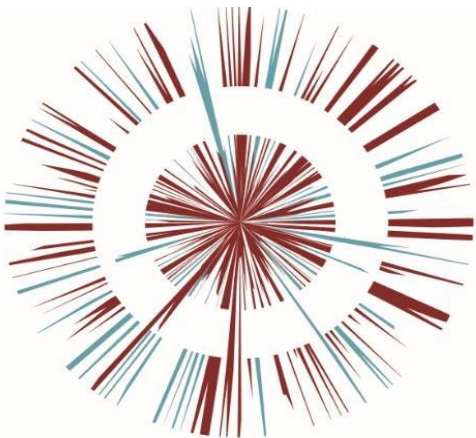




OMEGA ZONE 8, ST HELENS

Omega St Helens Ltd / T J Morris Ltd



**Hydraulic Conductivity
Testing Letter Report
UNIT 1 DOC. 13.**



Colin Graham
Omega Warrington Limited (OWL)
C/O Miller Developments
201 West George Street
Glasgow
G2 2LW

Our ref: 70060349/11625

22 June 2020

CONFIDENTIAL

Omega Zone 8 – Hydraulic Conductivity Testing Letter Report

1. INTRODUCTION AND OBJECTIVE

WSP UK limited was instructed by Omega Warrington Limited (OWL) to undertake hydraulic conductivity testing at the Zone 8 site within the Omega South development (henceforth referred to as 'the site'). The works are required in order to provide an indication of the potential suitability of sustainable drainage to assist in discharging associated planning conditions related to the commercial development of the site (Planning Ref: P/2020/0061/HYBR).

2. BACKGROUND

A previous geo-environmental and geotechnical investigation has been completed at the wider Omega Zone 8 site by WSP and reported in the Ground Investigation Report issued in February 2020 (ref: 70062937/11482). A site location plan is presented in Appendix A.

The WSP (2020) ground investigation generally recorded a sequence of topsoil overlying predominantly cohesive Till deposits reported to be between 7.1m and 14.2m thick. Underlying the Till, Sandstone bedrock was observed, which dipped to the south.

Hydraulic conductivity testing has been carried out in existing onsite monitoring wells (installed in the cohesive Till) and the results of the hydraulic conductivity testing are reported herein.

3 FIELDWORKS

3.1 Hydraulic Conductivity Testing

Hydraulic conductivity testing was completed within three groundwater monitoring wells with response zones located within the shallow cohesive Till (BH8A02, WS8A01 and WS8B04) between 05 June and 08 June 2020. An exploratory hole location plan is located within Appendix A and relevant exploratory logs are presented within Appendix B.

Electronic pressure transducers/data loggers were installed in the monitoring wells and up to three falling and rising head tests were carried out in each position. The data was interpreted using Bouwer and Rice (1976)¹ and details of the tests completed are presented in Appendix C.

¹ *Bouwer and Rice (1976) A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, vol. 12, no. 3, pp. 423-428.*

4 FINDINGS

The hydraulic conductivity/permeability test results considered to most accurately represent the permeability of the tested soils were reviewed to generate conductivity curves from which approximate hydraulic conductivities have been determined. The conductivity curves are presented in Appendix C. It should be noted that due to the limited recovery of the water level during a number of tests, the hydraulic conductivity could not be determined. The details of the tests are presented within Appendix C.

The maximum, minimum and overall mean hydraulic conductivity (metres per day) recorded are summarised in Table 1 below.

Table 1 Summary of Calculated Hydraulic Conductivity

Location	Strata unit targeted	No. of tests	Hydraulic Conductivity (metres per day)		
			Maximum	Minimum	Geometric mean
BH8A02	Cohesive Glacial Till	3	2.0×10^{-2}	8.9×10^{-3}	9.4×10^{-3}
WS8A01		3	2.8×10^{-3}	<2cm water level recovery over tests	
WS8B04		3	<1cm water level recovery over tests		

The test results from BH8A02, WS8A01 and WS8B04 are considered to be representative of the hydraulic conductivity of the Till and are indicative of a low permeability formation. The hydraulic conductivity results are within the reported literature values for a Till – i.e. 8.64×10^{-08} m/day and 0.17m/day (Domenico and Schwartz, 1990)².

5 CONCLUSIONS

The potential for lateral and vertical migration of water within the Till will be limited by the predominantly cohesive nature of the Till.

Based on the calculated hydraulic conductivity of the Till, it is considered unlikely that traditional infiltration / soakaway drainage will be feasible for the site.

