Report on:

GEOTECHNICAL STUDY PROPOSED INDUSTRIAL DEVELOPMENT LOTS 8 AND 16 STIRLING CRESCENT HIGH WYCOMBE

WAG240438-01 001 R Rev2

Submitted to:

Sarich Building
Suite 1, 162 Colin Street
WEST PERTH WA 6005

2 April 2025

CONTENTS

1. INTRODUCTION

This revised report presents the outcomes of Galt Geotechnics' (Galt's) geotechnical study for the proposed industrial development, at Lots 8 and 16 Stirling Crescent, High Wycombe ("the site").

This report is to be read in conjunction with the appended "Geotechnical Definitions, Recommendations, Requirements and Limitations". 'Clause GDR1', etc. refer to this Appendix, found at the back of this report.

This revision incorporates revised development plans

2. KEY FINDINGS

The encountered subsurface conditions typically comprise Bassendean Sand to maximum investigation depth of 6.9 m. Cemented soil / "Coffee Rock" was encountered at depths ranging between 2 m to 4 m. Sand was typically loose to depths of up to about 1 m, and then typically becomes medium dense.

Groundwater was encountered in standpipes at depths between 1.2 m to 2 m (RL 20.5 m to RL 21.6 m AHD) below the current ground surface during our investigation (November 2024). The DBCA mapping data base indicates that the site is mapped as "Sumpland / Dampland", being a seasonally waterlogged area. **Design groundwater levels for the site must be assessed by a suitably qualified civil engineer or hydrologist**. **Filling with the site permeable sand and subsoil drains could be required.**

A site classification, in accordance with AS 2870-2011, of "Class A" is applicable to this site in its current condition. This classification does not take into account possible shallow groundwater discussed above.

Soak wells could be considered for the site if the base of soakwells are no closer than 0.5 m to the design groundwater level. This is likely to require filling / raising of the site and subsoil drains.

3. SITE DESCRIPTION

Table 1: Summary of Site

Item	Comment
Site Extent	Refer Figure 1, Site and Location Plan
Site Area	Around 2 ha (Lot 8 – 10,010 m^2, Lot 16 – 10,032 m^2)
Current Site Surface Levels[1]	Lot 8: RL 22.5 m AHD to the north to RL 23.5 m AHD to the south Lot 16: RL 21.5 m AHD to the north to RL 23.0 m AHD to the south
Vegetation	Light grass and bushes with mature trees along lot / property boundaries.
Existing Infrastructure	Single storey residences and other associated structures (sheds/greenhouse etc.) in the north east part of the site
Site History[2]	A review of historical aerial images indicates the site was previously occupied by a farm (possibly stable or piggery), demolished around the mid-1980s. The current residential dwellings were constructed later, with the site relatively unchanged since.

NOTES: ***1.*** *Site levels based on the supplied feature survey plan.*

2. *Site history based on aerial imagery (Landgate).*

4. PROPOSED DEVELOPMENT

Table 2: Summary of Proposed Development

Item	Comment
Proposed Development	18 warehouses ranging from 280 m^2 and 1,240 m^2 (refer Appendix A).
Proposed Finished Level	around RL 23.60 m AHD (or possibly higher).
Cut/Fill	Filling of about 0.2 m to 2.0 m to achieve proposed design level. Dewatering may be required for temporary excavations.
Assumed Foundation Type	Slabs on ground supported by shallow footings.
Assumed Retaining Walls	Gravity walls possibly up to about 1 m high.

NOTES: ***1.*** *Proposed development details based on supplied information presented in Appendix A.*

5. PROJECT OBJECTIVES

The objectives of the study were to:

- assess subsurface soil and groundwater conditions across the site;
- provide recommendations on suitable footing systems for the proposed development;
- provide allowable bearing pressure and settlement estimates for shallow foundations;
- provide a site classification(s) in accordance with AS 2870-2011 “Residential Slabs and Footings”;
- provide recommendations and geotechnical design parameters for earth retaining structures, including temporary support;
- assess the appropriate site subsoil class for the site in accordance with AS 1170.4-2007
- recommend appropriate site preparation procedures including compaction criteria;
- assess the permeability of the soils at the site for potential on-site disposal of stormwater by infiltration; and
- provide a subgrade California bearing ratio (CBR) value for pavement thickness design by others.

6. FIELDWORK

6.1. General

Fieldwork was carried out by Galt on 19 and 20 November 2024 and comprised:

Table 3: Summary of Field Data

Type	Results Appendix	Summary	GDR Clause	Equipment Used	No. Tests	Depth Range (m)
Site Plan	Figure 1	-	-	Hand held GPS[1]	-	-
Photographs	B	-	-	-	-	-
Cone Penetration Tests (CPTs)	C	Section 9	GDR3.2	Pagani TG 73-200	10	2.5 – 6.9
Machine Auger Borehole (BH)	D	Section 9	GDR3.3	Scout	16	2.1 – 3.0
Infiltration Tests (IT)	E	Section 6.2	GDR3.7	Inverse auger hole	5	
Guelph Permeameter Tests (G)	F	Section 6.3	GDR3.8	Guelph permeameter	4	
Standpipe (SP)	-	Section 6.4	-	32mm PVC pipe	2	2.62 – 2.76

NOTES: ***1.*** *Hand held GPS is accurate to ±5 m.*

6.2. Infiltration Test Results

Table 4: Infiltration Test Results

Test Location	Soil Description	Depth (m)	Minimum Unsaturated Hydraulic Conductivity, k_{unsat} (m/day)
BH07/IT01	SAND (SP)	0.88	>15
BH08/IT02		0.86	6.3
BH10/IT03		0.82	3.9
BH16/IT04		0.77	7.1
BH06/IT05		0.77	>15

NOTES: **1.** *Infiltration test method using inverse auger is explained in GDR3.7*

2. *Conductivities greater than 15 m/day not reported due to inaccuracies of the test in highly permeable soils.*

6.3. Guelph Permeameter Test Results

Table 5: Guelph Permeameter Test Results

Test Location	Soil Description	Depth (m)	Minimum Saturated Hydraulic Conductivity, k_{sat} (m/day)	Soil Type[2]
G01	SAND (SP)	0.44	5.11	1
G02		0.50	3.17	
G03		0.39	3.26	
G04		0.40	10.95	

NOTES: **1.** *Constant head Guelph Permeameter tests were carried out in hand-auger boreholes in accordance with Appendix G of AS1547 (2012) "On-site domestic wastewater management".*

2. *Soil type is as per Table L1 of AS1547-2012.*

6.4. Standpipe Details

PVC (32mm diameter) standpipes were installed within/near the proposed LAA (land application area) at 2 locations within the boreholes.

Table 6: Standpipe Details

Test Location	Depth of Installation (m)	Stickup – above ground (m)	Depth to Groundwater (m BGL)		Groundwater Levels (m AHD)	Construction Details
			20/11/2024	25/11/2024		
SP01 (G01)	2.62	0.38	1.20	1.23	20.5	1.5 m solid section over 1.5 m slotted section
SP02 (BH16)	2.76	0.24	1.96	2.02	21.6	

NOTES: **1.** *"BGL" – below existing ground level at the time of our investigation.*

2. *Standpipes were dipped on the day after installation on 20/11/2024 and again on 25/11/2024.*

3. *Site surface levels based on client-provided feature survey*

7. LABORATORY TESTING

Geotechnical and chemical laboratory testing of soil samples was undertaken by Western Geotechnical and Laboratory Services (WGLS) and Envirolab Services (WA) at their NATA accredited laboratory. Laboratory test results along with the test methods followed are presented in Appendix G and summarised in Attached Tables 1 and 2.

8. SITE CONDITIONS

8.1. Geology

Table 7: Summary of Geology Mapping

Map Sheet	Map Scale	Mapped Soils	Site Findings
Perth	1:250,000	BASSENDEAN SAND of variable thickness over GUILDFORD FORMATION clayey soils. Peaty Clay Swamp Deposits mapped in south west part of site.	SAND (SP) interbedded with cemented layers (“coffee rock”), extending to maximum depth investigated of 6.9 m. Swamp deposits not encountered.

8.2. Groundwater

Table 8: Summary of Groundwater Levels

Item	Date	Depth Range (m bgl)	Elevation Range (m AHD)	Comment
Perth Groundwater Atlas	2004	7.0 to 9.5[1]	14.0 to 14.5	Typical end of summer groundwater level. Could possibly represent deeper aquifer at the site.
Perth Groundwater Atlas	2019	2.5 to 5.5[1]	18.0 to 19.0	Season maximum groundwater level in 2019 only.
DBCA Mapping	-	-	-	Site mapped as “Sumpland / Dampland”, being a seasonally waterlogged area.
Site observations[1]	Nov 2024	1.2 to 2.0	20.5 to 21.6[1]	-
Recommended Design	-	-	-	Design groundwater levels for the site must be assessed by a suitably qualified civil engineer or hydrologist. Filling with the site permeable sand and subsoil drains could be required.

NOTES:

1. *Based on ground levels inferred from feature survey plan provided.*
2. *“bgl” – below existing ground level at the time of our investigation*
3. *‘Groundwater not encountered’ note on borehole logs is not an absence of groundwater – groundwater likely present within all drilled depths, however holes collapsed prior to being able to measure the depth to groundwater.*

9. GROUND MODEL

The encountered subsurface conditions can be summarised as comprising:

- **SAND (SP):** fine to medium grained, subangular to subrounded, grey, trace fines, trace rootlets near surface, typically loose to about 0.5 m to 1.0 m depth, and then becomes medium dense medium dense to investigated depth of 6.9 m; **Interbedded with**
- **"Coffee Rock" / Iron Cemented Sand:** typically recovered as sand, fine to medium grained, sub-angular to subrounded, dark grey/brown, trace fines variable cementation, layers present between about 1.8 m and 4.0 m depth. Resulting in refusal of boreholes / CPTs in the footprint of Lot 8 (proposed warehouse 1 to 4) between about 2.0 m and 3.0 m depth.

Geotechnical design parameters for the generalised subsurface units are described in Table 9 below.

Table 9: Geotechnical Model Units and Design Parameters

Unit Name	γ_{bulk} (kN/m^3)	ϕ' (°)	E_v (MPa)	k_0	Wall Friction=0		Wall Friction=0.5ϕ	
					k_a	k_p	k_a	k_p
Approved Fill Refer Table 10	18	36	50	0.41	0.26	3.85	0.22	6.54
Surficial Loose Sand to about 0.5 m to 1.0 m depth	18	32	10	0.47	0.31	3.25	0.27	4.96
Medium Dense Sand	18	36	30	0.41	0.26	3.85	0.22	6.54

NOTES:

1. *These units are a generalization of results from individual tests, which should be referred to for more information.*

2. *Conditions at CPT locations below depth of soil sample recovery are inferred (refer to clause GDR3.2)*

3. *Topsoil and coffee rock are not included as a discrete unit.*

4. *For all earth pressure coefficients (retaining wall design) refer to clause GDR11.2 for more detail and interpretation. Unit weights for retaining structure design should be as per GDR11.2 or 1 kN/m^3 greater than the values in the table above.*

γ_{bulk} *– bulk unit weight*

ϕ' *– effective friction angle*

E_v *– vertical elastic modulus*

k_a *– coefficient of active earth pressure (Coulomb – AS4678-2002, Appendix E)*

k_p *– coefficient of passive earth pressure (Coulomb – AS4678-2002, Appendix E)*

k_0 *– coefficient of at-rest earth pressure (Jaky)*

10. GEOTECHNICAL ASSESSMENT

10.1. Summary

Table 10: Summary of Geotechnical Assessment

Type	Clause	Parameter	Comment
Site Suitability	-	-	We consider the site to be geotechnically suitable for the proposed development. **However, raising the site with fill (and possibly subsoil drains) is likely to be required to achieve adequate clearance to design groundwater levels. Design groundwater levels must be assessed by a suitably qualified civil engineer or hydrologist.**
Site Classification (AS2870)	GDR5	A	AS2870-2011 is not strictly applicable to the proposed development. This site classification assumes that there is adequate clearance from the design groundwater level as discussed above.
Site Subsoil Class (AS1170.4)	-	Ce	-
Site Preparation	GDR6	-	**GDR6.2.1 Common Measures** followed by **GDR6.2.2 Sand Sites.**
Approved Fill	GDR8	-	**Approved Fill** for this site is to comprise **General Sand, with a minimum saturated hydraulic conductivity of 3 m/day.** All in situ sand may be assumed to be **Approved Fill**. If additional fill is required, imported **Approved Fill** will be needed.
Compaction Control	GDR7	-	A PSP may be used for compaction control on site-derived **Approved Fill.** Deemed to comply values for 'Bassendean' sand in GDR7.4 are applicable. Difficulty may be experienced achieving compaction when the groundwater is within about 1 m of the surface. **Localised dewatering may be required, particularly if works occur during winter.**
Shallow Footings	GDR9	q_{all} = 170 kPa to 250 kPa	Refer to Section 10.2. Groundwater assumed to be no higher than footing invert level.
Earth Pressure Coefficients	GDR11	GDR3.4	Earth pressure coefficients can be used for the generalised subsurface units presented in Table 9.
Batters	GDR12	1V:2H (temporary) 1V:3H (permanent)	Batter angles apply to sand units above the water table, as per GDR12.3. Retention below groundwater will require structural retaining elements (i.e. shoring). **Localised dewatering may be required, particularly if works occur during winter.**
Excavation Conditions	GDR12	10 tonne excavator	The **possible presence of coffee rock**, and other obstructions (i.e. buried services, old footings and slabs, etc..) must be taken into account when selecting excavation equipment.
Unsaturated Hydraulic Conductivity	GDR13	k_{unsat} = 3 m/day	k_{unsat} value applies where disposing into **Approved Fill** or natural sand, **minimum 0.5 m above the groundwater table** GDR13.4. Raising the site with fill and possibly subsoil drains is likely to be required to achieve adequate clearance to groundwater as discussed above.
Pavement Subgrade CBR	GDR16	CBR = 10%	Subgrade to comprise compacted **Approved Fill** or compacted in situ sand

NOTES: ***1.*** *q_{all} – allowable bearing pressure (maximum for all footings, refer to footing tables for further details)*

10.2. Shallow Footings

Table 11: Isolated Pad Footing Allowable Bearing Pressures and Estimated Settlements

d_e (m)	b (m)	q_{all} (kPa)	s (mm)
0.5	0.5	250	< 5
0.5	1.0	250	5 to 10
0.5	2.0	250	10 to 15
1.0	1.0	250	5 to 10
1.0	2.0	250	10 to 15

NOTES:

1. *d_e – minimum embedment depth (below finished ground level or floor slab).*
2. *b – Footing breadth (footings assumed approximately square).*
3. *q_{all} – allowable bearing pressure (peak). Limited to keep estimated settlements less than 25 mm. Higher q_{all} may be possible if higher settlements can be tolerated – refer queries to us.*
4. *s – estimated settlement (excludes shrink/swell from site class).*
5. *Refer to GDR9.*
6. *Groundwater assumed to be no higher than footing invert level.*

Table 12: Isolated Strip Footing Allowable Bearing Pressures and Estimated Settlements

d_e (m)	b (m)	q_{all} (kPa)	s (mm)
0.5	0.5	170	< 5
0.5	1.0	200	10 to 15
0.5	2.0	220	20 to 25
1.0	1.0	250	10 to 15
1.0	2.0	250	20 to 25

NOTES:

1. *d_e – minimum embedment depth (below finished ground level or floor slab).*
2. *b – Footing breadth (footings assumed long relative to breadth).*
3. *q_{all} – allowable bearing pressure (peak). Limited to keep estimated settlements less than 25 mm. Higher q_{all} may be possible if higher settlements can be tolerated – refer queries to us.*
4. *s – estimated settlement (excludes shrink/swell from site class).*
5. *Refer to GDR9.*
6. *Groundwater assumed to be no higher than footing invert level.*

11. CLOSURE

GALT GEOTECHNICS

Owen Woodland
Geotechnical Engineer

William Yukun Feng
Geotechnical Engineer

https://galtgeo.sharepoint.com/sites/wag240438/shared documents/01 sarich si/03 correspondence/wag240438-01 001 r rev2 - geotech.docx

Attached Table 1: Summary of Geotechnical Index Test Results

Test Name	Sample Depth (m)	Soil Class (AS1726 2017)	Fines (%)	Sand (%)	Gravel (%)
G01	0.1 – 0.5	(SP) SAND	4	96	0
BH16	0.1 – 0.5	(SP) SAND	4	96	0

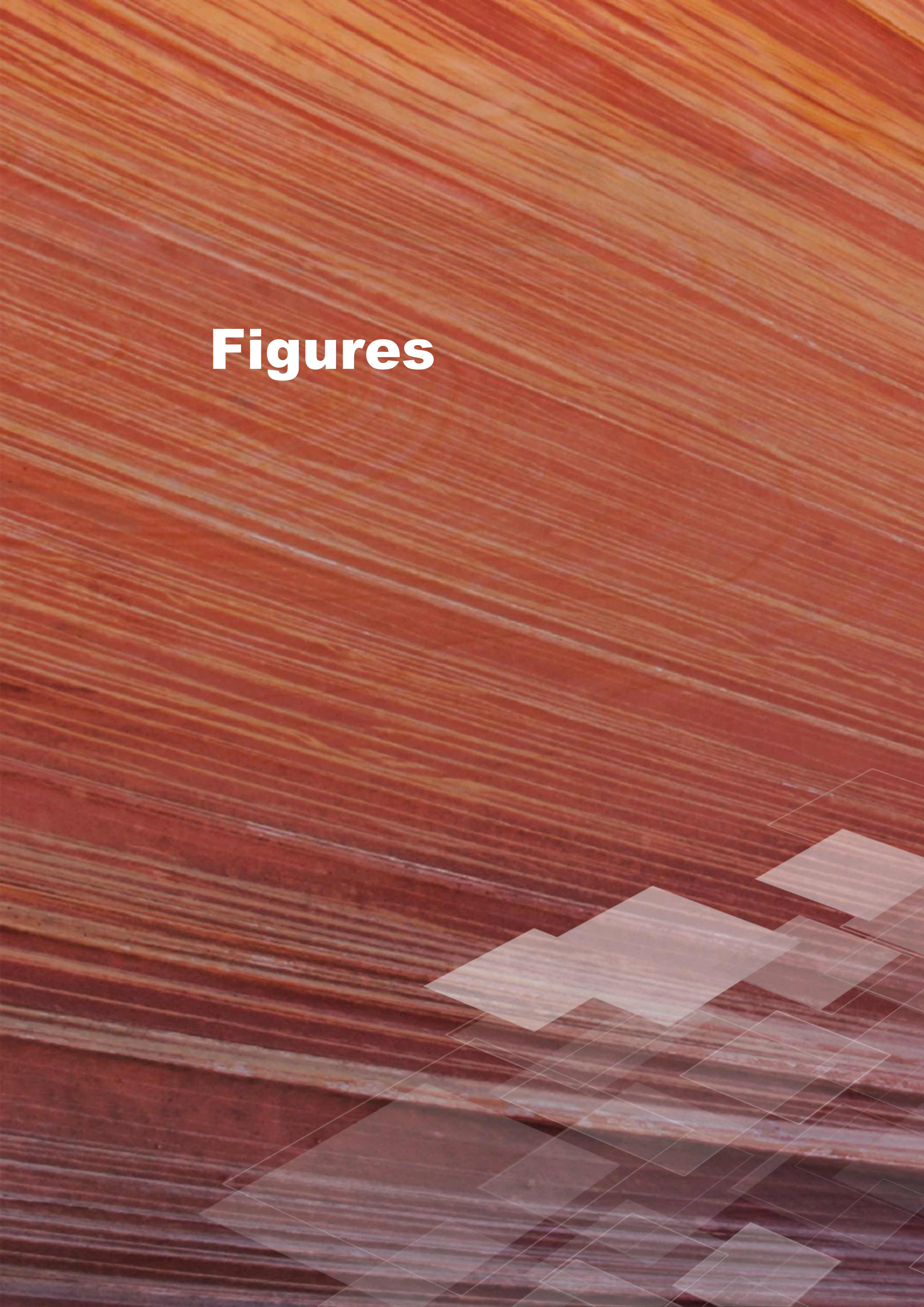
Notes 1. *Particle size distribution (by mass)*

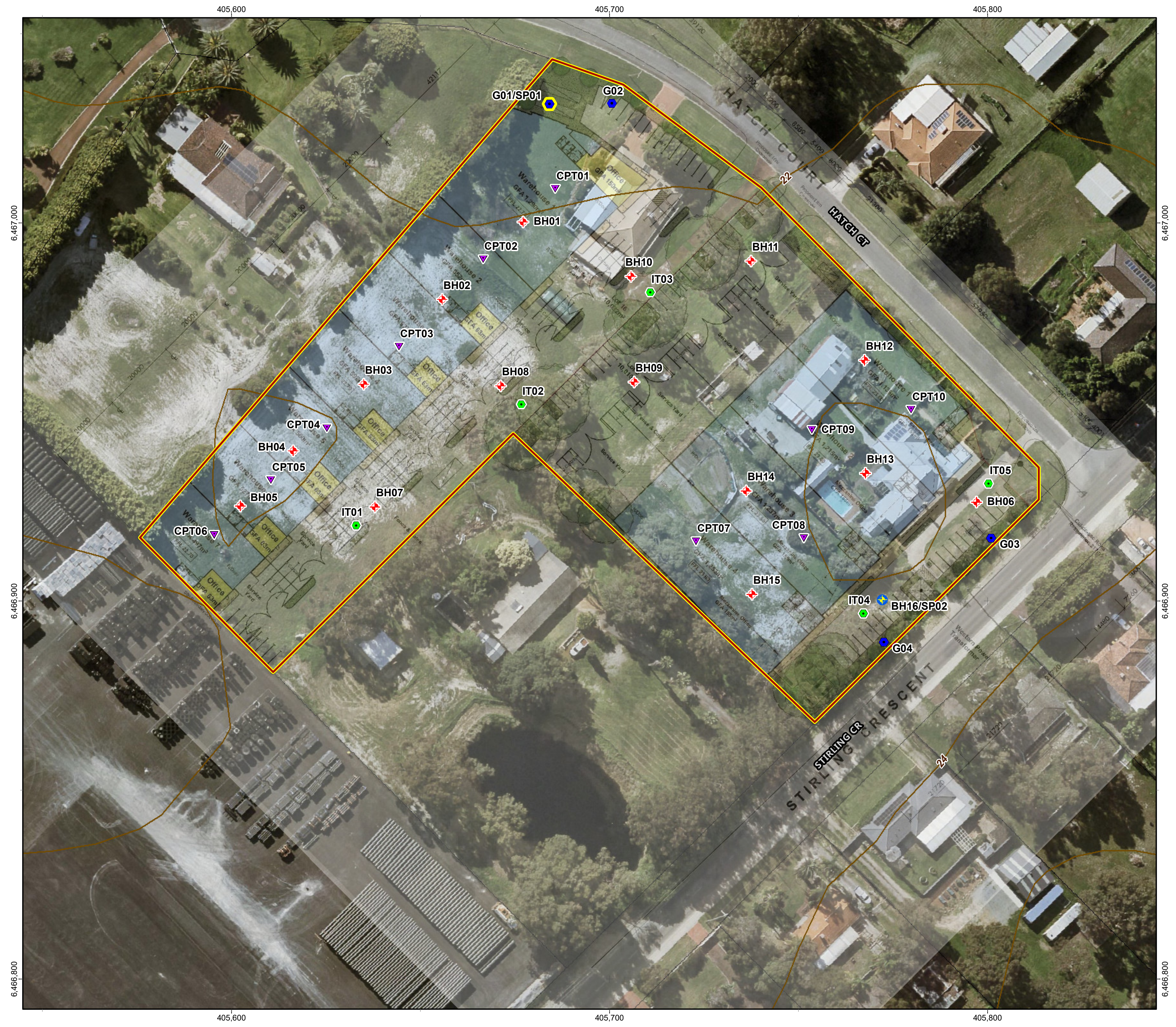
Gravel: 2.36 mm – 63 mm *Sand: 0.075 mm – 2.36 mm* *Fines: <0.075 mm*

Attached Table 2: Summary of Chemical Test Results

Test Name	Sample Depth (m)	Soil Class (AS1726 2017)	Electric Conductivity (us/cm)	pH	Phosphorus Retention Index	Exchangeable Sodium Percentage (%)
G01	0.1 – 0.5	(SP) SAND	32	5.8	-0.11	Not Reportable
BH16	0.1 – 0.5	(SP) SAND	36	6.2	-0.25	Not Reportable

Figures





Legend

- 🟥 Site Boundary
- ✚ Borehole
- ✚ Borehole / Standpipe
- ▼ Cone Penetration Test
- ● Guelph Permeameter
- ● Guelph Permeameter / Standpipe
- ● Infiltration Test

