Gore Quarry Abstraction Licence Application – Pumping Test Report

5 October 2023

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Gore Quarry Abstraction Licence Application – Pumping Test Report

Prepared for

Tarmac Trading Ltd
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Report reference:

331201262R2D1, October 2023

Report status: Final

CONFIDENTIAL

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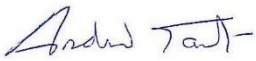
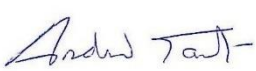
	Name	Signature
Author	Juan Rivera, Lucy Janus	
Checked by	Andrew Tait	
Reviewed by	Andrew Tait	

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Issue	Date	Status	Comment	Author	Checker	Reviewer
1	04/10/23	Draft		JFR/LJ	AWT	AWT
2	05/10/23	Final		JFR/LJ	AWT	AWT

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1 Introduction

1.1 Background

The Gore Quarry (the Site) is a gritstone quarry located immediately to the north of Burlingjobb, 200 m to the east of the village of Old Radnor in the County of Powys (see Figure 1-1).

Tarmac instructed Stantec UK Ltd (Stantec) to prepare and submit an abstraction licence application (ref: PAN-019189) to Natural Resources Wales (NRW) for the future dewatering at the Site. The planning permission allows working to 164 mAOD, with the quarry base currently being at c. 242 mAOD. Up to the current working depth, Tarmac have considered that the discharged water is almost entirely surface water and have, up to now, not pursued an abstraction licence application for quarry dewatering. However, as the quarry progresses downwards, groundwater will be intercepted and thus, dewatering would require an abstraction licence. Moreover, an existing Abstraction Borehole, located at SO 25669 59311 within the Site, abstracts groundwater from the same source that will be dewatered; therefore, a full abstraction licence is required.

As part of the application process, a groundwater investigation consent (ref: PAN-019333, see Appendix A) was issued by NRW, which required a constant rate pumping test of the Abstraction Borehole to assess the hydraulic characteristics of the aquifer at the Site.

1.2 Water requirements

Whilst the majority of dewatering water will not be used, only transferred, groundwater from the Abstraction Borehole will be used for operational purposes (which include wheel washing and dust suppression). The requested abstraction volumes are summarised in Table 1.1.

Table 1.1 Proposed water requirements

Type	Maximum (m^3/year)	Maximum (m^3/day)	Maximum (m^3/hour)
Abstraction	19,244[1]	100[2]	12.5[3]

[1] – 2020 total.

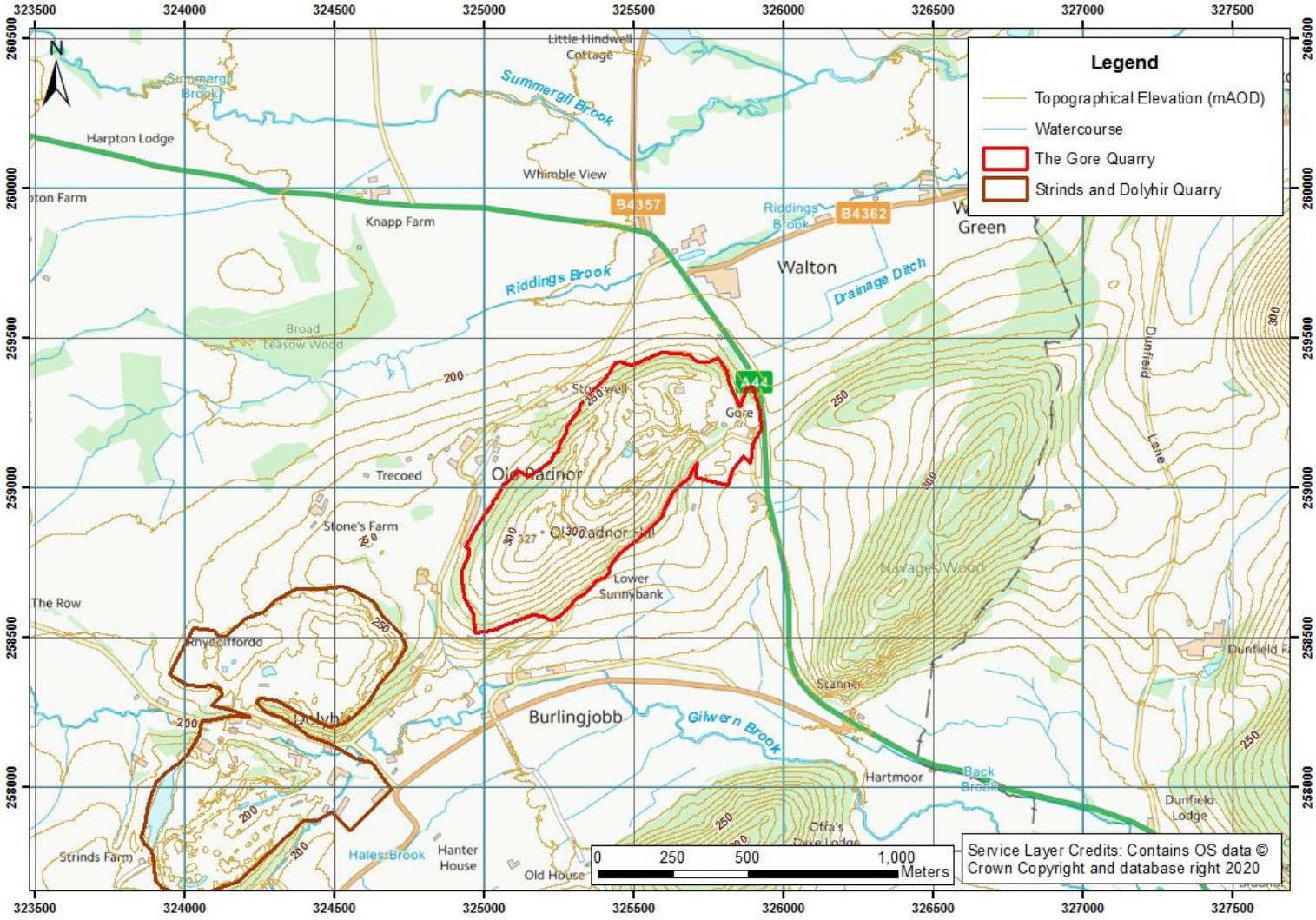
[2] – Typical daily requirement.

[3] – Based on 8 hours of abstraction per day.

1.3 Objectives and scope

The objective is to investigate the hydraulic characteristics of the aquifer at the Site through a pumping test at the Abstraction Borehole and to assess the quantity of groundwater available in order to confirm that the source is viable and sustainable. Similarly, the effects of the abstraction on surrounding water dependant features and other users are assessed.

Figure 1-1 Location map



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Report Status: Final

2 Baseline conditions

2.1 Site details

The Gore Quarry is located immediately to the north of the hamlet of Burlingjobb and 200 m to the east of the village of Old Radnor in the County of Powys (Figure 1-1). The Site covers an area of approximately 36 hectares and is 300 m northeast of Dolyhir & Strinds Quarry, also operated by Tarmac. The surrounding land is of predominantly agricultural land use.

2.2 Geology

The quarry works predominantly Precambrian "gritstone" (of the Strinds Formation), which is a very high-quality product used for road surfaces. The geology is summarised in Table 2.1 with the bedrock geology and superficial deposits shown in Figure 2-1 and Figure 2-2 respectively.

The metamorphosed Precambrian strata consists of micaceous sandstone (Strinds Formation) with interbedded siltstones, mudstones and sandstones (Yat Wood Formation). The Dolyhir Limestone Formation, lying unconformably on the Precambrian strata, is present off site to the northwest and southeast, and undifferentiated Silurian rocks are found to the east.

Figure 2-2 shows superficial deposits are absent below, and within 50 m of, the Site. However, Glacial Till deposits are found to the north, and alluvium and glaciofluvial deposits are present to the south.

Table 2.1 Regional geology

Age	Formation	Lithological Description	Regional Thickness (m)	Local Thickness (m)
Quaternary	Glacial till	Mixture of clay, sand, gravel and boulders	0 - 15	10 – 15
Silurian	Silurian rocks - Wenlock and Ludlow Strata undifferentiated	Grey/brown mudstone, siltstone and sandstone	< 50	< 14
	Dolyhir Limestone Formation	Grey massive shelly limestone	20 - 30	5 - 45
Precambrian	Strinds Formation	Green/grey micaceous sandstone	> 150	-
	Yat Wood Formation	Siltstone, mudstone and sandstone	-	-

Figure 2-1 Bedrock Geology

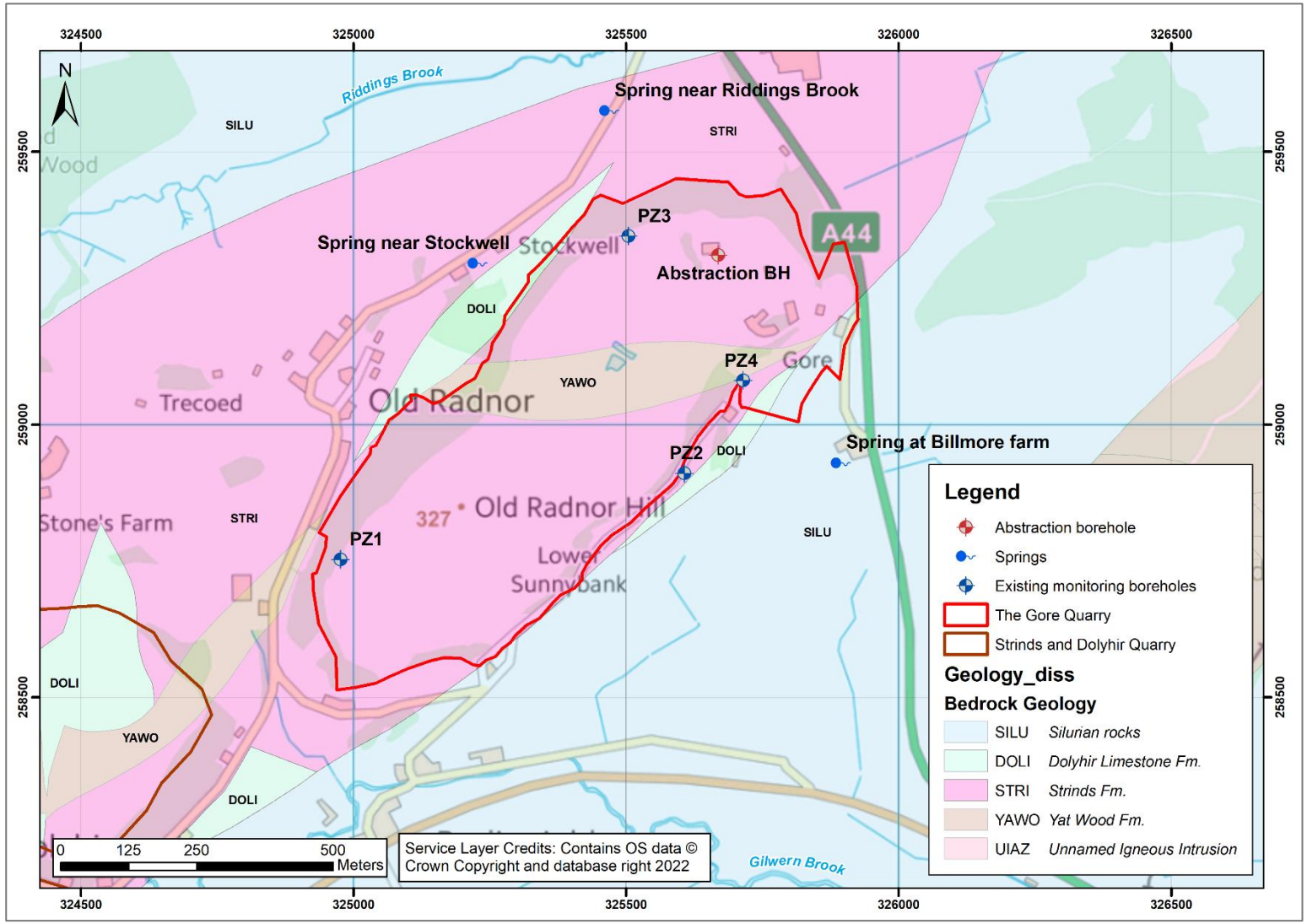
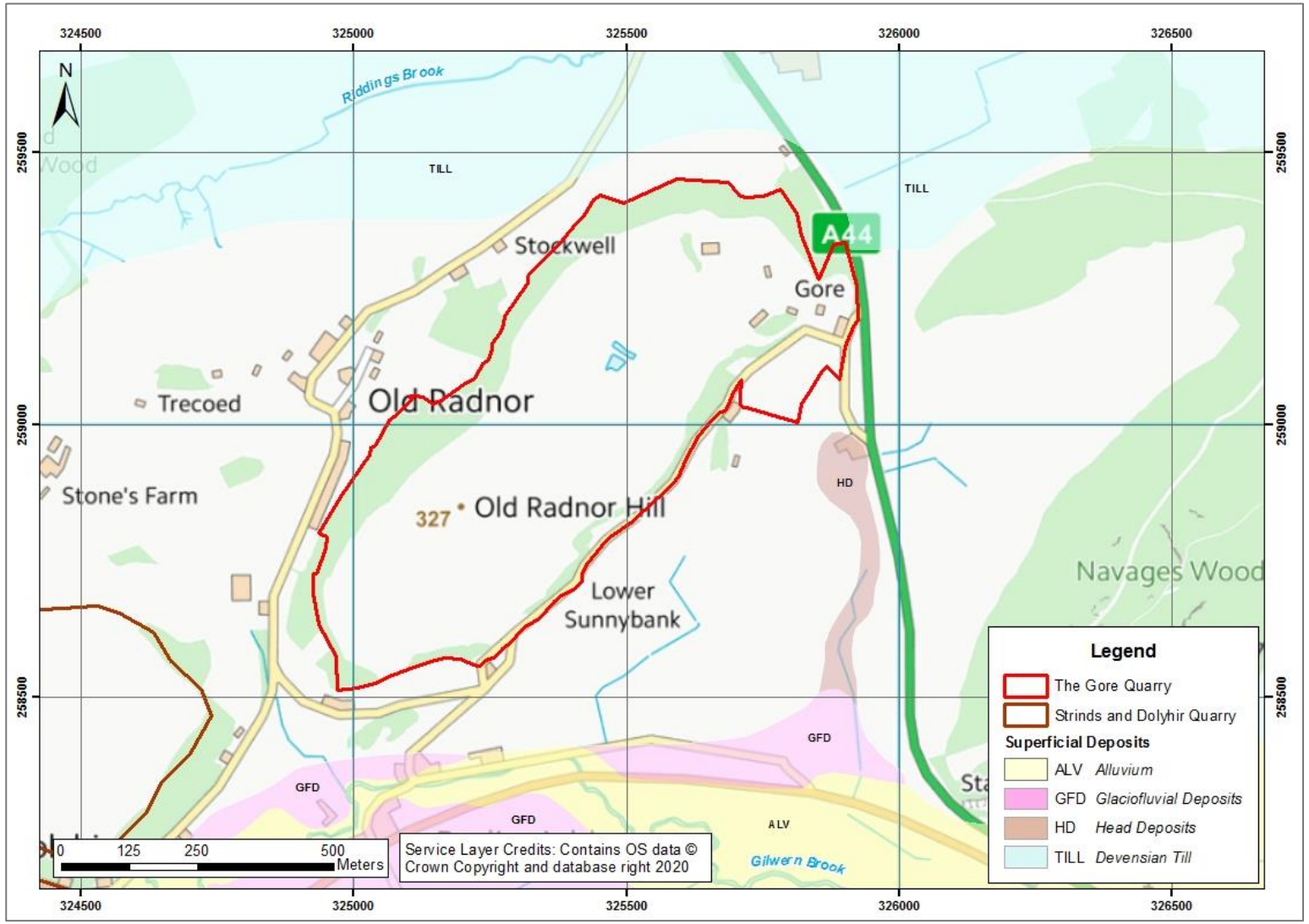