Yours sincerely



Digitally signed by
Kinchington, Jess
(UKJJK032)
Date: 2020.06.22 17:06:02
+01'00'

Jess Kinchington
Senior Consultant - Ground and Water

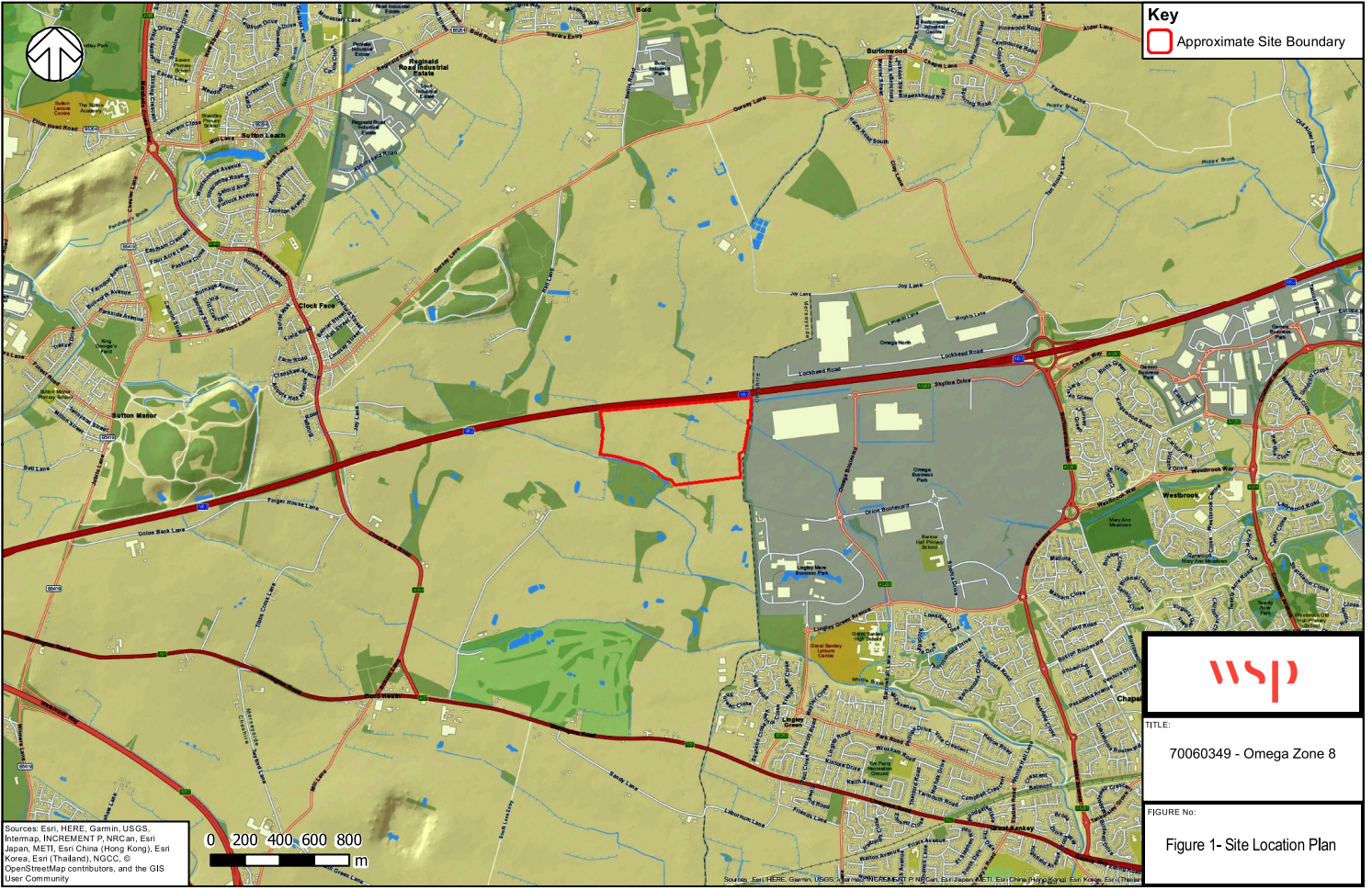
Enclosures

- Appendix A - Figure 1 - Site Location Plan
- Figure 2 - Exploratory Hole location Plan
- Appendix B – Selected Exploratory Hole Logs
- Appendix C - Hydraulic Conductivity Data


² Domenico and Schwartz (1990) *Physical and Chemical Hydrogeology*, John Wiley & Sons, New York, pp 824