N

0 10 20 30 40 50

Meters

NOTES

Aerial Imagery and Cadastre sourced from Landgate/SLIP

SCALE	1:1,000	(A3)
DRAWN	CED	
DATE DRAWN	3/4/2025	
CHECKED	_	
DATE CHECKED	_	
PROJECTION	GDA 1994 MGA Zone 50	

Galt Geotechnics Pty Ltd
ACN : 138 490 865
Tel : +61 (0)8 6272-0200
Address : 50 Edward Street
Osborne Park WA 6017

CLIENT **SARICH BUILDING**

PROJECT PROPOSED INDUSTRIAL DEVELOPMENT

LOCATION LOTS 8 AND 16 SIRLING CRESCENT
HIGH WYCOMBE

TITLE SITE & LOCATION PLAN

Job No WAG240438-01 Fig No FIGURE 1 Rev **A**

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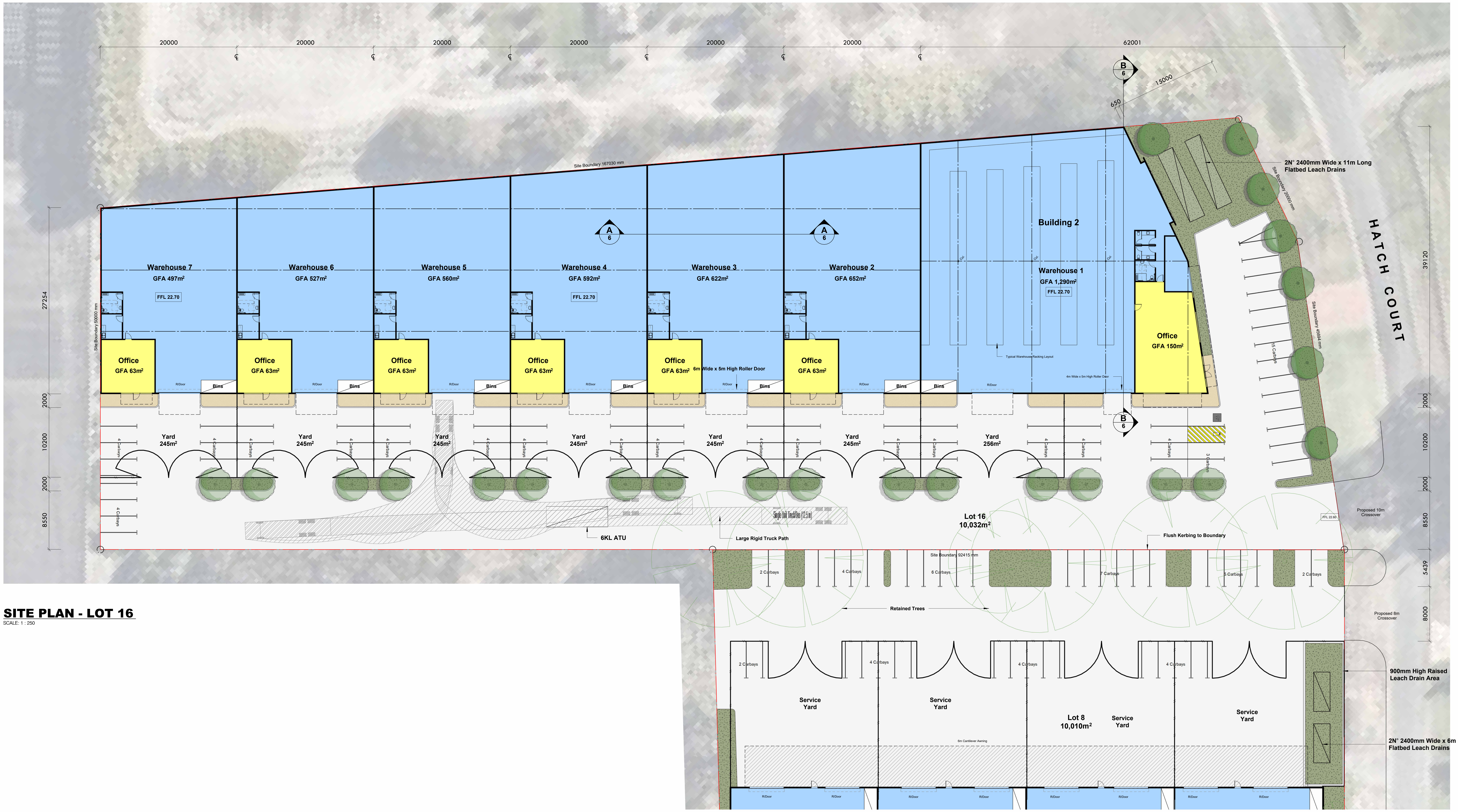
Appendices

Appendix A: Supplied Information



SITE PLAN - LOT 16

SCALE: 1 : 250

SITE CRITERIA

Lot 16

1. Site Area			
a. Site Area			**10,032m²**
2. Landscaping			
a. Provided			
Soft			**530m²**
3. Floor Area			
a. External Walls			62m²
b. Dividing Walls			15m²
c. Lunch			100m²
d. Toilets			85m²
e. Warehouse NLA			4,478m²
Total W/H GFA			**4,740m²**
f. Office NLA			504m²
G. Dividing Walls			24m²
Total Office GFA			**528m²**
Total GFA			**5,250m²**
4. Carparking (GFA)			
i. Cars Required			
a. Warehouse	3,000m²	@ 1/100	30 Cars
c. Industrial	1,740m²	@ 2/100	35 Cars
d. Office	504m²	@ 4/100	20 Cars
Total Car required			**85 Cars**
ii. Cars Required			
a. Cars Provided			86 Cars
Total			**86 Cars**
5. Plot Ratio			
i. Required Plot Ratio of 0.5			**5,016m²**
ii. Provided			
a. Warehouse NLA			4,478m²
b. Office NLA			504m²
Total Plot Ratio			**4,982m²**

Landscaping
A. Soft Landscaping
Defined as vegetative landscaping.

Gross Floor Area : GFA
A. All Floor Areas on this plan are shown as GROSS FLOOR AREA. Unless otherwise noted as Nett Floor Area
B. Definition of Gross Floor Area is defined as:
i/ GROSS FLOOR AREA OF TENANCY:
Gross Floor Area of an individual Tenancy is defined as the area contained between the centre line of common tenancy walls and the outside edge of external walls.
ii/ GROSS FLOOR AREA OF A BUILDING:
Gross Floor Area of a Building is defined as the total area contained between the outside edge of external walls

Nett Floor Area : NFA
A. Nett Floor Area of a Tenancy on this plan is defined as the area between external or tenancy dividing walls.
B. This area is inclusive of toilets if the toilets are exclusive to the Tenancy.

SITE DESIGN CHECKLIST

- ☐ **1. SEWER MAINS LOCATION TO BE DETERMINED**
- ☐ **2. FIRE MAINS PRESSURE TEST REQUIRED**
- ☐ **3. FIRE TANKS OR PUMPS TO BE DETERMINED**
- ☐ **4. WESTERN POWER TRANSFORMER LOCATION TO BE DETERMINED**
- ☐ **5. CROSSOVER & ACCESS TO STREET TO BE DETERMINED BY LOCAL AUTHORITY**
- ☐ **6. FULL FEATURE SITE SURVEY REQUIRED**
- ☐ **7. DIAL BEFORE YOU DIG REQUIRED**
- ☐ **8. BUSHFIRE ATTACK LEVEL (BAL) TO BE DETERMINED**
- ☐ **9. STREET POWER POLES TO BE DETERMINED**
- ☐ **10. SITE ZONING & USE TO BE DETERMINED**

NOTE: Any of the following items that do not have an 'X' in the provided square require determination.

LEGEND

🟦	**BUILDING FOOTPRINT - SHOWROOM / WAREHOUSE / FACTORY**
🟨	**BUILDING FOOTPRINT - OFFICE**
▨	**EXTENT OF CONCRETE HARDSTAND**
⬜	**EXTENT OF ROADBASE HARDSTAND**
▩	**EXTENT OF BITUMEN PAVING**
🟧	**EXTENT OF BRICK PAVING / CONCRETE PAVING**
🟩	**EXTENT OF LANDSCAPING**

meyer
shircore
architects

PROPOSED INDUSTRIAL DEVELOPMENT

LOCATION : LOT 16 CNR HATCH COURT & STIRLING CRESCENT, HIGH WYCOMBE
BY : SARICH

SARICH
BUILDING INDUSTRY

Member
Australian Institute of Architects

DATE: MARCH 2025
REVISION: SK010
SHEET: 3
SCALE: As indicated @B1

PROJECT NUMBER
9512

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PO Box 1294 Subiaco WA 6904
t: 08 9381 8511 e: msa@meyershircore.com.au

SITE CRITERIA

1. Site Area			
a. Cul-de-sac Road Resumption			217m²
b. Site Balance			9,793m²
Total			**10,010m²**
2. Landscaping			
a. Provided			**1,032m²**
Soft			
3. Floor Area			59m²
a. External Walls			47m²
b. Dividing Walls			119m²
c. Stairs + Foyer			102m²
d. Toilets & Lunch			4,517m²
e. Warehouse NLA			**4,844m²**
Total GF GFA			
			95m²
f. Mezzanine Toilets & Lunch Room			487m²
g. Mezzanine Office NLA			38m²
h. External Walls			**620m²**
Total MEZZ GFA			
			5,464m²
Total GFA			
4. Carparking (GFA)			
i. Cars Required			45 Cars
a. Warehouse	4,517m²	@ 1/100	19 Cars
b. Mezzanine Office	487m²	@ 4/100	**64 Cars**
Total Car required			
ii. Cars Required			61 Cars
a. Cars Provided			**61 Cars**
Total			
5. Plot Ratio			**5,005m²**
i. Required Plot Ratio of 0.5			
ii. Provided			487m²
a. First Floor Office NLA			4,517m²
b. Ground Floor Warehouse NLA			**5,004m²**
Total Plot Ratio			

Landscaping
A. Soft Landscaping
Defined as vegetative landscaping.

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LEGEND

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🟨	BUILDING FOOTPRINT - OFFICE
▨	EXTENT OF CONCRETE HARDSTAND
☐	EXTENT OF ROADBASE HARDSTAND
▨	EXTENT OF BITUMEN PAVING
▨	EXTENT OF BRICK PAVING / CONCRETE PAVING
🟩	EXTENT OF LANDSCAPING
●	EXISTING TREES TO BE RETAINED
●	PROPOSED TREES

SITE PLAN
SCALE: 1 : 200

meyer shircore architects

PROPOSED INDUSTRIAL DEVELOPMENT

LOCATION : LOT 8 CNR HATCH COURT & STIRLING CRESCENT, HIGH WYCOMBE
BY : SARICH

SARICH
BUILDING INDUSTRY

Member Australian Institute of Architects

0 2 4 6 8 10 20

DATE: MAR 2025
REVISION: SK027
SHEET: 3
SCALE: As indicated @B1

PROJECT NUMBER
24-9352

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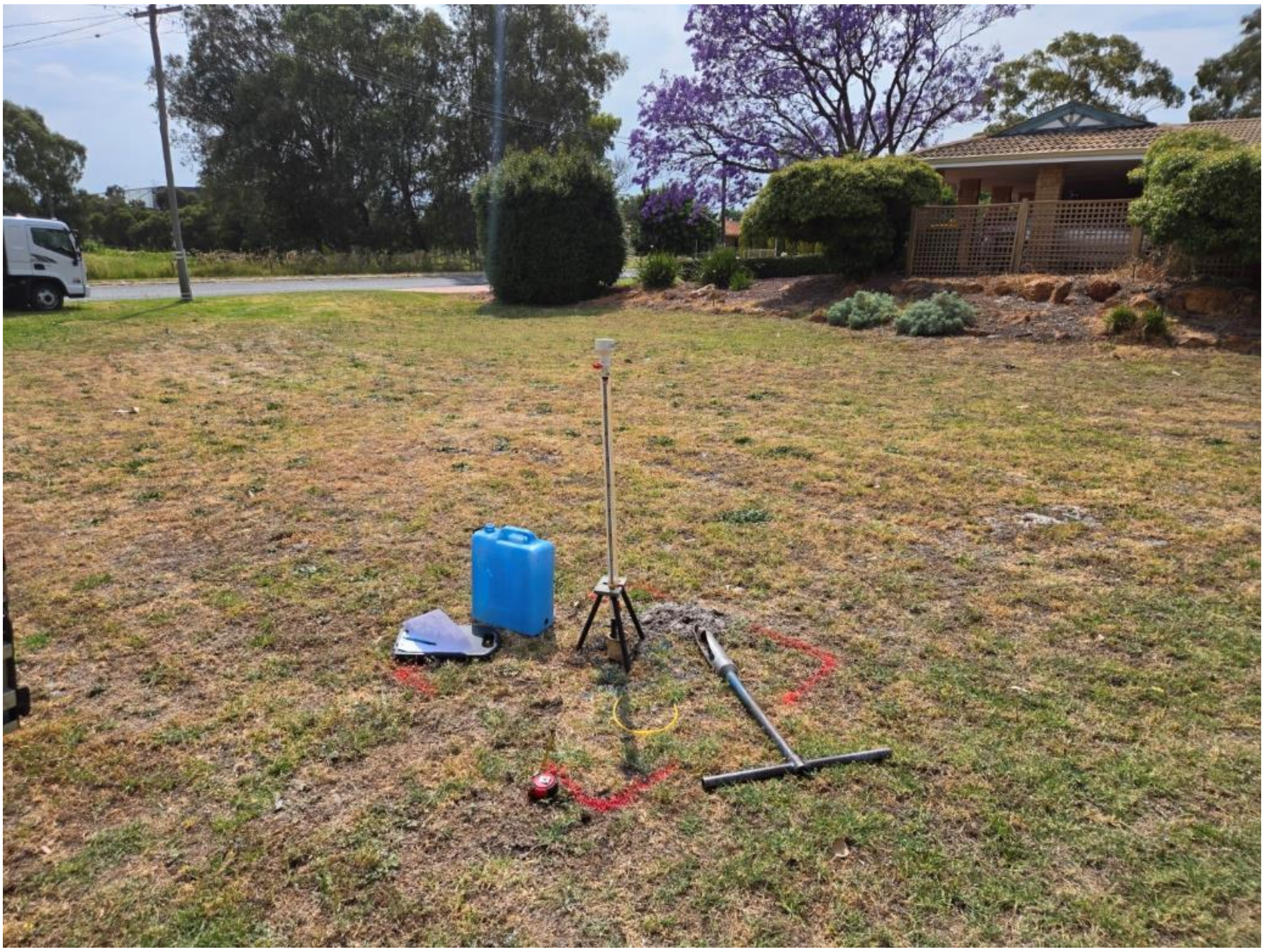
Appendix B: Site Photographs

Photograph 1:SP01 installed at G01

Photograph 2:SP02 installed at BH16

Photograph 3: Constand head permeability testing in progress at G01

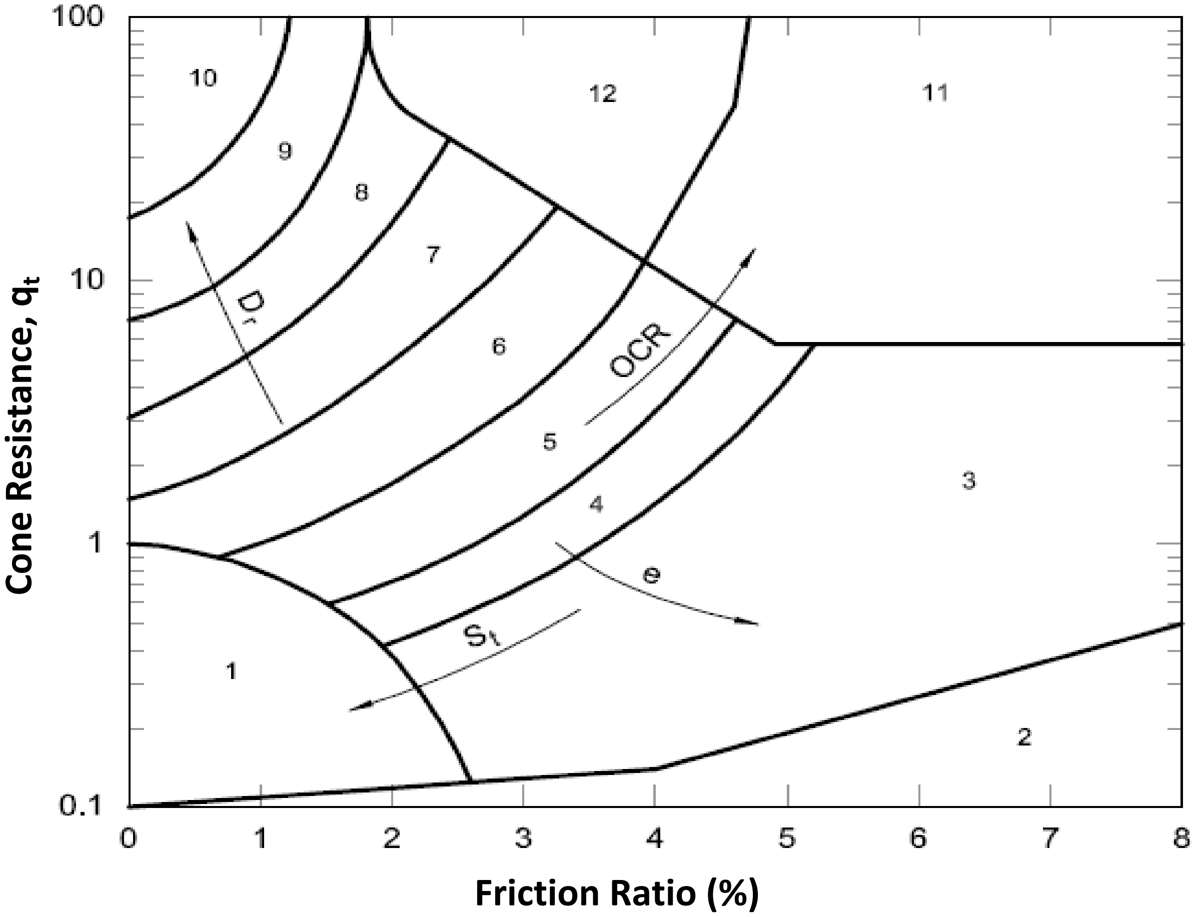


Photograph 4: CPT testing in progress at CPT04

Photograph 5: Existing residence on Lot 16 – no signs of settlement/ground movement related defects noted.

Photograph 6:Existing residence on Lot 8 – no signs of settlement/ground movement related defects noted.

Appendix C: CPT Test Results



DEFINITIONS

q_t : Cone tip resistance corrected for pore water pressure
S_t : Sensitivity
e : Void ratio
D_r : Relative density
OCR : Overconsolidation ratio
OC : Overconsolidated

SOIL BEHAVIOUR TYPE ZONES

1. Sensitive fine grained
2. Organic material
3. Clay
4. Silty clay to clay
5. Clayey silt to silty clay
6. Sandy silt to clayey silt
7. Silty sand to sandy silt
8. Sand to silty sand
9. Sand
10. Gravelly sand to sand
11. Very stiff fine grained material (OC/cemented)
12. Sand to clayey sand (OC/cemented)

NOTES

A. Some overlap in type zones is expected
B. Local correlations are preferred and may indicate soil type boundaries that are different from those shown above

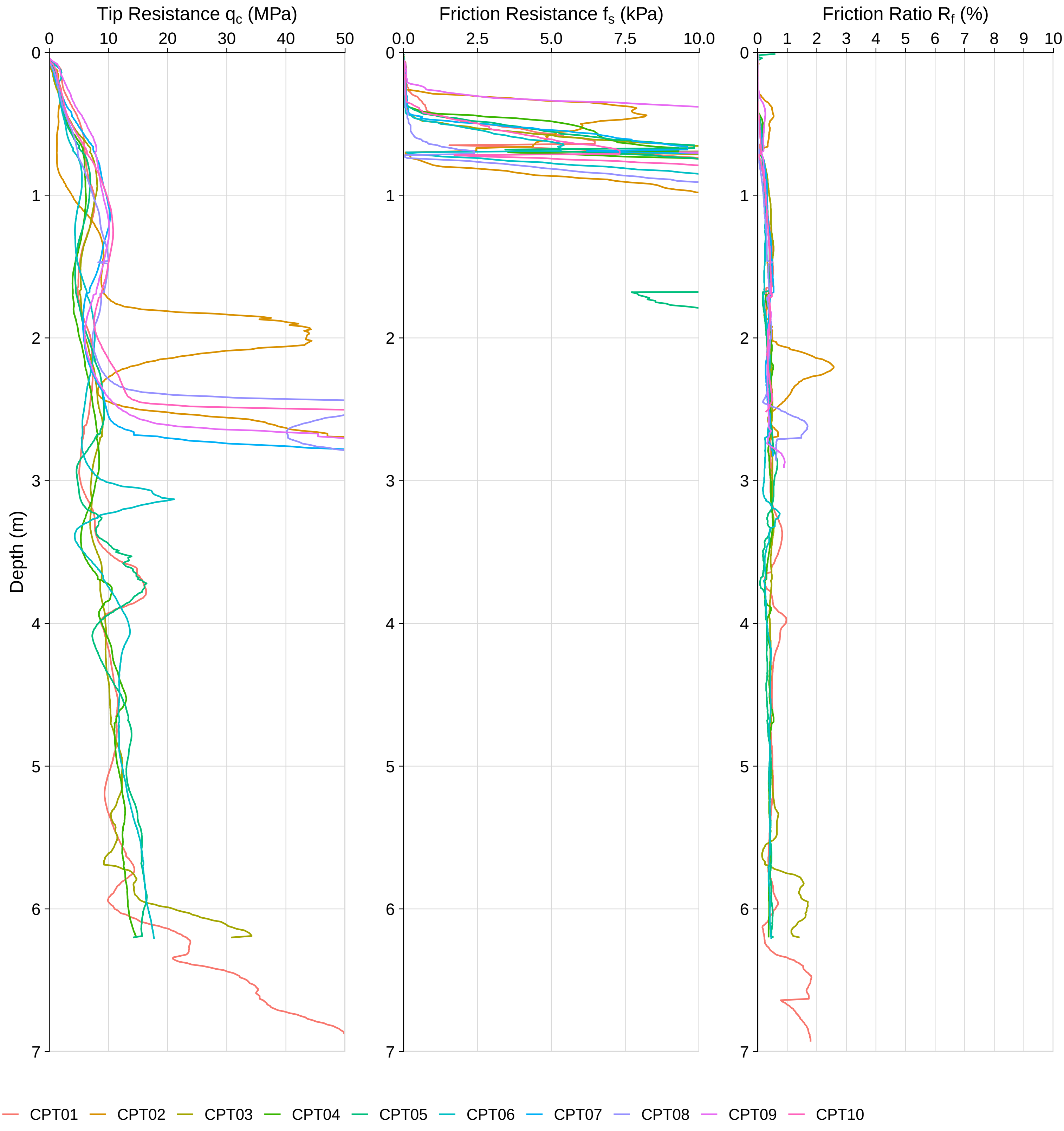
Reference: Robertson, P.K., Campanella, R.G., Gillespie, D. and Grieg, J. (1986) "Use of Piezometer Cone Data". Proceedings of the ASCE Speciality Conference In Situ '86: Use of In Situ Tests in Geotechnical Engineering, Blacksburg, pp 1263-80, American Society of Civil Engineers (ASCE)

Galt GEOTECHNICS

CONE PENETRATION TESTING (CPT) SOIL TYPE INTERPRETATION

CONE PENETRATION TEST

ALL TESTS		**CLIENT:**	SARICH BUILDING
JOB NUMBER:	WAG240438-01	**PROJECT:**	PROPOSED WAREHOUSE
DATE:	19/11/2024	**LOCATION:**	STIRLING CRESCENT, HIGH WYCOMBE



