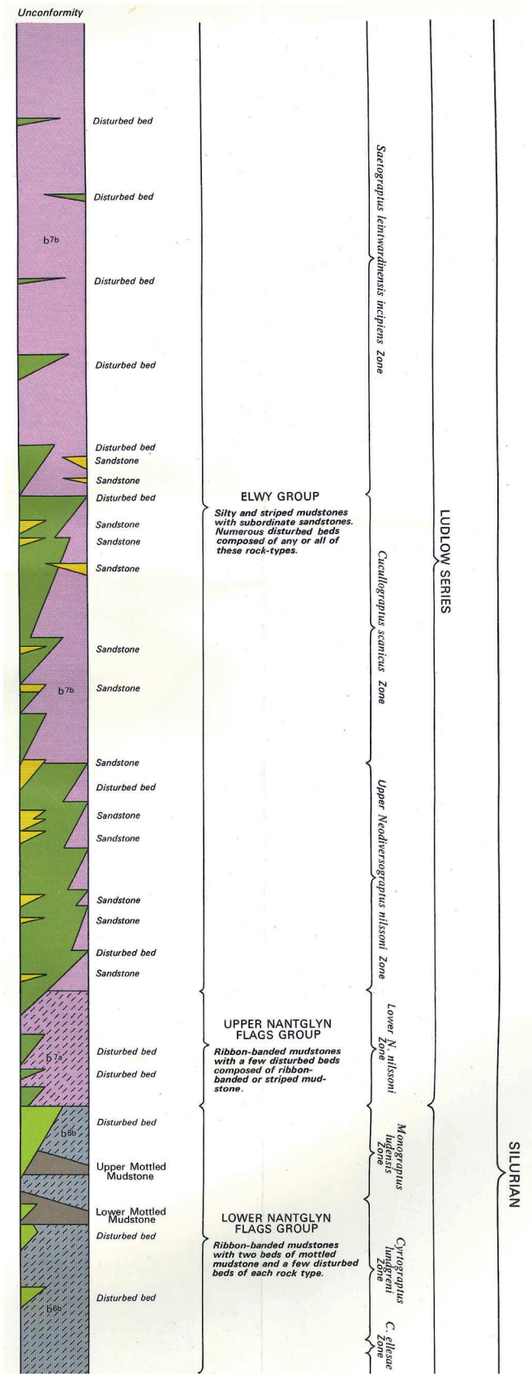
Ref: P19-247 - Cott DC Lic\figure 1: site location Date: 21/10/2019	**Decantae Mineral Water**
Figure 1	Site & Source Location Plan



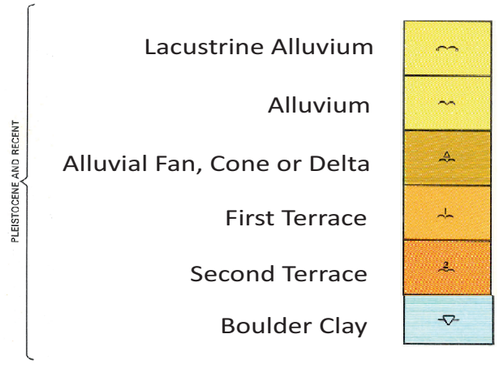
envireau WATER	Ref: P19-247 - Cott DC Lic\Fig. 2 As Built BH Cons Date: 14/10/2019	**Decantae Mineral Water**
	Figure 2	Production Borehole As-Built Construction