Figure 2-2 Superficial deposits



2.3 Surface water features

The quarry is excavated into the Old Radnor Hill; this hill drains in all directions away from the Site, while the quarry drains to the northeast towards the quarry discharge permit location. These water features are shown in Figure 2-3.The maximum height of the hill was c. 330 mAOD prior to quarrying with the floor level currently at c. 242 mAOD.

Surface water to the north is captured by the Riddings Brook, located about 245 m to the north of the Site (at an elevation of c. 185-195 mAOD) and flowing from west to east. It joins the Hindwell Brook about 3 km to the northeast which subsequently joins the River Lugg about 10 km to the northeast. A drainage ditch commencing in fields immediately to the northeast of the Site reaches the Riddings Brook about 800 m to the northeast.

For the pumping test, NRW requested for three potential springs to be monitored. A summary of these locations is given in Table 2.2, and the location of the springs and watercourses are shown on Figure 2-3.

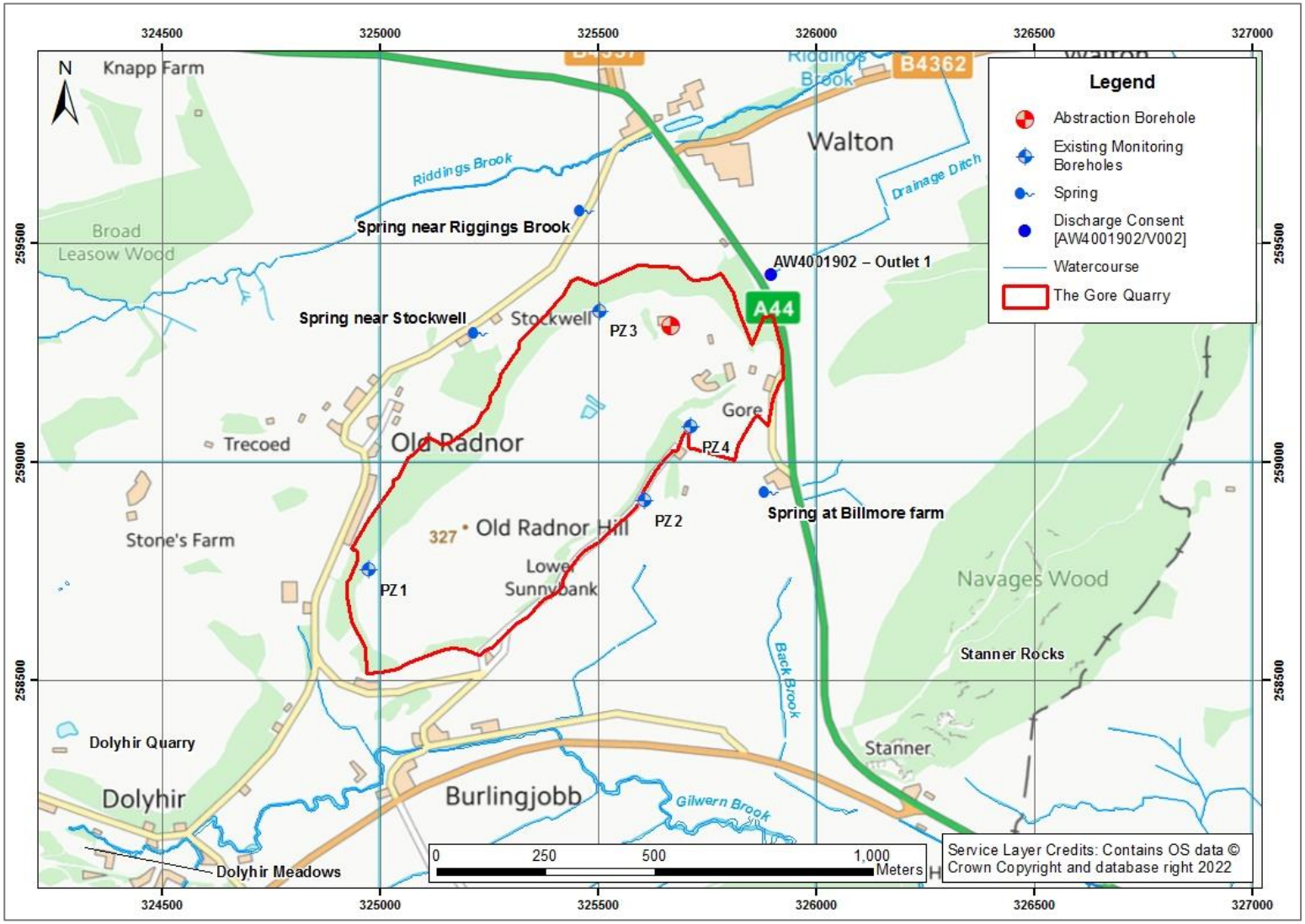
Two springs are located to the north of the Site: a spring near Riddings Brook and a spring near Stockwell, at elevations of 193 mAOD and 229 mAOD, respectively. The third is at Billmore Farm, located to the south of the Site, at an approximate elevation of 210 mAOD

Before, during and after the pumping test (dates between 25 August 2023 and 04 September 2023) wet ground, but no flow, was observed. Vegetation was present at the spring at Billmore Farm and the spring near Stockwell; however, at the spring near Riddings Brook dry vegetation was observed. Additionally, Ordnance Survey mapping does not show the development of a stream from these springs. It should be noted that the Spring at Billmore Farm could not be accessed close up for observations prior to and after the pumping test. Photographs of the springs that could be accessed are shown in Appendix B.

Table 2.2 Springs locations

Name	East	North	Approximate surface elevation (mAOD)
Spring at Billmore Farm	325894	258930	210
Spring near Riddings Brook	325469	259576	193
Spring near Stockwell	325228	259296	229

Figure 2-3 Surface water features and boreholes



2.4 Hydrogeology

The Strinds Formation, Yat Wood Formation and Dolyhir Limestone Formation are classified by the British Geological Survey (BGS) as Secondary B bedrock aquifers. Secondary B aquifers are predominantly lower permeability strata which may have the ability to store and yield limited amounts of groundwater by virtue of localised features such as fractures and weathering.

Superficial Deposits are absent around the Site, and Glacial Till is only found to the north. Due to its location on the crown of a hill, recharge at the Site is expected to be directly from rainfall infiltration on the rocks with higher theoretical hydraulic conductivities (i.e., sandstone and limestone).

The metamorphosed Precambrian strata consists of micaceous sandstone (Strinds Formation) with interbedded siltstones, mudstones and sandstones (Yat Wood Formation). The Dolyhir Limestone Formation is found to the northwest and southeast of the Site and is believed to have a low hydraulic conductivity; however, this formation has a limited lateral extent.

Silurian rocks are found to the southeast. The presence of springs to the south of the Site suggests a degree of hydraulic connection between the Precambrian rocks (Strinds and Yat Wood Formations) and the Silurian rocks.

The low hydraulic conductivity of the Glacial Till to the north indicates that the hydraulic connection between the aquifer and Riddings Brook to the north is likely to be limited.

3 Pumping test details

3.1 Technical characteristics

The Abstraction Borehole is a vertical well used for operational purposes which include wheel washing and dust suppression. It is located at SO 25669 59311 within the Site.

The Abstraction Borehole has a diameter of 0.80 m, its base is 11.54 m below the reference point (mbrp) at the top of the casing, and the stickup of the casing is c. 0.6 m above ground level. The average groundwater level monitored during four days before the pumping test is 10.18 m below the reference point, which results in an available drawdown of 1.36 m.

Construction details of the Abstraction Borehole are not available; however, it is understood the borehole is open hole.

The submersible pump is installed in the Abstraction Borehole and has a 2" PVC rising main that connects the borehole to storage tanks from where the water is taken for use.

3.2 Pumping test schedule

The pump test key dates are summarised in Table 3.1 below.

Table 3.1 Pump test key dates

Event	Date
Commencement of baseline monitoring	Friday 25th August (AM)
Pump calibration (20 to 40 minute duration)	Friday 25th August (PM)
Start of constant rate test (CRT)	Tuesday 29th August (10:35 am)
End of CRT and start of recovery	Friday 1st September (13:00 pm)
Completion of recovery / post-test monitoring	Monday 4th September (AM)

3.3 Monitoring requirements

The following monitoring requirements were set out in the groundwater investigation consent:

- Rate of pumping – to be maintained at a maximum of 100 m^3/d (c. 1.16 l/s) for a minimum duration of 48 hours;
- The duration of the test should be until water levels have stabilised in the Abstraction Borehole. Testing should be for a minimum duration of 48 hours and a maximum of 96 hours.
- The pumped water should be disposed of in such a way as to prevent re - circulation back to the aquifer.