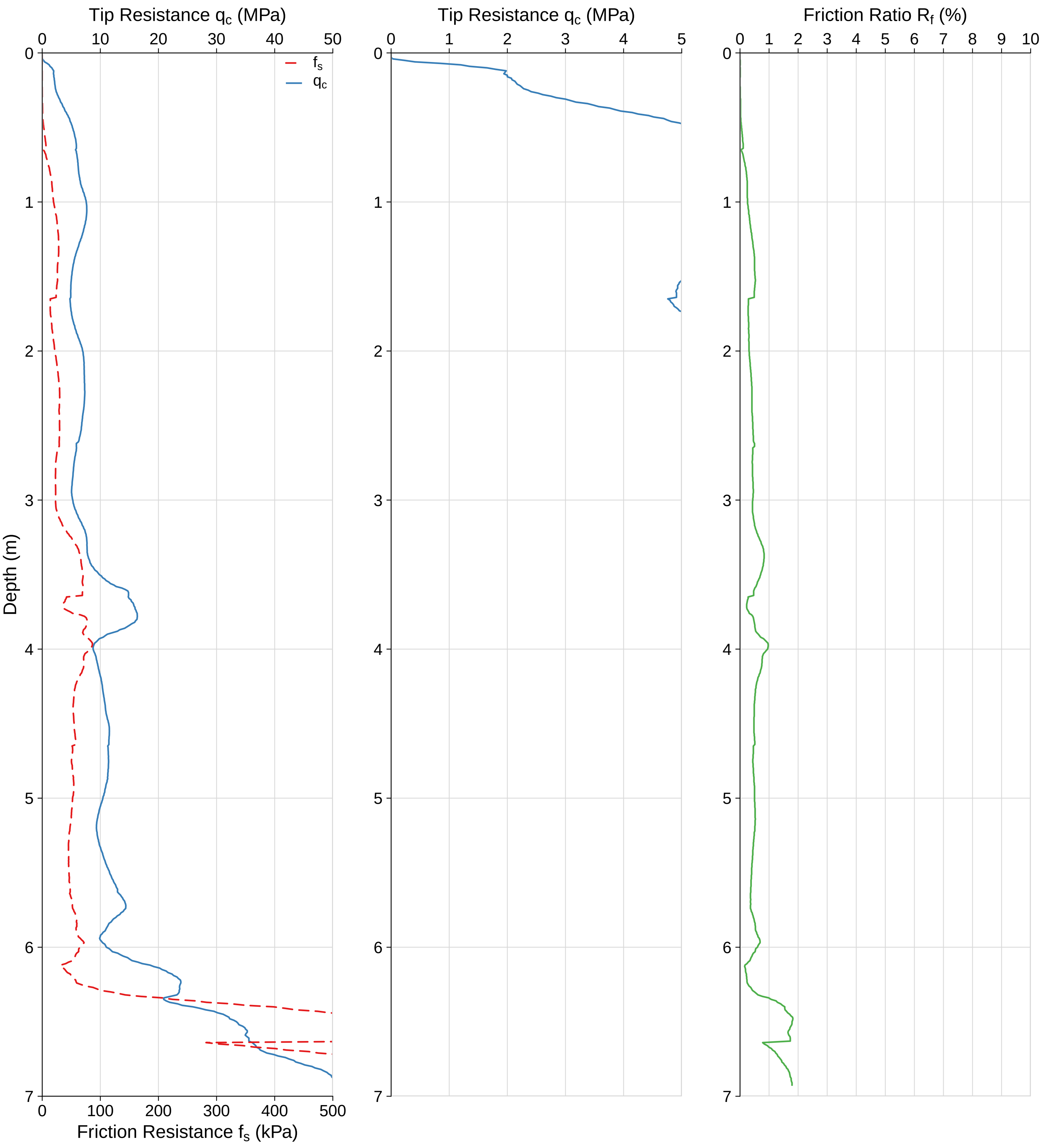
RIG: Pagani TG 73-200 200kN

GBI

Groundbreaking Investigations - Tested in accordance with AS 1289.6.5.1-1999

CONE PENETRATION TEST

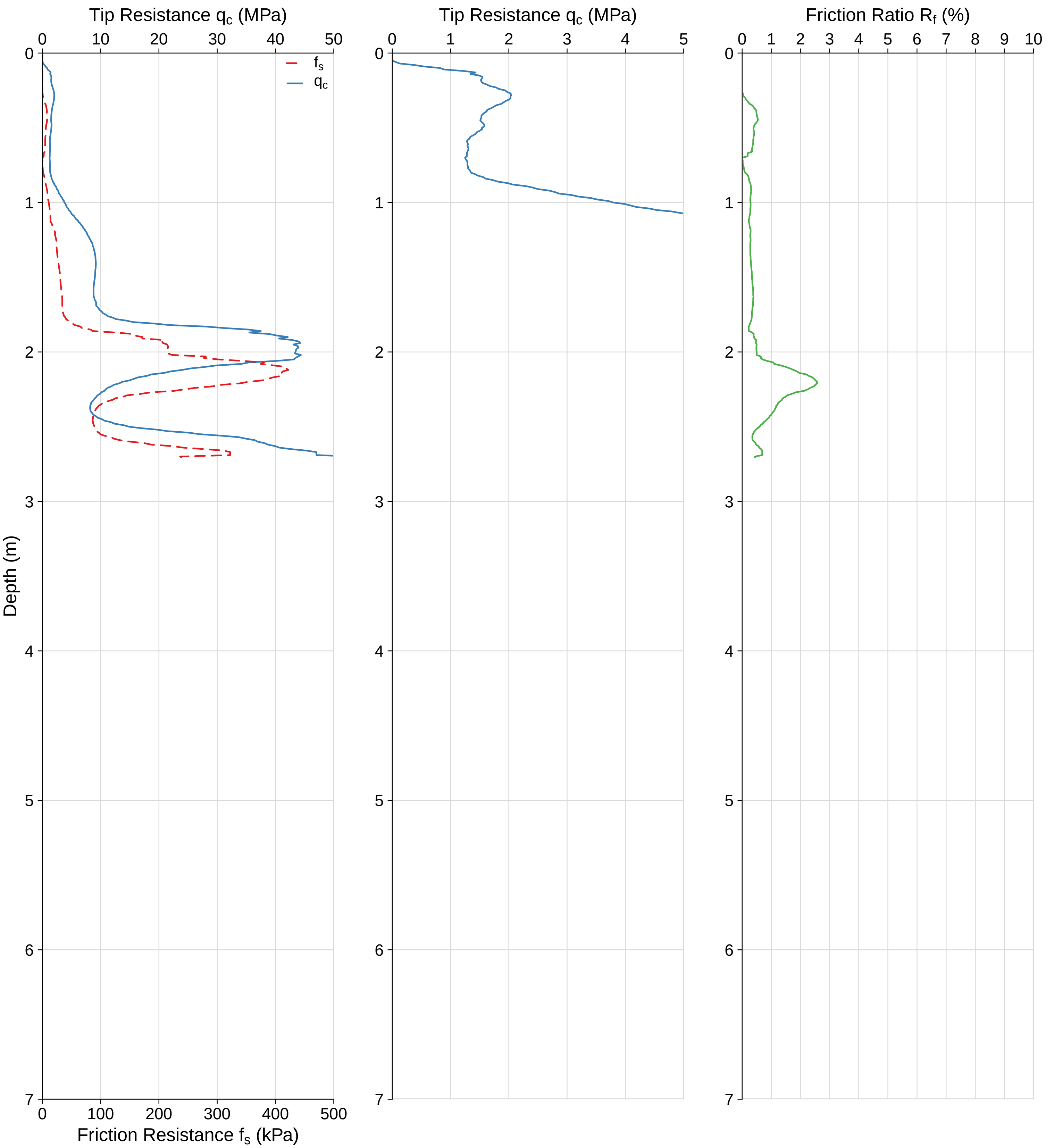
CPT ID:	CPT01	**CLIENT:**	SARICH BUILDING
JOB NUMBER:	WAG240438-01	**PROJECT:**	PROPOSED WAREHOUSE
DATE:	19/11/2024	**LOCATION:**	STIRLING CRESCENT, HIGH WYCOMBE



WATER:	Collapsed Dry @ 0.7m.	**CO-ORDS:**	
TERMINATION:	Target Depth 6.9M	**ELEVATION:**	
DUMMY PROBE:		**PRE-DRILL:**	
RIG:	Pagani TG 73-200 200kN	**WASHER/DISC:**	Steel

CONE PENETRATION TEST

CPT ID:	CPT02	**CLIENT:**	SARICH BUILDING
JOB NUMBER:	WAG240438-01	**PROJECT:**	PROPOSED WAREHOUSE
DATE:	19/11/2024	**LOCATION:**	STIRLING CRESCENT, HIGH WYCOMBE

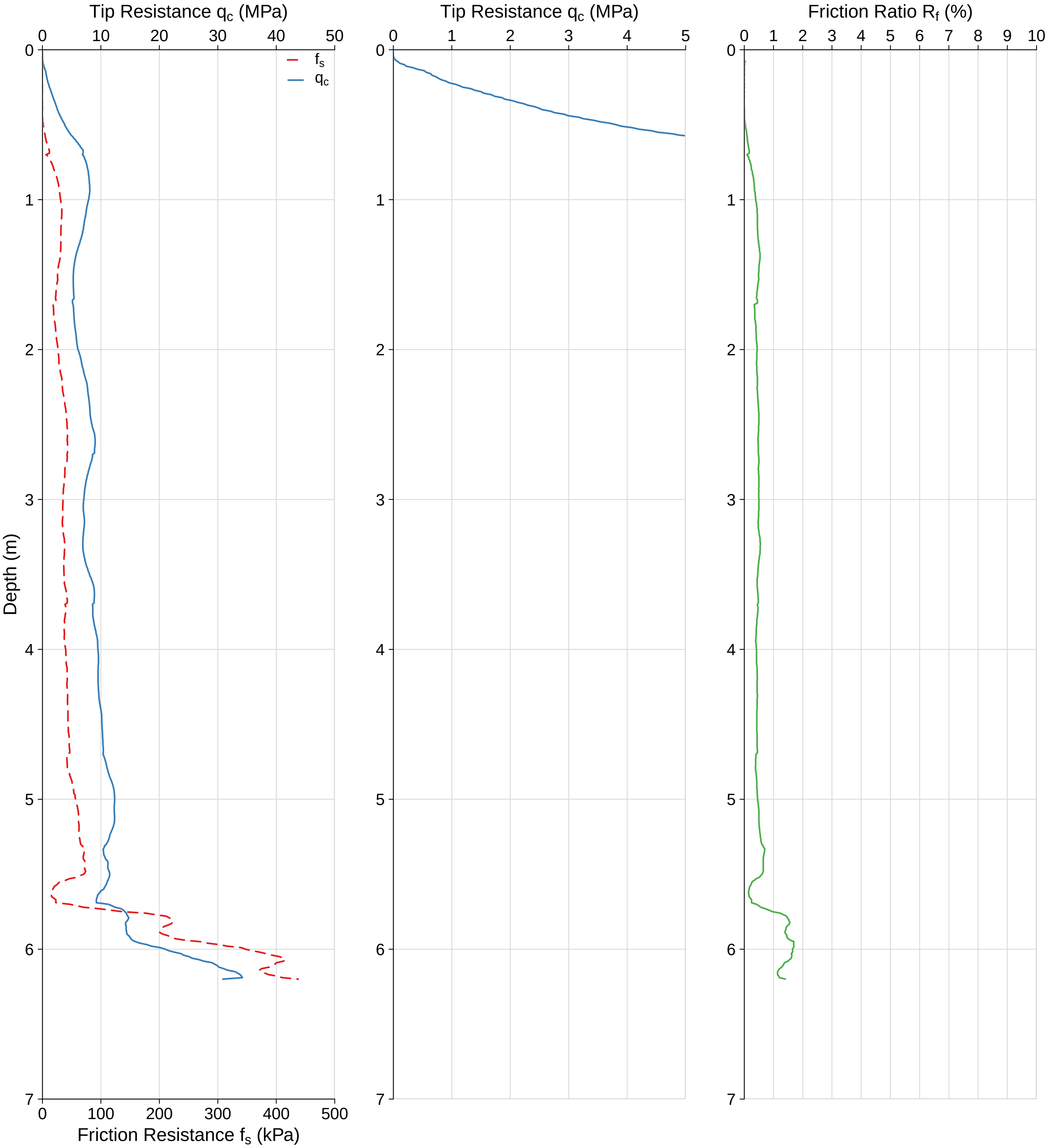


WATER:	Collapsed Dry @ 0.7m.	**CO-ORDS:**	
TERMINATION:	Refusal @ 2.7m.	**ELEVATION:**	
DUMMY PROBE:		**PRE-DRILL:**	
RIG:	Pagani TG 73-200 200kN	**WASHER/DISC:**	Steel

Groundbreaking Investigations - Tested in accordance with AS 1289.6.5.1-1999

CONE PENETRATION TEST

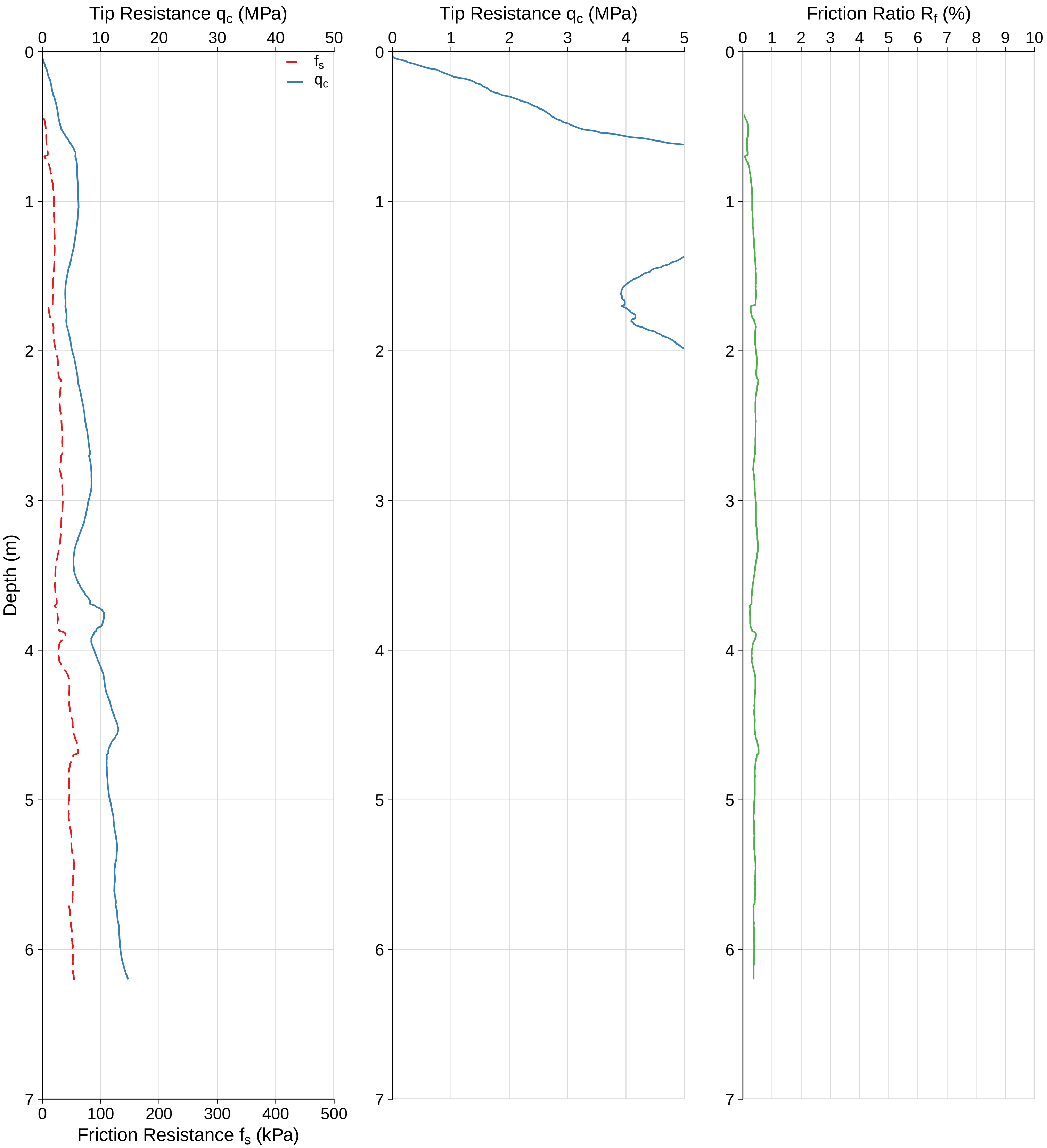
CPT ID:	CPT03	**CLIENT:**	SARICH BUILDING
JOB NUMBER:	WAG240438-01	**PROJECT:**	PROPOSED WAREHOUSE
DATE:	19/11/2024	**LOCATION:**	STIRLING CRESCENT, HIGH WYCOMBE



WATER:	Dry @ 0.3m.	**CO-ORDS:**	
TERMINATION:	Target Depth 6.2M	**ELEVATION:**	
DUMMY PROBE:		**PRE-DRILL:**	
RIG:	Pagani TG 73-200 200kN	**WASHER/DISC:**	Steel

CONE PENETRATION TEST

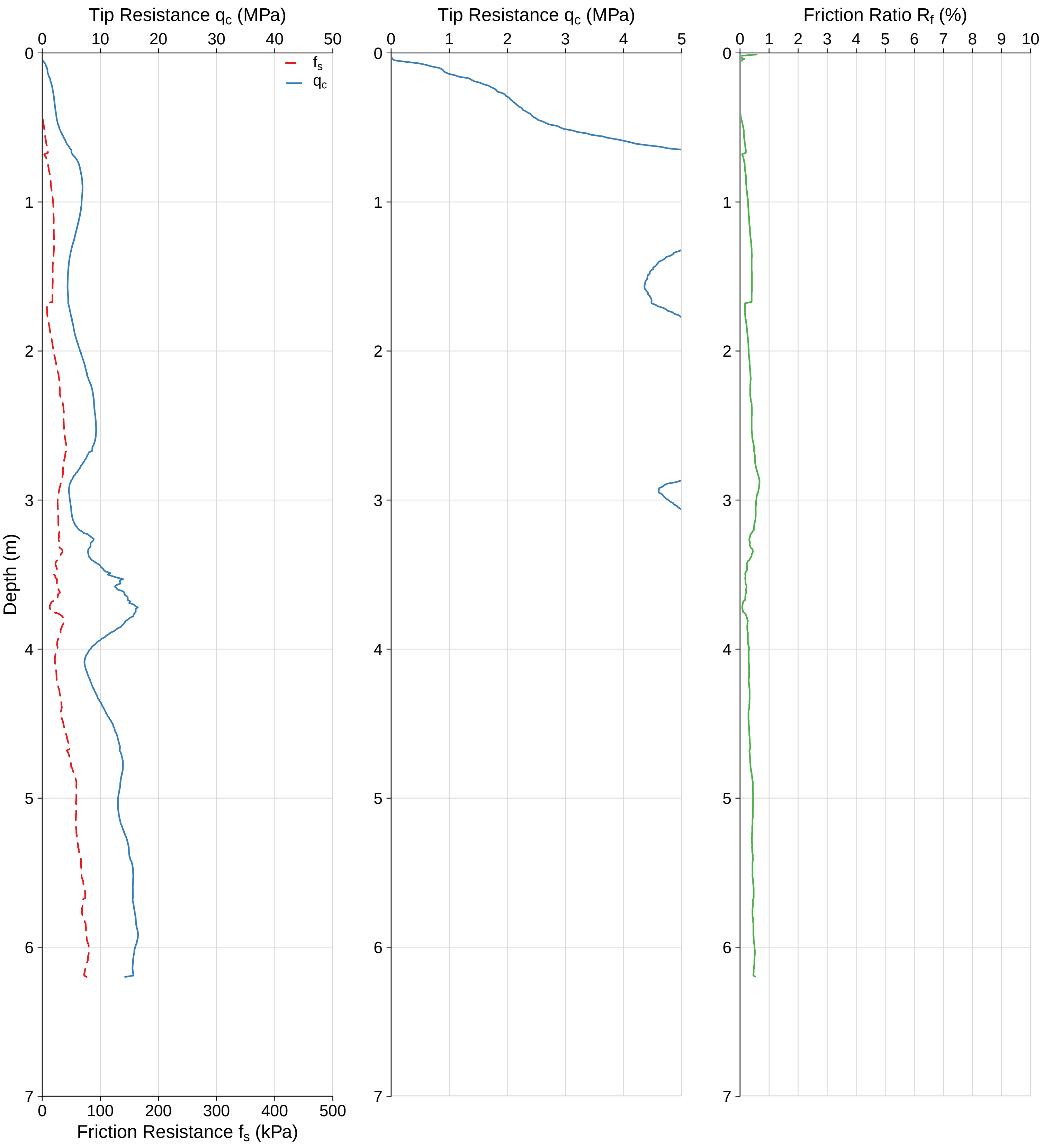
CPT ID:	CPT04	**CLIENT:**	SARICH BUILDING
JOB NUMBER:	WAG240438-01	**PROJECT:**	PROPOSED WAREHOUSE
DATE:	19/11/2024	**LOCATION:**	STIRLING CRESCENT, HIGH WYCOMBE



WATER:	Dry @ 0.3m.	**CO-ORDS:**	
TERMINATION:	Target Depth 6.2M	**ELEVATION:**	
DUMMY PROBE:		**PRE-DRILL:**	
RIG:	Pagani TG 73-200 200kN	**WASHER/DISC:**	Steel

CONE PENETRATION TEST

CPT ID:	CPT05	**CLIENT:**	SARICH BUILDING
JOB NUMBER:	WAG240438-01	**PROJECT:**	PROPOSED WAREHOUSE
DATE:	19/11/2024	**LOCATION:**	STIRLING CRESCENT, HIGH WYCOMBE



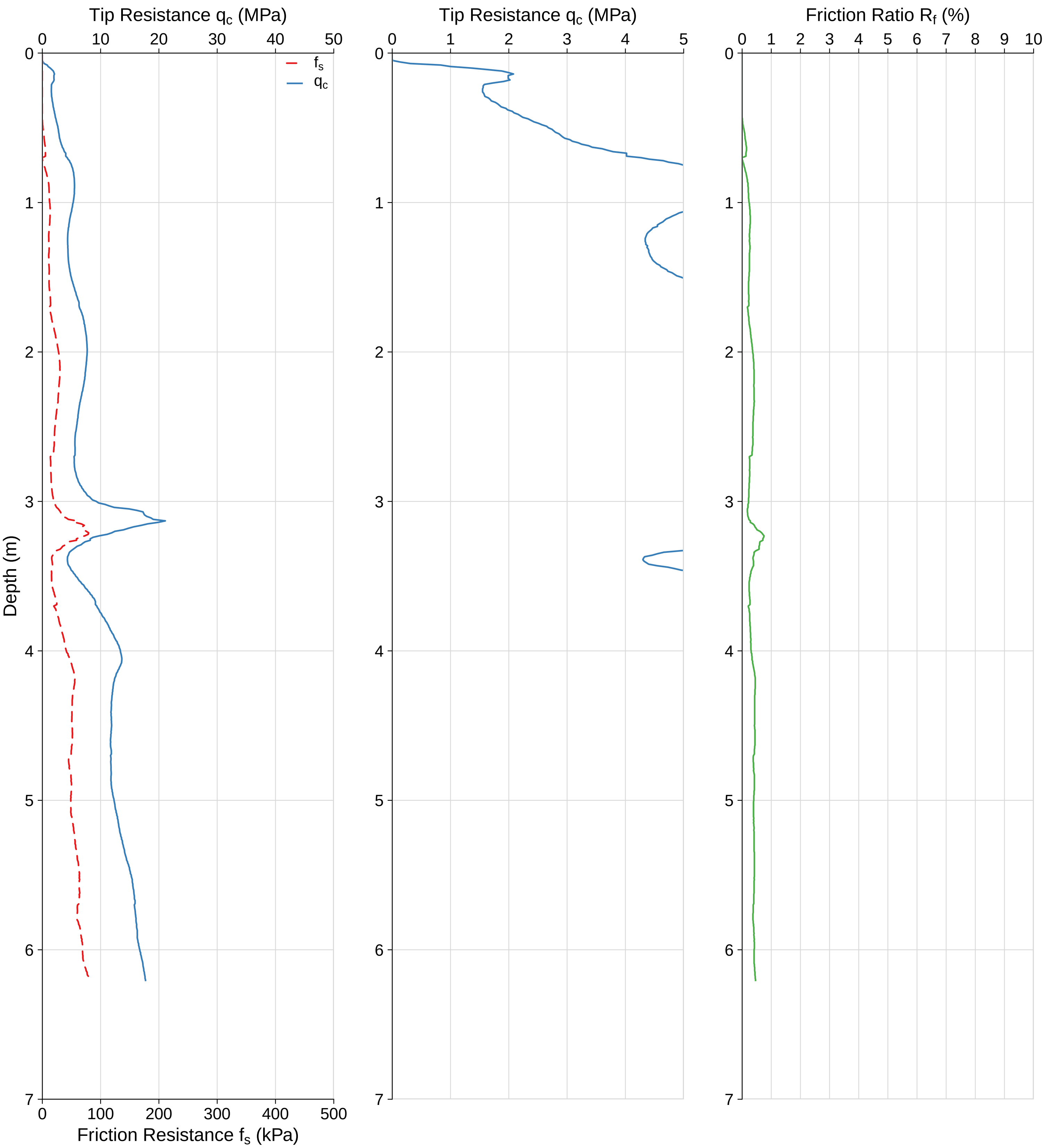
WATER:	Dry @ 0.3m.	**CO-ORDS:**	
TERMINATION:	Target Depth 6.2M	**ELEVATION:**	
DUMMY PROBE:		**PRE-DRILL:**	
RIG:	Pagani TG 73-200 200kN	**WASHER/DISC:**	Steel