APPENDIX A - FIGURES



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Key
 Approximate Site Boundary

wsp

TITLE:
70060349 - Omega Zone 8

FIGURE No:
Figure 1- Site Location Plan

Date Modified: 04/11/2019

Drawn By: LK026032

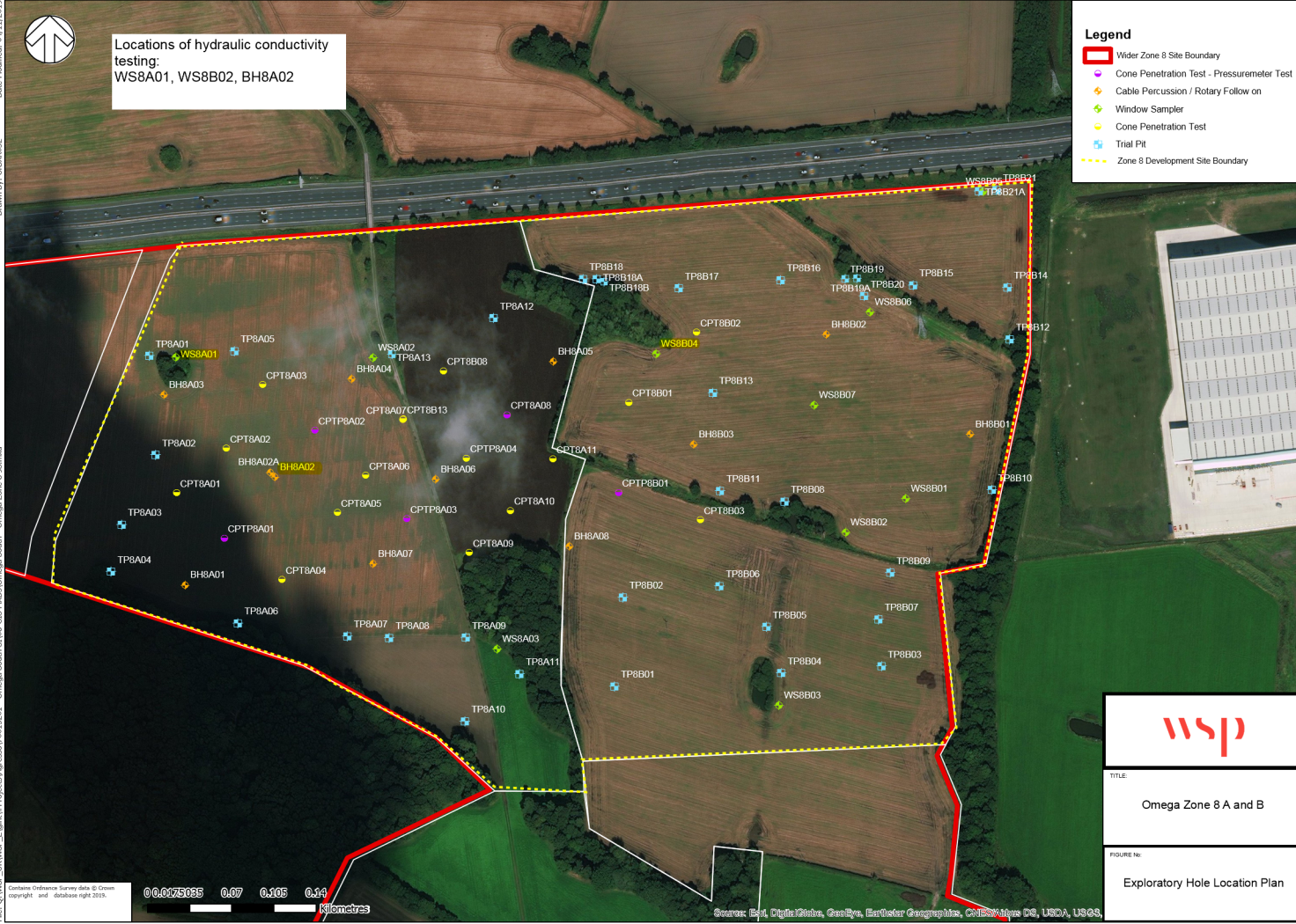
File: G:\Wsp_E\Wsp_E\Wsp_E\Projects\Omega\Omega_South - Omega Zone 8 B_S.mxd



Locations of hydraulic conductivity testing:
WS8A01, WS8B02, BH8A02

Legend

- Wider Zone 8 Site Boundary
- Cone Penetration Test - Pressuremeter Test
- Cable Percussion / Rotary Follow on
- Window Sampler
- Cone Penetration Test
- Trial Pit
- Zone 8 Development Site Boundary



Contains Ordnance Survey data © Crown copyright and database right 2018.