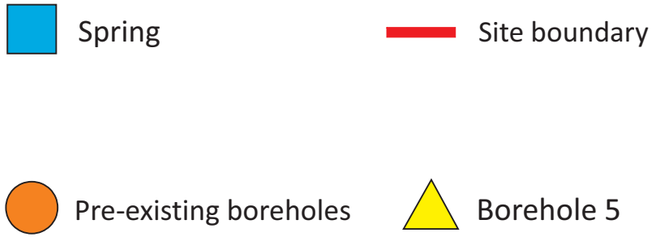
BEDROCK GEOLOGY



SUPERFICIAL GEOLOGY



KEY



Scale 1 : 10,000: at A3

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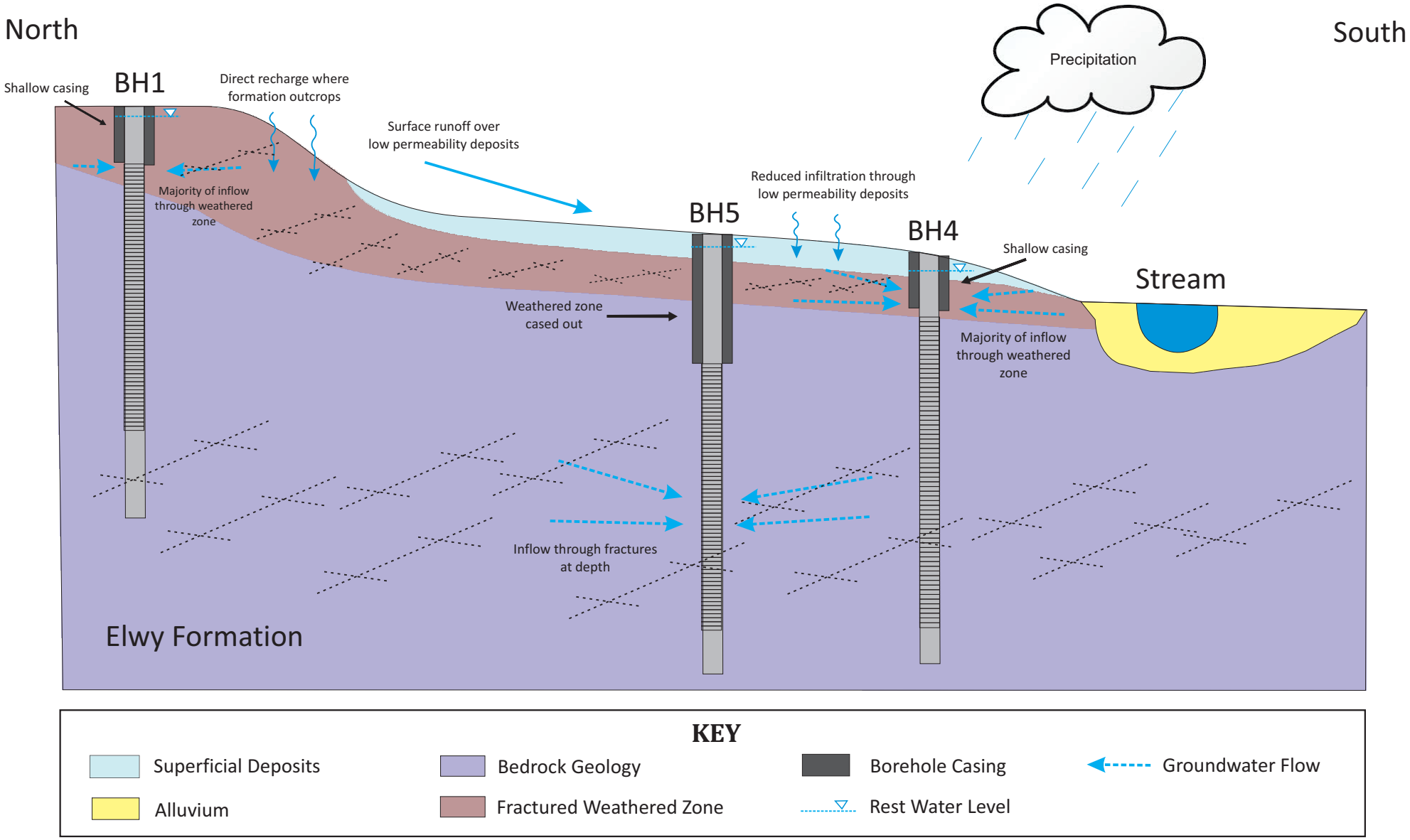