Groundbreaking Investigations - Tested in accordance with AS 1289.6.5.1-1999

CONE PENETRATION TEST

CPT ID: CPT06
JOB NUMBER: WAG240438-01
DATE: 19/11/2024

CLIENT: SARICH BUILDING
PROJECT: PROPOSED WAREHOUSE
LOCATION: STIRLING CRESCENT, HIGH WYCOMBE



WATER: Dry @ 0.3m.
TERMINATION: Target Depth 6.2M
DUMMY PROBE:
RIG: Pagani TG 73-200 200kN

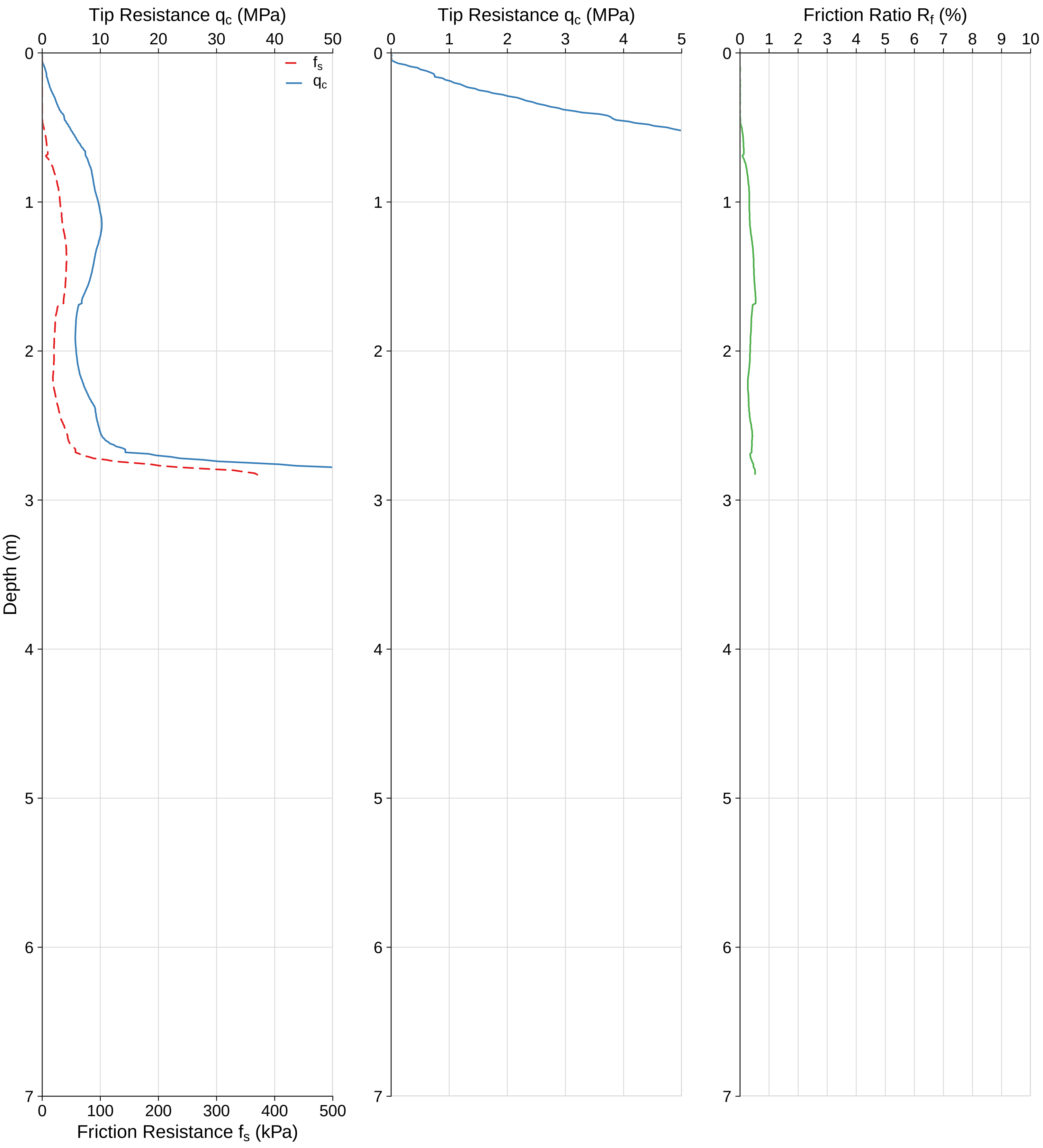
CO-ORDS:
ELEVATION:
PRE-DRILL:
WASHER/DISC: Steel

Groundbreaking Investigations - Tested in accordance with AS 1289.6.5.1-1999

CONE PENETRATION TEST

CPT ID: CPT07
JOB NUMBER: WAG240438-01
DATE: 19/11/2024

CLIENT: SARICH BUILDING
PROJECT: PROPOSED WAREHOUSE
LOCATION: STIRLING CRESCENT, HIGH WYCOMBE



WATER: Dry @ 0.2m.
TERMINATION: Refusal @ 2.83m
DUMMY PROBE:
RIG: Pagani TG 73-200 200kN

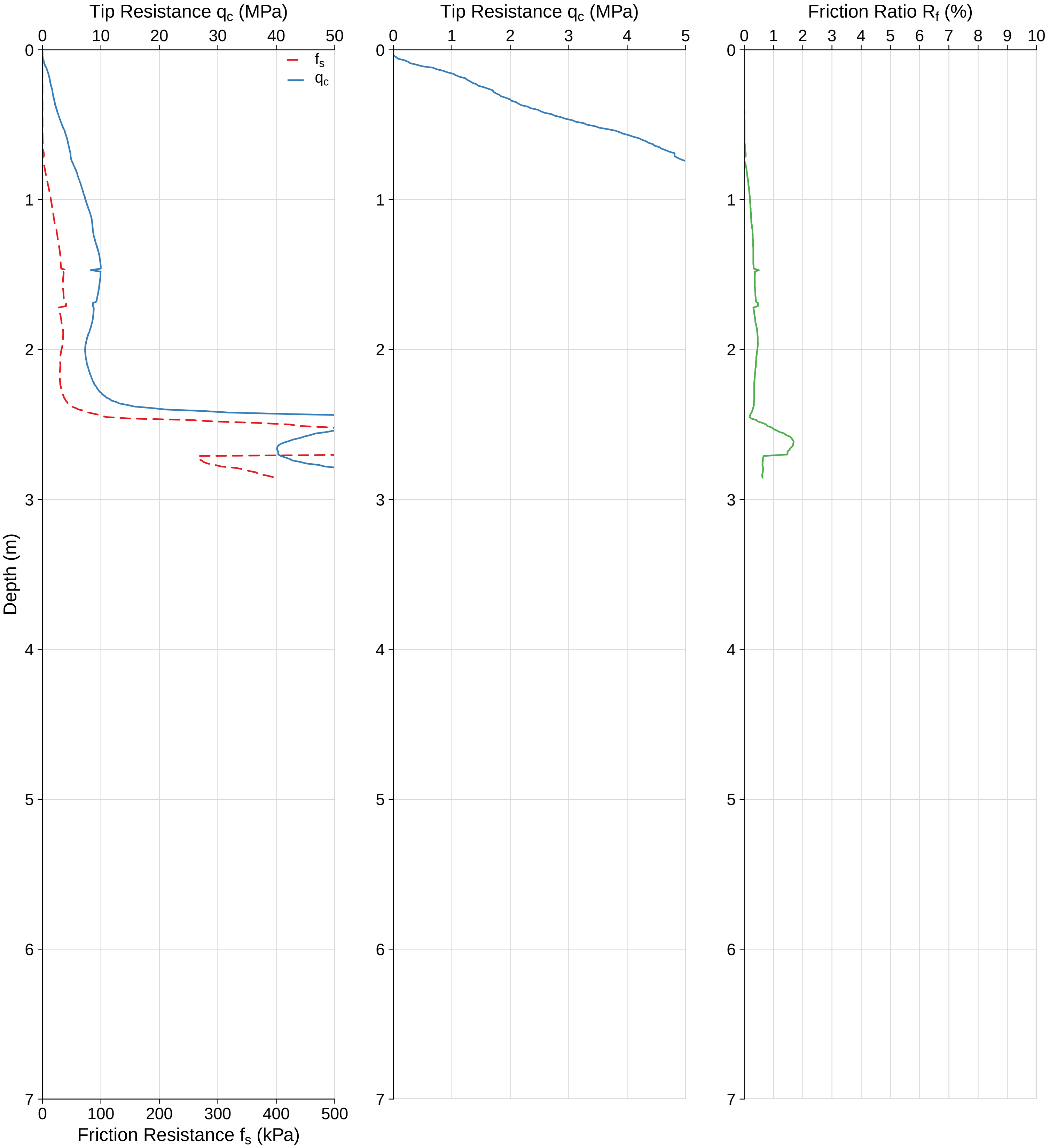
CO-ORDS:
ELEVATION:
PRE-DRILL:
WASHER/DISC: Steel

Groundbreaking Investigations - Tested in accordance with AS 1289.6.5.1-1999

CONE PENETRATION TEST

CPT ID: CPT08
JOB NUMBER: WAG240438-01
DATE: 19/11/2024

CLIENT: SARICH BUILDING
PROJECT: PROPOSED WAREHOUSE
LOCATION: STIRLING CRESCENT, HIGH WYCOMBE



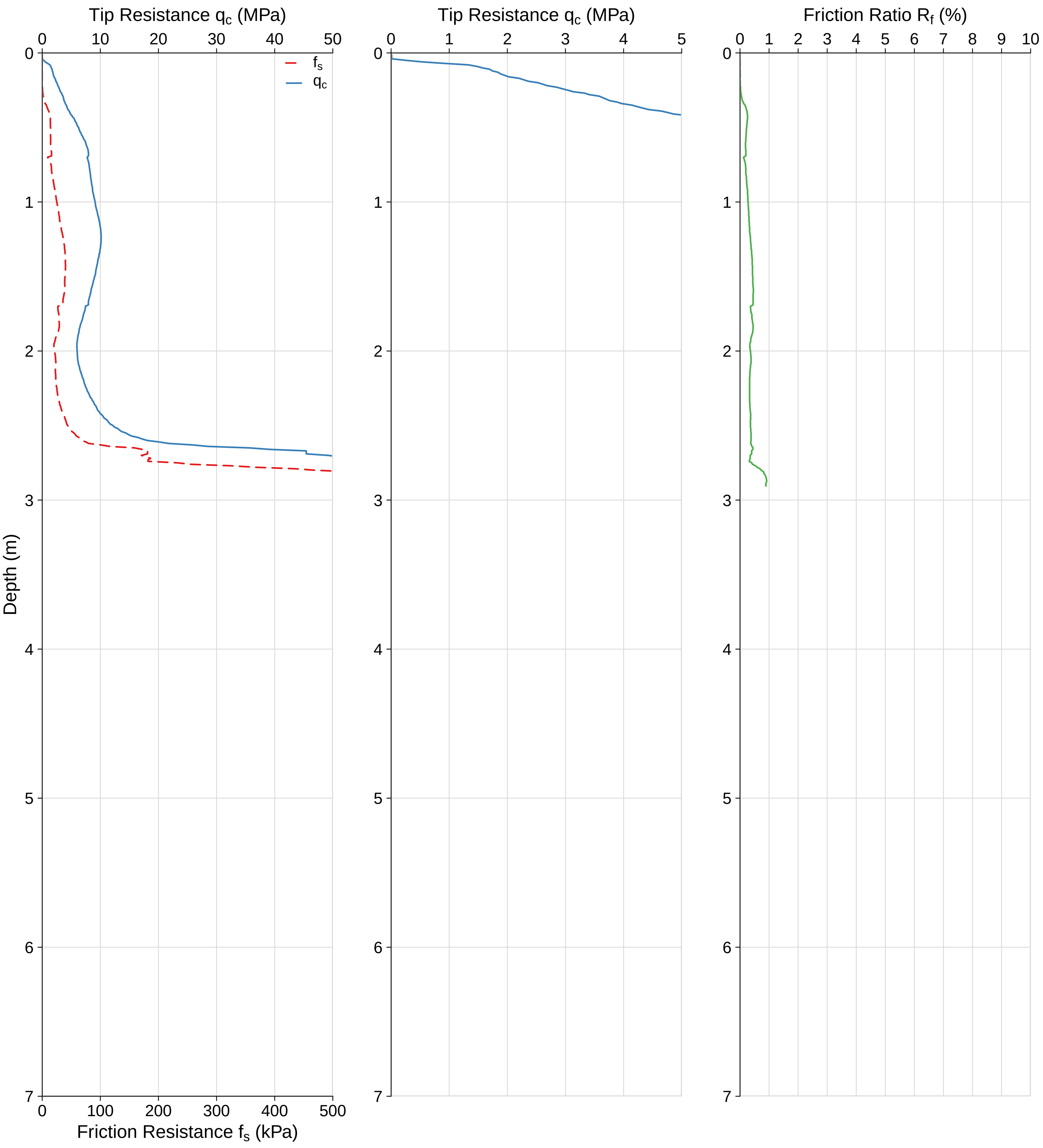
WATER: Dry @ 0.3m.
TERMINATION: Refusal @ 2.86m
DUMMY PROBE:
RIG: Pagani TG 73-200 200kN

CO-ORDS:
ELEVATION:
PRE-DRILL:
WASHER/DISC: Steel

CONE PENETRATION TEST

CPT ID: CPT09
JOB NUMBER: WAG240438-01
DATE: 19/11/2024

CLIENT: SARICH BUILDING
PROJECT: PROPOSED WAREHOUSE
LOCATION: STIRLING CRESCENT, HIGH WYCOMBE

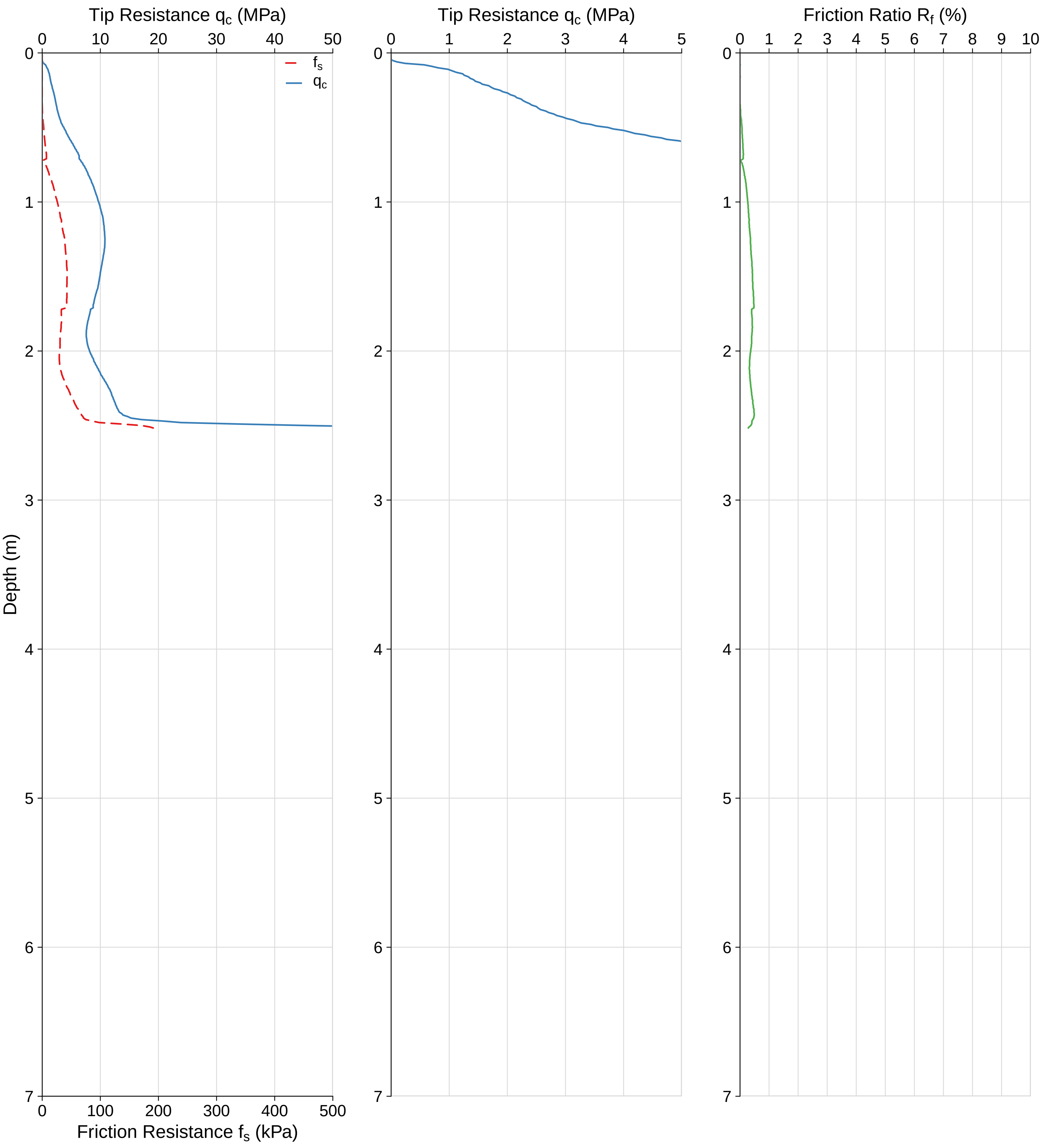


WATER: Dry @ 2m.
TERMINATION: Refusal @ 2.91m
DUMMY PROBE:
RIG: Pagani TG 73-200 200kN

CO-ORDS:
ELEVATION:
PRE-DRILL:
WASHER/DISC: Steel

CONE PENETRATION TEST

CPT ID:	CPT10	**CLIENT:**	SARICH BUILDING
JOB NUMBER:	WAG240438-01	**PROJECT:**	PROPOSED WAREHOUSE
DATE:	19/11/2024	**LOCATION:**	STIRLING CRESCENT, HIGH WYCOMBE



WATER:	Dry @ 1.2m.	**CO-ORDS:**	
TERMINATION:	Refusal @ 2.51m	**ELEVATION:**	
DUMMY PROBE:		**PRE-DRILL:**	
RIG:	Pagani TG 73-200 200kN	**WASHER/DISC:**	Steel

Appendix D: Borehole Reports

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & SOIL CLASSIFICATION SYMBOLS

Graphic	USCS	Soil Name
▨		FILL (various types)
▨		COBBLES / BOULDERS
▨	GP	GRAVEL (poorly graded)
▨	GW	GRAVEL (well graded)
▨	GC	Clayey GRAVEL
▨	GM	Silty GRAVEL
▨	SP	SAND (poorly graded)
▨	SW	SAND (well graded)
▨	SC	Clayey SAND

Graphic	USCS	Soil Name
▨	SM	Silty SAND
▨	ML	SILT (low liquid limit)
▨	MH	SILT (high liquid limit)
▨	CL	CLAY (low plasticity)
▨	CI	CLAY (medium plasticity)
▨	CH	CLAY (high plasticity)
▨	OL	Organic SILT (low liquid limit)
▨	OH	Organic SILT (high liquid limit)
▨	Pt	PEAT

NOTE: Dual classification given for soils with a fines content between 5% and 12%.

SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

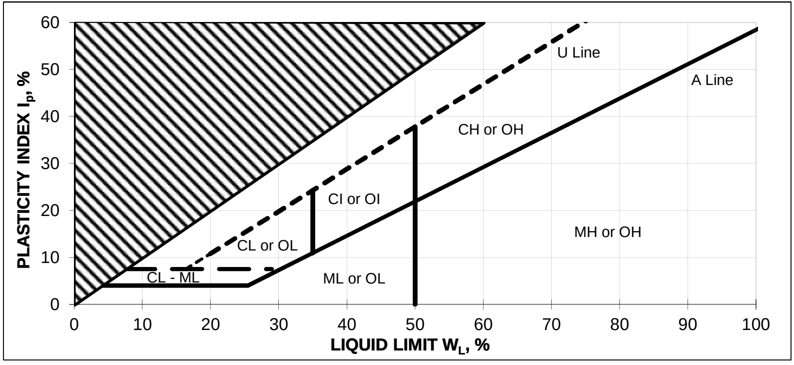
Soil descriptions are based on AS1726-2017. Material properties are assessed in the field by visual/tactile methods in combination with field and laboratory testing techniques (where used).

NOTE: AS 1726-2017 defines a fine grained soil where the total dry mass of fine fractions (<0.075 mm particle size) exceeds 35%.

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	19 to 63
	Medium	6.7 to 19
	Fine	2.3 to 6.7
SAND	Coarse	0.6 to 2.36
	Medium	0.21 to 0.6
	Fine	0.075 to 0.21
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY - MODIFIED CASAGRANDE CHART - AS1726-2017



RESISTANCE TO EXCAVATION

Symbol	Term	Description
VE	Very easy	All resistances are relative to the selected method of excavation
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

MOISTURE CONDITION

Symbol	Term
D	Dry
M	Moist
W	Wet

CEMENTATION

Cementation	Description
Weakly cemented	Soil may be easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate the soil by hand in air or water

CONSISTENCY

Symbol	Term	Undrained Shear Strength (kPa)
VS	Very Soft	0 to 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very Stiff	100 to 200
H	Hard	>200

ORGANIC SOILS

Material	Organic Content % of dry mass
Inorganic soil	<2%
Organic soil	2% to 25%
Peat	>25%

DENSITY

Symbol	Term	Density Index (%)
VL	Very Loose	<15
L	Loose	15 to 35
MD	Medium Dense	35 to 65
D	Dense	65 to 85
VD	Very Dense	>85

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

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METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after
HP	Hand Penetrometer		150 mm seating interval
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Length of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

BOREHOLE: BH01

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0 – 3.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, pale grey, trace fines, trace organics (rootlets), near surface	D (0.0–1.0) M - W (1.0–3.0)		
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH02

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0						SAND: fine to medium grained, pale grey, trace organics (rootlets) near surface, trace fines			
			0.5							D		
			1.0									
AD/V			1.5					SP				
			2.0							M - W		
									Becoming brown/dark grey			
			2.5									
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH03

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0						SAND: medium to fine grained, pale grey, trace organics (rootlets) near surface, trace fines			
			0.5							D		
			1.0									
AD/V			1.5					SP				
			2.0							M - W		
			2.5									
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH04

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0						SAND: medium to fine grained, pale grey, trace organics (rootlets) near surface, trace fines			
			0.5							D		
			1.0									
AD/V			1.5					SP				
			2.0							M - W		
			2.5									
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH05

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling	Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: fine to medium grained, pale grey, trace organics (rootlets) near surface, trace fines			
			0.5							D		
		▼	1.0									
			1.5							M - W		
			2.0									
			2.5						Becoming brown			
									Hole terminated at 2.70 m Refusal on inferred "Coffee Rock" at 2.70 m Groundwater encountered at 1.2 m			
			3.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH06

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown/pale grey, trace organics (rootlets) near surface, trace fines	D	MD D	
			0.5									
			1.0							M - W		
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH07

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0						Start Non-Cored Borehole @ 0.20 m			
AD/V			0.5				∴	SP	SAND: fine to medium grained, pale grey, trace organics (rootlets) near surface, trace fines	D		
			1.0 1.5 2.0 2.5							M - W		
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH08

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: medium to fine grained, pale grey, trace organics, trace fines	D		
			0.5									
			1.0							W		
			1.5									
									Becoming dark grey/brown			
			2.0						Hole terminated at 2.00 m Refusal on inferred "Coffee Rock" at 2.00 m Groundwater not observed.			
			2.5									
			3.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH09

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, brown/pale grey, trace fines, trace organics (rootlets) near surface	D		
			0.5									
			1.0							M - W		
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH10

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling	Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, pale grey/grey, trace fines, trace organics (rootlets) near surface	D		
			0.5									
			1.0							M - W		
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH11

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0				⁘		SAND: fine to medium grained, sub-angular to sub-rounded, pale grey/grey, trace fines, trace organics (rootlets) near surface			
			0.5				⁘			D		
			1.0				⁘					
AD/V			1.5				⁘	SP				
			2.0				⁘			M - W		
			2.5				⁘					
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH12

Sheet 1 OF 1

Job Number: WAG240438-01
Client: Sarich Building
Project: Proposed Industrial Development
Location: Lots 8 and 16 Stirling Crescent, High Wycombe

Contractor: GBI
Drill Rig: Scout
Inclination: -90°

Date: 20/11/2024
Logged: DA
Checked Date: 27/11/2024
Checked By: WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, pale grey/grey, trace fines, trace organics (rootlets) near surface	D		
			0.5									
			1.0							M - W		
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH13

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					**Sampling**	**Field Material Description**						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, pale grey/grey, trace fines, trace organics (rootlets) near surface	D		
			1.0							M - W		
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH14

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, pale grey/grey, trace fines, trace organics (rootlets) near surface	D	MD	
			0.5								D	
			1.0							M - W		
			1.5									
			2.0									
			2.5						Becoming dark grey/brown, trace fine to medium grained gravel ("Coffee Rock")			
			3.0						Hole terminated at 2.85 m Refusal on inferred "Coffee Rock" Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH15

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0					SP	SAND: fine to medium grained, sub-angular to sub-rounded, pale grey/grey, trace fines, trace organics (rootlets), near surface	M	MD	
			0.5								D	
			1.0									
			1.5									
			2.0									
									Becoming dark grey/brown, trace fine to medium grained gravel ("Coffee Rock")			
			2.5						Hole terminated at 2.30 m Refusal on inferred "Coffee Rock" Groundwater not observed.			
			3.0									

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH16

Sheet 1 OF 1

Job Number:	WAG240438-01	**Contractor:**	GBI	**Date:**	20/11/2024
Client:	Sarich Building	**Drill Rig:**	Scout	**Logged:**	DA
Project:	Proposed Industrial Development	**Inclination:**	-90°	**Checked Date:**	27/11/2024
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe			**Checked By:**	WF

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V			0.0 0.5					SP	SAND: fine to medium grained, sub-angular to sub-rounded, pale grey/grey, trace fines, trace organics (rootlets) near surface	D		
			1.0 1.5 2.0 2.5							M - W		
			3.0						Hole terminated at 3.00 m Groundwater not observed.			