0 0.0125 0.025 0.05 0.1
Kilometres

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNR/Air Force DS, USDA, USGS,

TITLE:
Omega Zone 8 A and B

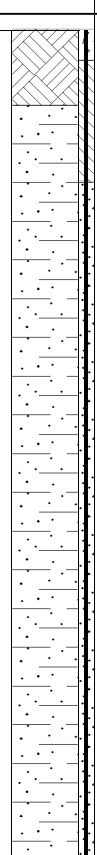
FIGURE NO:
Exploratory Hole Location Plan



APPENDIX B - EXPLORATORY HOLE LOGS

BOREHOLE RECORD - Dynamic Sampler

Project **OMEGA DEVELOPMENT GI** Engineer **WSP** Borehole **WS8A01**
 Project No **PN194027**
 Client **WSP** National Grid Coordinates **354707.6 E**
390774.1 N Ground Level **25.89 m OD**

Sampling			Properties			Strata			Scale 1:50		
Depth	Sample Type	Depth Cased & (to Water)	Strength kPa	w %	SPT N	Description	Depth	Legend	Level m OD		
0.20	ES					Rough grass over TOPSOIL: Soft dark brown slightly sandy slightly gravelly clay with some rootlets. Gravel is subangular to subrounded fine to medium of various lithologies.	G.L.		25.89		
0.50	ES				0.50		25.39				
1.00- 2.00	B				S16	Firm brown slightly sandy CLAY with occasional pockets (up to 15mm) of orange fine to medium sand. Below 1.20m, stiff.					
1.00- 2.00	D										
1.00	ES										
1.20- 1.65											
2.00- 3.00	B				S26	Below 2.00m, occasional pockets (up to 15mm) of shale fragments.					
2.00- 3.00	D										
2.00- 2.45											
3.00- 3.20	D				S21						
3.00- 3.45											
3.20- 4.00	B										
4.00- 4.20	D				S18						
4.00- 4.45											
4.20- 5.00	B										
5.00- 5.45					S20						
End of Borehole							5.45		20.44		

Boring				Progress					Groundwater					
Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater
1.20		Inspection Pit	IH	G.L.			07/10/19	08:00						None encountered.
5.45	0.10	Dynamic Sampler	IH	5.45		DRY	07/10/19	18:00						

Remarks **Inspection pit hand excavated to 1.20m depth and no services were found.**
ABS sample = 1 x 60ml glass vial, 2 x 258ml amber glass jars.
 A 50mm gas monitoring pipe was installed to 5.45m with a geowrapped slotted section from 1.00m to 5.45m with upright lockable protective cover. Backfill details from base of hole: gravel filter up to 1.00m, bentonite seal up to 0.20m, concrete up to ground level.

Symbols and abbreviations are explained on the accompanying key sheet.
 All dimensions are in metres. Logged in accordance with BS5930:2015

Logged by **CW**
 Figure **1 of 1**
 18/12/2019


geotechnics

BOREHOLE RECORD - Cable Percussion and Rotary

Project **OMEGA DEVELOPMENT GI** Engineer **WSP** Borehole **BH8A01**
 Project No **PN194027**
 Client **WSP** National Grid Coordinates **354715.5 E**
390584.6 N Ground Level **23.89 m OD**


Drilling		Properties/Sampling				Strata		Scale 1:50		
Core Run/Depth (Core Dia/Time)	Depth Cased & (to Water)	Type TCR/SCR%	Length Max/Min	RQD %	SPT N (FI)	Description General	Description Detail	Depth	Legend	Level m OD
					(15)					
21.00-22.50		67 0	- -	0	(AZCL)					
					(10)					
					(NI)					
					(9)					
22.50-24.00		100 59	0.27 0.02	58	(10)					
					(NI)					
					(4)					
24.00-25.50		100 90	0.40 0.05	87	(NI)					
					(8)					
					(0)					
End of Borehole								25.50		-1.61

Drilling				Progress					Groundwater					
Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks 

Symbols and abbreviations are explained on the accompanying key sheet.
 All dimensions are in metres. Logged in accordance with BS5930:2015

Logged by **MM**
 Figure **3 of 3**
 18/12/2019



BOREHOLE RECORD - Cable Percussion and Rotary

Project **OMEGA DEVELOPMENT GI** Engineer **WSP** Borehole **BH8A02**
 Client **WSP** National Grid Coordinates **354789.9 E** Project No **PN194027**
390674.5 N Ground Level **26.00 m OD**