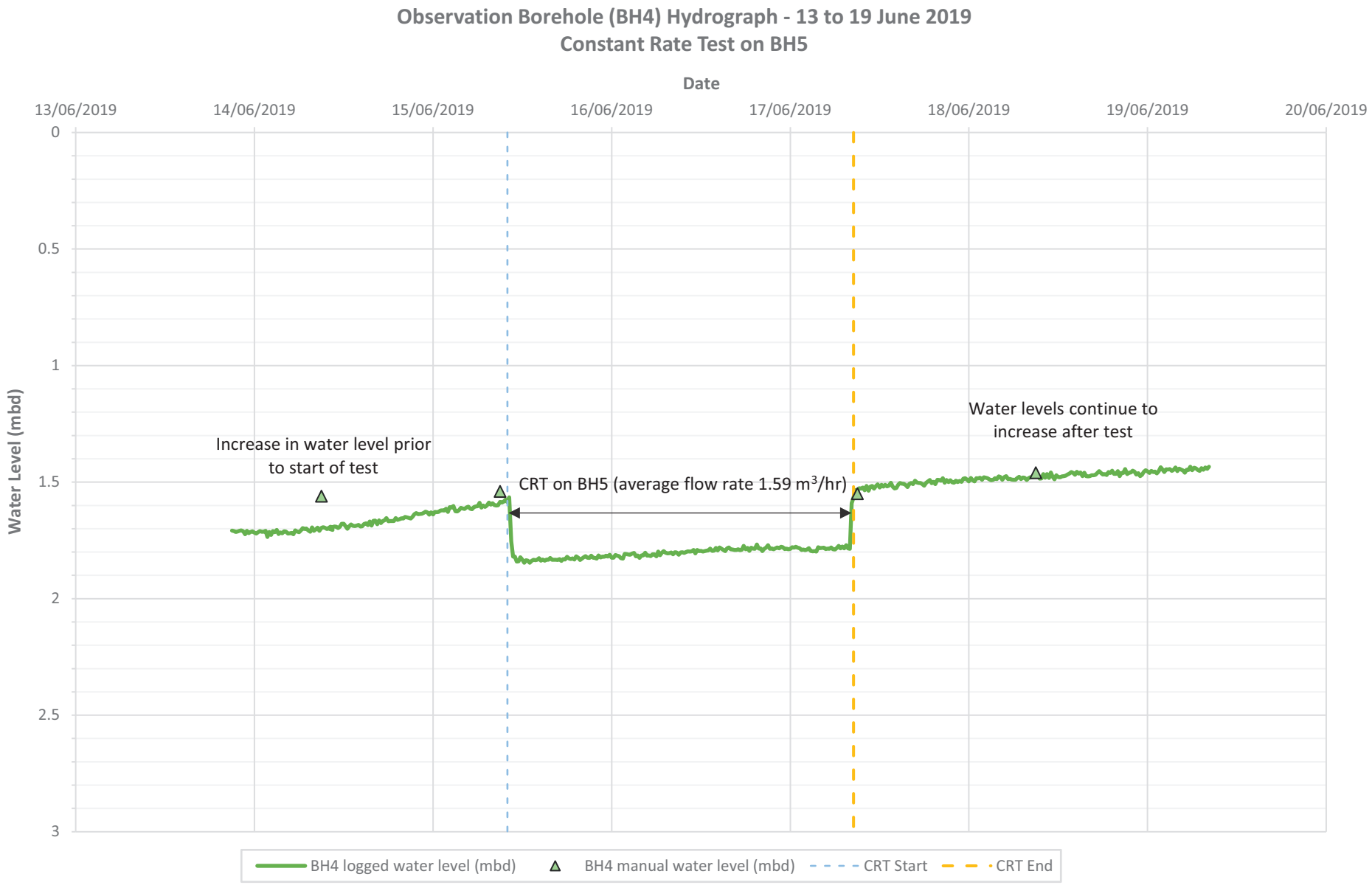
Ref: P19-247 - Cott DC Lic\Fig. 3 Geological Setting Date: 22/10/2019	**Decantae Mineral Water**
Figure 3	Geological Setting



