S/BSL/DQ/H&HIA/003

Breedon Trading Limited

Denbigh Quarry

Denbigh, Denbighshire

Extension to Existing Mineral Workings

Hydrological & Hydrogeological Impact Assessment

02nd Febuary 2022

Appendix 9.1 Guidance & Information Sources

BCL HYDRO
BCL Consultant Hydrogeologists Limited

Technology Centre, Wolverhampton Science Park, Glashier Drive, Wolverhampton
West Midlands, WV10 9RU. Tel: 01902 824111, Fax: 01902 824112
email: info@bclhydro.co.uk, web: http://www.bclhydro.co.uk
Registered Office: 33, Wolverhampton Road, Cannock, West Midlands, WV11 1AP
Registered in England & Wales. Company Registration Number: 4043373

Regulatory & Industry Standard Guidance, Methodologies & Literature References

Published Data Sources

- Ordnance Survey (OS): Topographic maps at scales of 1:50,000 and 1:25,000.
- OS open-source digital data (Meridian 2, Panorama & Terra50 data-sets).
- British Geological Survey (BGS): Published 1:50,000 scale solid and drift geological mapping, sheets-no. E107 (Denbigh).
- BGS Geoindex, well details and borehole logs, 2019.
- Natural Resources Wales (NRW), 2019 data regarding licenced abstractions, source protection zones, flood risk mapping & landfill sites.
- Natural Resources Wales (NRW), 2015, 'Clwyd Catchment Abstraction Management Strategy'.
- "Climate & Drainage", Technical Bulletin No.34, Ministry of Agriculture Fisheries & Food (MAFF), September 1976.
- Centre for Ecology & Hydrology Flood Estimation Handbook Web Service, FEH13 Rainfall Model (https://fehweb.ceh.ac.uk/), November 2018.
- "The Calculation of Actual Evaporation and Soil Moisture Deficit over Specified Catchment Areas", Grindley J, November 1969, Hydrological Memorandum 38, Meteorological Office, Bracknell, UK.
- "Estimation of Open Water Evaporation, Guidance for Environment Agency Practitioners", R&D Handbook W6-043/HB, J W Finch and R L Hall, October 2001.
- Environment Agency / British Geological Survey, 'The Physical Properties of Major Aquifers in England and Wales', Hydrogeology Group Technical Report WD/97/34, 1997.
- British Geological Survey, 'The Hydrogeology of Wales', 2015.
- "Greenfield Runoff Estimation for Sites", HR Wallingford (HRW), on-line calculation tool, UK Sustainable Drainage, Guidance & Tools.
- Flood studies report, Volume II: Meteorological Studies", National Environment Research Council (NERC), 1975.
- "Flood Estimation for Small Catchments (IH 124)", Institute of Hydrology, Report No.124, Marshall DCW & Bayliss AC, June 1994.
- Environment Agency, 'Hydrogeological Impact Appraisal for Dewatering Abstractions', Science Report SC040020/SR1, 2007.
- Environment Agency, 'Hydrogeological Impact Appraisal for Groundwater Abstractions', Science Report SC040020/SR2, 2007.
- "Minerals Planning Policy (Wales), Minerals Technical Advice Note (Wales), 1: Aggregates", Welsh Assembly Government (WAG), March 2004.
- "Planning Policy Wales, Technical Advice Note 15: Development and Flood Risk" (TAN15), WAG, July 2004.
- North Wales Caving Club [WWW], northwalescavingclub.org.uk.
- Natural Resources Wales, 'Clwyd Management Catchment Summary'.

Site Specific Data Sources

- Sigma Survey, 'Denbigh Quarry Update Survey', 21/08/2019, DBQU210819_A1.
- Pleydell Smithyman, 'Denbigh Quarry, Preliminary Development Plans', Nos. M18.155.D.004, 024, 025, 026, 027 & 007.
- Key GeoSolutions Ltd, 'Denbigh Quarry, Report on Geological Exploration In Western Extension', March 2003.
- Hughes Drilling Ltd, 2007 drilling logs, Denbigh Quarry.
- BCL Consultant Hydrogeologists Limited, 2019 Drilling and Piezometer Construction Logs, Denbigh Quarry.
- Pleydell Smithyman, 'Denbigh Quarry, Formal Request for a Scoping Opinion Relating to The Winning and Working of Limestone from the Western Extension of Denbigh Quarry', 2019.
- Denbighshire County Council, Scoping Opinion, 01/2019/0573, 14/08/2019.
- Dewatering Discharge Records, Denbigh Quarry, 1999.
- Hydrometric Monitoring Data, BCL Consultant Hydrogeologists Limited / Breedon Trrading Limited, 2022.

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Breedon Trading Limited

Denbigh Quarry

Denbigh, Denbighshire

Extension to Existing Mineral Workings

Hydrological & Hydrogeological Impact Assessment

02nd Febuary 2022

Appendix 9.2 Drilling Logs

BCL HYDRO
BCL Consultant Hydrogeologists Limited

Technology Centre, Wolverhampton Science Park, Glashier Drive, Wolverhampton
West Midlands, WV10 9RU. Tel: 01902 824111, Fax: 01902 824112
email: info@bclhydro.co.uk, web: http://www.bclhydro.co.uk
Registered Office: 33, Wolverhampton Road, Cannock, West Midlands, WV11 1AP
Registered in England & Wales. Company Registration Number: 4043373

BORE HOLE LOG

Client: HANSON.

Site/Location: DENBIGH

B.H. No.(s): 2, 1. Sheet No:

HUGHES DRILLING

Church Stretton, Shropshire, SY6 6LU.
Tel. 01694 731470 Fax. 01694 731469
Email: hughesdrilling@tiscali.co.uk

Job No:

Date Started: Completed: Drillers: M. O'SULLIVAN. S. WARD

Rig Type: 340. Flush/Additives: AIR

Drill Method: RC. HAMMER. Casing Detail/Depth:

In-hole Equip: Others:

SAMPLE INTERVAL					DESCRIPTION OF STRATA/SAMPLE	INSTALLATION DETAILS			
RUN / SAMPLE No.	FROM: O mts	TO:	Mts Drilled	Recovery Mts. Good / Poor etc.	DRILLERS OBSERVATIONS Re: Rock Type, B.H. Conditions, Water Strikes etc.	TYPE: SIZE: HEADWORKS:			
						From:			To:
BH2.	0.00	1.00	1.00		FILL / WEATHERED LIMESTONE	10 BAGS.			
		4.00	3.00		FRACTURED RED / GREY LIMESTONE.			1.00	4.00
	4.00	24.00	20.00		FRACTURED LIGHT GREY LIMESTONE			4.00	5.50
					WITH VERY FREQUENT RED BANDS.			5.50	6.50
								6.5	9.00
								9.00	11.50
								11.50	14.00
								14.00	16.50
								16.50	19.00
								19.00	21.50
								21.50	24.00
BH1.	0.00	13.00	13.00		LIGHT GREY FRACTURED LIMESTONE	20 BAGS			
		20.00	7.00		LIGHT GREY LIMESTONE WITH.			ALL AT	
					RED / PURPLE BANDS.			1 METRE	
								INTERVALS	
								0.0	1.00
								1.00	2.00 ETC.

BORE HOLE LOG

Client: HANSON.