Sampling			Properties			Strata		Scale 1:50		
Depth	Sample Type	Depth Cased & (to Water)	Strength kPa	w %	SPT N (F)	Description	Depth	Legend	Level m OD	
0.20- 0.60	B					Grass over TOPSOIL: Soft dark brown slightly sandy clay with some rootlets.	G.L.		26.00	
0.25	ES						0.40		25.60	
0.50	ES					Firm reddish brown mottled yellow slightly sandy slightly gravelly CLAY. Gravel is subangular to rounded fine to coarse of sandstone, mudstone, quartz and coal.				
0.60- 1.20	B									
1.00	ES									
1.20- 1.65	UT42	(DRY)	72	19						
1.70	D									
1.80	D									
2.00- 2.45	B									
2.00- 2.45		1.70 (DRY)			S17		Below 2.30m, stiff.			
2.80	D									
3.00- 3.45	UT77	3.00 (DRY)		13						
3.50	D									
3.80	D									
4.00- 4.45	B									
4.00- 4.45		4.00 (DRY)			S19					
4.80	D									
5.00- 5.45	UT67	4.50 (DRY)	100	13						
5.50	D									
6.00	D									
6.50- 6.95	B									
6.50- 6.95		6.00 (DRY)			S26	Below 6.90m, very stiff.				
7.50	D									
8.00- 8.45	UT100	8.00 (DRY)								
8.50	D									
9.00	D									
9.50- 9.95	B									
9.50- 9.93		9.00 (DRY)			S50/282					

Boring				Progress				Groundwater						
Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater
1.20		Inspection Pit	SL	G.I.			09/10/19	08:00						None encountered.
12.00	0.15	Cable Percussion	SL	5.00	4.70	DRY	09/10/19	18:00						
13.00	0.13	Rotary Core	JB	5.00	4.50	4.30	10/10/19	08:00						
				12.00	12.00	ADDED	10/10/19	18:00						
				12.00	12.00	11.20	11/10/19	08:00						
				13.00	12.00	12.30	11/10/19	18:00						

Remarks Inspection pit hand excavated to 1.20m depth and no services were found.
 ES sample = 1 x vial, 1 x plastic jar and 1 amber jar.
 Water was added to assist boring at 12.00m where borehole encountered an obstruction - probable boulder - no progress despite chiselling for 1 hour, so switched to rotary techniques.
 A 50mm gas monitoring pipe was installed to 5.00m with a geowrapped slotted section from 1.00m to 5.00m with upright lockable protective cover. Backfill details from base of hole: collapsed material up to 10.00m, bentonite seal up to 5.00m, gravel filter up to 1.00m,
 Logged in accordance with BS5930:2015

Logged by **MM**
 Figure **1 of 2**
 18/12/2019

BOREHOLE RECORD - Cable Percussion and Rotary

Project **OMEGA DEVELOPMENT GI**

Engineer **WSP**

Borehole **BH8A02**
Project No **PN194027**

Client **WSP**

National Grid Coordinates **354789.9 E**
390674.5 N

Ground Level **26.00 m OD**


Sampling			Properties			Strata		Scale 1:50		
Depth	Sample Type	Depth Cased & (to Water)	Strength kPa	w %	SPT N (F)	Description		Depth	Legend	Level m OD
10.50	D									
11.00-11.45	UT100	10.50 (DRY)								
11.50	D									
12.00	D							12.00		14.00
Core Run/Depth (Core Dia/Time)	Depth Cased	TCR/SCR / Type	Length Max/Min	RQD %	SPT (F)	Continued by Rotary techniques General				
12.00-12.50	12.00 (11.20)	100 / 100	0.50 / 0.50	100	(0) (AZCL)	BOULDERS of extremely strong white mottled grey and black granite.				
12.50-13.00	12.00 (ADDED)	80 / 80	0.40 / 0.40	80	(0)	At 12.00m, boulder of granite. Between 12.50-12.60m, band of red fine to coarse sand.		13.00		13.00
End of Borehole										

Boring				Progress					Ground water					
Depth	Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks
 bentonite seal up to 0.20m, concrete up to ground level.
 Chiselling: 10.50-11.00m for 60 minutes and 12.00-12.00m for 60 minutes.
 Flush: 12.00-13.00m, Water, 100% return.