- Water features identified during the water feature survey should be monitored throughout the pumping test. These monitoring boreholes and springs are listed in Table 3.2.

Borehole logs and installation details are not available; however, it is understood that the Abstraction Borehole and monitoring boreholes are screened in the Strinds Formation, with the response zone being across the bottom 12 m of the monitoring boreholes.

Monitoring of the static water levels commenced 4 days before the CRT. Dynamic water level monitoring continued during the CRT and after pumping stopped, to allow affected monitoring locations to recover and obtain the water level recovery data.

Other key details of the monitoring are summarised below:

- Data loggers reading groundwater levels every 10 minutes were placed in PZ2b, PZ3 and PZ4 from the pre-test period onwards. The data logger in the Abstraction Borehole recorded groundwater levels every 30 seconds prior to and after the test and every 15 seconds throughout the CRT. Regular manual dip readings were also taken at all monitoring wells.
- Barometric pressure was measured and used to correct the water level measurements as the data loggers were of the non-vented type. The top of the piezometer tubes and borehole cover at the Abstraction Borehole was used as the reference point for all water level measurements.
- Flow rates were recorded using a cumulative calibrated flow meter. The calibration certificate is presented in Appendix C.
- Observations of the springs off site were conducted prior to, during and after the constant rate test.
- All monitoring was carried out according to the relevant British Standard (BS14686:2003).

3.4 Pumping test discharge

Groundwater pumped from the Abstraction Borehole was diverted to storage tanks on the Site. There are three storage tanks, one with a capacity of 100,000 L and two tanks with capacities of 54,000 L.

Table 3.2 Key monitoring requirements

Location	Easting (m)	Northing (m)	Elevation (mAOD)	Type	Distance to Abstraction Borehole (m)	Depth to Bottom of Borehole (mbrp)	Measurement	Type of measurement	Lithology expected
Abstraction BH	325669	259311	241.4	Borehole	-	11.54	Groundwater level and flow rate	Data logger / dips, flow meter	Strinds Fm.
PZ2a	325607	258911	249.9	Borehole	404.8	28.2	Groundwater level	Dips	Strinds Fm.
PZ2b				Borehole		35.9	Groundwater level	Data logger / dips	Strinds Fm.
PZ3	325504	259346	260.7	Borehole	168.7	77.3	Groundwater level	Data logger / dips	Strinds Fm.
PZ4	325715	259081	244.0	Borehole	234.6	54.4	Groundwater level	Data logger / dips	Strinds Fm.
Spring near Stockwell	325228	259296	229	Spring	441.3	-	Visual changes	Observation	Strinds Fm.
Spring near Riddings Brook	325469	259576	193	Spring	331.9	-	Visual changes	Observation	Strinds Fm.
Spring at Billmore Farm	325894	258930	210	Spring	442.4	-	Visual changes	Observation	Silurian Rocks

4 Pumping test results and interpretation

4.1 Constant rate test

The CRT at the Abstraction Borehole commenced at 10:35 am on 29/08/2023 at a constant rate of 107.9 m^3/day, which then stabilized to 102.7 m^3/day. Small fluctuations in drawdown were noted during the test; however, these fluctuations do not seem to coincide with the pumping rate changes. The pumping rate did not vary by more than 3% after being stabilized at the beginning of the CRT, which is within reasonable limits for a constant rate test. The average pumping rate for the duration of the CRT was 101.7 m^3/day.

Drawdown in the Abstraction Borehole appeared to be stable and very mild for the first 90 minutes of the test, indicative of bore/casing storage depletion, and high hydraulic conductivity in the surrounding strata. The rate of drawdown increased between 90 and 900 minutes and increased further between 900 and 4465 minutes (end of the CRT). The steepening in the drawdown curve, compared to a theoretical time-drawdown, is interpreted by Freeze and Cherry (1979), and Kruseman and De Ridder (2000) as a reduced permeability boundary being reached by the cone of depression.

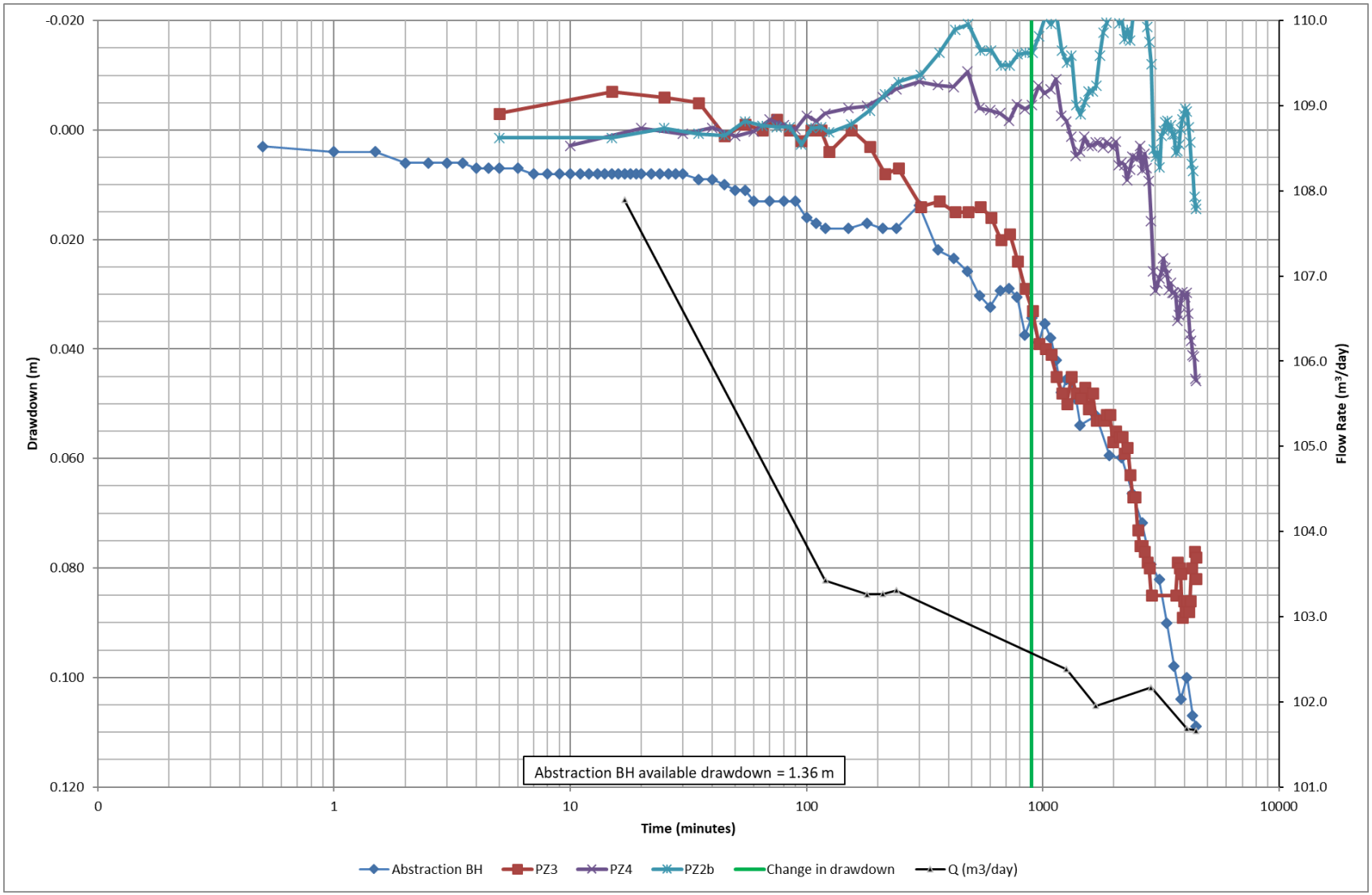
Differences in drawdown in monitoring boreholes were observed (see Figure 4-1). While PZ3 showed a similar drawdown pattern as the Abstraction Borehole, monitoring boreholes PZ2b and PZ4 showed an opposite response to pumping in the Abstraction Borehole with water level increases during the first 2885 minutes and 1260 minutes respectively. The rate of drawdown steeply increased 2820 minutes after pumping started, which was perhaps a delayed response due to the impermeable boundary interpreted at the Abstraction Borehole. Therefore, drawdown is characterized by two periods, marked by a green line in Figure 4-1.

The maximum recorded drawdown in monitoring borehole PZ3 was 0.089 m. The maximum drawdown in monitoring boreholes with a different response was less than 0.05 m, which is within the range of natural variation.

The CRT was terminated at 13:00 hours on 01/09/2023 after 74.4 hours of pumping. Drawdown in the Abstraction Borehole at the end of the CRT was 0.109 m. A semi-log plot of drawdown against time in the Abstraction Borehole and monitoring boreholes is presented in Figure 4-1. Logger data has been simplified for this figure as the high frequency of the readings compromise the legibility of the data plot. Data logger readings corroborated the manual readings.

Springs in the vicinity did not show an observable response and have been excluded from the drawdown plot. Photos of the springs were taken before, during and after the pumping test, and are available in Appendix B.

Figure 4-1 Constant rate test at Abstraction Borehole



4.2 Recovery test

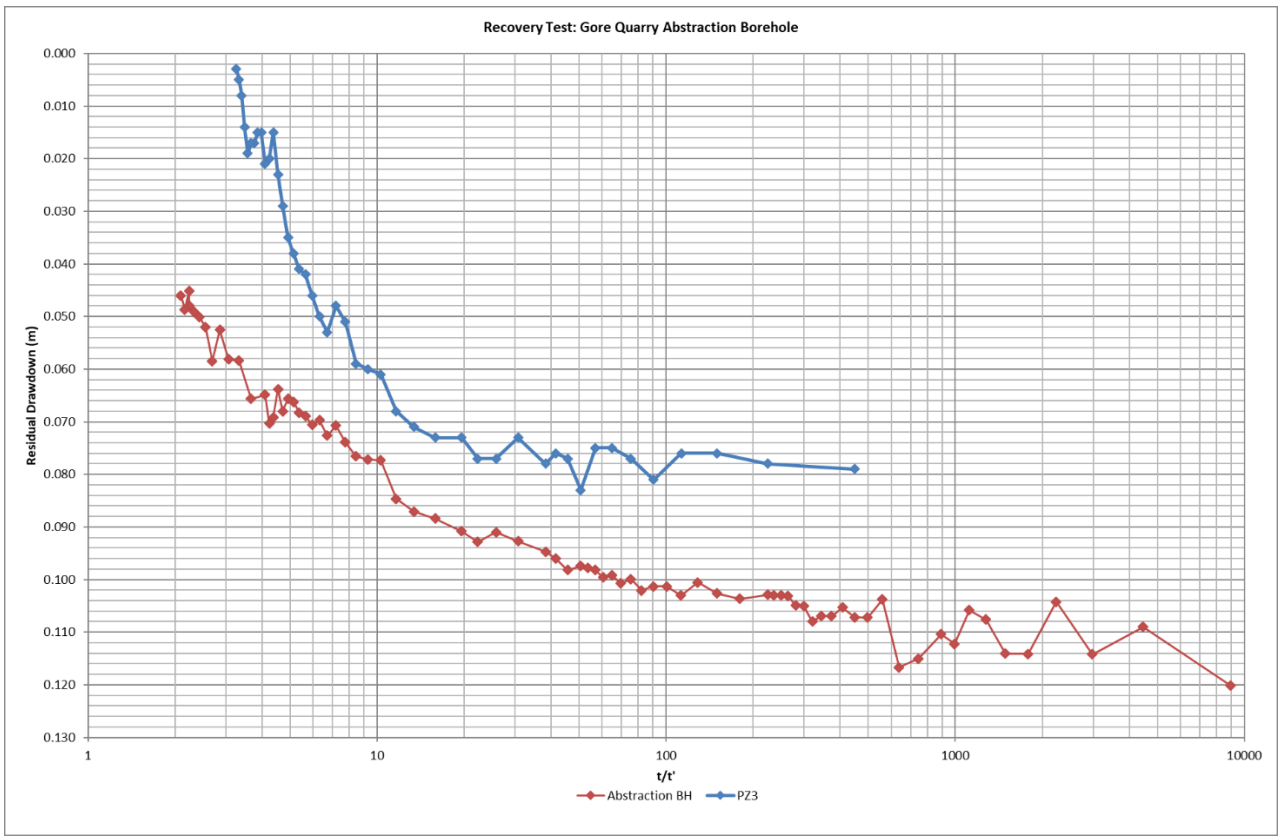
Recovery water levels were recorded in the Abstraction Borehole and monitoring boreholes for a period of 68 hours (4,080 minutes) after the cessation of pumping. The recovery data (residual drawdown versus log t/t') for the Abstraction Borehole and PZ3 is presented in Figure 4-2.