Not to Scale : at A4

envireau WATER

Ref: P19-247 Cott DC Lic\Fig. 4 conceptual model Date: 29/10/2019	**Decantae Mineral Water**
Figure 4	Hydrogeological Conceptual Model



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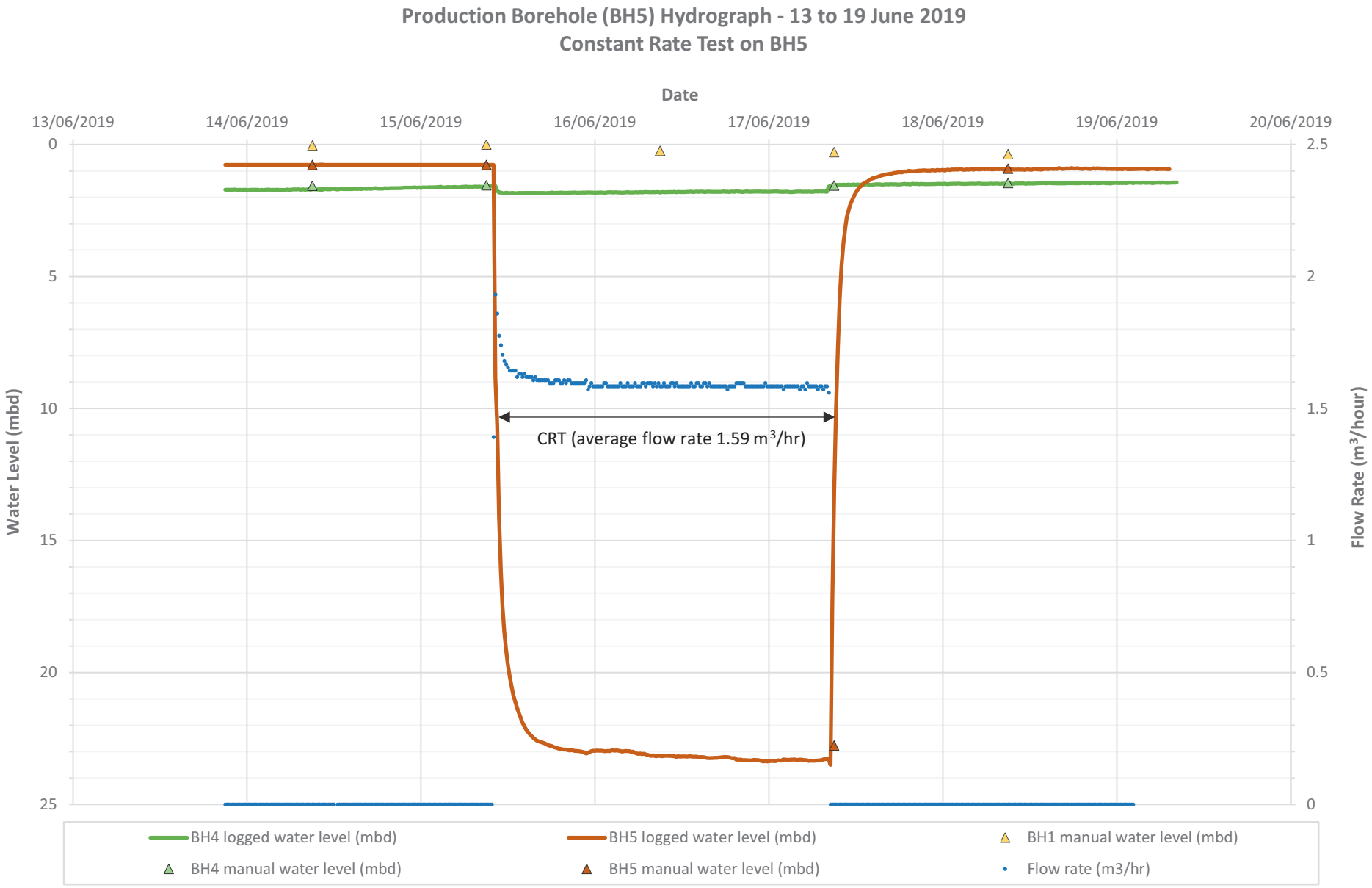
Ref: P19-247 - Cott DC Lic\Fig. 5a BH4 Hydrograph Date: 04/11/2019	**Decantae Mineral Water**
Figure 5a	BH4 Hydrograph