Logged by **MM**
 Figure **2 of 2**
 18/12/2019

All dimensions are in metres. Logged in accordance with BS5930:2015



BOREHOLE RECORD - Dynamic Sampler

Project **OMEGA DEVELOPMENT GI** Engineer **WSP** Borehole **WS8B04**
 Project No **PN194027**

Client **WSP** National Grid Coordinates **355106.5 E**
390776.8 N Ground Level **22.84 m OD**

Sampling			Properties			Strata		Scale 1:50		
Depth	Sample Type	Depth Cased & (to Water)	Strength kPa	w %	SPT N	Description	Depth	Legend	Level m OD	
0.10- 0.30	B					Crops over TOPSOIL: Very soft dark brown slightly gravelly sandy clay with some rootlets. Gravel is angular to subrounded fine to coarse of siltstone and quartz.	G.L.		22.84	
0.20	D						0.35		22.49	
0.20	ES					Firm orangish brown mottled grey slightly sandy slightly gravelly CLAY with some pockets of sand. Gravel is subangular to rounded fine to coarse of siltstone and quartz.				
0.40- 1.00	B									
0.50	D									
0.50	ES									
1.00	ES									
1.20- 2.00	B	(WET)			S9					
1.20- 1.65	D		16							
1.50	D									
2.00- 3.00	B	(WET)			S18		Below 2.00m, stiff.			
2.00- 2.45	D									
2.50	D									
3.00- 3.45		(DRY)			S25					
3.50	D									
4.00- 4.45		(DRY)			S17					
4.50	D									
5.00- 5.45		(DRY)			S15					
End of Borehole							5.45		17.39	

Boring				Progress					Groundwater					
Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater
1.20	0.40	Inspection Pit	JP	G.L.			01/10/19	08:00	0.70					Slow inflow.
5.45	0.10	Dynamic Sampler	JP	5.45		WET	01/10/19	18:00						

Remarks Inspection pit hand excavated to 1.20m depth and no services were found.
 ABS sample = 1 x 60ml glass vial, 2 x 258ml amber glass jars.
 A 50mm standpipe was installed to 4.50m with a geowrapped slotted section from 0.50m to 4.50m with flush lockable protective cover. Backfill details from base of hole: bentonite seal up to 4.50m, gravel filter up to 0.50m, bentonite seal up to 0.20m, concrete up to ground level.

Symbols and abbreviations are explained on the accompanying key sheet.
 All dimensions are in metres. Logged in accordance with BS5930:2015

Logged by **NC**
 Figure **1 of 1**
 18/12/2019



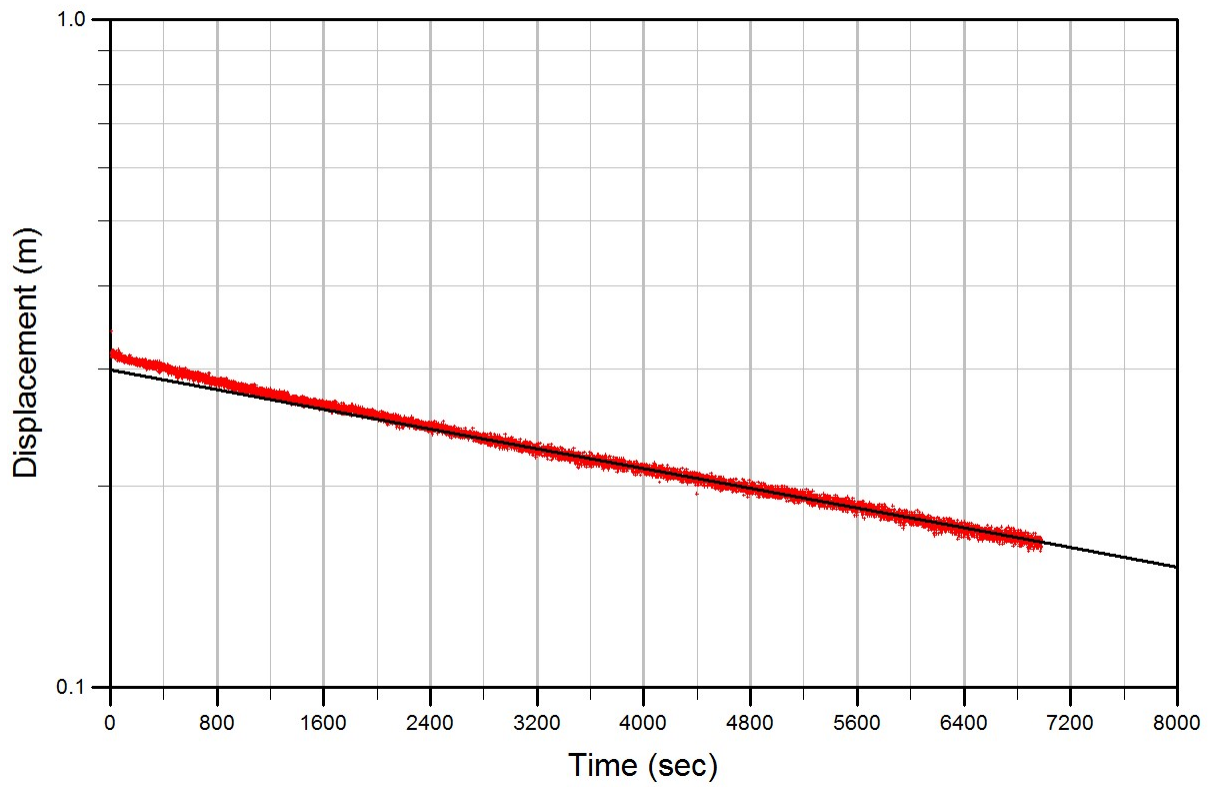
APPENDIX C - HYDRAULIC CONDUCTIVITY DATA