The data show the water level in the Abstraction Borehole had recovered to 58% of the original static water level within 68 hours of cessation of pumping when monitoring ceased. PZ3 was completely recovered 33 hours after pumping was stopped.

Both the Abstraction Borehole and PZ3 show a similar recovery trend, including small fluctuations. Initial recovery at the Abstraction Borehole and PZ3 was relatively slow and bouncy, approximately 2.1 cm in the initial 5 hours at the Abstraction Borehole, and 0.5 cm for the same recovery time at PZ3. The remainder of the recovery continued at a slow pace.

Similar to the CRT, the long recovery time suggests that an impermeable boundary has been intercepted and more time is required for the regional groundwater inflows to replenish the storage.

Figure 4-2 Recovery test at Abstraction Borehole



4.3 Hydraulic parameters

For the interpretation of the constant rate test and recovery test three methods were applied using the AquiferWin32 software: the Cooper-Jacob straight line method, the Theis method, and the Theis Recovery method.

Since two of the three monitoring boreholes had different responses (see Figure 4-1), the distance-drawdown method was not found suitable for interpretation.

Calculation results and graphs are shown in Appendix D. The curve deviation depicted in the semi-log time drawdown, and the log-log Theis curves, as well as the long recovery time, suggests that pumping from the Abstraction Borehole intercepted an impermeable boundary. For this reason, the hydraulic parameters were estimated for both early and late time periods. Early time values may have some influence from well losses and the surrounding geology, which could have been affected by quarry operation; however, these values will represent the maximum radius of influence. Although late time values will be influenced by the impermeable boundary interpreted to the south, these will represent the long-term impacts from pumping at the Abstraction Borehole.

A summary of characteristic hydraulic parameters derived from the pumping test are presented in Table 4.1.

4.4 Radius of influence

Drawdown at the Abstraction Borehole and monitoring boreholes has not exceeded 11 cm after 3.1 days of continuous pumping. Considering the water requirements (see Table 1.1) based on 8 hours of abstraction per day, and the location of the Abstraction Borehole at the top of a hill, this drawdown can be considered negligible. Similarly, the radius of influence is not considered to be significant.

Table 4.1 Summary of hydraulic parameters

Method	Data used	T (m^2/d)	S_y	Confidence	Results
Theis	Abstraction Borehole - Early time	6672	-	Medium	**Early time:** Geomean T: 3,689 m^2/d Geomean S_y: 0.005 **Late time:** Geomean T: 204 m^2/d Geomean S_y: 0.005
	Abstraction Borehole - Late time	146	-	High	
	PZ3 - Late time	196	0.006	T: High, S_y: Low	
	PZ4 - Late time	25	0.007	Low – different formation	
	PZ2b - Late time	0.56	0.0002	Low – different formation	
Cooper - Jacob	Abstraction Borehole - Early time	6686	-	Medium	
	Abstraction Borehole - Late time	187	-	High	
	PZ3 – Early time	1125	0.005	T: High, S_y: Low	
	PZ3 - Late time	232	0.005	T: High, S_y: Low	
Theis Recovery	Abstraction Borehole - Early time	2175	-	High	
	Abstraction Borehole - Late time	414	-	High	
	PZ3 – Early time	6262	-	Medium	
	PZ3 - Late time	141	-	High	

5 Discussion and Conclusions

The pumping test performed at the Abstraction Borehole shows a maximum drawdown of 0.109 m, while the maximum recorded drawdown in monitoring borehole PZ3 was 0.089 m. The data recorded at the Abstraction Borehole and PZ3 show a steepening in the drawdown curve in the late time data, which has been interpreted as a reduced permeability boundary being reached by the cone of depression.

Given this interpretation, hydraulic parameters were estimated for both early and late time periods. Early time values may have some influence of well losses and the surrounding geology, while late time values will be influenced by the impermeable boundary.

The analysis of drawdown on monitoring boreholes PZ2b and PZ4 during the CRT shows different response and transmissivity (T) values. Since PZ2b and PZ4 are located to the south of the Abstraction Borehole, to the south of the Yat Wood Formation outcrop (which is formed by siltstones, mudstones), and faults are not found in the area, it is interpreted that rocks from the Yat Wood Formation create the reduced permeability boundary (see Figure 2-1).

Values of T for early time data are high, with a geomean of 3,689 m^3/day. The T found for late time data, influenced by the impermeable boundary, is also high with a geomean of 204 m^3/day. The hydraulic conductivity (K) inferred from T is between 10 and 150 m/d for late time data, depending on the depth of the aquifer used (between 20 m and 1.36 m, respectively), which represents fractured or weathered rock (Kruseman and De Ridder, 2000), rather than sandstone from the Strinds Formation. K values from slug tests at monitoring boreholes PZ2, PZ3 and PZ4 (Stantec, 2022a) are generally four orders of magnitude lower than K estimates from the pumping test, suggesting that the tested section of the monitoring boreholes correspond to fresh sandstone, and that the sandstone found at the Abstraction Borehole is fractured and/or weathered.

Specific yield (S_y) values for unconfined aquifers usually range from 0.01 and 0.3 (Kruseman and De Ridder, 2000). S_y values obtained from the pumping test analyses are one order of magnitude lower, hence the low confidence assigned to these estimated values in Table 4.1. The small drawdown observed during the CRT and the small available drawdown at the Abstraction Borehole (1.36 m) could have contributed to the underestimation of the S_y.

The findings from the pumping test interpretation indicate that the Abstraction Borehole will be able to support the required pumping rate without impacting any surrounding receptor listed in Stantec (2022b). The maximum drawdown of 0.109 m at the Abstraction Borehole after 3.1 days of continuous pumping, and the measurements and observations at the other monitoring locations, indicate that drawdowns from this abstraction will have a negligible impact on the aquifer and other surrounding receptors.

REFERENCES

Freeze, R.A. and Cherry, J.A. (1979). Groundwater.

Kruseman, G.P. and De Ridder, N.A. (2000). Analysis and evaluation of pumping test data.

Stantec (2022a). The Gore Quarry: Assessment of Future Requirements Dewatering.

Stantec (2022b). Technical Note. Gore Quarry: Groundwater Investigation Consent Application.

APPENDICES

Appendix A

Groundwater Investigation Consent (ref: PAN-019333)

CONSENT TO INVESTIGATE A GROUNDWATER SOURCE

Section 32(3) Water Resources Act 1991 (as amended)

This **CONSENT** is issued by the Natural Resources Body for Wales (hereafter referred to as "Natural Resources Wales") to:

Delia Boulis of Tarmac Trading Limited ("the Consent Holder")
Ground Floor, T3 Trinity Park
Bickenhill Lane
BIRMINGHAM
B37 7ES

Company Registration Number: 00453791

This consent authorises the Consent Holder to investigate a groundwater source described in the schedule of conditions and subject to the provisions of that schedule. The consent commences from the date of signature and shall remain in force until the date of expiry shown below.

"The Consent Holder" means the person (whether an individual or organisation) to whom consent is granted. Where the Consent Holder is two or more persons (e.g. a partnership) such persons shall be jointly and severally liable for the proper fulfilment of the conditions of this consent.

This consent is effective from the date below and **expires on 30 September 2023**

Issued by: Trystan James – Technical Team Leader (Geoscience)
Date 8th November 2022

SCHEDULE OF CONDITIONS

1 Location

1.1 Underground strata comprising of Strinds Formation (Pre-Cambrian) at National Grid Reference SO 25669 59311.

2 Construction details

2.1 A borehole not exceeding 10.93 metres in depth and 800 millimetres in diameter installed into underground strata as specified in condition 1.1

2.2 Boreholes and wells must be provided with a means of measurement access (such as a dip tube) so that a cable dipper or automatic water level recorder can be lowered to measure the water level.

3 Maximum Quantities of Water to be abstracted during test pump

3.1 100 cubic metres per day

Note: A day means any period of 24 consecutive hours

4 Duration of testing

4.1 The duration of test should be until water levels have stabilised in the abstraction borehole. Testing should be for a minimum duration of 48 hours and a maximum duration of 4 days (96 hours).

4.2 The Licence Holder shall notify NRW if groundwater levels in the abstraction source have not stabilised after pumping for 4 days (96 hours).

5 Water feature assessment

The pumping test should be designed to assess the effect of this abstraction on the following water features and abstractions:

Piezometers on site – PZ2, PZ3 and PZ4.
Springs at Stockwell, Riggings Brook and Billmore Farm.

6 Discharge of water

6.1 The pumped water should be disposed of in such a way as to prevent re-circulation back to the aquifer.

6.2 Discharged water shall not contain any other cooling waters or process effluents unless otherwise authorized by an environmental permit or registered exemption.

7 Notifying Natural Resources Wales following expiry of consent

7.1 You must notify us within 14 days of the expiry date of this consent to advise us if you intend to apply for a groundwater abstraction licence.

ADDITIONAL INFORMATION

Modification or removal of consent
This consent may be modified or revoked at any time by Natural Resources Wales.

Indemnity
We shall not be liable to pay for any of the testing nor for any of the consequences that may arise from this consent. The Consent Holder shall be responsible for making good and compensating for any loss, damage or injury (whether to persons or property, including water resources generally or derogation from individual sources of supply) resulting from this consent.

Right of access
Possession of this consent no rights of entry onto land. Permission to enter land or premises must be obtained from the owner or occupier

Interpretation of conditions
Condition 2.1 The borehole, well or spring catchpit should be constructed as detailed in the application form WRC.

Condition 4.1: Sufficient data must be collected to enable analysis of aquifer properties and assess the long-term effects on identified water features.

Conditions 4.2 and 7 and for general queries the Consent Holder can contact:
Geoscience Team, Natural Resources Wales, Ty Cambria, 29 Newport Road, Cardiff, CF24 0TP
Tel: 0300 065 3000
Email: geoscience@cyfoethnaturiolcymru.gov.uk

Condition 5: The results of testing must be incorporated into a hydrogeological impact assessment to be submitted with any subsequent application for a groundwater abstraction licence. You must declare in this assessment if any complaints were received from nearby landowners or water uses during your test pumping. We will expect you to carry out the pumping tests and produce a groundwater impact assessment in line with relevant guidance and best practice, including:

- British Standard ISO 14686 (2003) "Hydrometric determinations – pumping tests for water wells – considerations and guidelines for design, performance and use".

- Environment Agency (2012) 'Hydrogeological Impact Appraisal for groundwater abstractions

- Scottish Environment Protection Agency (2013). Regulatory Method (WAT-RM-24) Pumping Test Methodology

Condition 6.1 If groundwater is re-circulated back into the aquifer during the pumping test it may affect the monitoring results

Condition 6.2 Under the Environmental Permitting Regulations 2016 it is an offence to undertake a groundwater activity without an environmental permit, or having registered an exemption.

Condition 7.1 This consent provides an exemption allowing you to test the borehole under Section 32 of the Water Resources Act. After the consent expires you must not abstract more than 20m^3 per day until you obtain an abstraction licence.

Appendix B

Spring photos

Spring near Stockwell before pumping test – 25th August 2023

Spring near Stockwell during pumping test – 31st August 2023

Spring near Riddings Brook location before pumping test – 25th August 2023

Spring near Riddings Brook location during pumping test – 31st August 2023

Spring near Riddings Brook after pumping test – 4th September 2023

Appendix C

Calibration Certificate

Report Reference: 331201262R2D1

Report Status: Final

CALIBRATION CONTROL LTD
INSTALLATION, CALIBRATION & REPAIR OF PROCESS CONTROL EQT

Water & Admixture Calibration Report

Revision 1.28 03/01/2019.

11 Speechly Drive, Rugeley
Staffordshire, WS15 2PT
Tel: 01889 800993. Mob: 07723 361796

SHEET 1 OF 1	DATE OF VISIT 11th August 2023	No.CB / V / 08 - 14

CUSTOMER / CLIENT…**TARMAC** …….. SITE / DEPOT …**GORE QUARRY**…….