Site/Location: DENBIGH

B.H. No.(s): 3, 5, 4 Sheet No:

HUGHES DRILLING

Church Stretton, Shropshire, SY6 6LU.
Tel. 01694 731470 Fax. 01694 731469
Email: hughesdrilling@tiscali.co.uk

Job No:

Date Started: Completed: Drillers: M. O'SULLIVAN. S. WILD

Rig Type: 340. Flush/Additives: AIR

Drill Method: RC. HAMMER. Casing Detail/Depth:

In-hole Equip: Others:

SAMPLE INTERVAL					DESCRIPTION OF STRATA/SAMPLE	INSTALLATION DETAILS			
RUN / SAMPLE No.	FROM: O mts	TO:	Mts Drilled	Recovery Mts. Good / Poor etc.	DRILLERS OBSERVATIONS Re: Rock Type, B.H. Conditions, Water Strikes etc.	TYPE: SIZE: HEADWORKS:			
						From:			To:
BH 3	0.00	15.00	15.00		LIGHT GREY FRACTURED LIMESTONE WITH FREQUENT RED BANDS.				
	15.00	20.00	5.00		LIGHT GREY FRACTURED LIMESTONE			20.	BAGS
								ALL	AT
								ONE	METRE
								INTERVALS.	
BH 5	0.00	21.00	21.00		LIGHT GREY FRACTURED LIMESTONE WITH FREQUENT RED/PINK BANDS.			21	BAGS
								ALL	AT
								ONE	METRE
								INTERVALS.	
BH 4	0.00	8.00	8.00		LIGHT GREY FRACTURED LIMESTONE WITH RED/PINK BANDS.			22	BAGS
	8.00	22.00	14.00		LIGHT GREY FRACTURED LIMESTONE			ALL	AT
								ONE	METRE
								INTERVALS.	

BORE HOLE LOG

Client: HANSON

Site/Location: DENBIGH

B.H. No.(s): 6, 7 Sheet No:

HUGHES DRILLING

Church Stretton, Shropshire, SY6 6LU.
Tel. 01694 731470 Fax. 01694 731469
Email: hughesdrilling@tiscali.co.uk

Job No:

Date Started: Completed: Drillers: M. O'SULLIVAN J. WILD

Rig Type: B50 Flush/Additives: AIR

Drill Method: RC. HAMMER. Casing Detail/Depth:

In-hole Equip: Others:

SAMPLE INTERVAL					DESCRIPTION OF STRATA/SAMPLE	INSTALLATION DETAILS	
RUN / SAMPLE No.	FROM: O mts	TO:	Mts Drilled	Recovery Mts. Good / Poor etc.	DRILLERS OBSERVATIONS Re: Rock Type, B.H. Conditions, Water Strikes etc.	TYPE: SIZE: HEADWORKS: From:	To:
BH6	0.00	6.00	6.00		LIGHT GREY/RED/PINK LIMESTONE		24 BAGS
		7.00	1.00		CAVITY NET. NO SAMPLE		ALL AT
	7.00	25.00	18.00		LIGHT GREY FRACTURED LIMESTONE		ONE METRE
					OCCASSIONAL RED/PINK BAND.		INTERVAL.
							NO SAMPLE
							6.0 - 7.00.
BH7	0.00	10.00	10.00		LIGHT GREY FRACTURED LIMESTONE		11 BAGS
					WITH RED/PINK BANDS		0.00 1.00
	10.00	25.00	25.00		LIGHT GREY FRACTURED LIMESTONE		1.00 3.00
							3.00 5.00
							5.00 7.50
							7.50 10.00
							10.00 12.50
							12.50 15.00
							15.00 17.50
							17.50 20.00
							20.00 22.50
							22.50 25.00

BORE HOLE LOG

Client: HANSON

Site/Location: DENBIGH

B.H. No.(s): 10, 9, 8, Sheet No:

HUGHES DRILLING

Church Stretton, Shrop
Tel. 01694 731470 F
Email: hughesdrilling@

Dan

Job No:

Date Started: Completed: Drillers: M. O'SHAUGHNESSY J WILD

Rig Type: 340

Drill Method: RC HAMMER

In-hole Equip:

Flush/Additives: AIR

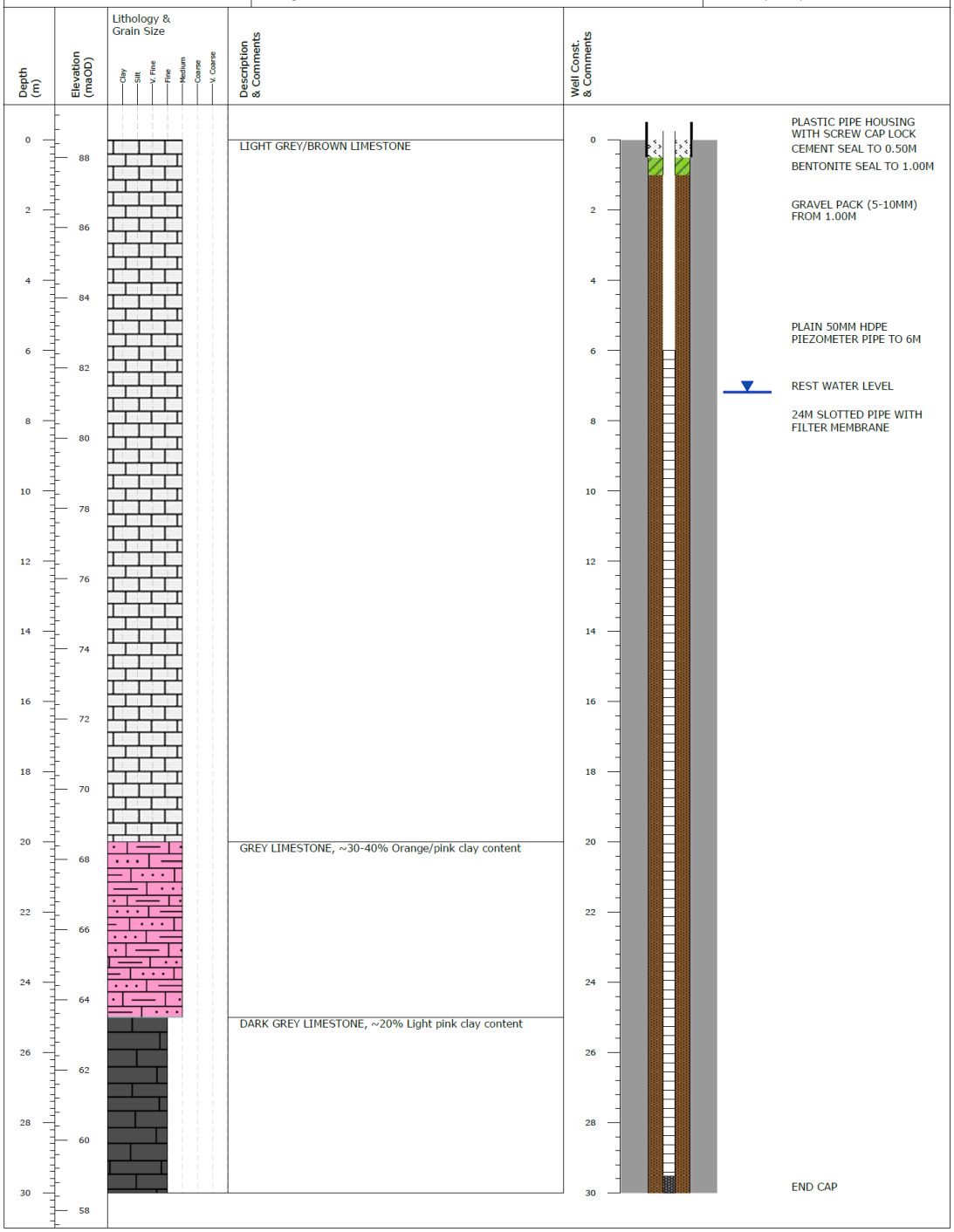
Casing Detail/Depth:

Others:

SAMPLE INTERVAL					DESCRIPTION OF STRATA/SAMPLE	INSTALLATION DETAILS			
RUN / SAMPLE No.	FROM: O mts	TO:	Mts Drilled	Recovery Mts. Good / Poor etc.	DRILLERS OBSERVATIONS Re: Rock Type, B.H. Conditions, Water Strikes etc.	TYPE: SIZE: HEADWORKS:	From:		To:
BH 10	0.00	17.50	17.50		LIGHT GREY FRACTURED LIMESTONE WITH FREQUENT RED/PINK BANDS.			20 BAGS ALL AT	
	17.50	50.00	32.50		LIGHT GREY FRACTURED LIMESTONE.			2.5M INTERVALS.	
BH 9.	0.00	12.50	12.50		LIGHT GREY RED/PINK FRACTURED LIMESTONE			19 BAGS ALL AT	
	12.50	30.00	17.50		LIGHT GREY FRACTURED LIMESTONE			2.5M INTERVALS	
		32.50	2.50		RED/PINK LIMESTONE				
	32.50	48.00	7.50		LIGHT GREY FRACTURED LIMESTONE			MST SAMPLE 45-48M.	
BH 8.	0.00	5.00	5.00		LIGHT GREY RED/PINK LIMESTONE			13 BAGS ALL AT	
		12.50	7.50		LIGHT GREY FRACTURED LIMESTONE				
	12.50	25.00	12.50		LIGHT GREY FRACTURED LIMESTONE WITH CLAY BANDS			2.5M INTERVALS	
	25.00	32.50	7.50		CAVITYS / JOINTS SILTY SAND WITH CLAY.				