Omega Zone 8A Hydraulic Conductivity Testing
Jun-20

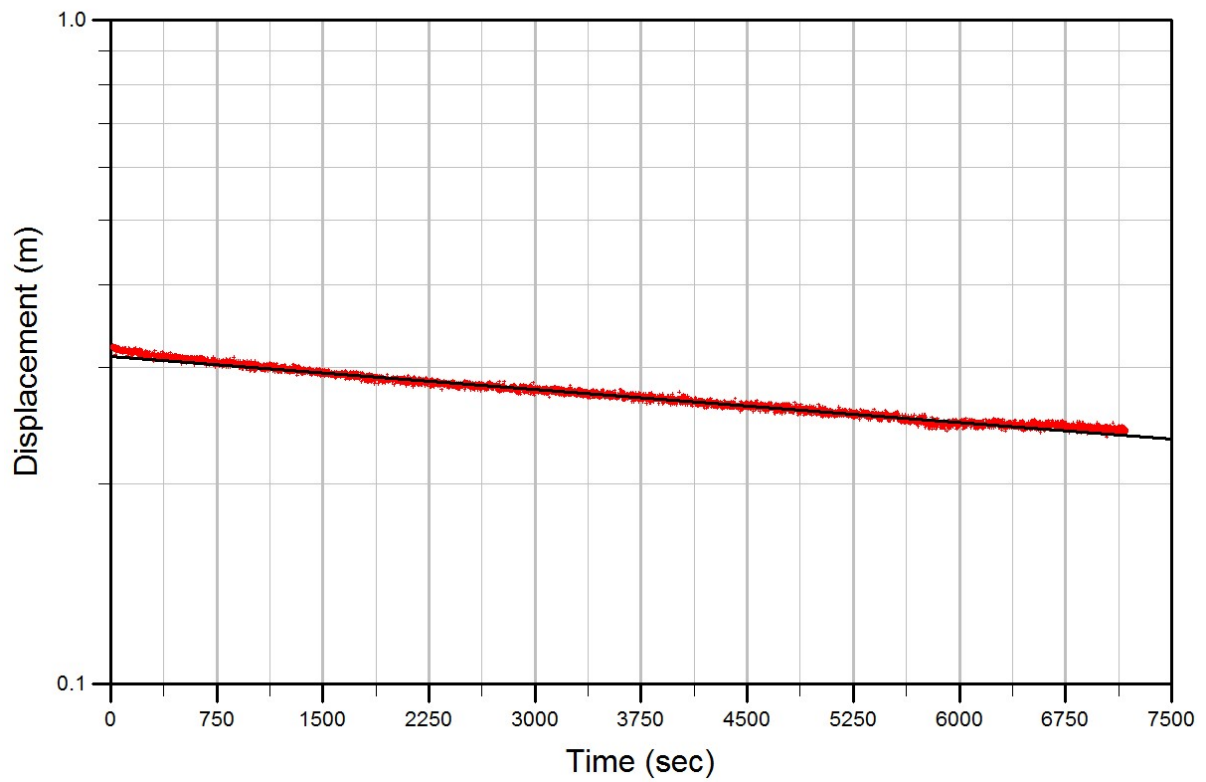
Borehole	Test ref	K (m/s)	Comment	K (m/day)
BH8A02	FH1	2.3E-07	Rest water level and test above wellscreen. Incomplete recovery (53%). Indicative of low permeability formation.	2.0E-02
	RH1	1.0E-07	Rest water level and test above wellscreen. Incomplete recovery (25%). Indicative of low permeability formation.	8.9E-03
	FH2	1.8E-07	Rest water level and test above wellscreen. Incomplete recovery (21%). Indicative of low permeability formation.	1.6E-02
WS8A01	FH1	-	Minimal (2cm) change in water level over 90 minute test. Indicative of low permeability formation.	
	RH1	3.2E-08	Rest water level and test within wellscreen. Early time data impacted by drainage of filter pack; matched to late time data which is likely to be response from formation. Incomplete recovery (10%). Indicative of low permeability formation.	2.8E-03
	FH2	-	Minimal (1cm) recovery in water level over 60 minute test. Indicative of low permeability formation.	
WS8B04	FH1	-	No change in water level over 120 minute test. Indicative of low permeability formation.	
	RH1	-	Pressure transducer cord tangled with slug and pulled up above water table. Unable to process test.	
	FH2	-	Minimal (1cm) recovery in water level over 90 minute test. Indicative of low permeability formation.	
<i>Geometric mean</i>		<i>1.1E-07</i>	<i>From 4 tests</i>	0.0094