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

Appendix E: Infiltration Test Results

Hydraulic Conductivity Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	WAG240438-01
Client:	Sarich Building
Project:	Industrial Development
Location:	Lot 8 and 16 Stirling Cres. High Wycombe
BH Name:	BH07/IT01
Test Depth:	0.88 m

Spreadsheet author:	ORW	17-Oct-09

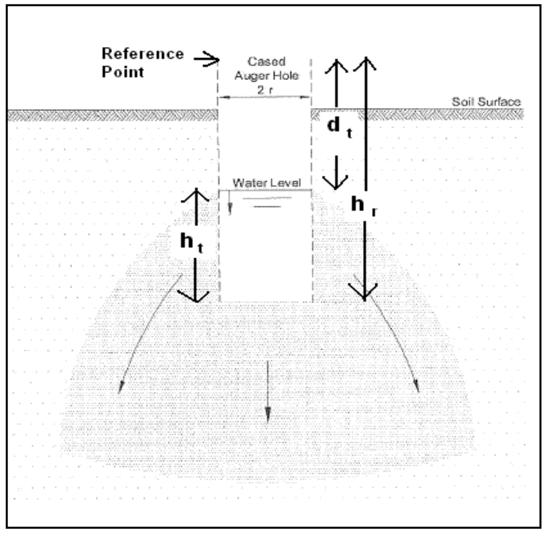
$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	1	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m



Test 1

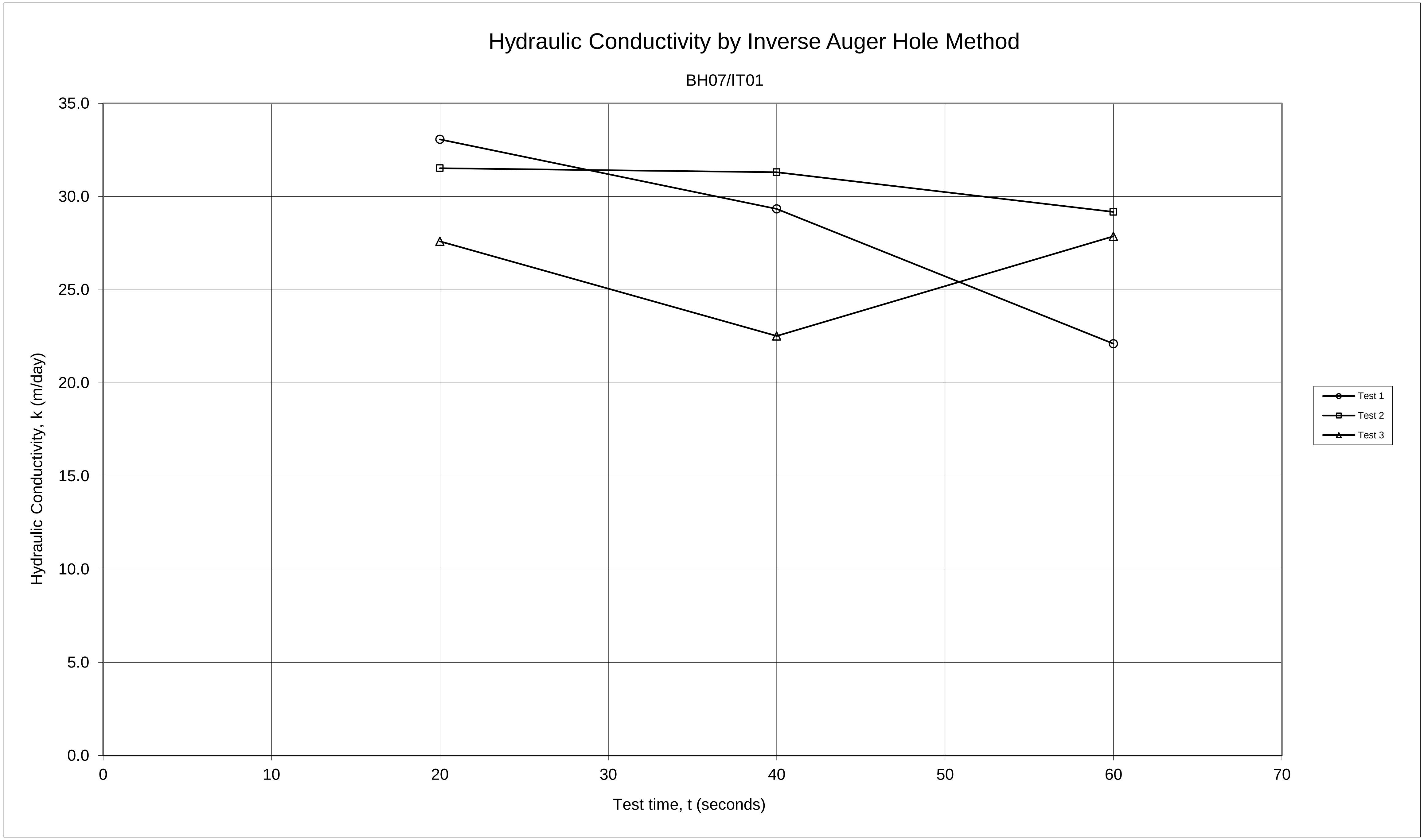
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.78	0.22	☒	☒
20	0.85	0.15	3.8E-04	33.1
40	0.89	0.11	3.4E-04	29.3
60	0.9	0.1	2.6E-04	22.1
		AVERAGE	3.3E-04	28.2

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.77	0.23	☒	☒
20	0.84	0.16	3.6E-04	31.5
40	0.89	0.11	3.6E-04	31.3
60	0.92	0.08	3.4E-04	29.2
		AVERAGE	3.5E-04	30.7

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.78	0.22	☒	☒
20	0.84	0.16	3.2E-04	27.6
40	0.87	0.13	2.6E-04	22.5
60	0.92	0.08	3.2E-04	27.9
		AVERAGE	3.0E-04	26.0



https://galtgeo.sharepoint.com/sites/WAG240438/Shared Documents/01 Sarich SI/08 Analysis/Permeability Inverse Auger Hole Method - Rev2

Hydraulic Conductivity Calculation - Inverse Auger Hole Method

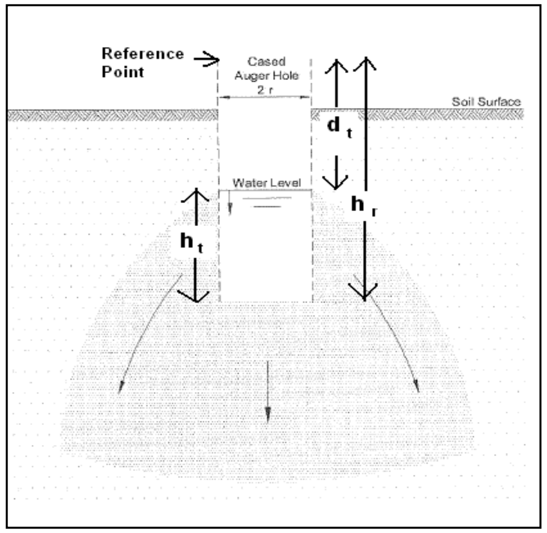
Galt Geotechnics

Spreadsheet author: ORW 17-Oct-09

Job No:	WAG240438-01
Client:	Sarich Building
Project:	Industrial Development
Location:	Lot 8 and 16 Stirling Cres. High Wycombe
BH Name:	BH08/IT02
Test Depth:	0.86 m

$$K = 1.15r\frac{\log_{10}(h_0+\frac{1}{2}r)-\log_{10}(h_t+\frac{1}{2}r)}{t-t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

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🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	1	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m

Test 1

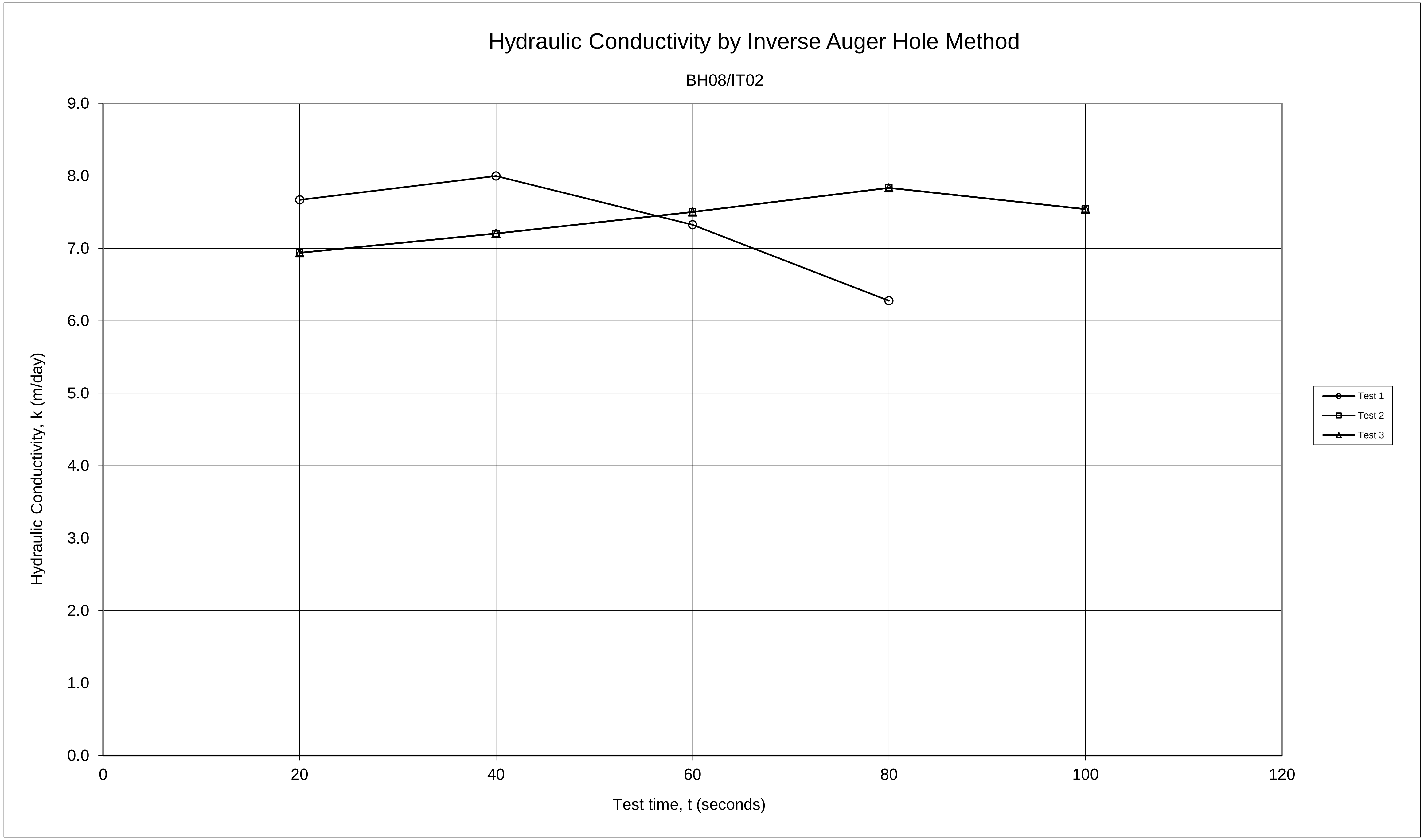
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.825	0.175	☒	☒
20	0.84	0.16	8.9E-05	7.7
40	0.855	0.145	9.3E-05	8.0
60	0.865	0.135	8.5E-05	7.3
80	0.87	0.13	7.3E-05	6.3
		AVERAGE	8.5E-05	7.3

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.805	0.195	☒	☒
20	0.82	0.18	8.0E-05	6.9
40	0.835	0.165	8.3E-05	7.2
60	0.85	0.15	8.7E-05	7.5
80	0.865	0.135	9.1E-05	7.8
100	0.875	0.125	8.7E-05	7.5
		AVERAGE	8.6E-05	7.4

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.805	0.195	☒	☒
20	0.82	0.18	8.0E-05	6.9
40	0.835	0.165	8.3E-05	7.2
60	0.85	0.15	8.7E-05	7.5
80	0.865	0.135	9.1E-05	7.8
100	0.875	0.125	8.7E-05	7.5
		AVERAGE	8.6E-05	7.4



https://galtgeo.sharepoint.com/sites/WAG240438/Shared Documents/01 Sarich SI/08 Analysis/Permeability Inverse Auger Hole Method - Rev2

Hydraulic Conductivity Calculation - Inverse Auger Hole Method

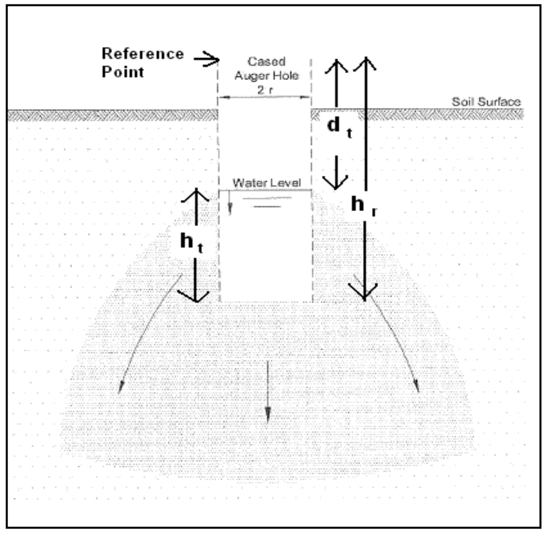
Galt Geotechnics

Job No:	WAG240438-01
Client:	Sarich Building
Project:	Industrial Development
Location:	Lot 8 and 16 Stirling Cres. High Wycombe
BH Name:	BH10/IT03
Test Depth:	0.82 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

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🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	1	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m

Test 1

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.865	0.135	☒	☒
20	0.875	0.125	7.4E-05	6.4
40	0.885	0.115	7.6E-05	6.6
60	0.89	0.11	6.5E-05	5.6
80	0.9	0.1	7.1E-05	6.1
100	0.905	0.095	6.6E-05	5.7
120	0.91	0.09	6.3E-05	5.4
140	0.915	0.085	6.1E-05	5.3
		AVERAGE	6.8E-05	5.9

Test 2

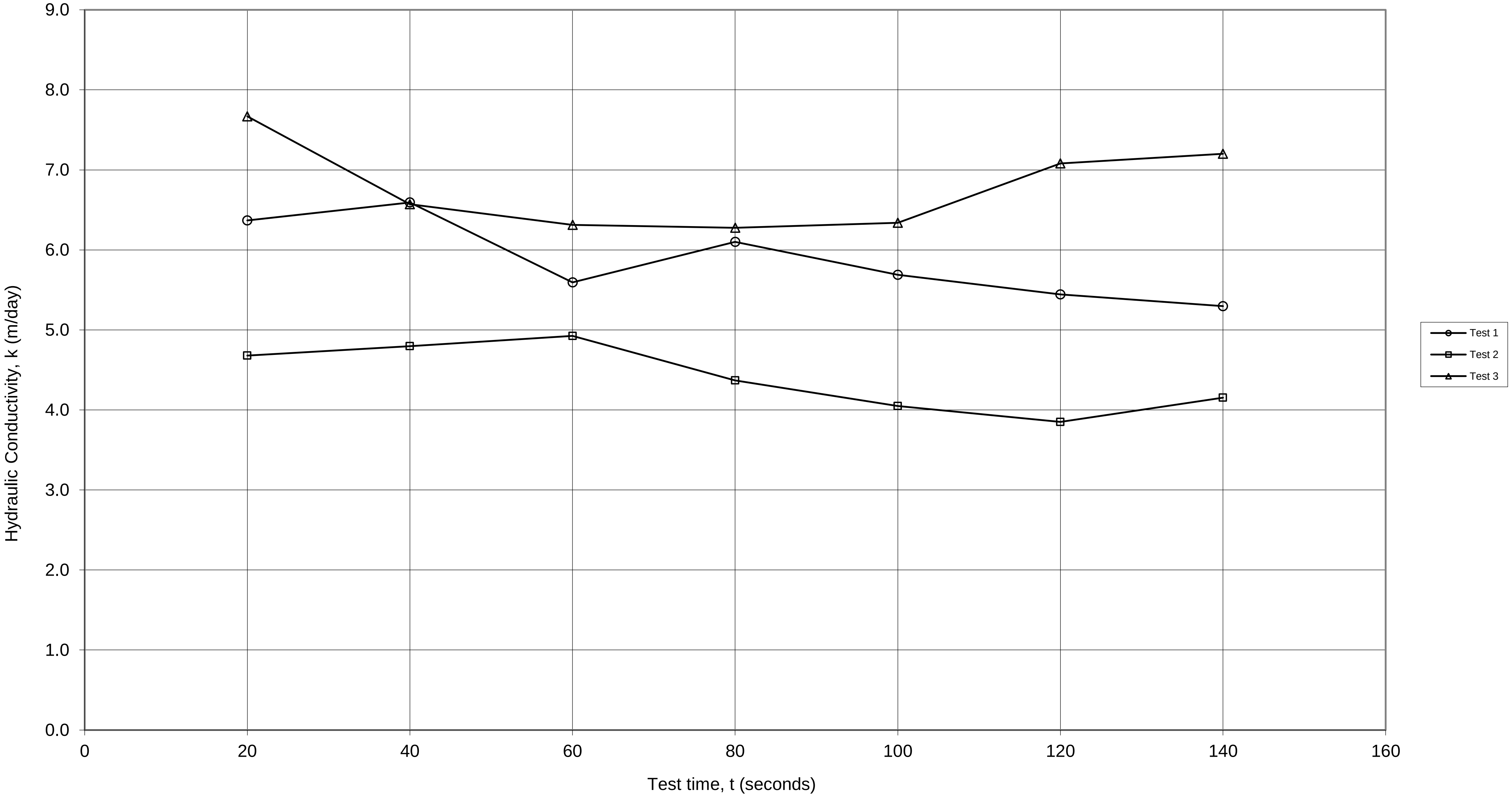
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.81	0.19	☒	☒
20	0.82	0.18	5.4E-05	4.7
40	0.83	0.17	5.6E-05	4.8
60	0.84	0.16	5.7E-05	4.9
80	0.845	0.155	5.1E-05	4.4
100	0.85	0.15	4.7E-05	4.0
120	0.855	0.145	4.5E-05	3.9
140	0.865	0.135	4.8E-05	4.2
		AVERAGE	5.1E-05	4.4

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.825	0.175	☒	☒
20	0.84	0.16	8.9E-05	7.7
40	0.85	0.15	7.6E-05	6.6
60	0.86	0.14	7.3E-05	6.3
80	0.87	0.13	7.3E-05	6.3
100	0.88	0.12	7.3E-05	6.3
120	0.895	0.105	8.2E-05	7.1
140	0.905	0.095	8.3E-05	7.2
		AVERAGE	7.8E-05	6.8

Hydraulic Conductivity by Inverse Auger Hole Method

BH10/IT03



https://galtgeo.sharepoint.com/sites/WAG240438/Shared Documents/01 Sarich SI/08 Analysis/Permeability Inverse Auger Hole Method - Rev2

Hydraulic Conductivity Calculation - Inverse Auger Hole Method

Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09	

Job No:	WAG240438-01
Client:	Sarich Building
Project:	Industrial Development
Location:	Lot 8 and 16 Stirling Cres. High Wycombe
BH Name:	BH16/IT04
Test Depth:	0.77 m

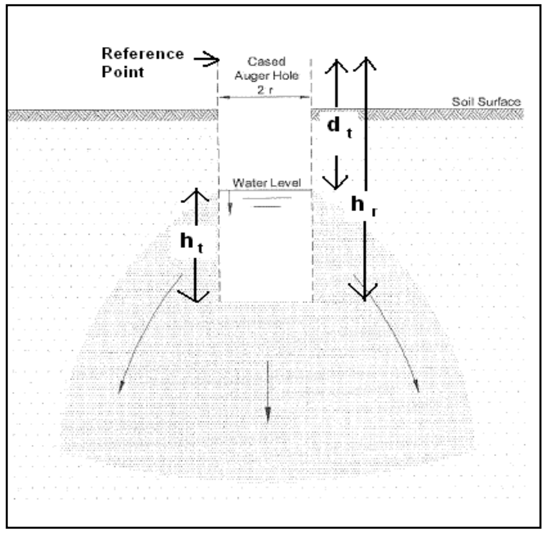
$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	1	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m



Test 1

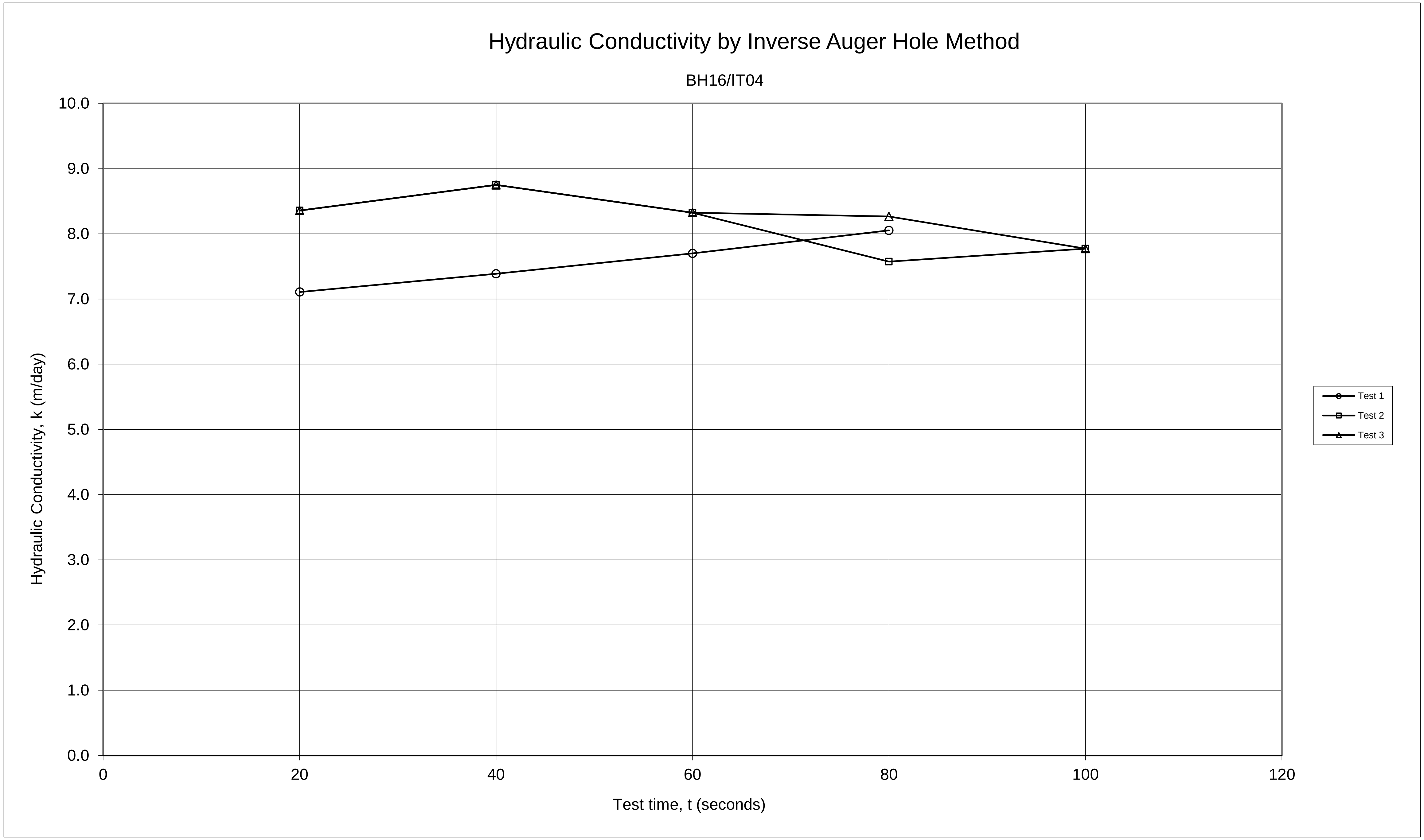
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.81	0.19	☒	☒
20	0.825	0.175	8.2E-05	7.1
40	0.84	0.16	8.6E-05	7.4
60	0.855	0.145	8.9E-05	7.7
80	0.87	0.13	9.3E-05	8.1
		AVERAGE	8.8E-05	7.6