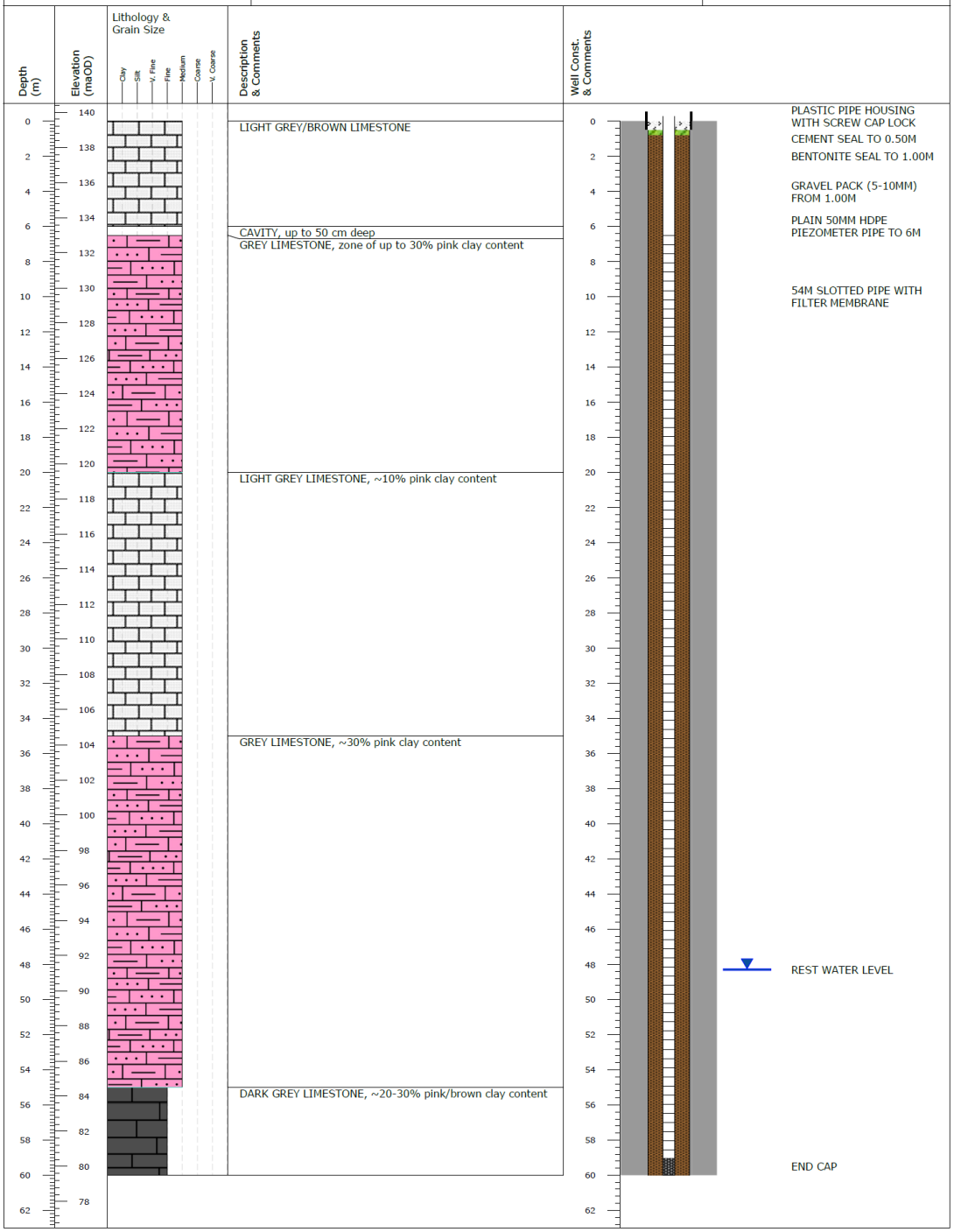
BCL Consultant Hydrogeologists Limited

Project:	Breedon Group	Hole No:	P1/19
Site:	Denbigh Quarry	Sheet:	1 of 1
Job No:	BCL/PI/0519/001	Eastings:	305303
Logged By:	Gavinder Meetca	Northings:	366911
Drill Rig:	Soilmec PSM8GT	Inc/Ori:	90 / 0
Contractor:	Hughes Drilling	Depth (m):	30
Driller:	M. O'Sullivan	Elevation (maOD):	88.5
		Drilling Started:	31 May 2019 9:00 AM
		Drilling Finished:	31 May 2019 12:00 PM