Max **1000L x 1L** **BOREHOLE** Flow meter (Count At End 50218.110 CuM)

Test Amount Measured	Actual Amount Dispensed	Error in Liters	% Error	Within 3% Tolerance (Y/N)
1000	**1004**	**+4**	**<0.5%**	**Y**

Max **800** x **1** **DISCHARGE WATER** Flow meter (Count At End 716.22 CuM)

Test Amount Measured	Actual Amount Dispensed	Error in Liters	% Error	Within 3% Tolerance (Y/N)

Was the equipment in good working condition Yes / No
Are pipes and valves working correctly Yes / No
Is display working correctly Yes / No
Does the display / counter zero after use Yes / No
Do all non-return valves and diverters work Yes / No

Was the calibration within +/- 3% allowance Yes / No
Any further action required……
……
Test Equipment Serial No CC/ W02 / PD01
Equipment Test Date…14 / 07 / 2023……..

Max 10000 x 10 **ADMIXTURE ONE** Flow meter / Weighed / Pressure

Test Amount Measured	Actual Amount Dispensed	Error in Liters	% Error	Within 5% Tolerance (Y/N)

Max x **ADMIXTURE TWO** Flow meter / Weighed / Pressure

Test Amount Measured	Actual Amount Dispensed	Error in Liters	% Error	Within 5% Tolerance (Y/N)

Max x **ADMIXTURE THREE** Flow meter / Weighed / Pressure

Test Amount Measured	Actual Amount Dispensed	Error in Liters	% Error	Within 5% Tolerance (Y/N)

Is equipment in good working order Yes / No
Are all pipes labeled correctly Yes / No
Do all non return valves work correctly Yes / No
Is sight glass clean and legible Yes / No
Is Zero/Empty point correct Yes / No
Can dosage be set accurately Yes / No

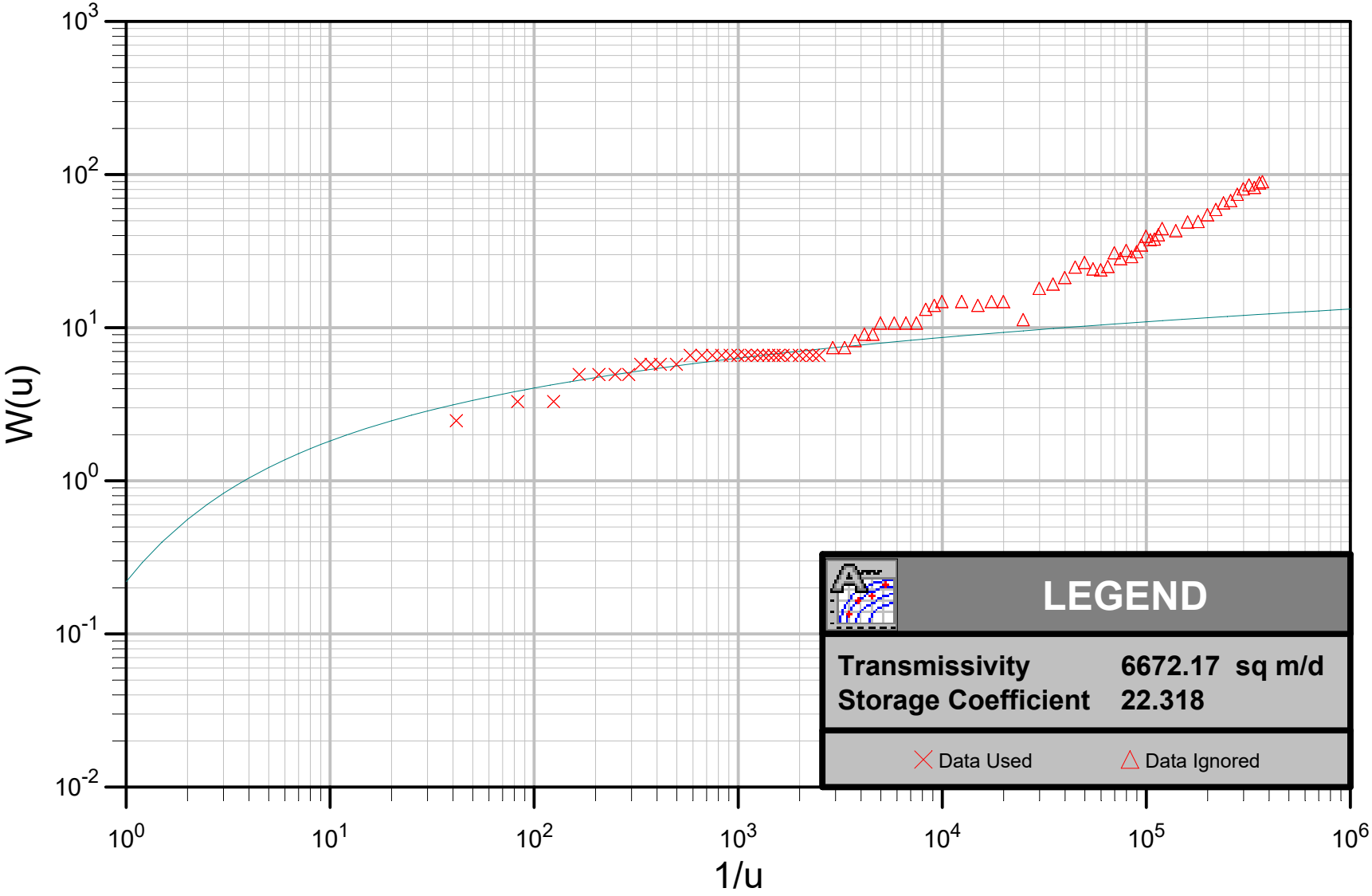
After use did the equipment return to zero Yes / No
If fitted – does water flush work Yes / No
No calibration errors due to foaming Yes / No
Calibration was within +/- 5% Yes / No
If fitted, does “No Flow” system work Yes / No
Any remedial / further action required……
Test equipment serial number CC/ AM 01 02 03 /

Signature of Engineer…COLIN BOYLE……..

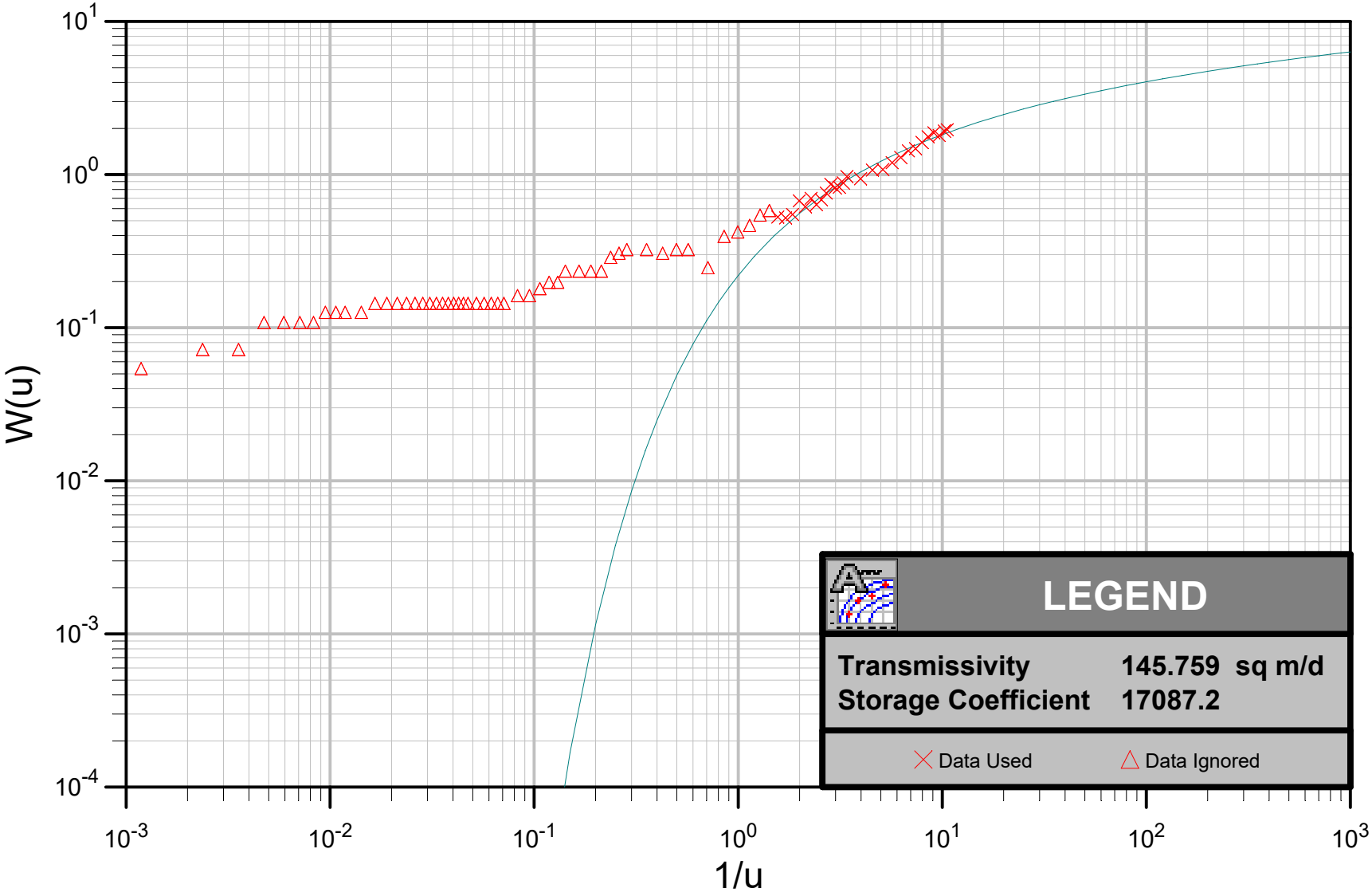
Signature of Plant Supervisor…NEIL CARTER ……

Appendix D
Calculation Results

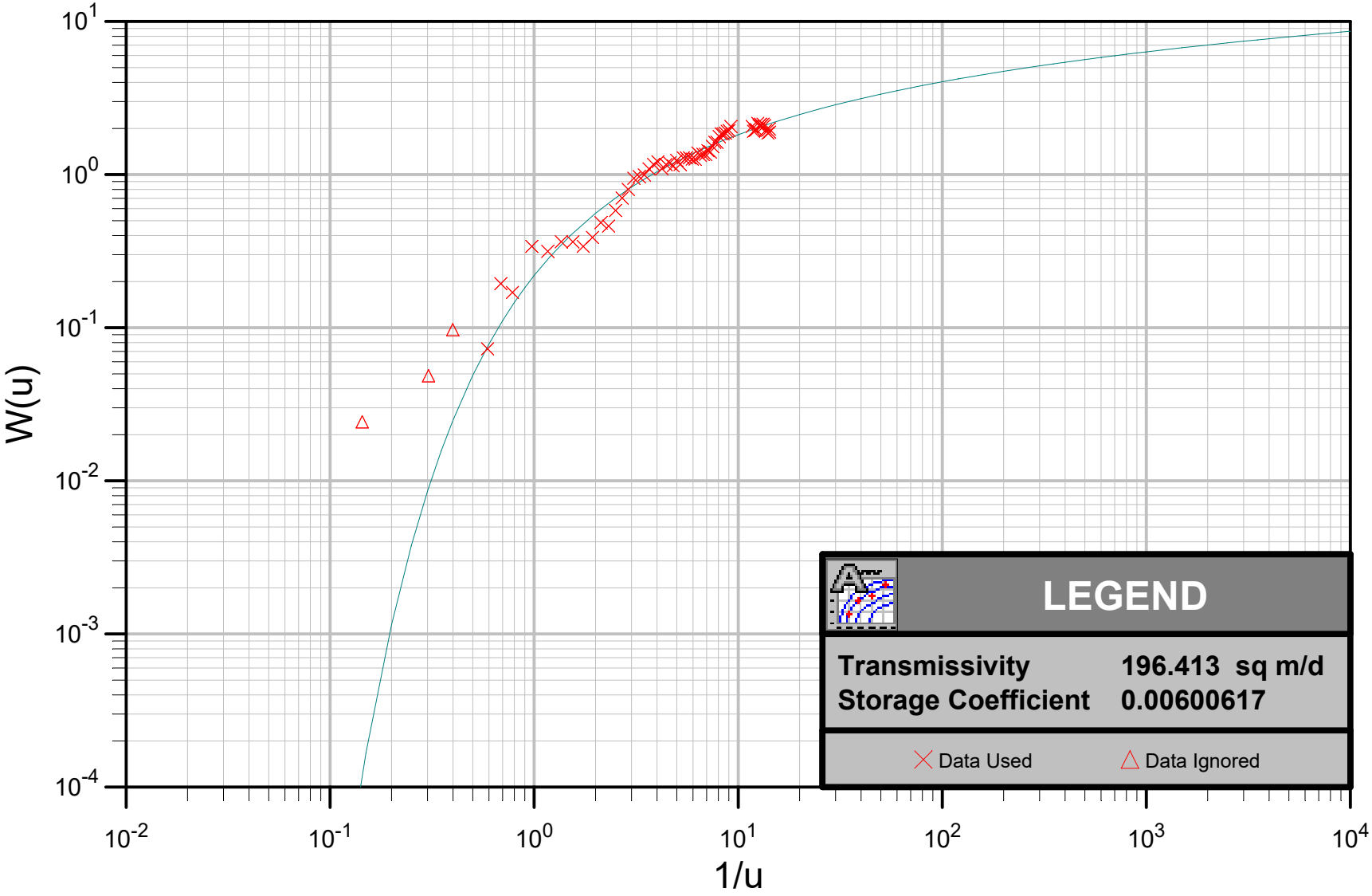
Theis Analysis - Abstraction BH Early Time