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.78	0.22	☒	☒
20	0.8	0.2	9.7E-05	8.4
40	0.82	0.18	1.0E-04	8.8
60	0.835	0.165	9.6E-05	8.3
80	0.845	0.155	8.8E-05	7.6
100	0.86	0.14	9.0E-05	7.8
		AVERAGE	9.4E-05	8.2

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.78	0.22	☒	☒
20	0.8	0.2	9.7E-05	8.4
40	0.82	0.18	1.0E-04	8.8
60	0.835	0.165	9.6E-05	8.3
80	0.85	0.15	9.6E-05	8.3
100	0.86	0.14	9.0E-05	7.8
		AVERAGE	9.6E-05	8.3



https://galtgeo.sharepoint.com/sites/WAG240438/Shared Documents/01 Sarich SI/08 Analysis/Permeability Inverse Auger Hole Method - Rev2

Hydraulic Conductivity Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	WAG240438-01
Client:	Sarich Building
Project:	Industrial Development
Location:	Lot 8 and 16 Stirling Cres. High Wycombe
BH Name:	BH06/IT05
Test Depth:	0.77 m

Spreadsheet author:	ORW	17-Oct-09

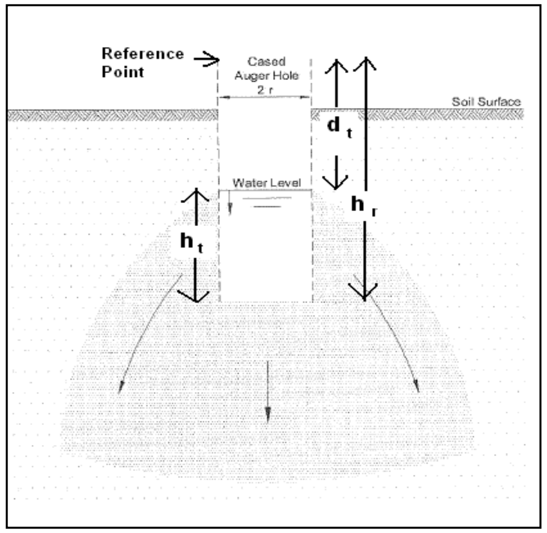
$$K = 1.15r \frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	1	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m



Test 1

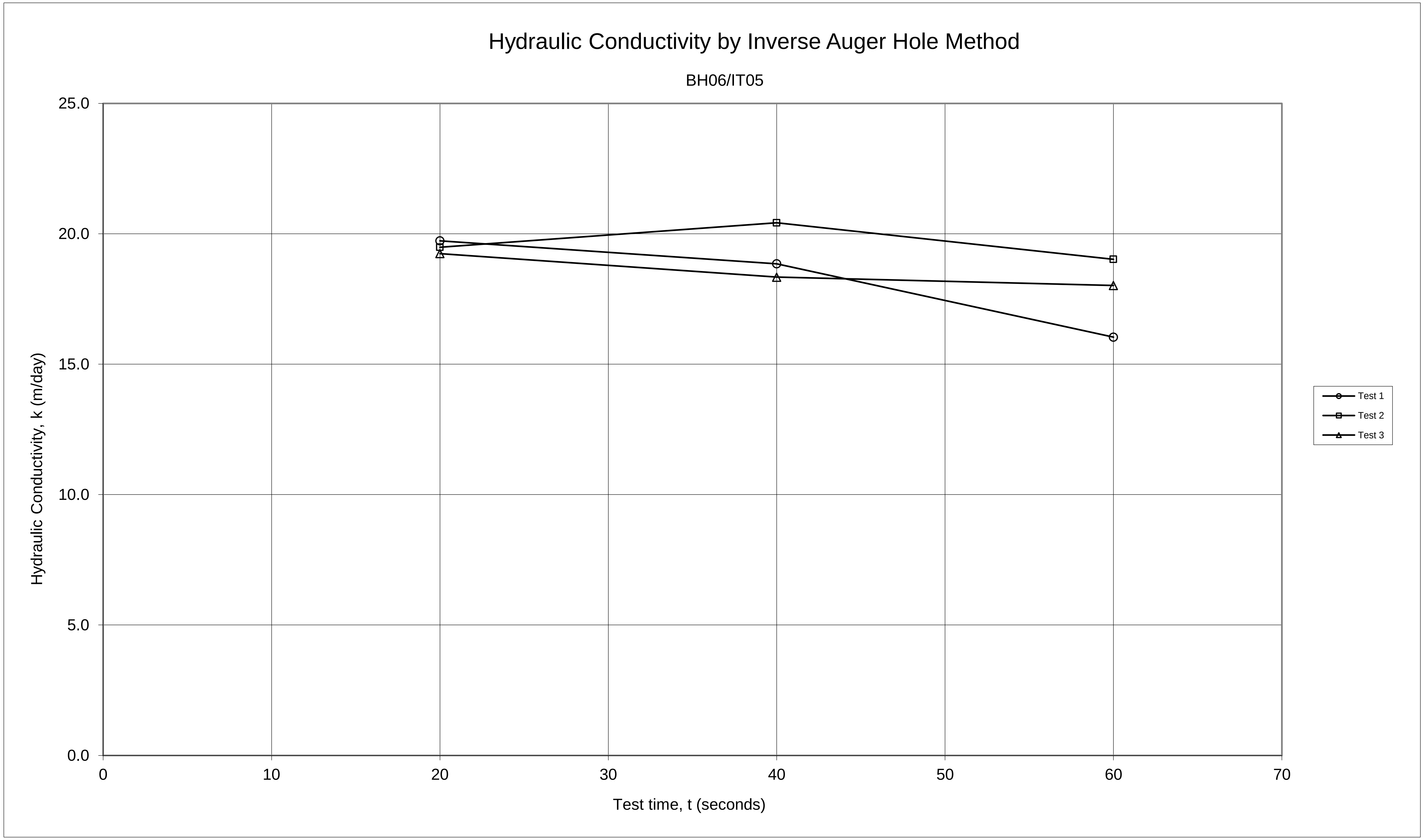
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.805	0.195	☒	☒
20	0.845	0.155	2.3E-04	19.7
40	0.875	0.125	2.2E-04	18.9
60	0.89	0.11	1.9E-04	16.0
		AVERAGE	2.1E-04	18.2

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.775	0.225	☒	☒
20	0.82	0.18	2.3E-04	19.5
40	0.86	0.14	2.4E-04	20.4
60	0.885	0.115	2.2E-04	19.0
		AVERAGE	2.3E-04	19.6

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.8	0.2	☒	☒
20	0.84	0.16	2.2E-04	19.2
40	0.87	0.13	2.1E-04	18.3
60	0.895	0.105	2.1E-04	18.0
		AVERAGE	2.1E-04	18.5



https://galtgeo.sharepoint.com/sites/WAG240438/Shared Documents/01 Sarich SI/08 Analysis/Permeability Inverse Auger Hole Method - Rev2

Appendix F: Gulph Permeameter Test Results

Hydraulic Conductivity Calculation - Constant Head by Permeameter

Galt Geotechnics

Spreadsheet author:	ORW	6-May-22

REFERENCE: AS1547-2012, "On-site domestic wastewater management" - Appendix G

Job No:	WAG240438-01
Client:	Sarich Building
Project:	Industrial Development
Location:	Lots 8 and 16 Stirling Cres.
Calc by:	WF
Test Name	G01

$$K = \frac{4.4Q[0.5\ \sinh^{-1}\left(\frac{H}{2r}\right) - \sqrt{\left(\frac{r}{H}\right)^2 + 0.25} + \frac{r}{H}]}{2\,\pi H^2}$$

Parameter	Description	Value	Units
K_{sat}	Saturated hydraulic conductivity	☒	cm/min
D	Depth of auger hole	44	cm
H	Head of water above base	18	cm
r	Radius of auger hole	3	cm
S	Depth to impermeable stratum	-	cm
Reservoir	Chosen Guelph reservoir (inner or outer)	**Outer**	
Area	Area of chosen reservoir	7.07	cm^2
F	Reading of water level in reservoir	☒	cm

Spreadsheet Legend

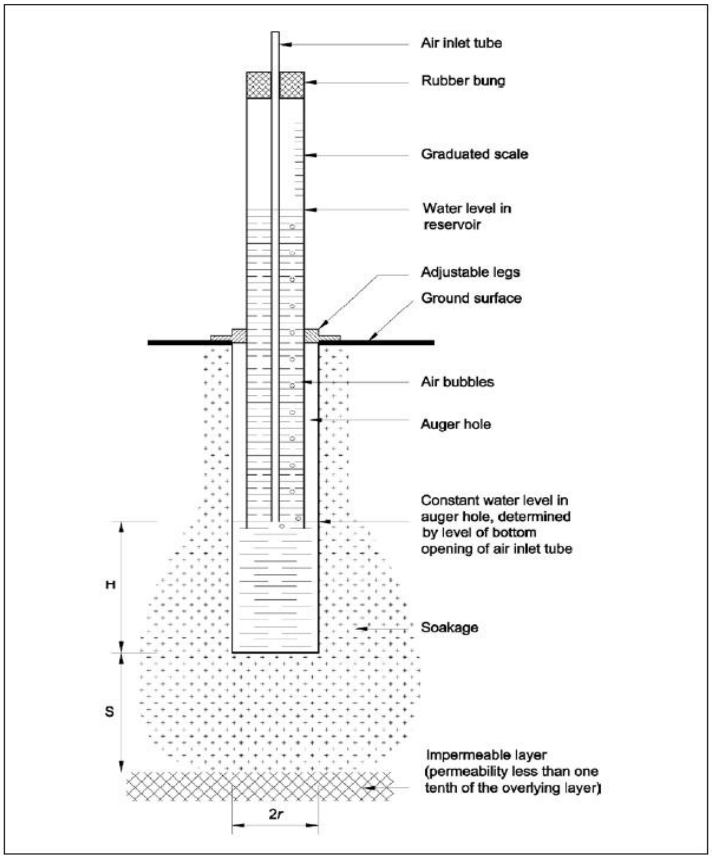
🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
0	68	☒	☒
0.166667	62.5	5.50	33.00
0.333333	57.5	5.00	30.00
0.5	52.5	5.00	30.00
0.833333	39.5	13.00	39.00
1	30	9.50	57.00
1.333333	19.5	10.50	31.50
1.5	13.5	6.00	36.00
1.666667	5.5	8.00	48.00
AVERAGE - LAST 5 READINGS			42.30

Calculation

Steady State Flow	42.30	cm/min
Flow from reservoir (Q)	299.06	cm^3/min
K_{sat}	0.355	cm/min
K_{sat}	5.913E-05	m/s
K_{sat}	**5.11**	**m/day**



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

Galt Geotechnics

Spreadsheet author:	ORW	6-May-22

REFERENCE: AS1547-2012, "On-site domestic wastewater management" - Appendix G

Job No:	WAG240438-01
Client:	Sarich Building
Project:	Industrial Development
Location:	Lots 8 and 16 Stirling Cres.
Calc by:	WF
Test Name	G01

$$K = \frac{4.4Q[0.5\ \sinh^{-1}\left(\frac{H}{2r}\right) - \sqrt{\left(\frac{r}{H}\right)^2 + 0.25} + \frac{r}{H}]}{2\ \pi H^2}$$

Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

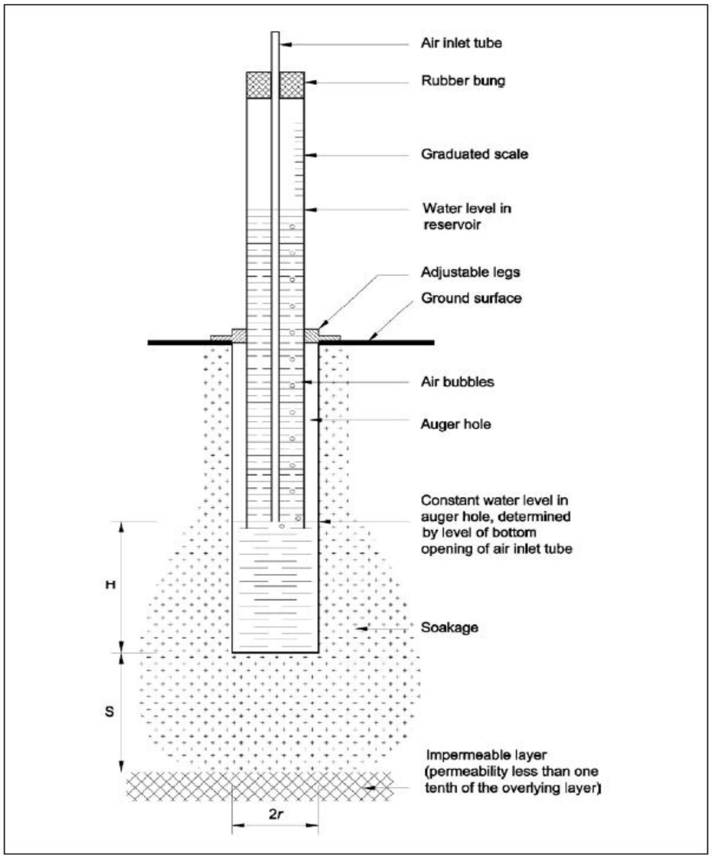
Parameter	Description	Value	Units
K_{sat}	Saturated hydraulic conductivity	☒	cm/min
D	Depth of auger hole	50	cm
H	Head of water above base	24	cm
r	Radius of auger hole	3	cm
S	Depth to impermeable stratum	-	cm
Reservoir	Chosen Guelph reservoir (inner or outer)	**Outer**	
Area	Area of chosen reservoir	7.07	cm^2
F	Reading of water level in reservoir	☒	cm

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
0	68.2	☒	☒
0.166667	63	5.20	31.20
0.333333	57	6.00	36.00
0.666667	44.5	12.50	37.50
0.833333	38	6.50	39.00
1	32.5	5.50	33.00
1.166667	25.5	7.00	42.00
1.333333	19	6.50	39.00
1.666667	5	14.00	42.00
AVERAGE - LAST 5 READINGS			39.00

Calculation

Steady State Flow	39.00	cm/min
Flow from reservoir (Q)	275.73	cm^3/min
K_{sat}	0.220	cm/min
K_{sat}	3.671E-05	m/s
K_{sat}	**3.17**	**m/day**



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

Galt Geotechnics

Spreadsheet author:	ORW	6-May-22	REFERENCE: AS1547-2012, "On-site domestic wastewater management" - Appendix G

Job No:	WAG240438-01
Client:	Sarich Building
Project:	Industrial Development
Location:	Lots 8 and 16 Stirling Cres.
Calc by:	WF
Test Name	G03

$$K = \frac{4.4Q[0.5\ \sinh^{-1}\left(\frac{H}{2r}\right) - \sqrt{\left(\frac{r}{H}\right)^2 + 0.25} + \frac{r}{H}]}{2\ \pi H^2}$$

Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

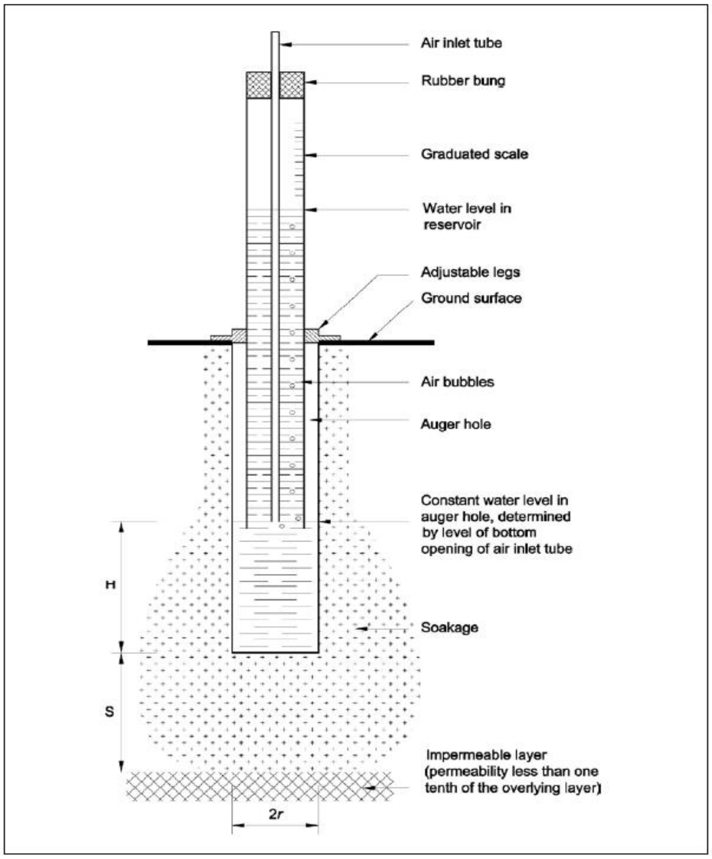
Parameter	Description	Value	Units
K_{sat}	Saturated hydraulic conductivity	☒	cm/min
D	Depth of auger hole	39	cm
H	Head of water above base	14	cm
r	Radius of auger hole	3	cm
S	Depth to impermeable stratum	-	cm
Reservoir	Chosen Guelph reservoir (inner or outer)	**Outer**	
Area	Area of chosen reservoir	7.07	cm^2
F	Reading of water level in reservoir	☒	cm

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
0	68	☒	☒
0.166667	65	3.00	18.00
0.333333	63.5	1.50	9.00
0.5	61	2.50	15.00
0.666667	58	3.00	18.00
0.833333	55.5	2.50	15.00
1	54	1.50	9.00
1.166667	52.5	1.50	9.00
1.333333	50.5	2.00	12.00
1.666667	45.5	5.00	15.00
2	40.5	5.00	15.00
2.666667	29.5	11.00	16.50
3	22	7.50	22.50
3.5	8	14.00	28.00
AVERAGE - LAST 5 READINGS			19.40

Calculation

Steady State Flow	19.40	cm/min
Flow from reservoir (Q)	137.16	cm^3/min
K_{sat}	0.226	cm/min
K_{sat}	3.774E-05	m/s
K_{sat}	**3.26**	**m/day**



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Hydraulic Conductivity Calculation - Constant Head by Permeameter

Galt Geotechnics

Spreadsheet author:	ORW	6-May-22

REFERENCE: AS1547-2012, "On-site domestic wastewater management" - Appendix G

Job No:	WAG240438-01
Client:	Sarich Building
Project:	Industrial Development
Location:	Lots 8 and 16 Stirling Cres.
Calc by:	WF
Test Name	G04

$$K = \frac{4.4Q[0.5\ \sinh^{-1}\left(\frac{H}{2r}\right) - \sqrt{\left(\frac{r}{H}\right)^2 + 0.25} + \frac{r}{H}]}{2\,\pi H^2}$$

Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

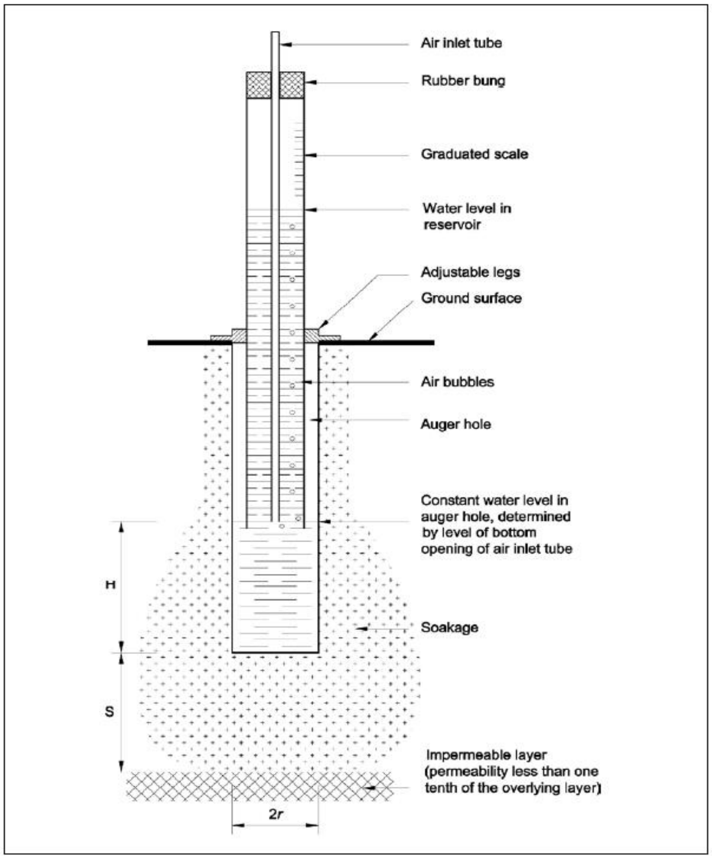
Parameter	Description	Value	Units
K_{sat}	Saturated hydraulic conductivity	☒	cm/min
D	Depth of auger hole	40	cm
H	Head of water above base	17	cm
r	Radius of auger hole	3	cm
S	Depth to impermeable stratum	-	cm
Reservoir	Chosen Guelph reservoir (inner or outer)	**Outer**	
Area	Area of chosen reservoir	7.07	cm^2
F	Reading of water level in reservoir	☒	cm

Test Results

Time (min)	F (cm)	ΔF (cm)	ΔF (cm)/min
0	68	☒	☒
0.166667	47	21.00	126.00
0.333333	38	9.00	54.00
0.5	25	13.00	78.00
0.666667	12	13.00	78.00
AVERAGE - LAST 5 READINGS			84.00

Calculation

Steady State Flow	84.00	cm/min
Flow from reservoir (Q)	593.88	cm^3/min
K_{sat}	0.760	cm/min
K_{sat}	1.267E-04	m/s
K_{sat}	**10.95**	**m/day**



where:
H = depth of water in test hole
S = the depth to an underlying impermeable layer
r = radius of the test hole

Appendix G: Laboratory Test Results

Envirolab Services (WA) Pty Ltd trading as MPL Laboratories
ABN 53 140 099 207
16-18 Hayden Court Myaree WA 6154
ph +61 8 9317 2505
lab@mpl.com.au
www.mpl.com.au

Certificate of Analysis PFK2023

Client Details

Client	Western Geotechnical & Laboratory Services
Contact	Laboratory
Address	235 Bank Street, WELSHPOOL, WA, 6101

Sample Details

Your Reference	S15244 - Proposed Warehouse
Number of Samples	2 Soil
Date Samples Received	28/11/2024
Date Instructions Received	28/11/2024

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for soils and on an as received basis for other matrices.

Report Details

Date Results Requested by	09/12/2024
Date of Issue	11/12/2024

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Accredited for compliance with ISO/IEC 17025. Tests not covered by NATA are denoted with *.