Data interpreted using Bouwer and Rice (1976). A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, vol. 12, no. 3, pp. 423-428.

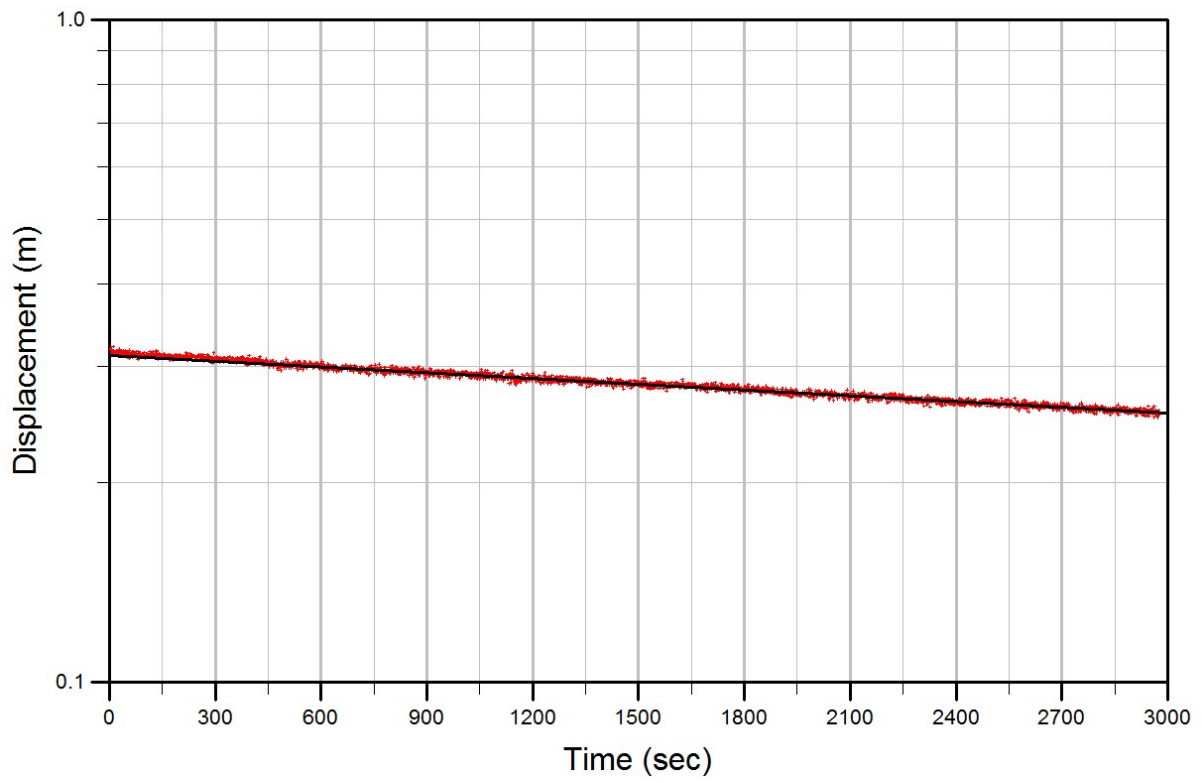
BH8A02 Falling head test 1



BH8A02 Rising head test 1



BH8A02 Falling head test 2



WS8A01 Falling head test 1