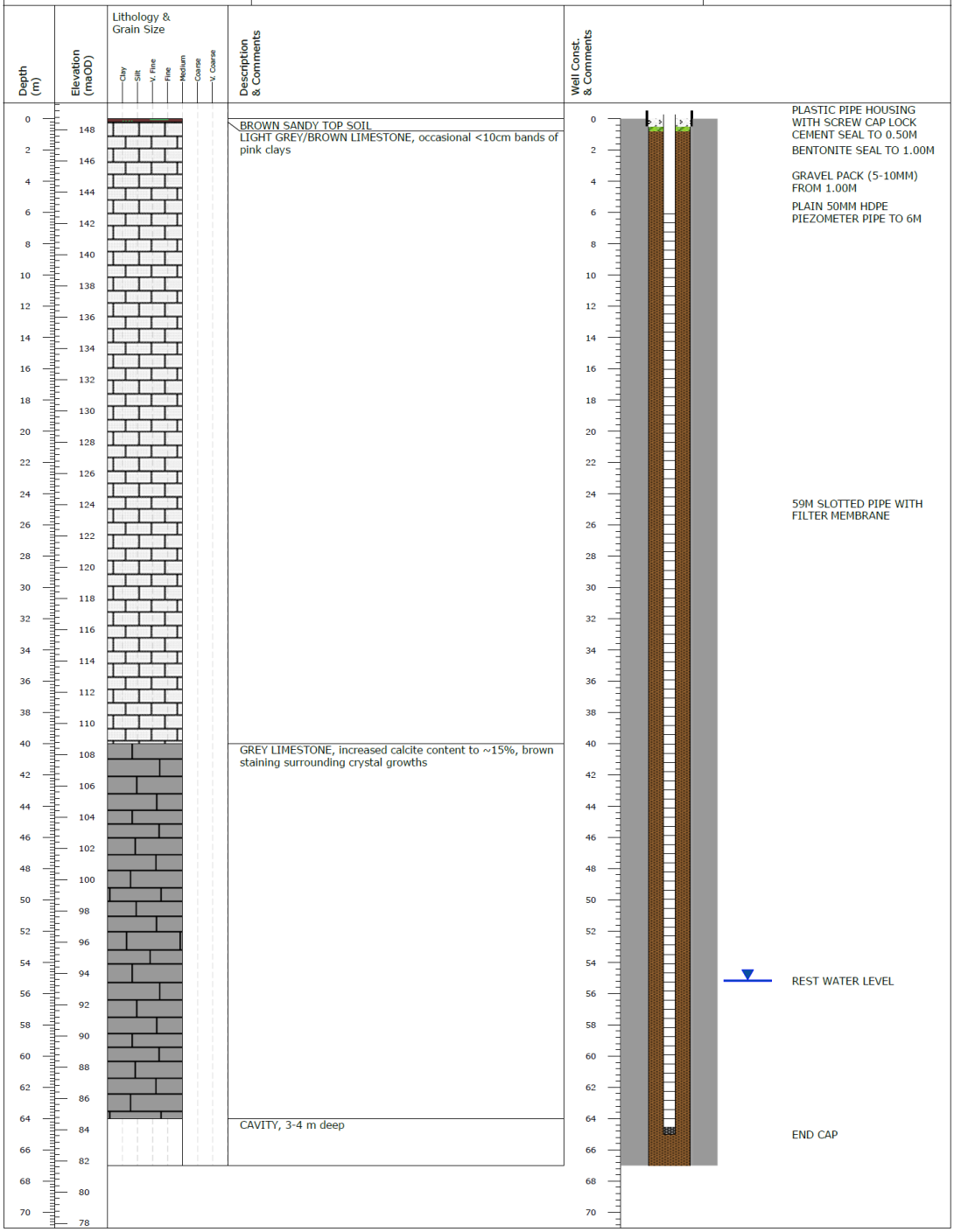
BCL Consultant Hydrogeologists Limited

Project:	Breedon Group	Hole No:	P2/19
Site:	Denbigh Quarry	Sheet:	1 of 1
Job No:	BCL/PI/0519/001	Eastings:	304966
Logged By:	Gavinder Meetca	Northings:	366901
Drill Rig:	Soilmec PSM8GT	Inc/Ori:	90 / 0
Contractor:	Hughes Drilling	Depth (m):	60
Driller:	M. O'Sullivan	Elevation (maOD):	139.5
		Drilling Started:	31 May 2019 9:00 AM
		Drilling Finished:	31 May 2019 12:00 PM



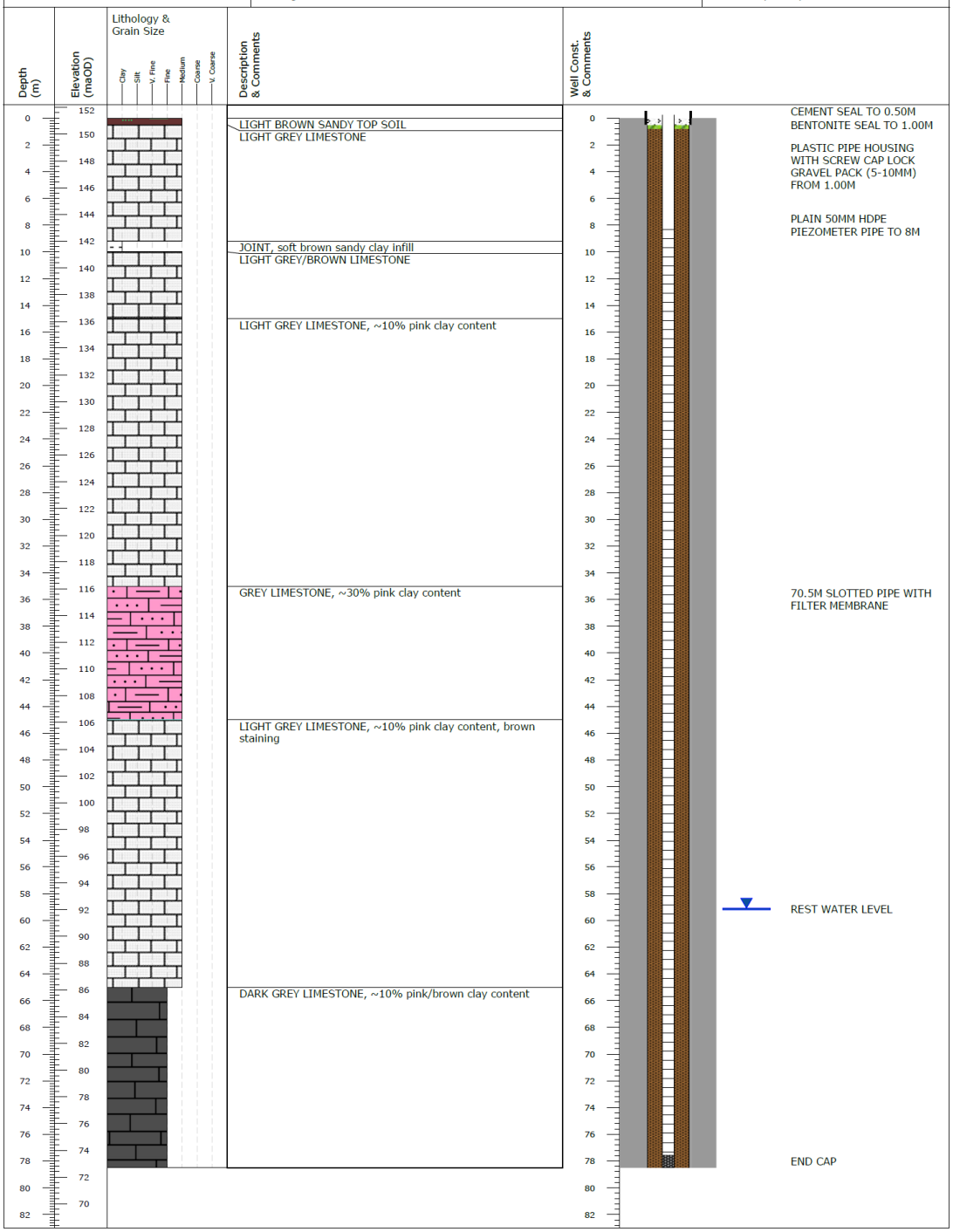
BCL Consultant Hydrogeologists Limited

Project:	Breedon Group	Hole No:	P3/19
Site:	Denbigh Quarry	Sheet:	1 of 1
Job No:	BCL/PI/0519/001	Eastings:	304588
Logged By:	Gavinder Meetca	Northings:	366956
Drill Rig:	Soilmec PSM8GT	Inc/Ori:	90 / 0
Drilling Started:	31 May 2019 9:00 AM	Depth (m):	67
Drilling Finished:	31 May 2019 12:00 PM	Elevation (maOD):	148.7
Contractor:	Hughes Drilling		
Driller:	M. O'Sullivan		