Authorisation Details

Results Approved By	Varsha Ho Wing, Inorganics and Metals Supervisor
Laboratory Manager	Michael Kubiak

Certificate of Analysis PFK2023

Samples in this Report

Envirolab ID	Sample ID	Matrix	Date Sampled	Date Received
PFK2023-01	WG24.18566 / G01 (0.1-0.5m)	Soil	28/11/2024	28/11/2024
PFK2023-02	WG24.18567 / BH16 (0.1-0.5m)	Soil	28/11/2024	28/11/2024

Certificate of Analysis PFK2023

Exchangeable Cations (Soil)

Envirolab ID	**Units**	**PQL**	PFK2023-01	PFK2023-02
Your Reference			WG24.18566 / G01 (0.1-0.5m)	WG24.18567 / BH16 (0.1-0.5m)
Date Sampled			28/11/2024	28/11/2024
Calcium	meq/100g	0.10	1.0	1.8
Potassium	meq/100g	0.10	<0.10	<0.10
Magnesium	meq/100g	0.10	0.33	0.43
Sodium	meq/100g	0.10	<0.10	<0.10
Cation Exchange Capacity (CEC)	meq/100g	0.10	1.4	2.3
Exchangeable Sodium Percentage (ESP)	%	1.0	Not Reportable	Not Reportable

Certificate of Analysis PFK2023

Inorganics - General Physical Parameters (Soil)

Envirolab ID	**Units**	**PQL**	PFK2023-01	PFK2023-02
Your Reference			WG24.18566 / G01 (0.1-0.5m)	WG24.18567 / BH16 (0.1-0.5m)
Date Sampled			28/11/2024	28/11/2024
pH	pH units		5.8	6.2
Electrical Conductivity	µS/cm	2.0	32	36

Certificate of Analysis PFK2023

PBI/PRI (Soil)

Envirolab ID	**Units**	**PQL**	PFK2023-01	PFK2023-02
Your Reference			WG24.18566 / G01 (0.1-0.5m)	WG24.18567 / BH16 (0.1-0.5m)
Date Sampled			28/11/2024	28/11/2024
Phosphorus Retention Index	-		-0.11	-0.25

Method Summary

Method ID	Methodology Summary
AGRI-003_PRI	Phosphorous Retention index (PRI) is the ratio of adsorbed phosphorus to the equilibrium concentration. Phosphorus is extracted using KCl and determined colourimetrically. Result value is used to calculate PRI as per Allen and Jefferey.
INORG-001	pH - Measured using pH meter and electrode. Please note that the results for water analyses are indicative only, as analysis can be completed outside of the recommended holding times. Solids are reported from a 1:5 water extract unless otherwise specified. Alternatively, pH is determined in a 1:5 extract using 0.01M calcium chloride or a solid is extracted at a ratio of 1:2.5 (AS1289.4.3.1), pH is measured in the extract.
INORG-002	Conductivity and Salinity - measured using a conductivity cell at 25°C. Soil results reported from a 1:5 Soil:Water extract unless otherwise specified. Please note Resistivity is estimated by calculation and may not correlate with results otherwise obtained using the Resistivity current method (based on AS 1289.4.4.1), depending on the nature of the soil being analysed.
METALS-020	Determination of various metals by ICP-OES.
METALS-020_008A	Determination of exchangeable cations and cation exchange capacity in soils using 1M Ammonium Chloride exchange and ICP-OES analytical finish.

Result Definitions

Identifier	Description
NR	Not reported
NEPM	National Environment Protection Measure
NS	Not specified
LCS	Laboratory Control Sample
RPD	Relative Percent Difference
>	Greater than
<	Less than
PQL	Practical Quantitation Limit
INS	Insufficient sample for this test
NA	Test not required
NT	Not tested
DOL	Samples rejected due to particulate overload (air filters only)
RFD	Samples rejected due to filter damage (air filters only)
RUD	Samples rejected due to uneven deposition (air filters only)
##	Indicates a laboratory acceptance criteria outlier, for further details, see Result Comments and/or QC Comments

Quality Control Definitions

Blank

This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, and is determined by processing solvents and reagents in exactly the same manner as for samples.

Surrogate Spike

Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

LCS (Laboratory Control Sample)

This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Matrix Spike

A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

Duplicate

This is the complete duplicate analysis of a sample from the process batch. The sample selected should be one where the analyte concentration is easily measurable.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria. Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction. Spikes for Physical and Aggregate Tests are not applicable. For VOCs in water samples, three vials are required for duplicate or spike analysis.

General Acceptance Criteria (GAC) - Analyte specific criteria applies for some analytes and is reflected in QC recovery tables.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% - see ELN-P05 QAQC tables for details (available on request); <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase. Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was typically insufficient in order to satisfy laboratory QA/QC protocols.

Miscellaneous Information

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached. We have taken the sampling date as being the date received at the laboratory.

Two significant figures are reported for the majority of tests and with a high degree of confidence, for results <10*PQL, the second significant figure may be in doubt i.e. has a relatively high degree of uncertainty and is provided for information only.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS where sediment/solids are included by default.

Urine Analysis - The BEI values listed are taken from the 2022 edition of *TLVs and BEIs Threshold Limits by ACGIH*.

Air volume measurements are not covered by Envirolab's NATA accreditation.

Data Quality Assessment Summary PFK2023

Client Details

Client	Western Geotechnical & Laboratory Services
Your Reference	S15244 - Proposed Warehouse
Date Issued	11/12/2024

Recommended Holding Time Compliance

No recommended holding time exceedances

Quality Control and QC Frequency

QC Type	Compliant	Details
Blank	Yes	No Outliers
LCS	Yes	No Outliers
Duplicates	Yes	No Outliers
Matrix Spike	Yes	No Outliers
Surrogates / Extracted Internal Standards	Yes	No Outliers
QC Frequency	Yes	No Outliers

Surrogates/Extracted Internal Standards, Duplicates and/or Matrix Spikes are not always relevant/applicable to certain analyses and matrices. Therefore, said QC measures are deemed compliant in these situations by default. See Laboratory Acceptance Criteria for more information

Data Quality Assessment Summary PFK2023

Recommended Holding Time Compliance

Analysis	Sample Number(s)	Date Sampled	Date Extracted	Date Analysed	Compliant
CEC | Soil	1-2	28/11/2024	03/12/2024	03/12/2024	Yes
ESP | Soil	1-2	28/11/2024	03/12/2024	03/12/2024	Yes
Exchangeable Cations | Soil	1-2	28/11/2024	03/12/2024	03/12/2024	Yes
EC | Soil	1-2	28/11/2024	04/12/2024	09/12/2024	Yes
pH | Soil	1-2	28/11/2024	04/12/2024	09/12/2024	Yes
PRI | Soil	1-2	28/11/2024	29/11/2024	11/12/2024	Yes

Quality Control PFK2023

METALS-020_008A | Exchangeable Cations (Soil) | Batch BFL0307

Analyte	Units	PQL	Blank	DUP1 PFK2023-01 Samp | QC | RPD %	LCS %	Spike % PFK2023-02
Calcium	meq/100g	0.10	<0.10	1.05 | 0.780 | 29.5	113	114
Potassium	meq/100g	0.10	<0.10	<0.10 | <0.10 | [NA]	103	104
Magnesium	meq/100g	0.10	<0.10	0.330 | 0.240 | [NA]	100	104
Sodium	meq/100g	0.10	<0.10	<0.10 | <0.10 | [NA]	96.6	100
Cation Exchange Capacity (CEC)	meq/100g	0.10	<0.10		[NA]	[NA]
Exchangeable Sodium Percentage (ESP)	%	1.0	<1.0		[NA]	[NA]

INORG-001 | Inorganics - General Physical Parameters (Soil) | Batch BFL0660

Analyte	Units	PQL	Blank	DUP1 PFK2023-01 Samp | QC | RPD %	LCS %
pH	pH units		5.9	5.8 | 5.8 | 0.688	102
Electrical Conductivity	µS/cm	2.0	2.40	32.1 | 27.3 | 16.2	106

AGRI-003_PRI | PBI/PRI (Soil) | Batch BFK5493

Analyte	Units	PQL	Blank	DUP1 PFK2023-01 Samp | QC | RPD %	LCS %
Phosphorus Retention Index	-		0.00	-0.115 | -0.403 | [NA]	104

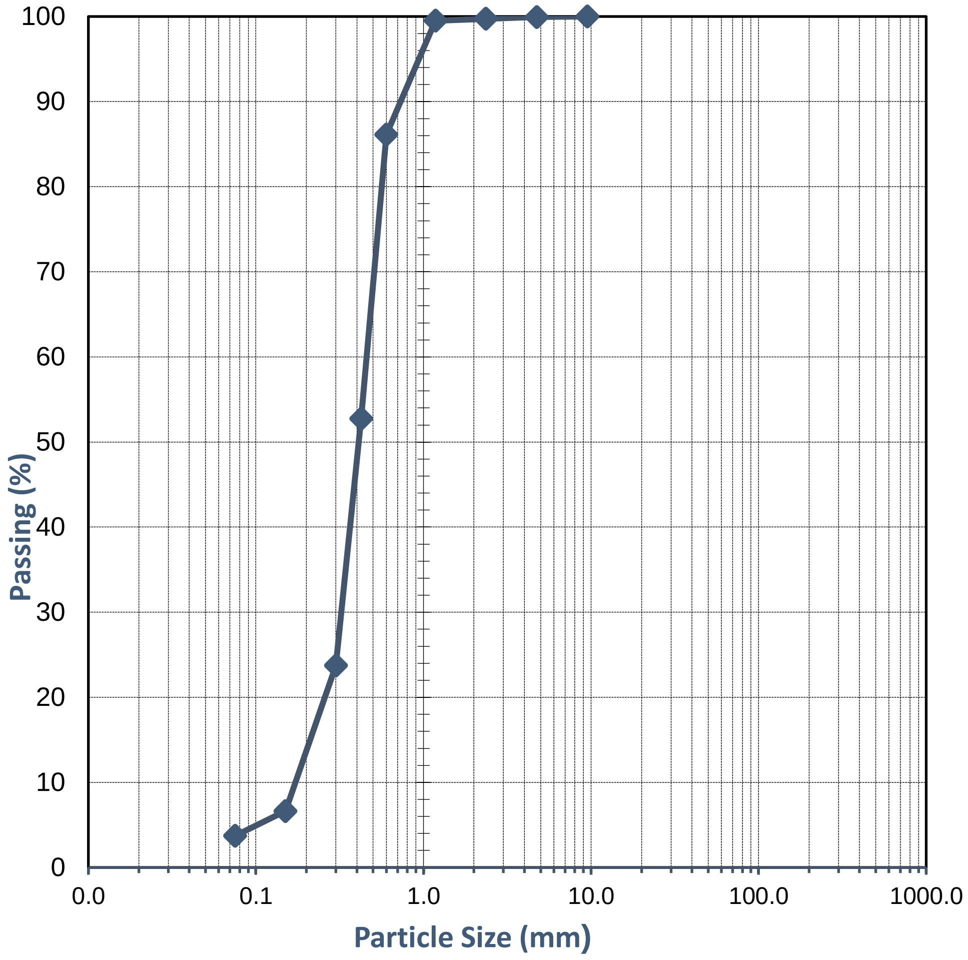
TEST REPORT - AS 1289.3.6.1

Client:	Sarich Building	*Ticket No.*	S15244
Client Address:	-	*Report No.*	WG24.18567_1_PSD
Project:	Proposed Warehouse	*Sample No.*	WG24.18567
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe	*Date Sampled:*	Not Specified
Sample Identification:	BH16 (0.1-0.5m)	*Date Tested:*	27/11 - 28/11/2024

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	100
1.18	100
0.600	86
0.425	53
0.300	24
0.150	7
0.075	4



Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 28/November/2024

Accreditation No. 20599
Accredited for compliance with ISO/IEC 17025 - Testing

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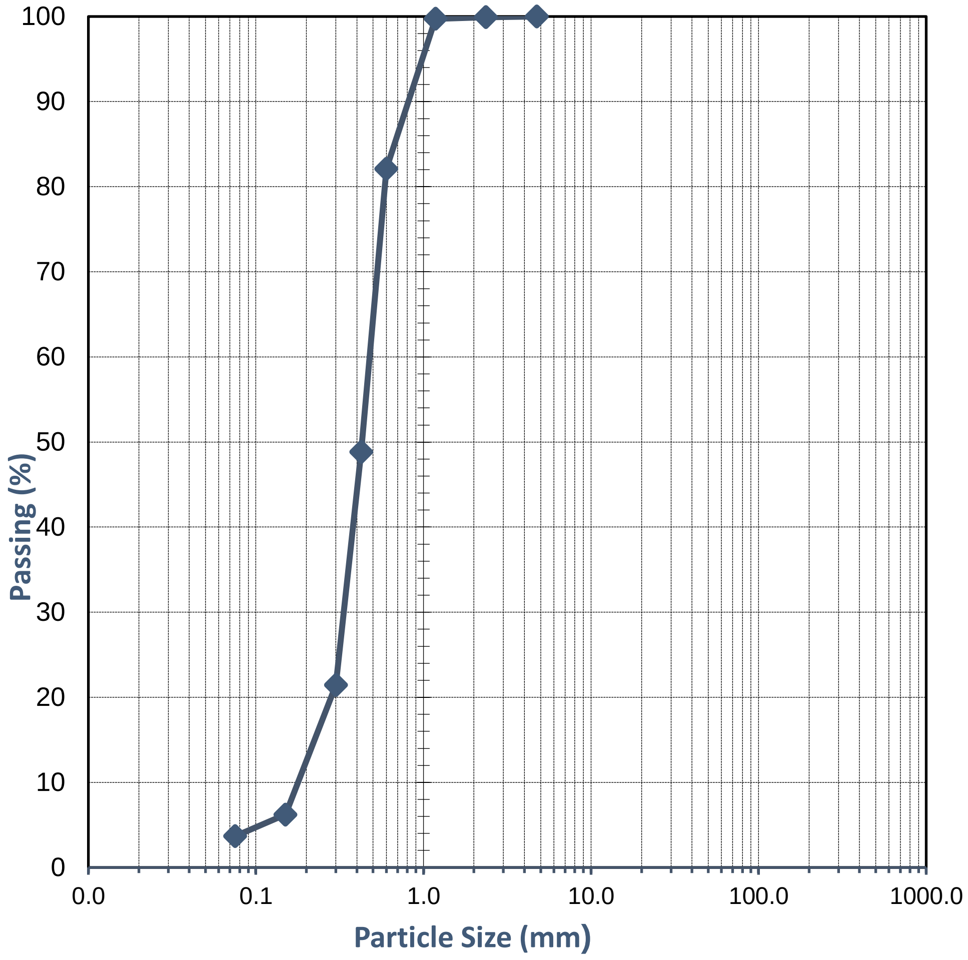
TEST REPORT - AS 1289.3.6.1

Client:	Sarich Building	*Ticket No.*	S15244
Client Address:	-	*Report No.*	WG24.18566_1_PSD
Project:	Proposed Warehouse	*Sample No.*	WG24.18566
Location:	Lots 8 and 16 Stirling Crescent, High Wycombe	*Date Sampled:*	Not Specified
Sample Identification:	G01 (0.1-0.5m)	*Date Tested:*	27/11 - 28/11/2024

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	100
1.18	100
0.600	82
0.425	49
0.300	21
0.150	6
0.075	4



Comments:

Approved Signatory:

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Standard Geotechnical Definitions, Recommendations, Requirements and Limitations

GDR1 ABOUT THIS APPENDIX

These technical notes are to be read with the attached report. These notes contain important information regarding the study in the attached report, and the report cannot be considered in isolation without full reading of these notes.

Where there are conflicts between this appendix and the report text, the report text takes precedence.

Unless noted otherwise, geotechnical investigations are conducted in accordance with AS1726-2017, "Geotechnical site investigations".

Unless noted otherwise, the report does not include any assessment (or implied assessment) of karst risk.

GDR2 DEFINITIONS

The following definitions apply:

- **Approved Fill** – fill that has been assessed and approved by the geotechnical engineer or civil designer for a particular purpose.
- **Bulk Fill** – Controlled fill intended to support future infrastructure, but potentially lacking some engineering properties required for upper fill layers or adjacent to structures, where fill with specific properties may be required. Contrast with Select Fill.
- **Civil Design** – the engineering design of the earthworks including surface water and erosion control and subsurface drainage control (where required) to achieve an earthworked, drained site which is capable of supporting the proposed development (including target site classification to AS2870, where relevant). This design is separate to this geotechnical investigation and is a required element of a site development.
- **Clay** – A component of a soil with particles smaller than 0.002 mm in size.
- **Cohesionless (Non-cohesive) Soil** – A soil mass that has does not hold together at low applied stress levels. The strength of the soil depends solely on friction between particles.
- **Cohesive Soil** – A soil mass that has holds together and can adhere to itself.
- **Collapsible Soil** – a soil with high void ratio that is typically strong when dry but loses strength and consolidates under constant stress when wetted, usually due to loss of soil matric suction or dissolving of a chemical cementing agent.
- **Compaction –** The process of increasing the soil density, typically be mechanical means.
- **Competent Person** – A person who has, through a combination of training, education and experience, acquired knowledge and skills enabling that person to correctly perform a specified task.
- **Consistency** – The stiffness of a cohesive soil, at specific moisture contents, to resist mechanical stress or manipulation (remoulding).
- **Controlled (or engineered) Fill** – Any fill for which engineering properties are controlled during placement. Also referred to as structural fill.
- **Dense –** with respect to sandy soils, at a relatively high density index or dry density ratio, exhibiting better engineering parameters with respect to strength and stiffness than the same material at a lower density index.
- **Density** – A measure of the mass of material per unit volume.
- **Eccentric Load** – a load incorporating either a varying vertical load and/or a horizontal load such that the peak vertical stress exceeds the average vertical stress.
- **Fill** – Any material that has been placed by anthropogenic processes.
- **Fines** – A component of a soil with particles smaller than 0.075 mm in size.
- **Groundwater** – Water located beneath the earth's surface in pore spaces, fractures and voids in soil or rock.
- **Gravel** – A component of a soil with particles between 2.36 mm and 63 mm in size.

- **Heavily Loaded** – in reference to mobile plant, particularly intended for equipment where ground bearing pressures exceed 50 kPa and/or equipment has a high centre of gravity and could be prone to toppling. In reference to buildings/structures, where footing pressures exceed 100 kPa and/or footing dimensions exceed 1 m wide.
- **Hydraulic Conductivity** – ratio of volume flux to hydraulic gradient – a quantitative measure of soil's ability to transmit water when subjected to a hydraulic gradient. k_{sat} – saturated hydraulic conductivity, intended for dewatering assessment, subsoil drainage design and other engineering assessments where saturated soils are relevant. k_{unsat} – unsaturated hydraulic conductivity, intended for design of stormwater disposal elements such as soakwells and infiltration basins, where the base of disposal elements is above the groundwater level.
- **In situ** – In the place and condition in which it exists naturally. May also refer to fill that is present at any site prior to an investigation taking place.
- **Limestone** – A sedimentary carbonate rock. The use of the term does not infer a specific strength, carbonate content or grain size. Refer to GDR4.1 for further detail.
- **Loose** – with respect to sand soils, at a relatively low density index or dry density ratio, typically indicating poorer engineering parameters with respect to strength and stiffness than the same material at a higher density index.
- **Material** – Matter that meets the definitions of 'soil', 'rock', other engineered matter (i.e., concrete, bricks etc.) or non-engineered matter (organics, contaminated refuse, deleterious material).
- **May** – Indicates that the statement is an option.
- **Must** – Indicates that the statement is mandatory.
- **Natural** – In the context of soil or rock, material which is present as a result of natural geological processes and has not been subject to anthropogenic engineering processes (such as filling, excavation, replacement, etc).
- **Organic** – In the context of soil, material derived from living matter, primarily plants.
- **Overconsolidated** – a soil that has been subjected to a greater vertical stress than its current state.
- **Permeable Soil** – soil that meets the civil design permeability requirements to allow relatively rapid flow of water through the soil matrix.
- **Rock** – Any aggregate of minerals and/or materials that cannot be disaggregated by hand in air or water without prior soaking.
- **Sand** – a component of soil with particle size between 0.075 mm and 2.36 mm.
- **Select Fill** – a controlled fill which has been chosen for particular engineering characteristics (such as strength, CBR, grading, permeability, etc), commonly for use as a higher-grade capping layer or adjacent to structures. Contrast with Bulk Fill.
- **Shall** – Indicates that the statement is mandatory.
- **Should** – Indicates that the statement is a recommendation.
- **Silt** – A component of a soil with particles between 0.075 mm and 0.002 mm in size.
- **Soil** – Particulate materials that occur in the ground and can be disaggregated or remoulded by hand in air or water without prior soaking.
- **Sand** – A component of a soil with particle between 0.075 mm and 2.36 mm in size.
- **Uncontrolled Fill** – Any material that has been deposited by anthropogenic process, which does not meet the definition of 'controlled fill'.

GDR3 GEOTECHNICAL TEST METHODS AND INTERPRETATION

GDR3.1 Test Pit Excavation

Test pit excavations are formed using mechanical excavation equipment (typically an excavator) or hand dug, with the objective of inspecting (or profiling) the soil exposed in the excavation.

Typical limitations on test pit excavations are:

- Limited depth of excavation – typically governed by reach of the excavator arm.
- Cannot be excavated below groundwater in cohesionless soils, due to collapse and water ingress.
- Cannot be excavated through very stiff / very dense soils (i.e., desiccated clays or cemented soils) or most rock.
- Cannot typically obtain rock samples that are suitable for strength testing.

Test pits are usually mechanically excavated with a toothed bucket (intended for excavation in clay or weak rock) or a flat-edged bucket (typically for sands).

When hand-dug test pits are excavated, it is usually for recovery of near-surface soils or inspection of shallow in-ground elements.

We note that where test pits are excavated on a site, they are only ever loosely backfilled during our studies. They must always be located during site preparation works, over-excavated to their full depth and plan extents and re-filled with approved fill in compacted layers.

GDR3.2 Cone Penetration Tests (CPTs)

Cone penetration testing (CPT) is done by Galt or specialist contractors and typically to AS1289.6.5.1. The test involves pushing an instrumented cone into the soil with a hydraulically operated pushing frame. The test measures tip resistance and sleeve friction on the cone, which are then plotted with depth.

We interpret soil types and associated geotechnical soil parameters from CPT data using the following:

Technical Interpretations and International Guides

- Robertson P.K., Campanella R.G., Gillespie D. and Grieg J. (1986). “Use of piezometer cone data”. Proceedings of the ASCE Speciality Conference In Situ ’86: Use of In Situ Tests in Geotechnical Engineering, Blacksburg, pp 1263-80, American Society of Civil Engineers (ASCE).
- Robertson, P.K., Cabal K.L. (2016) “Guide to Cone Penetration Testing for Geotechnical Engineering 6th Edition 2015”. Gregg Drilling & Testing, Inc., California.
- Baldi G., Bellotti R., Ghionna V.H., Jamiolkowski M., Lo Presti D. C. (1989) “Modulus of sands from CPTs and DMTs”. Proc. 12th Int. Conf. on SMFE, Rio de Janeiro, Vol 1, p165-170, Balkema, Rotterdam.

Local (Perth and Western Australia) Research, Interpretation and Guides

- Fahey, M., Lehane, B., Stewart, D. (2003) “Soil stiffness for shallow foundation design in the Perth CBD”. Australian Geomechanics Vol. 8 No. 3.
- Main Roads Western Australia (MRWA) (2009) “Structures Engineering Design Manual”. Document 3912/03, Perth.
- Lehane B. (2017). “CPT-Based Design of Foundations”, E.H. Davis Memorial Lecture, Australian Geomechanics, Vol 54. No. 4’ and
- Galt’s in-house correlations between CPT data and other geotechnical testing.

GDR3.3 Borehole Drilling

Boreholes are drilled for sampling of the soil and rock, with a small disturbance footprint. Typical techniques are:

- Auger drilling (hand auger or machine auger) – for recovery of soil at relatively shallow depths only. Cannot penetrate cemented soils or rock.
- Push probe drilling – for recovery of soil at relatively shallow depths and below groundwater. Cannot penetrate cemented soils or rock.
- Air core drilling – for recovery of soil, cemented soil and rock (typically up to high strength rock). Not suited to drilling of very high strength rock.
- Diamond coring (or rotary coring) – for recovery of cemented soil, rock and some soil types (typically not sand). Suited to all strengths of rock.

If used, standard penetration tests (SPTs) are done in accordance with AS1289.6.3.1. Correlations for consistency and density are based on:

- Standards Australia (2016), “HB160-2006, Soils Testing”.

GDR3.4 Dynamic Cone Penetrometer (DCP)

The DCP is a hand-held tool for assessing penetration resistance of a soil. This comprises a 16 mm rod equipped with a 20 mm cone, hammered into the ground using a falling 9 kg weight on a 510 mm slide hammer on the top of the rod. This is done in accordance with AS1289.6.3.2 and the blow counts to hammer in the rod are measured in 100 mm penetration increments. Where provided, correlations for consistency and density are based on:

- Standards Australia (2016), “HB160-2006, Soils Testing”.

GDR3.5 Perth Sand Penetrometer (PSP)

The PSP is a variation on a DCP and uses a 9 kg weight on a 600 mm slide hammer to hammer in a 16 mm rod with a blunt (square-faced) end. Testing is done in accordance with AS1289.6.3.3, with the following typical variations:

- Testing is often done to a greater depth than the 450 mm covered in the standard.
- Blow counts are sometimes recorded in 150 mm intervals (compared to 300 mm intervals used in the standard) to provide better resolution on the tests.

Where provided, correlations for density are based on:

- Standards Australia (2016), “HB160-2006, Soils Testing”.