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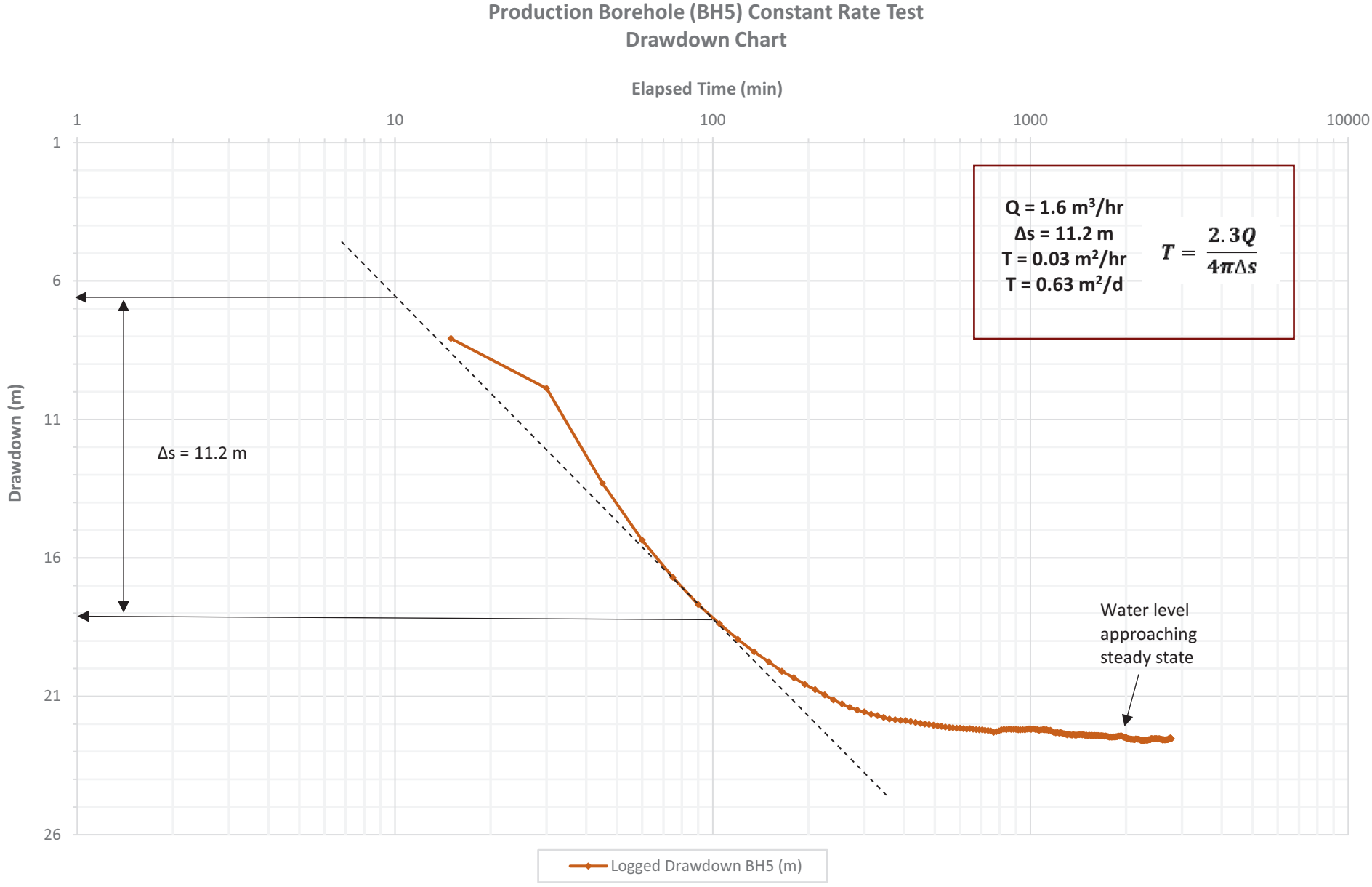
Ref: P19-247 - Cott DC Lic\Fig. 5b BH5 Hydrograph Date: 04/11/2019	**Decantae Mineral Water**
Figure 5b	BH5 Hydrograph



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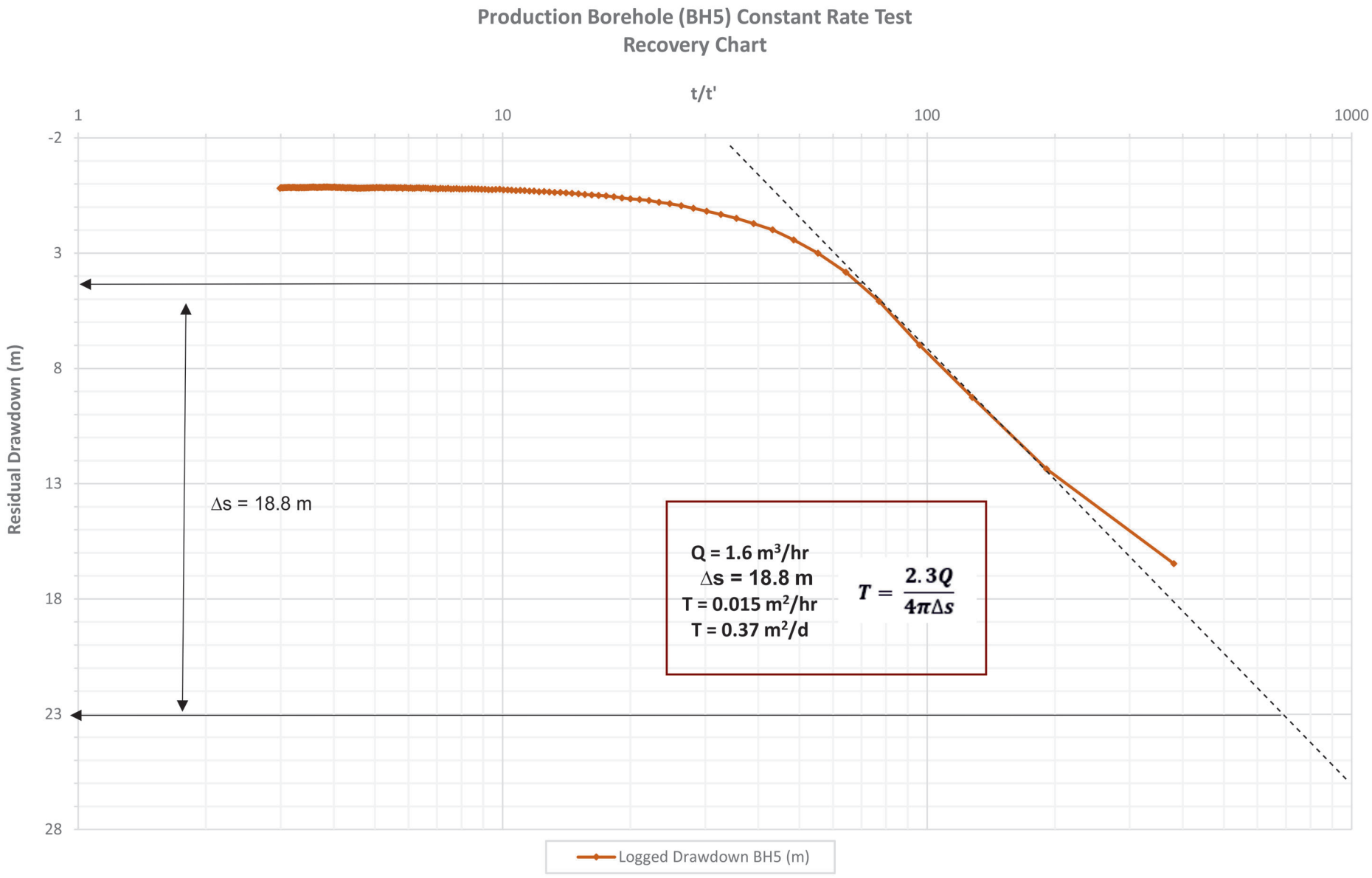
Ref: P19-247 - Cott DC Lic\Fig. 6 BH5 Constant Rate Test Drawdown Hydrograph Date: 04/11/2019	**Decantae Mineral Water**
Figure 6	BH5 Constant Rate Test Drawdown Hydrograph