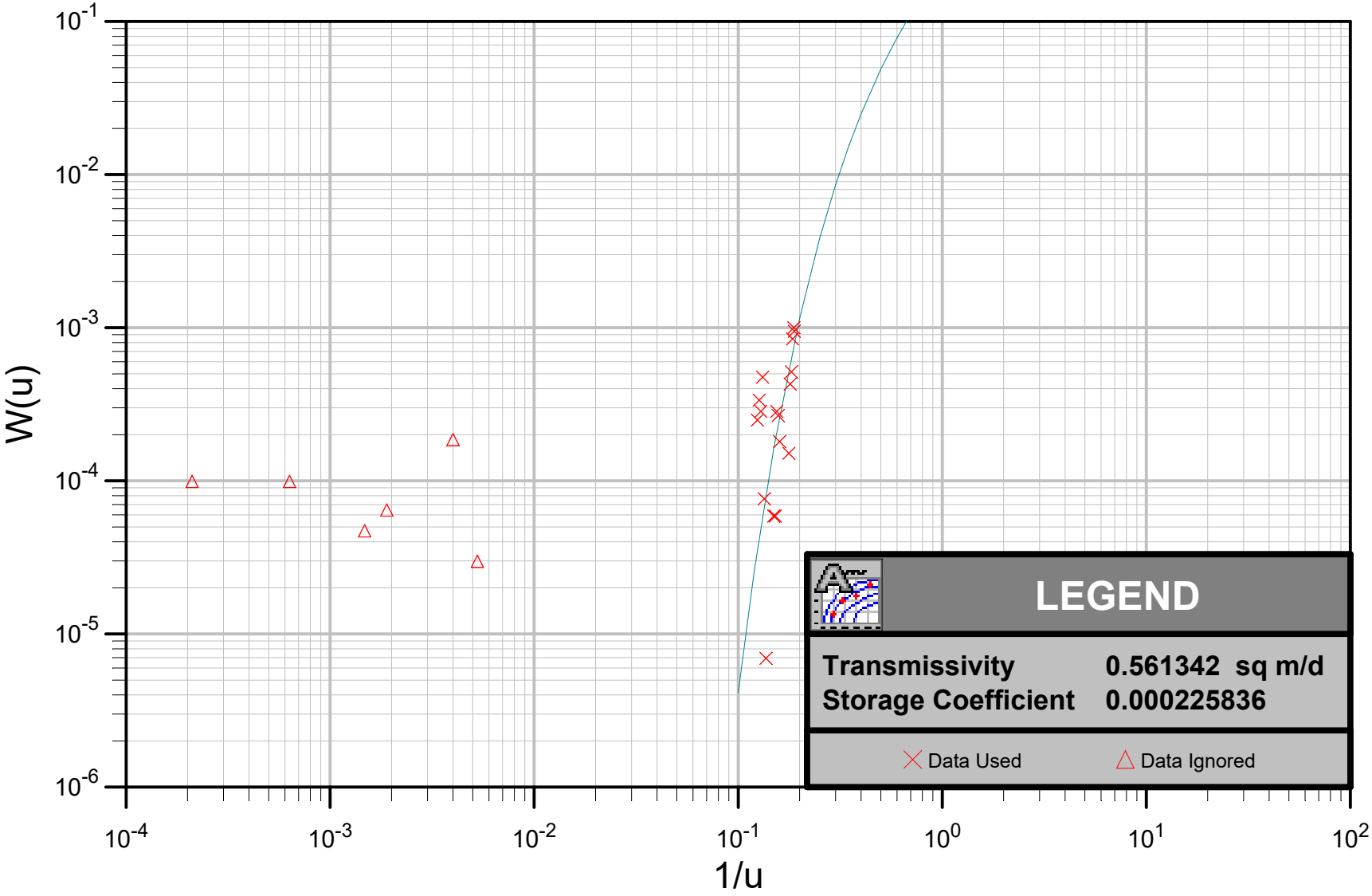
Theis Analysis - Abstraction BH Late Time