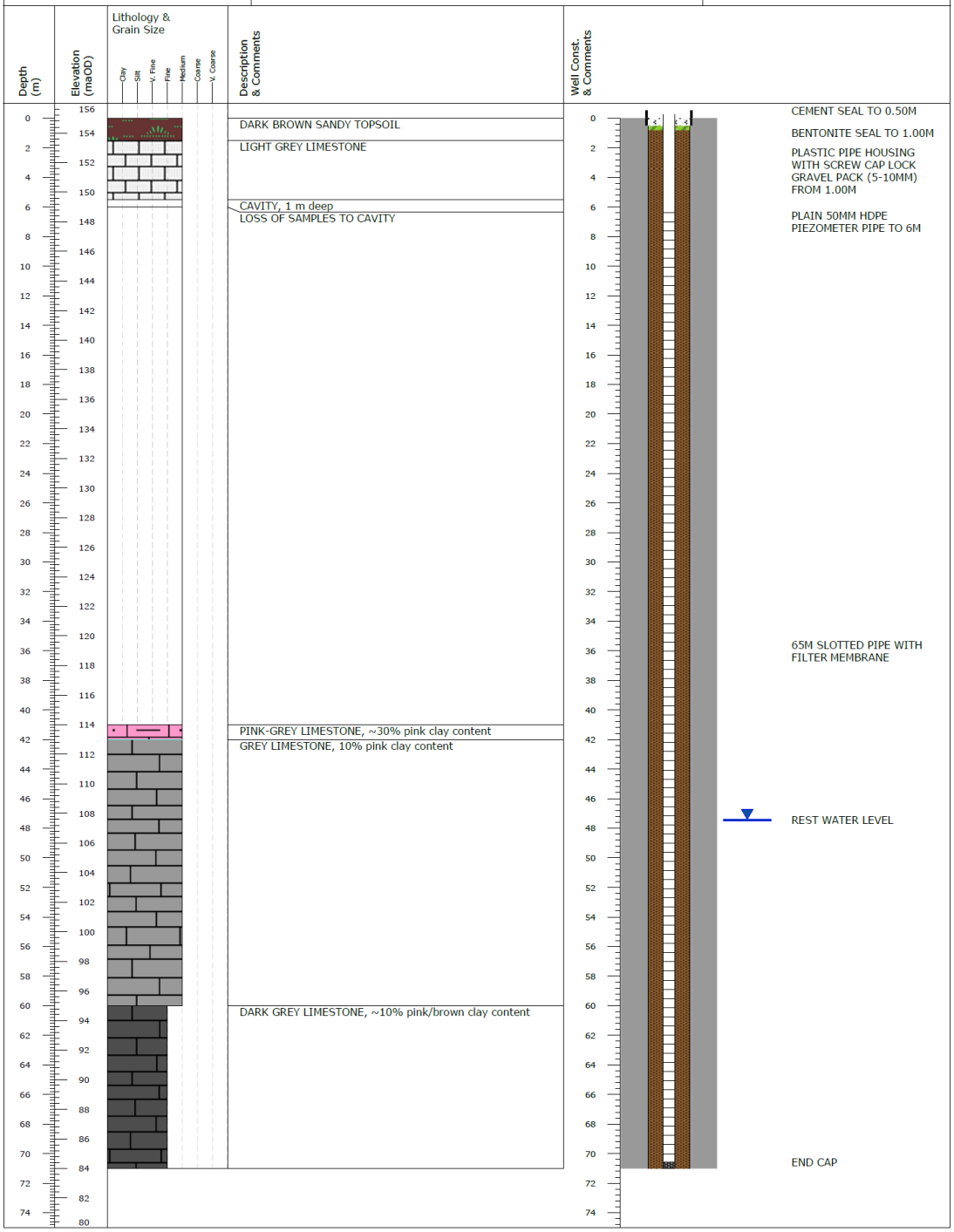
BCL Consultant Hydrogeologists Limited

Project:	Breedon Group	Hole No:	P4/19
Site:	Denbigh Quarry	Sheet:	1 of 1
Job No:	BCL/PI/0519/001	Eastings:	304803
Logged By:	Gavinder Meetca	Northings:	367197
Drill Rig:	Soilmec PSM8GT	Inc/Ori:	90 / 0
Contractor:	Hughes Drilling	Drilling Started:	31 May 2019 9:00 AM
Driller:	M. O'Sullivan	Drilling Finished:	31 May 2019 12:00 PM
		Depth (m):	78.5
		Elevation (maOD):	151.2



BCL Consultant Hydrogeologists Limited

Project:	**Breedon Group**	Hole No:	**P5/19**
Site:	**Denbigh Quarry**	Sheet:	**1 of 1**
Job No:	**BCL/PI/0519/001**	Eastings:	**305116**
Logged By:	**Gavinder Meetca**	Northings:	**367513**
Drill Rig:	**Soilmec PSM8GT**	Inc/Ori:	**90 / 0**
Drilling Started:	**31 May 2019 9:00 AM**	Depth (m):	**71**
Drilling Finished:	**31 May 2019 12:00 PM**	Elevation (maOD):	**155**
Contractor:	**Hughes Drilling**		
Driller:	**M. O'Sullivan**		



Breedon Trading Limited

Denbigh Quarry

Denbigh, Denbighshire

Extension to Existing Mineral Workings

Hydrological & Hydrogeological Impact Assessment

02nd Febuary 2022

Appendix 9.3 Falling Head Test Data

BCL HYDRO
BCL Consultant Hydrogeologists Limited

Technology Centre, Wolverhampton Science Park, Glashier Drive, Wolverhampton
West Midlands, WV10 9RU. Tel: 01902 824111, Fax: 01902 824112
email: info@bclhydro.co.uk, web: http://www.bclhydro.co.uk
Registered Office: 33, Wolverhampton Road, Cannock, West Midlands, WV11 1AP
Registered in England & Wales. Company Registration Number: 4043373

BREEDON GROUP: DENBIGH QUARRY - P1/19

BOUWER-RICE ANALYSIS (PARTIALLY PENTRATING BOREHOLE)

CALCULATION FOR HYDRAULIC CONDUCTIVITY (K) FROM SLUG TEST

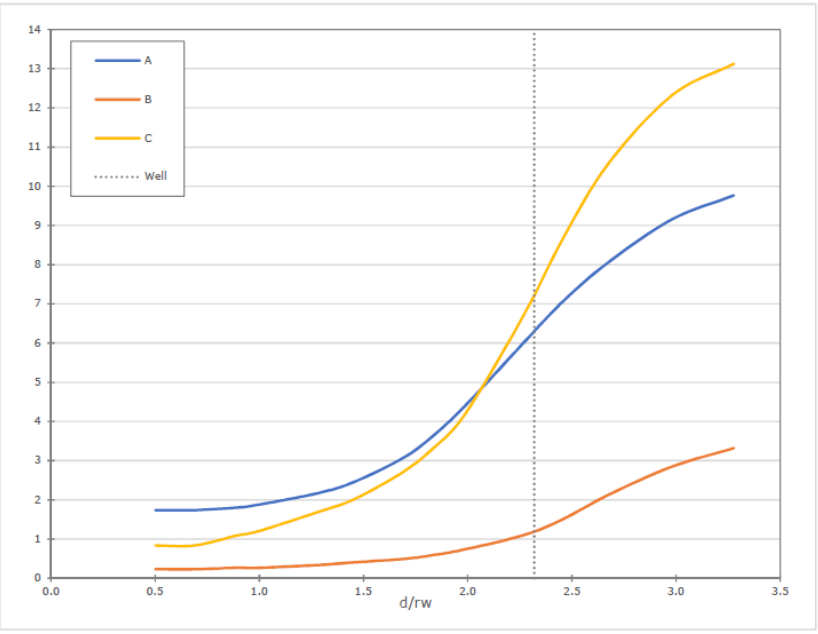
Assumes aquifer is unconfined, homogeneous etc.