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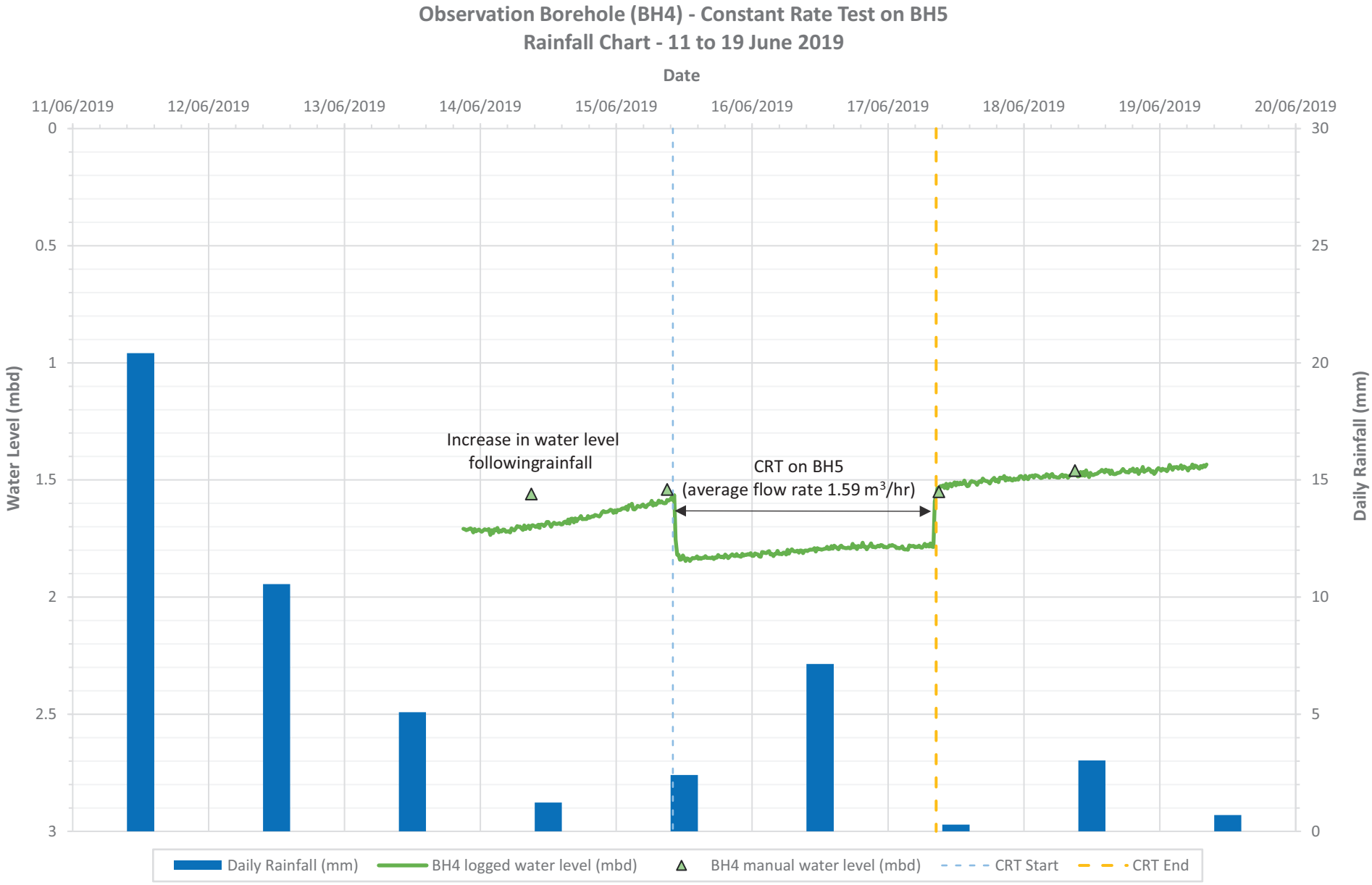
Ref: P19-247 - Cott DC Lic\Fig. 7 BH5 Constant Rate Test Recovery Chart Date: 04/11/2019	**Decantae Mineral Water**
Figure 7	BH5 Constant Rate Test Recovery Chart