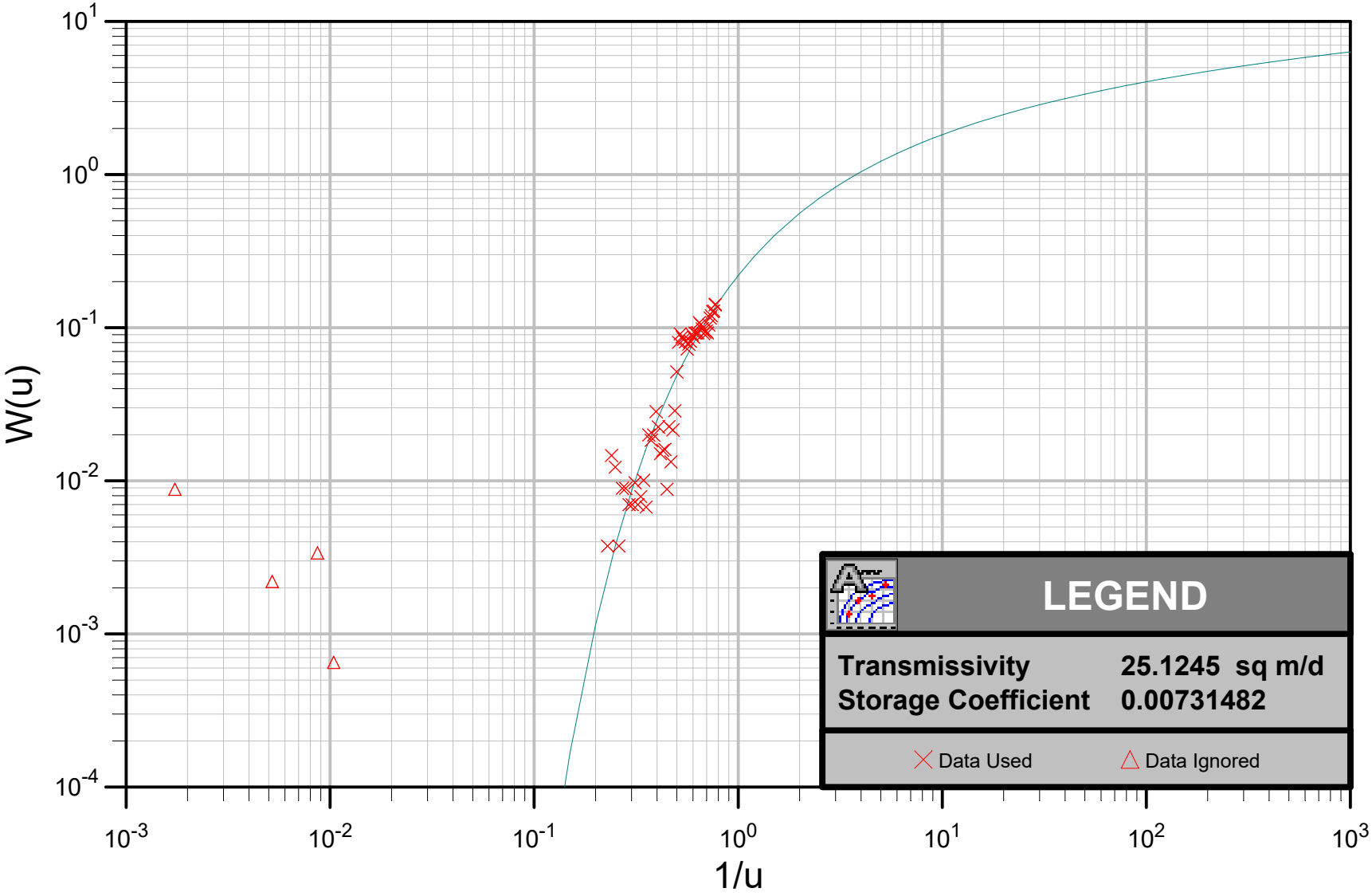
Theis Analysis - PZ3



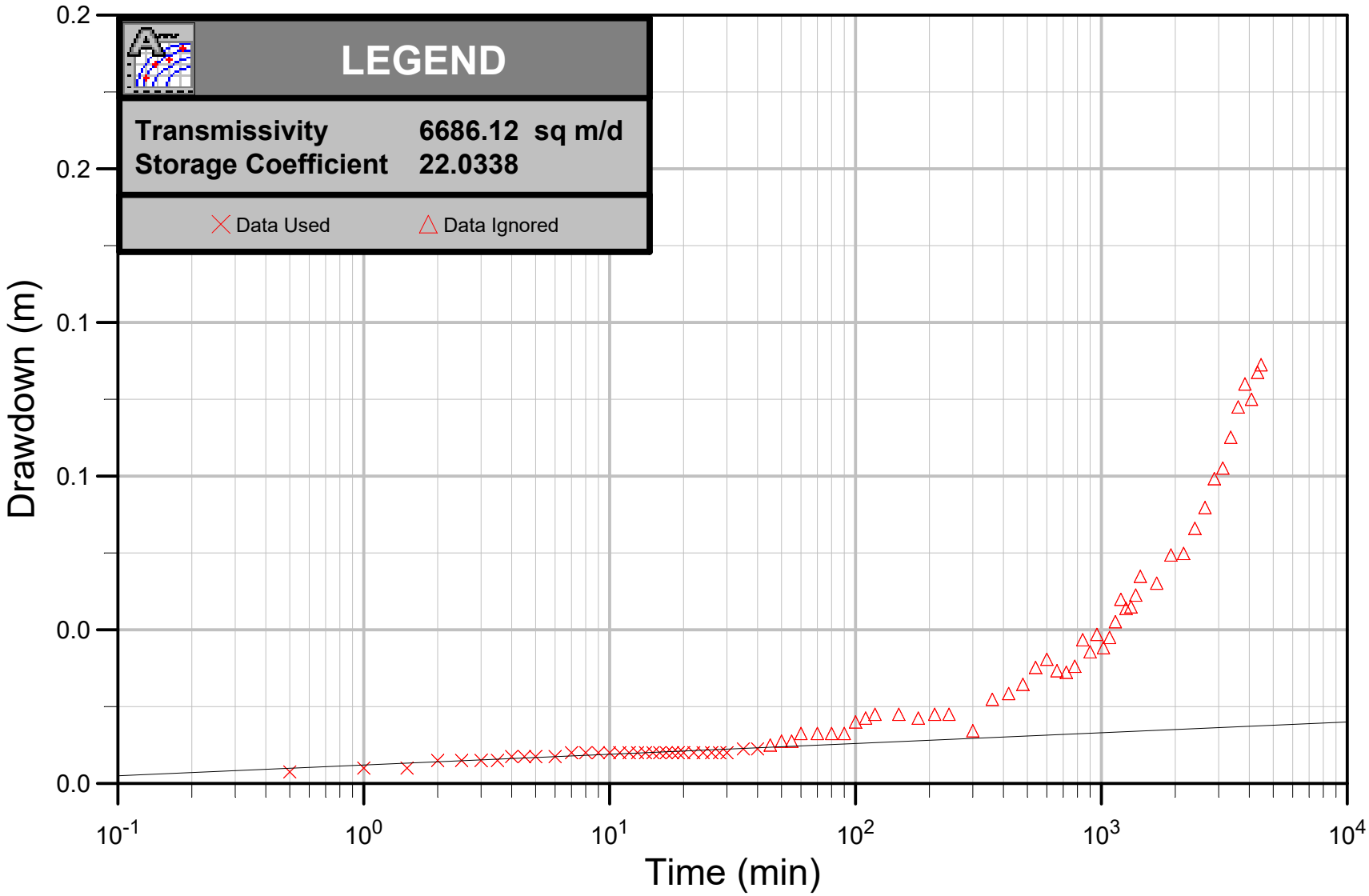
Theis Analysis - PZ2b



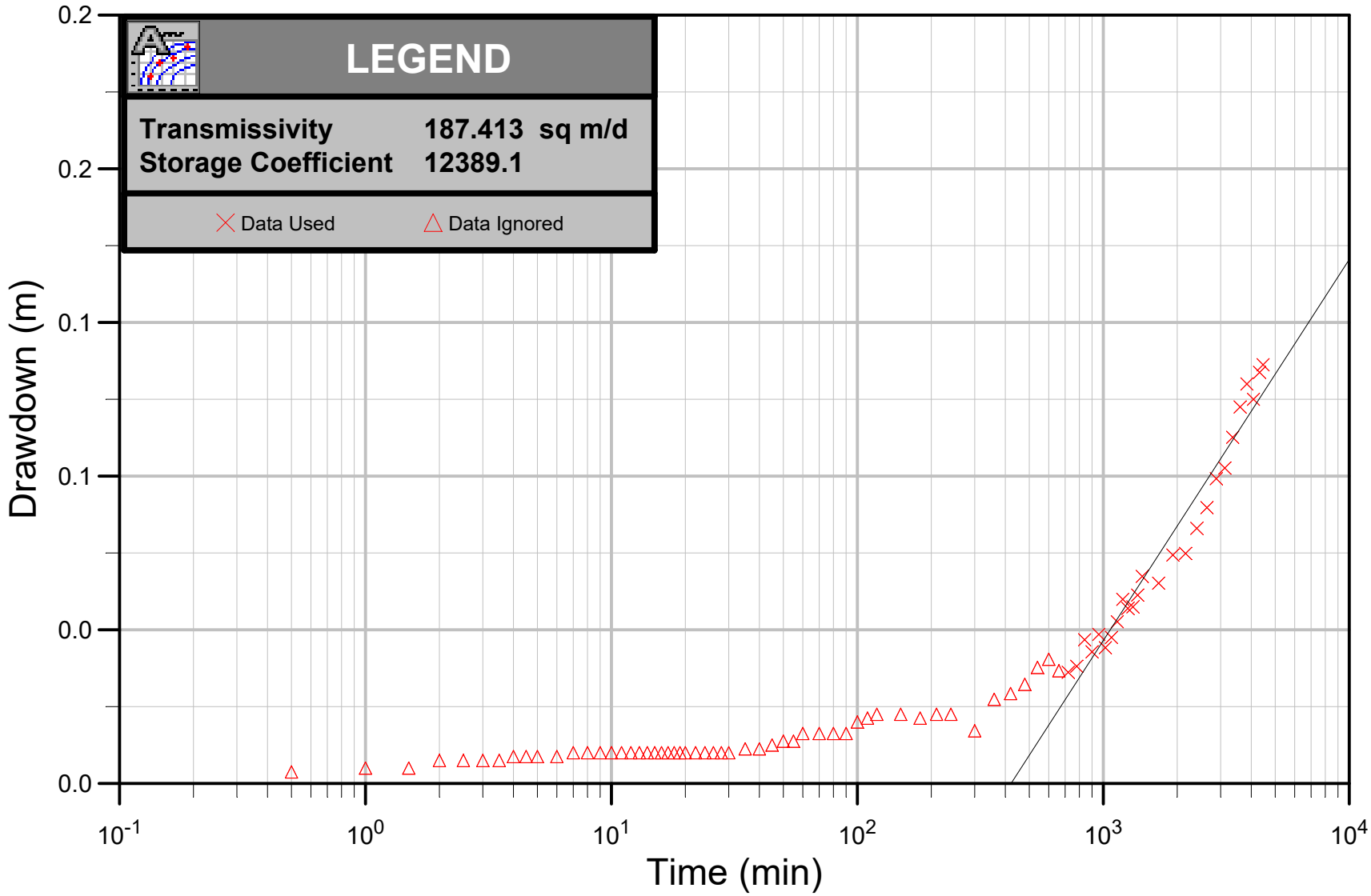
Theis Analysis - PZ4



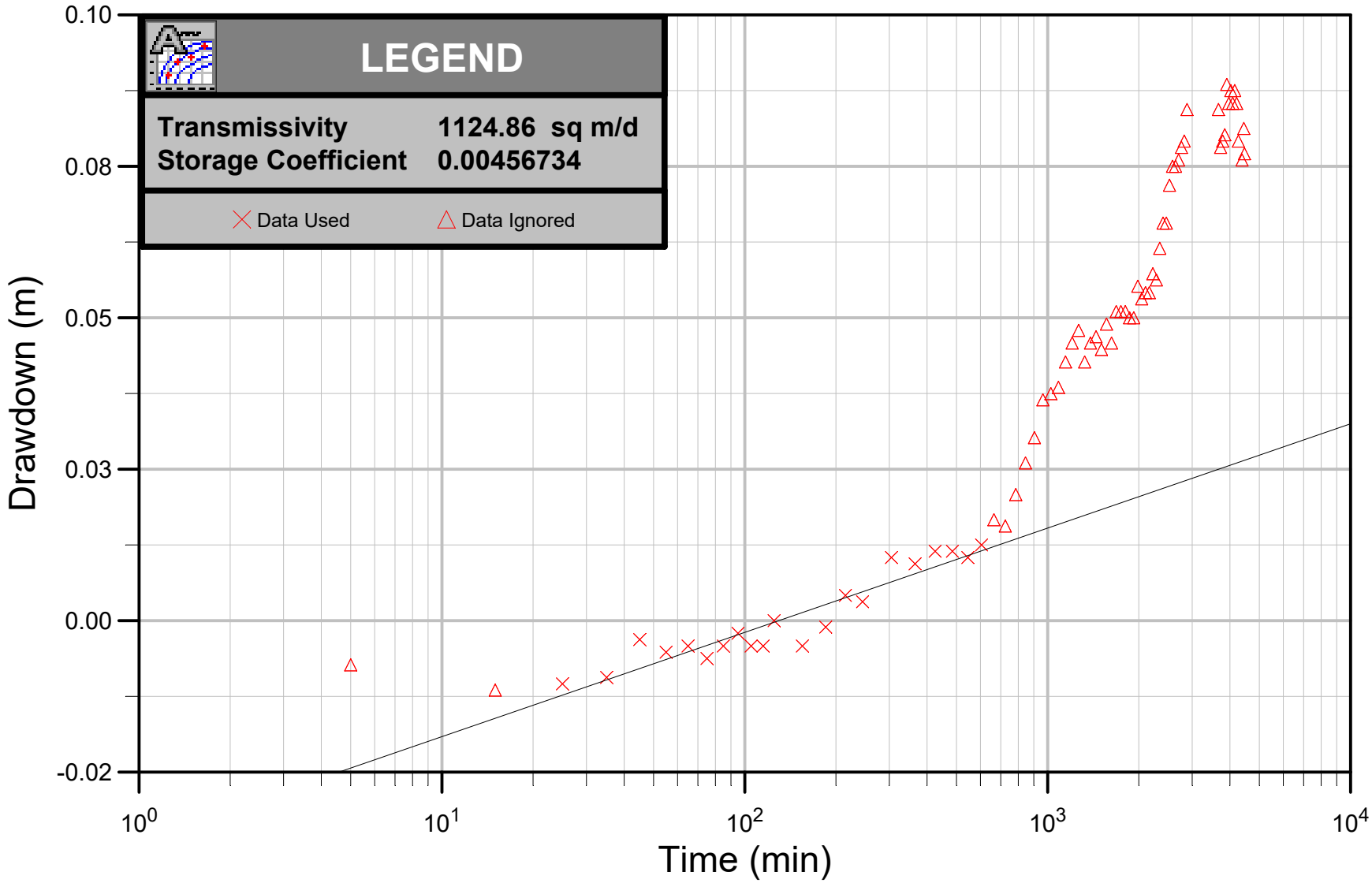
Cooper and Jacob Analysis - Abstraction BH Early Time



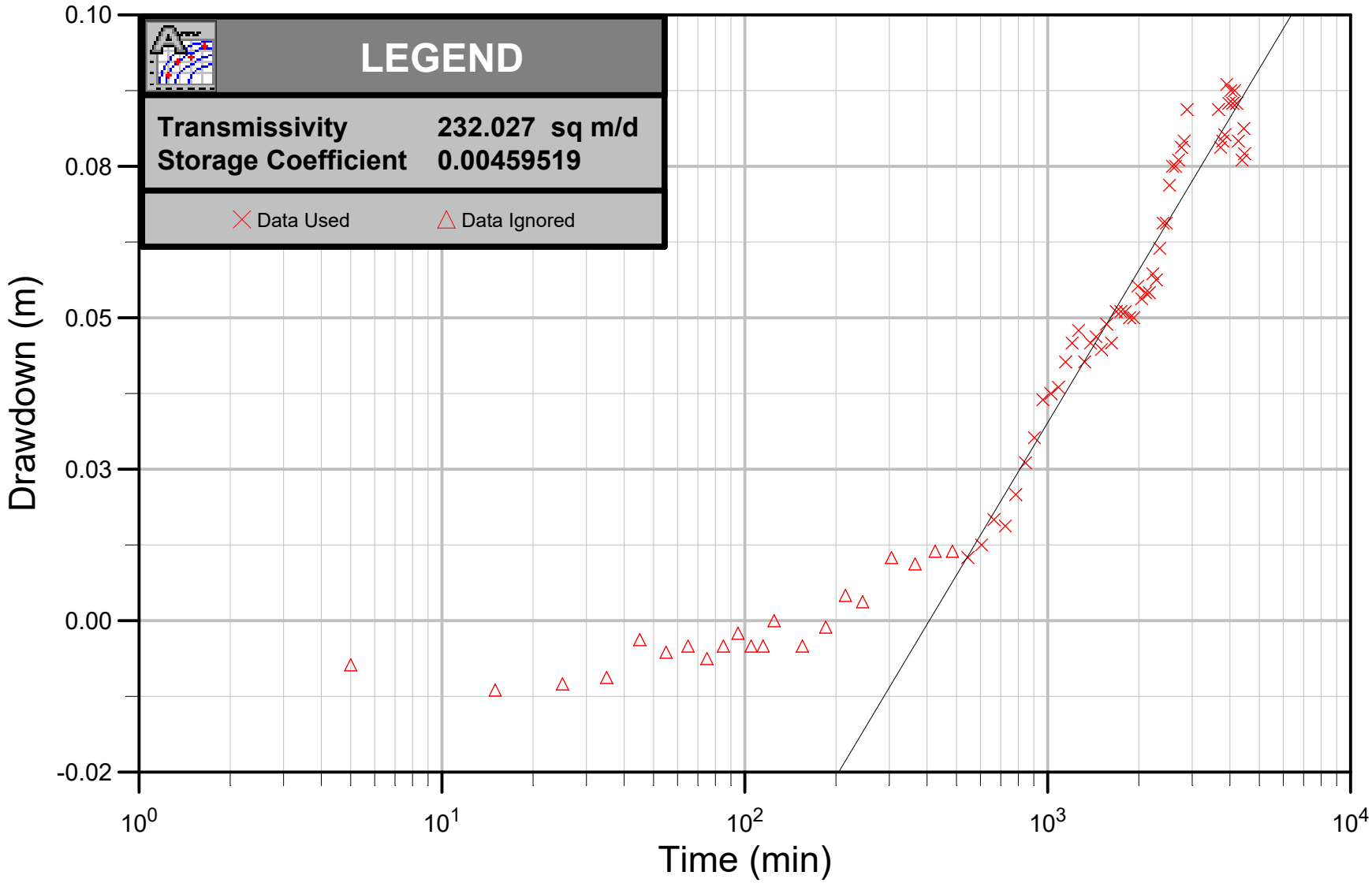
Cooper and Jacob Analysis - Abstraction BH Late Time