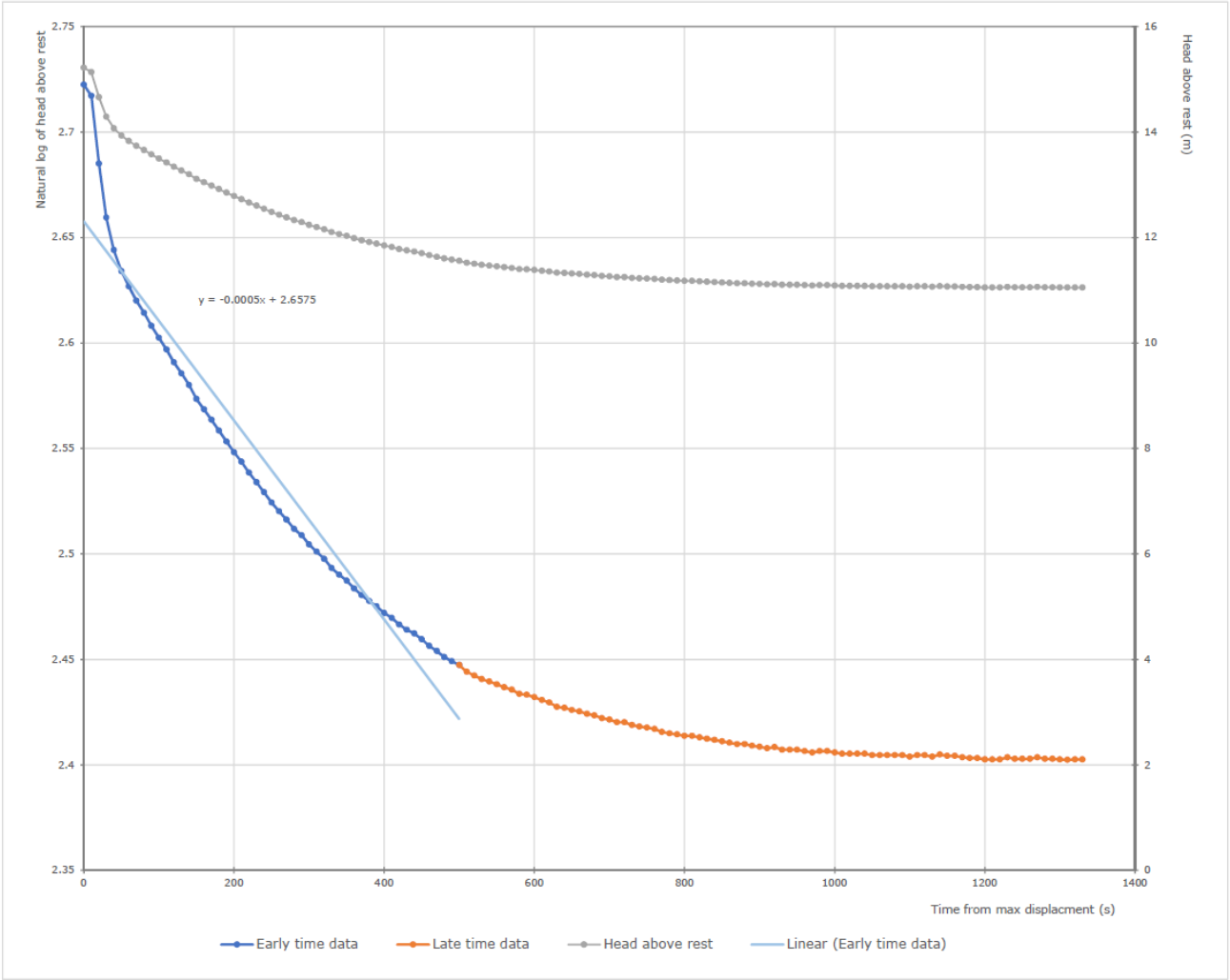
INPUTS

Screen length (m); d	=	24.00
Drilled radius (m); r_w	=	0.12
Casing radius (m); r_c	=	0.05
Base of deposit (mb collar)	=	100.00
Base of piezometer (mb collar)	=	30.00
Dip to water level (m)	=	7.93
Graph gradient (s^{-1}); $(1/t)\ln(h_0/h_t)$ (linear approx. to early time data)	=	0.0005
A	=	6.29425764
B	=	1.208834632
(Published graph from d/r_w)		

Calculations

D (m)	=	92.07
b (m)	=	22.07
d/r_w	=	208.6956522
$\ln(Re/r_w)$	=	3.616118592
K (ms^{-1})	=	9.41698E-08
K (md^{-1})	=	0.008136267





BREEDON GROUP: DENBIGH QUARRY - P2/19

BOUWER-RICE ANALYSIS (PARTIALLY PENTRATING BOREHOLE)

CALCULATION FOR HYDRAULIC CONDUCTIVITY (K) FROM SLUG TEST

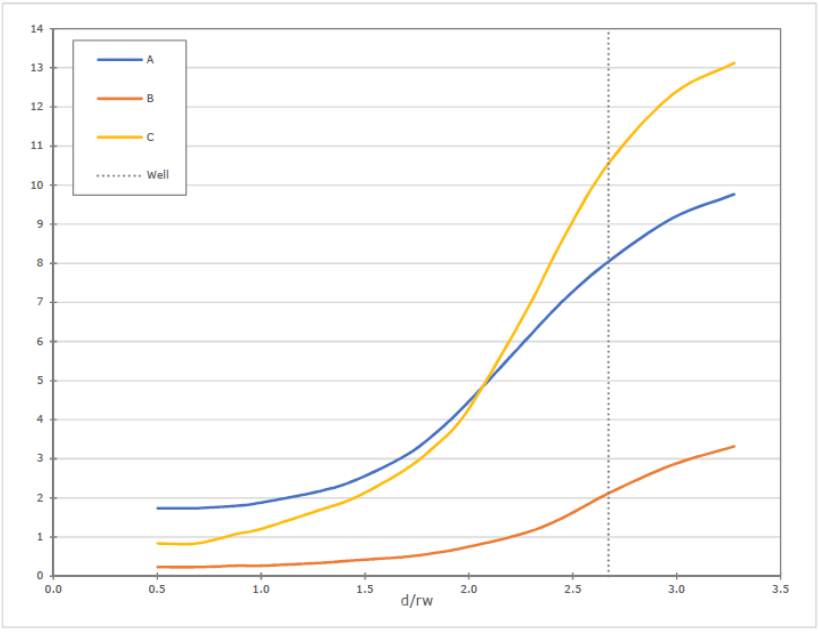
Assumes aquifer is unconfined, homogeneous etc.