Ref: P19-247 - Cott DC Lic\Fig. 8 Rainfall Hydrograph Date: 04/11/2019	**Decantae Mineral Water**
Figure 8	Rainfall Hydrograph

APPENDIX A
DRILLER'S BOREHOLE CONSTRUCTION LOG

ENVIRONMENT AGENCY

Form WR – 38	*Ref: decantae mineral water 2018*	Agency No.

BOREHOLE RECORD

A. **SITE DETAILS**

Borehole drilled for:	Mark Maberly, Decantae Mineral Water Co.			
Location:	Trofarth Farm, Trofarth, Llangernwy, Conwy, LL22 8RF			
N.G.R.:	SH285370			
Ground Level (if known):	SURFACE			
Drilling Company:	W.B. & A.D. MORGAN LTD., PRESTEIGNE, POWYS. LD8 2UF			
Date of Drilling:	**Commenced:**	9/4/18	**Completed:**	18/4/18

B. **CONSTRUCTION DETAILS**

Borehole datum (if not ground level) GROUNDLEVEL
(Point from which all measurements of depth are taken e.g. flange, edge of chamber, etc.)

Borehole drilled diameter..……		380	mm from	Surface	to	12	m/depth
		250	mm from	12	to	41	m/depth
			mm from		to		m/depth
Casing material: Stainless Steel and type (e.g. plain steel, plastic slotted)	diameter	275	mm from	Surface	to	12	m/depth
Casing material: u.P.V.C and type (e.g. plain steel, plastic slotted)	diameter	150	mm from	Surface	to	41	m/depth
Plain	diameter	150	mm from	Surface	to	11	m/depth
1mm Slotted	diameter	150	mm from	11	to	36	m/depth
Plain	diameter	150	mm from	36	to	41	m/depth
Slotted	diameter		mm from		to		m/depth
Plain	diameter		mm from		to		m/depth

Grouting details:	Pump 12m	to surface
Water struck at:	3m, 19m, 23m, 32	m (depth below datum – mbd)
Rest water level on completion:	Ground level	m (depth below datum – mbd)
Estimated blowout yield:	600	Gallons per hour

C. **STRATA LOG**

Description of Strata	**Thickness (m)**	**Depth (m)**
Brown sub soil	1	1
Light brown clays	1	2
Medium hard fractured black mudstone	2	4
Hard fractured black mudstone shale	14	18
Medium hard black shale	5	23
Hard fractured black shale	9	32
Medium hard black shale	9	41