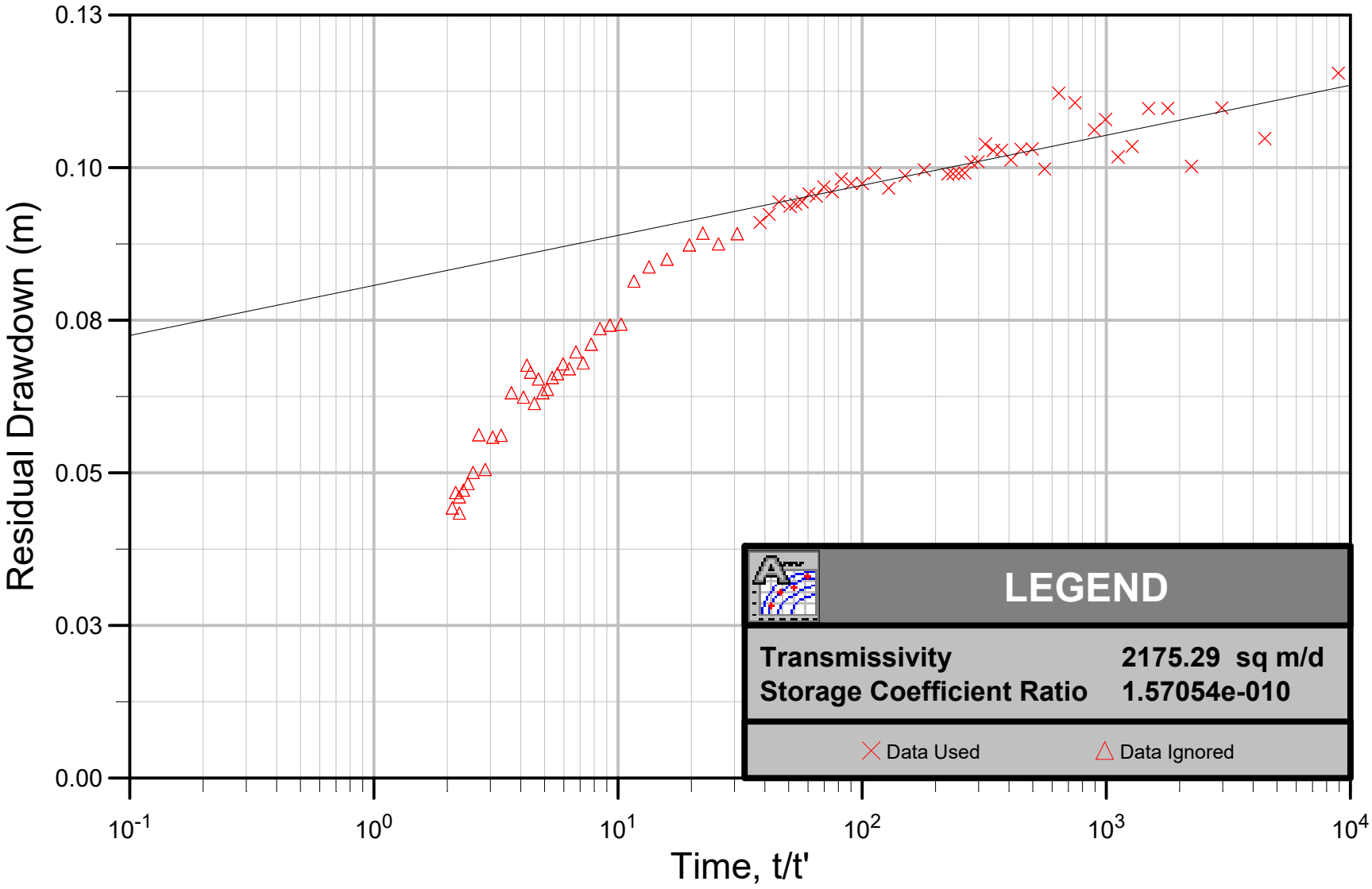
Cooper and Jacob Analysis - PZ3 Early Time



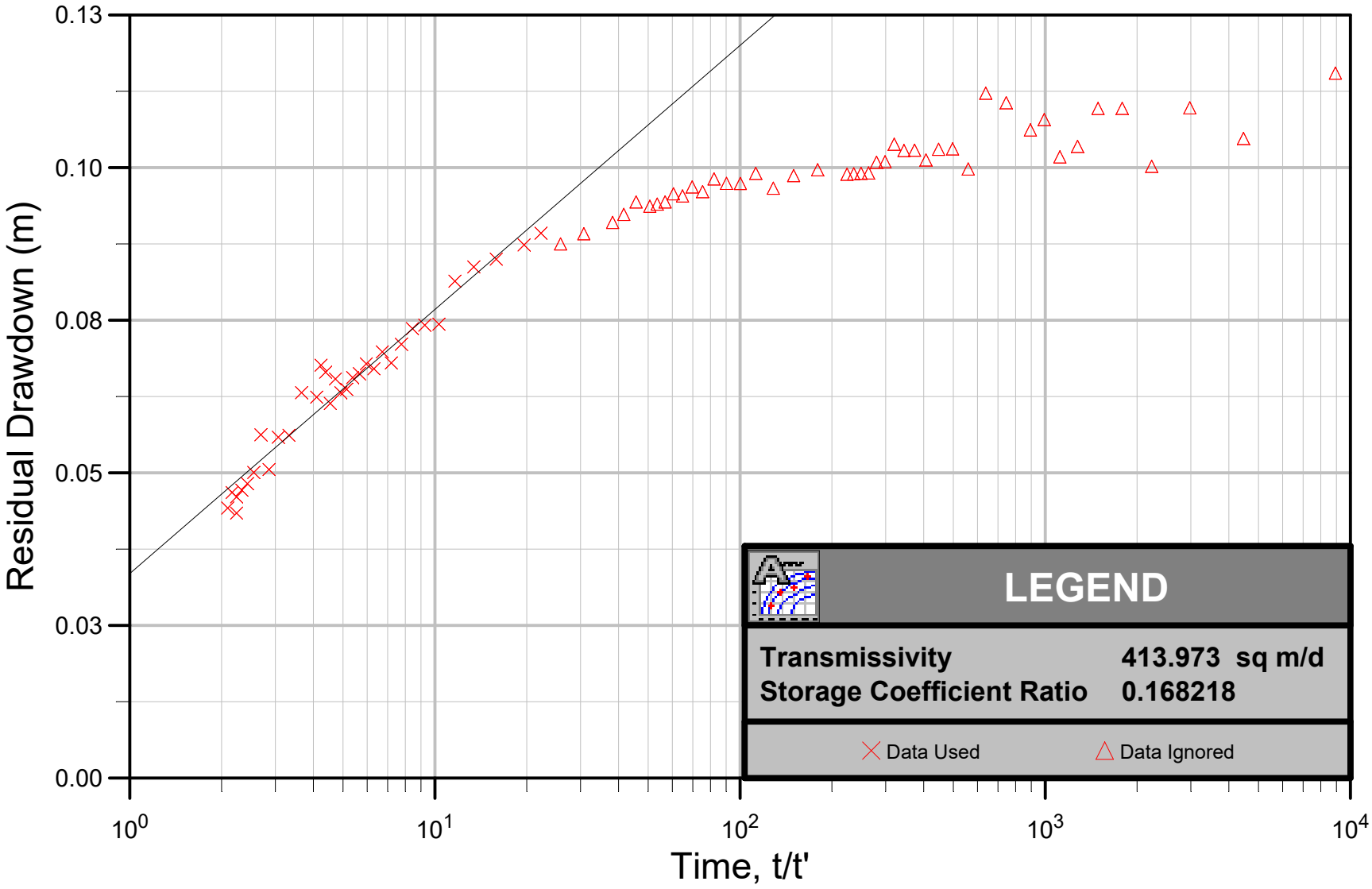
Cooper and Jacob Analysis - PZ3 Late Time



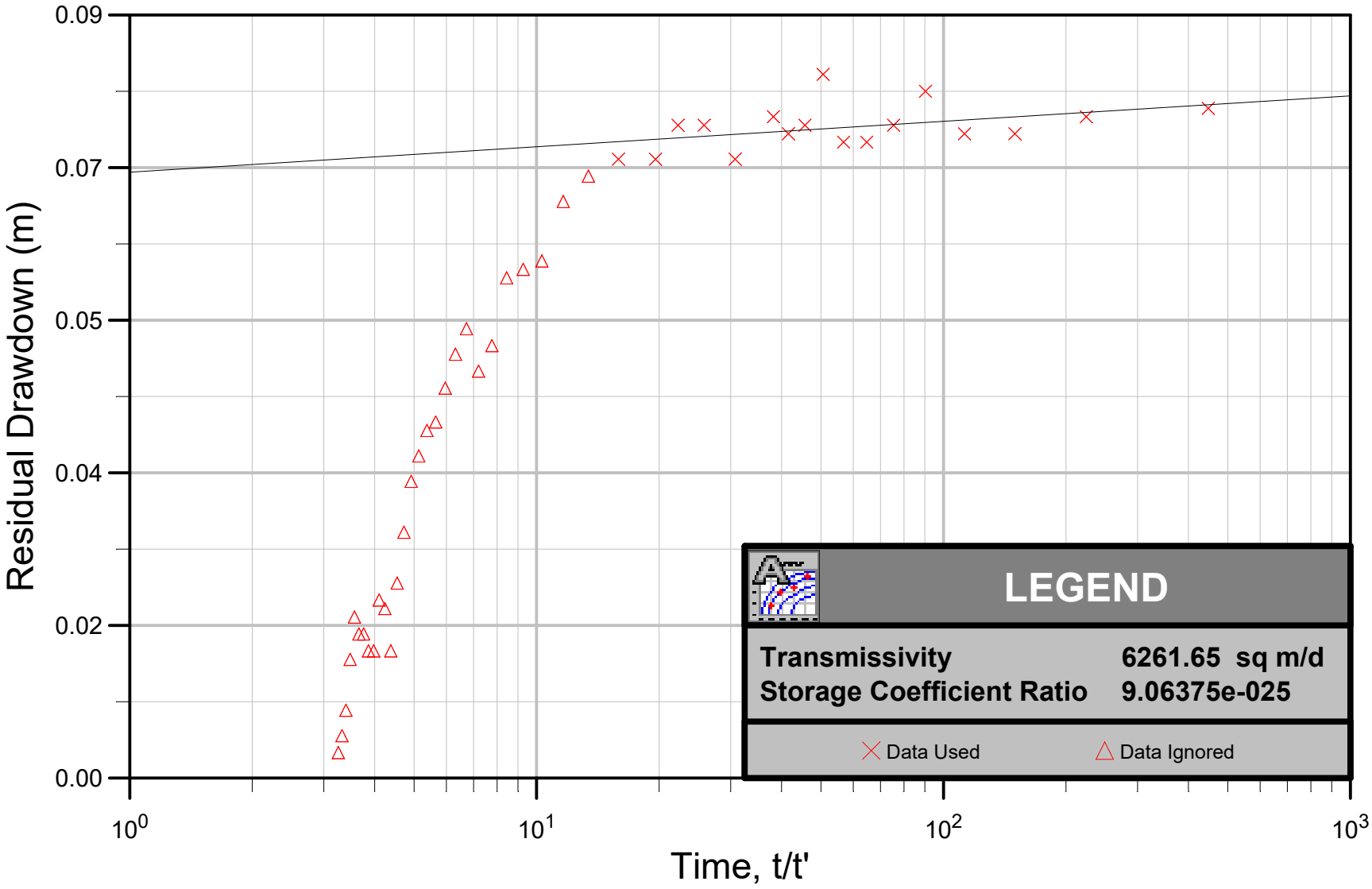
Theis Recovery Analysis - Abstraction BH Early Time



Theis Recovery Analysis - Abstraction BH Late Time



Theis Recovery Analysis - PZ3 Early Time



Theis Recovery Analysis - PZ3 Late Time