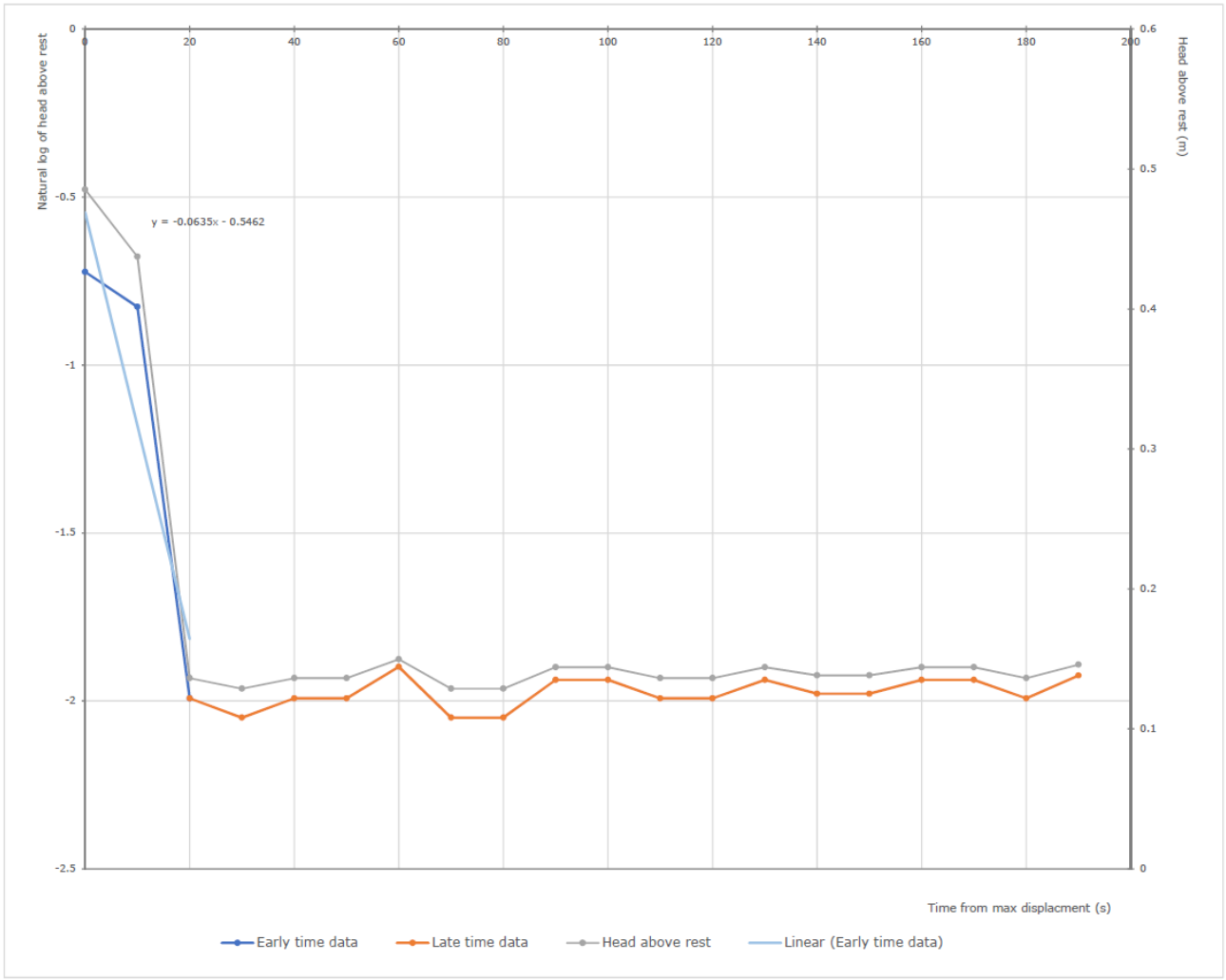
INPUTS

Screen length (m); d	=	54.00
Drilled radius (m); r_w	=	0.12
Casing radius (m); r_c	=	0.05
Base of deposit (mb collar)	=	100.00
Base of piezometer (mb collar)	=	60.00
Dip to water level (m)	=	50.28
Graph gradient (s^{-1}); $(1/t)\ln(h_0/h_t)$ (linear approx. to early time data)	=	0.0635
A	=	8.045220568
B	=	2.11706566
(Published graph from d/r_w)		

Calculations

D (m)	=	49.72
b (m)	=	9.72
d/r_w	=	469.5652174
$\ln(Re/r_w)$	=	3.4313452
K (ms^{-1})	=	5.04376E-06
K (md^{-1})	=	0.43578084





BREEDON GROUP: DENBIGH QUARRY - P3/19

BOUWER-RICE ANALYSIS (PARTIALLY PENTRATING BOREHOLE)

CALCULATION FOR HYDRAULIC CONDUCTIVITY (K) FROM SLUG TEST

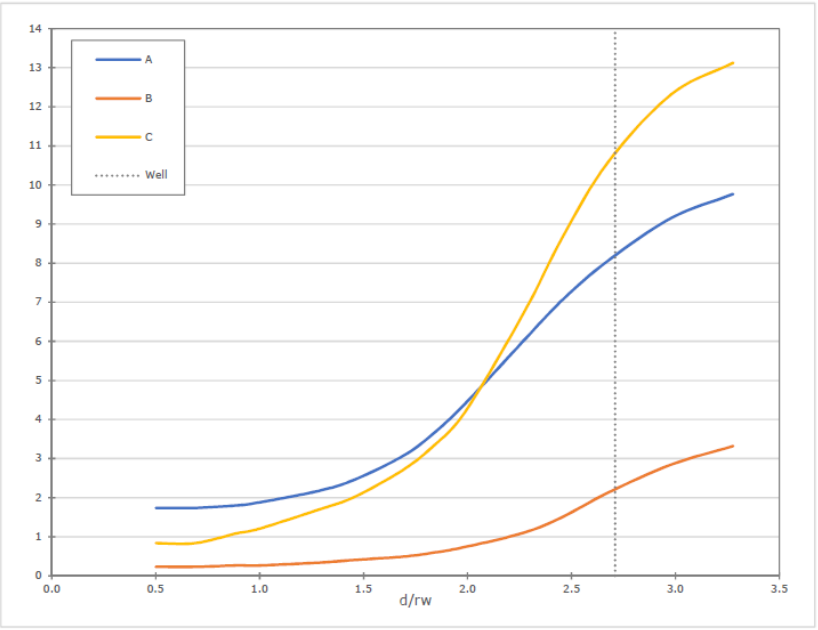
Assumes aquifer is unconfined, homogeneous etc.

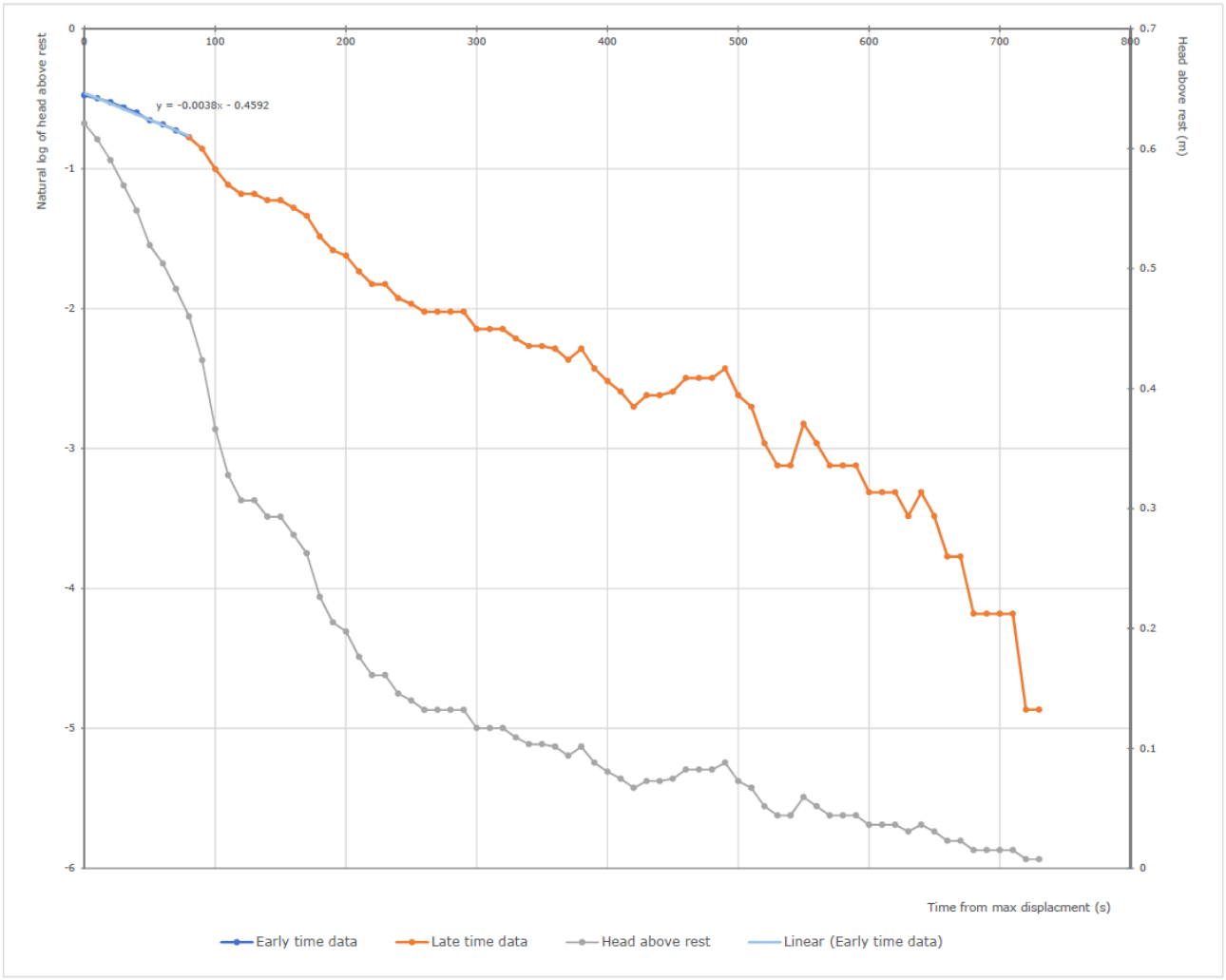
INPUTS

Screen length (m); d	=	59.00
Drilled radius (m); r_w	=	0.12
Casing radius (m); r_c	=	0.05
Base of deposit (mb collar)	=	100.00
Base of piezometer (mb collar)	=	67.00
Dip to water level (m)	=	58.02
Graph gradient (s^{-1}); (1/t)ln(h_0/h_t) (linear approx. to early time data)	=	0.0038
A	=	8.186683401
B	=	2.209672516
(Published graph from d/r_w)		