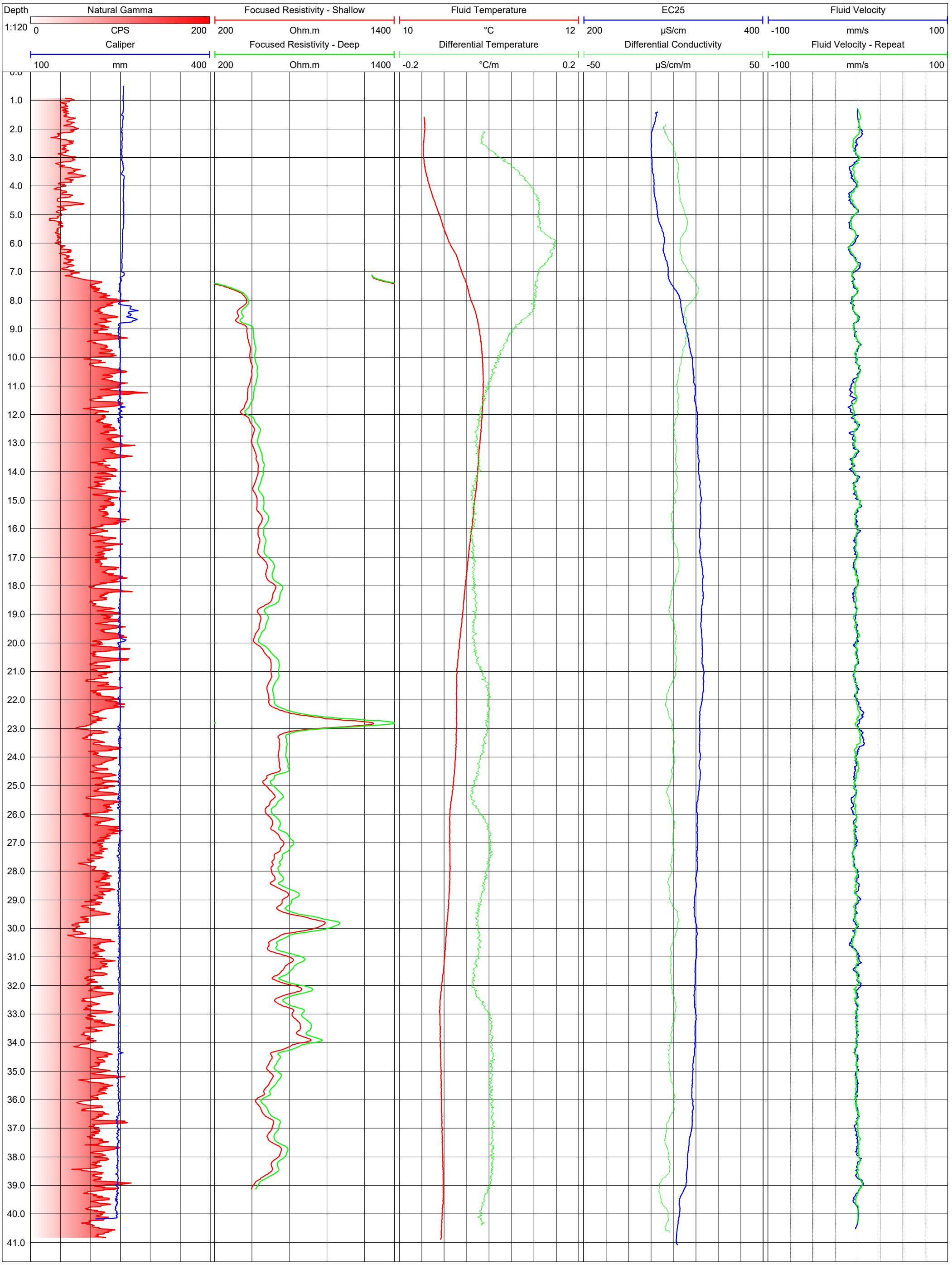
Other Comments (e.g. gas encountered, saline water intercepted, etc.)			
10mm Gravel Pack Quantity: 1,750kg	Coated Bentonite: 150kg	Temp Steel Casing: Depth and Diameter	8m x 408mm
Cement/Quik-Gel Mix: 1,950kg			
Rig & Crew:	Klemm 709, D. Morris, K. Clarke, R. Davies		

APPENDIX B
GEOPHYSICAL LOGGING

EUROPEAN GEOPHYSICAL SERVICES LTD
22 The Stables, Sansaw Business Park, Hadnall, Shrewsbury
Shropshire, SY4 4AS
T:01939 210710 F:01939 210532
E:eurogeophys@europeangeophysical.com
Web: www.europeangeophysical.com

Figure: 1. Composite Geophysical Field Log

CLIENT:	Envireau Water			DATE:	11th April 2018
SITE:	Abergele			PROJECT:	ENVW1804A
WELL id:	TBH 2018	Logging Datum:	Ground Level	ref:	TBH 2018 FIELD A3.WCL



APPENDIX C
ELECTRONIC DATA FILE