Calculations

D (m)	=	41.98
b (m)	=	8.98
d/r_w	=	513.0434783
$\ln(Re/r_w)$	=	3.415867747
K (ms^{-1})	=	2.75006E-07
K (md^{-1})	=	0.023760544





BREEDON GROUP: DENBIGH QUARRY - P4/19

BOUWER-RICE ANALYSIS (PARTIALLY PENTRATING BOREHOLE)

CALCULATION FOR HYDRAULIC CONDUCTIVITY (K) FROM SLUG TEST

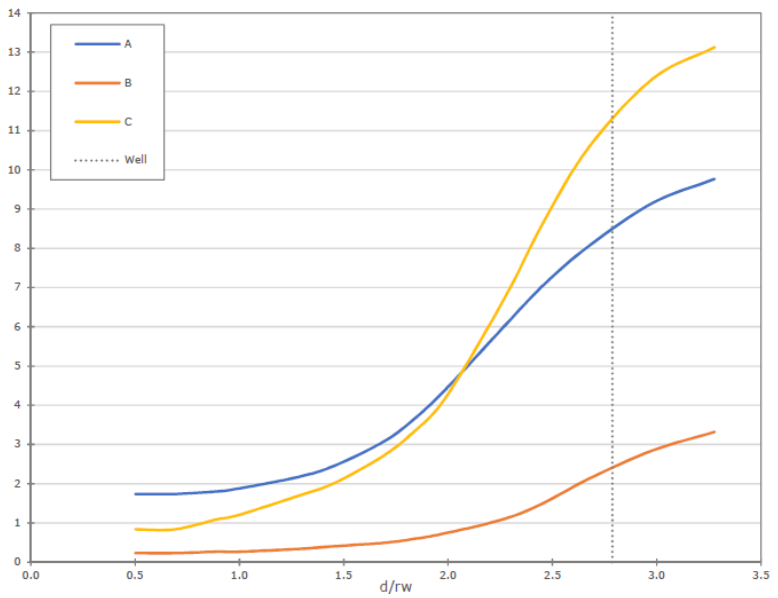
Assumes aquifer is unconfined, homogeneous etc.

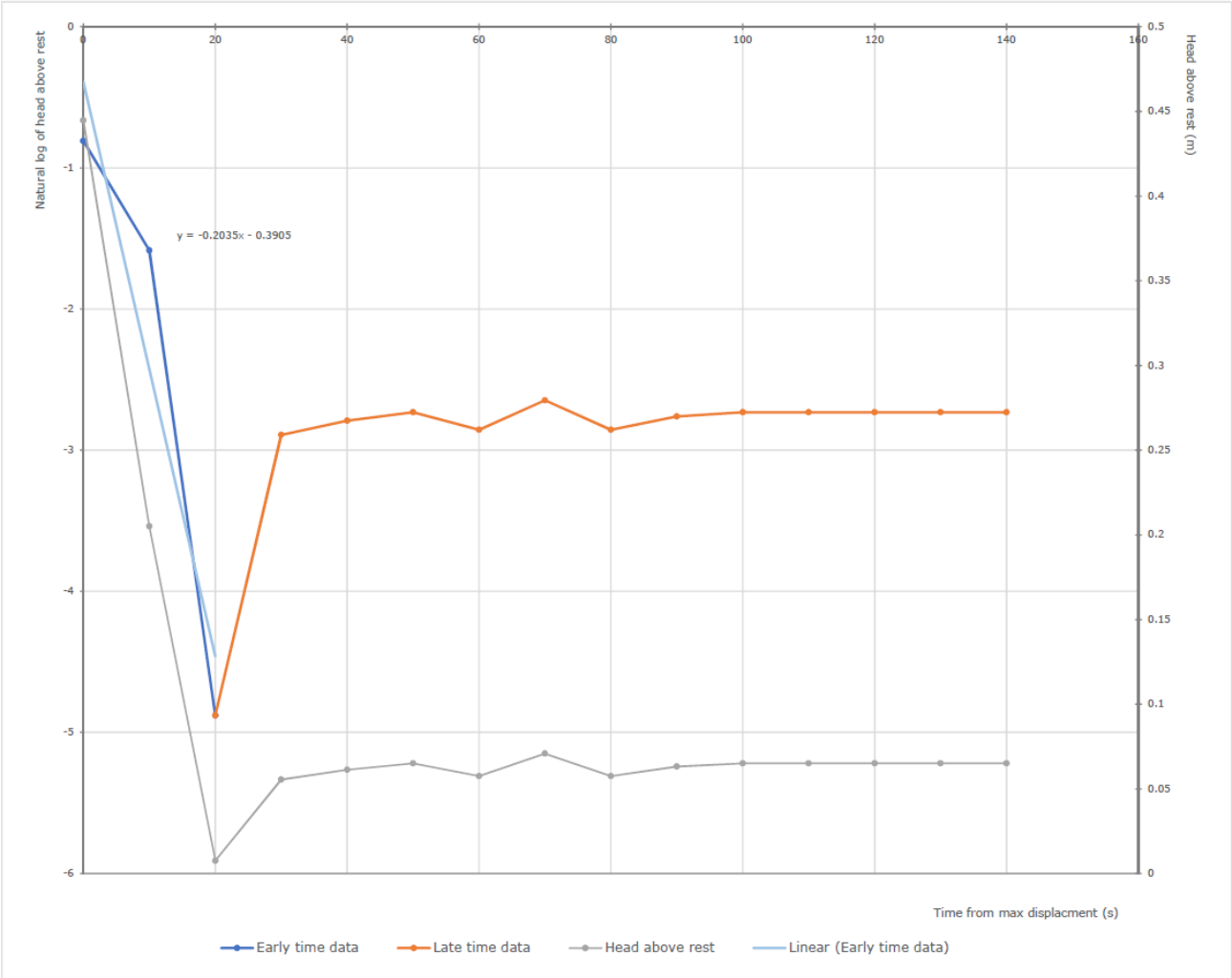
INPUTS

Screen length (m); d	=	70.50
Drilled radius (m); r_w	=	0.12
Casing radius (m); r_c	=	0.05
Base of deposit (mb collar)	=	100.00
Base of piezometer (mb collar)	=	78.50
Dip to water level (m)	=	64.30
Graph gradient (s^{-1}); $(1/t)\ln(h_0/h_t)$ (linear approx. to early time data)	=	0.2035
A	=	8.463870667
B	=	2.392352606
(Published graph from d/r_w)		

Calculations

D (m)	=	35.7
b (m)	=	14.2
d/r_w	=	613.0434783
$\ln(Re/r_w)$	=	3.807759732
K (ms^{-1})	=	1.3739E-05
K (md^{-1})	=	1.187048842





BREEDON GROUP: DENBIGH QUARRY - P5/19

BOUWER-RICE ANALYSIS (PARTIALLY PENTRATING BOREHOLE)

CALCULATION FOR HYDRAULIC CONDUCTIVITY (K) FROM SLUG TEST

Assumes aquifer is unconfined, homogeneous etc.

INPUTS

Screen length (m); d	=	65.00
Drilled radius (m); r_w	=	0.12
Casing radius (m); r_c	=	0.05
Base of deposit (mb collar)	=	100.00
Base of piezometer (mb collar)	=	71.00
Dip to water level (m)	=	54.66
Graph gradient (s^{-1}); $(1/t)\ln(h_0/h_t)$ (linear approx. to early time data)	=	0.0155
A	=	8.337437288
B	=	2.309026768
(Published graph from d/r_w)		

Calculations

D (m)	=	45.34
b (m)	=	16.34
d/r_w	=	565.2173913
$\ln(Re/r_w)$	=	3.856893546
K (ms^{-1})	=	1.14965E-06
K (md^{-1})	=	0.099329843