GDR3.6 Dynamic Probing Super Heavy (DPSH)

The DPSH test involves driving a solid cone (20 cm^2) into the ground using a 63.5 kg hammer falling 760 mm. Testing is done in accordance with EN ISO 22476-2 – Geotechnical engineering – Field testing – Part 2: Dynamic probing – DPSH-B.

Results may be presented as either:

- N10 (No. of blows required for every 100 mm penetration);
- N30 (No. of blows required for every 300 mm penetration); or
- q_d (dynamic tip resistance, analogous to CPT q_c).

GDR3.7 Inverse Auger Hole Infiltration Test (Falling Head, Unsaturated Soil)

Infiltration tests are carried out using the ‘inverse auger hole’ method described by:

- Cocks, G (2007), “Disposal of Stormwater Runoff by Soakage in Perth Western Australia”, Journal and News of the Australian Geomechanics Society, Volume 42 No. 3, pp 101-114

This test is an unsaturated falling head test, in that it is carried out above the groundwater table and is intended to mimic the behaviour of soak wells and similar drainage elements (i.e. soakage basins), which discharge stormwater into an unsaturated medium.

The hole is wetted only for a short period prior to the testing.

The test is usually repeated three times, with the intention that the second and third tests provide similar results (within about 10%-20%). Tests are done over a short duration, typically 2 minutes to 10 minutes. The focus of the testing is generally when the head is low (200 mm or lower), such that the relevant lateral zone is as saturated as the zone directly below the borehole.

The hydraulic conductivity derived from this test is not to be used for applications where saturated hydraulic conductivity is relevant, e.g.:

- Subsoil drainage design; and
- Dewatering estimations.

Based on Galt's in-house research, this method does not completely saturate the soil in any reasonable test length, and thus may not be suitable for assessment of soils at sites where the critical drainage condition is a fully saturated soil (i.e., in areas with high groundwater tables). Our research on sand sites indicates that the test does correlate well with actual soak well performance, in unsaturated sand zones without impermeable zones.

GDR3.8 Guelph Permeameter Test (Constant Head, Quasi-Saturated Soil)

The Guelph permeameter test, conducted in accordance with the constant head test method outlined in Appendix G of AS1547, is a constant-head test in nominally "saturated" soil (in that the test is conducted until a "steady state" is reached). However, we note that this test can only be done above the groundwater table and as such, is in an unsaturated zone. Therefore, the hydraulic conductivity derived from this test should be used with caution and evaluated against other test methods (such as saturated, constant-head permeability testing from laboratory samples, or in situ saturated hydraulic conductivity testing below the groundwater table).

GDR4 GEOLOGICAL UNITS

GDR4.1 Limestone

The term 'Limestone' is used to describe a carbonate rock. Tamala Limestone is the common limestone in Western Australia, and typically comprises cemented quartz and shell fragments cemented together by calcium carbonate.

Limestone can vary significantly across short distances in composition, strength and cementation. Tamala limestones in Western Australia also have known possible geological features including:

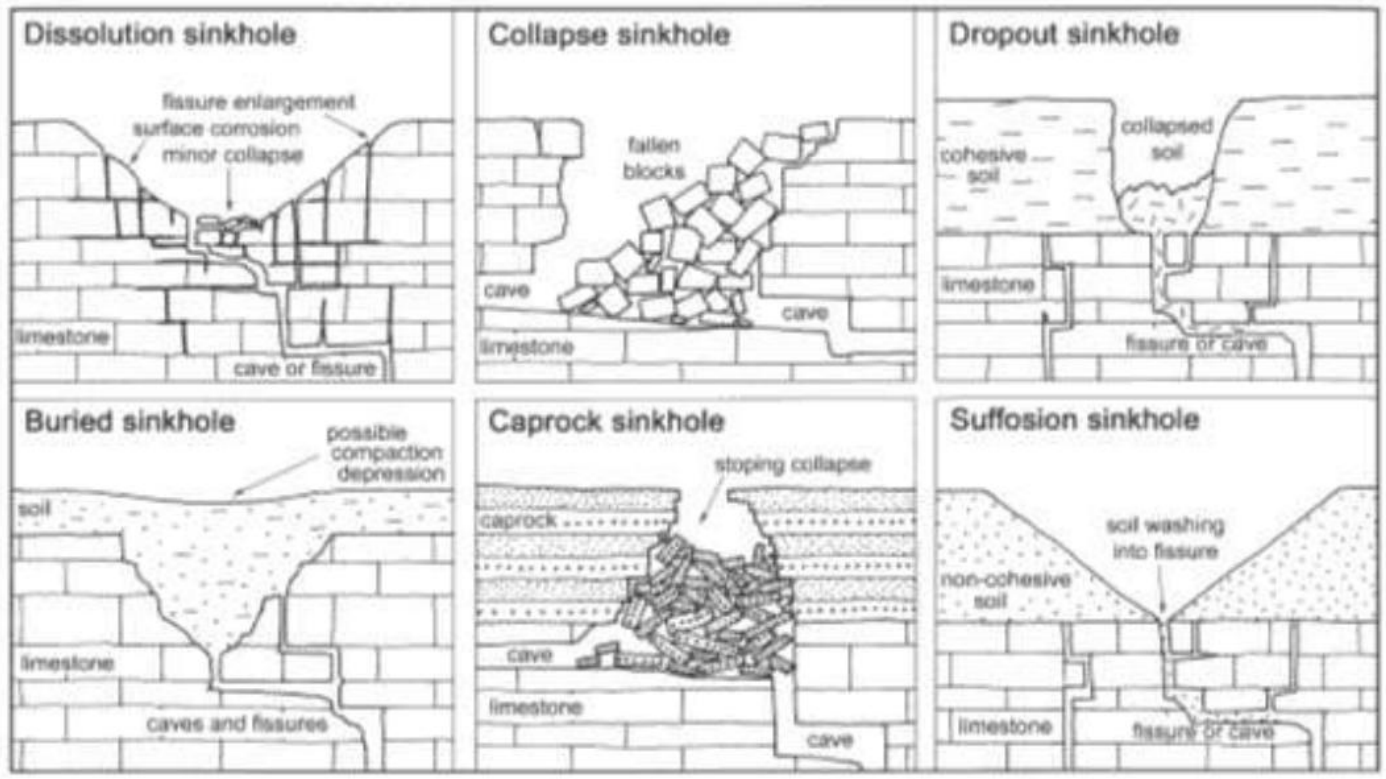
- Caprock/calcrete – The formation of a very hard duricrust, usually due to sun exposure. Caprock may be up to 3 m thick, but typically around 1.5 m thick. Caprock is very difficult to excavate and may require the use of hydraulic rock breakers or rock saws to excavate.
- Solution features/tubes – Often initially formed due to the presence of Eucalypt and Jarrah roots during limestone formation, and often increasing in depth and size due to ongoing weathering. May be up to 500 mm in diameter. These are typically filled with very loose, unconsolidated sand.
- Pinnacles – Pinnacles are usually the limestone that is left around surrounding solution features. Often can comprise very hard limestone/caprock that can be substantially higher than surrounding areas. Pinnacles may have also been formed by surrounding erosion (i.e., wind/water).
- Karst/caves – Karst is caused by the dissolution of limestone, typically where there is interaction in low-lying areas with water and limestone. Karst manifests itself as loose near-surface sand with cavities (caves) in the underlying limestone. This can lead to sinkholes and collapse of overlying structures.

Inline images showing typical pinnacle/solution features and Karstic features follow. These are taken from:

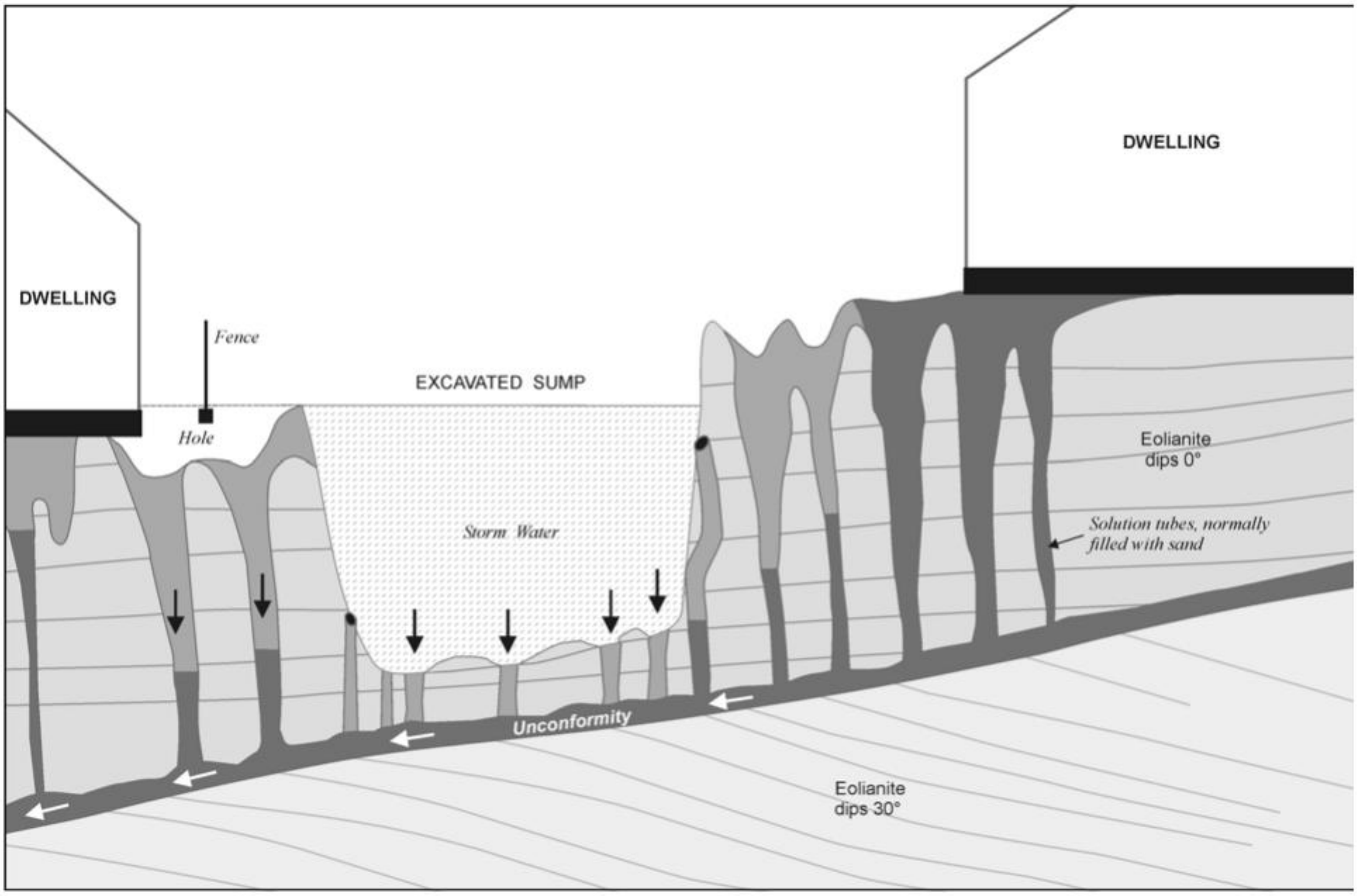
- Gordon, R. (2003). "Coastal Limestones". Australian Geomechanics Vol.38 No. 4, The Engineering Geology of Perth.

- Waltham, A. & Fookes, P. (2003). "Engineering Classification of Karst Ground Conditions: Quarterly Journal of Engineering Geology and Hydrogeology, Vol 36.

Inline Image GDR 1 - Karstic Sinkhole Features from Waltham and Fookes (2003)



Inline Image GDR 2: Pinnacle/Solution Features from Gordon (2003)



GDR4.2 Pindan Sands and Collapsible Soils

In the Western Australian context, Pindan sands are sandy soils present predominantly across the Pilbara and Kimberley regions. Pindan sands are typically:

- Red brown in colour.
- Between 10% and 40% fines.
- Of aeolian origin, usually resulting in unconsolidated in situ conditions (nuclear density gauge testing often indicates these soils have in situ density ratios of 80%-85% of modified maximum dry density).
- Very strong when dry due to high soil suctions in the fine fraction, which create strong bonds between the sand particles.

As the grains are usually held in place by the dry fine fraction, this can lead to:

- very high settlements (i.e., “collapse”) as the grain-to-grain bonds are weakened as matric suction decreases on soaking; and
- loss of vertical and horizontal strength/stiffness as the grain-to-grain bonds weaken.

The risks associate with Pindan sands are usually quantified in terms of the collapse potential/magnitude of possible collapse events.

Other similar soils are present in Western Australia that may exhibit similar collapse potential and may not strictly be Pindan sands (i.e., have other grain-to-grain bonding mechanisms).

GDR5 SITE CLASSIFICATION

Site classification refers to the assessment of a site in reference to AS2870-2011, “Residential slabs and footings”. The method for assessing the site class is outlined in Section 2 of AS2870-2011, which indicates that this may be done by:

- assessing the characteristic surface movement, due to seasonal moisture changes in the soil profile;
- assessing the performance of existing foundations; or
- assessment of the soil profile (where there are deleterious inclusions, landfill, putrescible waste etc.).

The site classifications based on the expected characteristic surface movement are summarised in Table GDR 1.

Table GDR 1: Summary of Site Classifications (AS2870-2011)

Class	Description	Characteristic Surface Movement (y_s)
A	Most sand and rock site with little or no ground movement from moisture change	Not Defined (typically <5 mm)
S	Slightly reactive clay sites with only slight ground movement from moisture changes	0 – 20 mm
M	Moderately reactive clay sites, which may experience moderate ground movements from moisture change	20 – 40 mm
H1	Highly reactive sites, which may experience high ground movements from moisture change	40 – 60 mm
H2	Highly reactive sites, which may experience very high ground movements from moisture change	60 – 75 mm
E	Extremely reactive sites, which may experience extreme ground movements from moisture change	>75 mm
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise	Not Defined

The calculated characteristic surface movement is predominantly based on:

- the reactivity (i.e., the shrink-swell potential) of the soil (and any proposed fill);

- the design depth of soil suction change, which is the maximum expected depth of soil suction change due to seasonal soil moisture changes; and
- the depth to any bedrock and groundwater table.

The design depth of soil suction change for Western Australia has been refined using the Thornthwaite Moisture Index (TMI). We have carried out assessment using the depths as detailed in:

- Hu Y, Saraceni P, Cocks G, Zhou M (2016). "TMI assessment and climate zones in Western Australia". Australian Geomechanics Journal, Vol.51 No.3.
- Hu Y, Raj A, Cocks G, Verheyde F (2019). "Re-assessment of TMI based climate zones in metropolitan Perth, WA". ANZ Geomechanics Conference 2019, Perth Australia.

The design depth of soil suction change for Northern Territory is based on the research presented in:

- Jackson, S (2022), "Thornthwaite moisture index and climate zones in the Northern Territory", Australian Geomechanics Journal, Vol. 57 No. 3.

We highlight that AS2870-2011 does not make any reference to the fines content of a soil when assessing the site classification.

Where a site classification is provided in our reports, it is always predicated on the requirement that the recommended site preparation procedures are carried out.

We also highlight that the footing performance and shrink-swell movements of a site can be impacted by the planting or removal of trees. This should be considered where appropriate, and we refer to the CSIRO BTF 18-2011 "Foundation Maintenance and Footing Performance: A Homeowner's Guide" for further information.

AS 2870 is limited to single and double storey residential buildings with normal shallow footings with a maximum bearing pressure of 100 kPa and is not applicable where development types other than this are proposed.

GDR6 SITE PREPARATION

GDR6.1 General

The intent of the site preparation guidelines provided in the above report are to ensure that the earthworks can be constructed to meet specific requirements, i.e., minimum compaction, fill requirements, removal of unsuitable material etc. The site preparation guidelines are not exhaustive, and on-site conditions may dictate that other preparation measures may be required to meet geotechnical requirements.

GDR6.2 Site Preparation

Site preparation measures outlined in this section relate to bulk earthworks at the site in preparation for the construction of buildings, pavements and other structures.

The preparation of a site in accordance with outlined measures below or those presented in the report text does not imply that the site is suitable for heavily loaded plant or eccentric loads. This is especially applicable for working platforms for mobile plant including cranes, crawlers or the like. The site surface may still not be trafficable for mobile plant. Individual working platform assessments must be done if heavily loaded mobile plant are proposed.

GDR6.2.1 Common Measures

The common measures outlined below are to prepare standard sites in advance of proof compaction, bulk excavation and filling. These measures are applicable to most sites, however the applicability of these measures is stated in the main report.

Table GDR 2: Common Measures

Measure	Commentary
Demolish and remove structures and pavements	Demolish existing structures and pavements, including removal of all buried services and footings and dispose off-site.
Remove demolition debris and other deleterious material	Remove any demolition debris and other deleterious material from site including old footings, slabs, soak wells, buried services, paving and building rubble.
Strip uncontrolled fill (where present)	Strip any uncontrolled fill from the site (where encountered) and, if suitable, stockpile it for potential re-use as non-structural fill. If contaminated, dispose off-site. Refer to the report text for discussions on the presence of detected uncontrolled fill and its composition. It is important to realise that undetected uncontrolled fill may be present between test locations and the absence of its identification in our report does not preclude its presence. If uncontrolled fill is detected during site works, please contact us for inspection and to provide recommendations.
Remove trees	All tree roots must be removed, this may result in significant excavation in places. Where tree roots and stumps are removed, the disturbed soil must be over-excavated and replaced with controlled, compacted fill. Backfilling of over-excavations is discussed in the following sections .
Strip and stockpile topsoil.	Strip and stockpile topsoil from unpaved areas of the site for potential re-use in non-structural applications. The topsoil strip is only necessary to remove roots and we recommend a topsoil strip as necessary to remove all roots from the soil.
Carry out bulk excavation	Excavate to the required level. Stockpile suitable excavated material for potential re-use as fill (the re-use of spoil as fill , if appropriate, is discussed in the report text) and remove unsuitable or excess material off-site.
Batter edges of excavation	Excavations should be battered to a temporary slope as given in the report text where applicable and not in close proximity to adjacent structures etc. If required, construct temporary/permanent retaining walls where batters cannot be accommodated.

By following these measures, the site should have been prepared to a point where topsoil and vegetation has been removed to expose either natural soil or controlled fill. Over-excavation to the required levels may then be required for some projects. Once complete, the site is now ready for proof compaction and filling.

GDR6.2.2 Sand Sites

The preparation measures outlined below are provided for sand sites meeting the following criteria:

- Site underlain by sand.
- No collapsible soils present.
- No deep loose sand.
- Compaction of a loose upper horizon to maximum 1 m depth.
- No shallow groundwater (<1 m deep).
- No limestone or other rock present at shallow depth.
- “Common Measures” outlined in Section GDR6.2.1 have been completed (as required).

The applicability of these measures is stated in the main report. These measures must be carried out for all areas where structures, footings, pavements and any other settlement-sensitive infrastructure is proposed.

Unless specified otherwise in the report, the **Approved Fill** to be used is outlined in Section GDR8 (**Permeable Sand** where permeable fill is required, else **General Sand**). The specific selection is subject to the requirements of the civil designer.

Table GDR 3: Sand Site Measures

Measure	Commentary
Moisture condition and proof compact.	Moisture condition and compact the exposed sandy ground to achieve the density specified in Section GDR7.1 (“sand”) to a depth of at least 900 mm.
Test proof compaction	Check that the density specified in Section GDR7.1 (“sand”) has been achieved to a depth of at least 900 mm. We note that the applicability of the use of the PSP for compaction control is discussed in the report. Unless specifically approved for use on the subject site, the contractor must **not** assume that the use of the PSP is appropriate.
Treat areas of loose or unsuitable material	Any areas of loose sand or unsuitable material (including over-excavated areas of former trees and root balls) must be removed and replaced with **Approved Fill** as outlined in the report or as noted above. The report will explain the suitability of site-derived materials for re-use as approved fill.
Carry out bulk filling	Where fill is required to build up levels, use **Approved Fill**, placed and compacted in layers of no greater than 300 mm loose thickness. Test compaction to achieve the density specified in Section GDR7.1.

In following this method, shallow/surficial loose sand will be compacted, and the site will be filled (where required) in preparation for supporting footings, ground slabs, pavements and the like.

GDR6.2.3 Deep Loose Sand Sites

The preparation measures outlined below are provided for sand sites meeting the following criteria:

- Site underlain by sand.
- Collapsible soils or deep loose sand present (if applicable, this is discussed in the report).
- Over-excavation, compaction and replacement of loose sand required.
- No shallow groundwater (<1 m deep).
- No limestone or other rock present at shallow depth.
- “Common Measures” outlined in Section GDR6.2.1 have been completed.

The greatest depth of compaction that can be achieved with standard compaction equipment (vibrating roller, etc) is around 1 m (for sands). As such, it is necessary to cut down the site level to a point where this compaction can be done to the lowest level needed to be improved.

The applicability of these measures is stated in the main report. These measures must be carried out for all areas where structures, footings and any other settlement-sensitive infrastructure are proposed. Not typically required for pavement subgrades, however, this is discussed in the report if required.

Unless specified otherwise in the report, the **Approved Fill** to be used is outlined in Section GDR8 (**Permeable Sand** where permeable fill is required, else **General Sand**). The specific selection is subject to the requirements of the civil designer.

Table GDR 4: Deep Loose Sand Site Measures

Measure	Commentary
Over-excavate to the required depth.	Over-excavate sand soil to the depth stated in the report and, if appropriate (discussed in report) retain it for re-use as fill. Over-excavation is likely to be done in stages depending on the site area available for earthworks. Excavations must be battered to a temporary slope as given in the report text where applicable and not in close proximity to adjacent structures etc. If required, construct temporary/permanent retaining walls where batters cannot be accommodated.
Moisture condition and proof compact.	Moisture condition and compact the exposed sandy ground to achieve the density specified in Section GDR7.1 (“sand”) to a depth of at least 900 mm.
Test proof compaction	Check that the density specified in Section GDR7.1 (“sand”) has been achieved to a depth of at least 900 mm. We note that the applicability of the use of the PSP for compaction control is discussed in the report. Unless specifically approved for use on the subject site, the contractor must **not** assume that the use of the PSP is appropriate.
Treat areas of loose or unsuitable material	Any areas of loose sand or unsuitable material (including over-excavated areas of former trees and root balls) must be removed and replaced with compacted **Approved Fill** as outlined in the report or as noted above. The report will explain the suitability of site-derived materials for re-use as approved fill.

Measure	Commentary
Carry out bulk filling	Where fill is required to build up levels (including restoration of the site surface level to the original level), use **Approved Fill**, placed and compacted in layers of no greater than 300 mm loose thickness. Test compaction as specified in Section GDR7.1.

In following this method, deep, loose sand will be compacted to a sufficient depth to reduce settlement impacts and the site will be filled (where required) in preparation for supporting footings, ground slabs, pavements and the like.

GDR6.2.4 Clayey Sites

The preparation measures outlined below are provided for sand sites meeting the following criteria:

- Site underlain by cohesive soils (typically >12% fines, i.e., clayey enough for the fines proportion of the soil to dominate behaviour).
- No collapsible soils present.
- No deep soft soils or organic soils.
- Over consolidated clayey soils present which will not be subject to significant primary or secondary consolidation (settlements expected to be within the limit of typical seasonal movements occasioned by moisture content changes, which would be captured in assignment of an AS2870 site classification).
- No shallow groundwater (<1 m deep)
- No rock present at shallow depth.
- “Common Measures” outlined in Section GDR6.2.1 have been completed.

The applicability of these measures is stated in the main report. These measures must be carried out for all areas where structures, footings, pavement subgrades and any other settlement-sensitive infrastructure is proposed.

Unless specified otherwise in the report, the **Approved Fill** to be used is **Clay** as outlined in Section GDR8.

Table GDR 5: Clay Site Measures

Measure	Commentary
Moisture condition and proof compact.	Moisture condition and compact the exposed clayey ground to achieve the density specified in Section GDR7.1 (“fine grained soils”) to a depth of at least 300 mm.
Test proof compaction	Check that the density specified in Section GDR7.1 (“fine grained soils”) has been achieved to a depth of at least 300 mm. The use of a penetrometer for compaction control of cohesive soils is not an appropriate substitute for in situ NDG testing.
Treat areas of loose or unsuitable material	Any areas of soft clayey soils or unsuitable material (including over-excavated areas of former trees and root balls) must be removed and replaced with compacted **Approved Fill**. The report will explain the suitability of site-derived materials for re-use as approved fill.
Carry out bulk filling	Where excavations are done into clayey soils (e.g. to treat soft zones, remove root balls and the like), they must not be backfilled filled with sand fill (even where a sand topping layer is proposed). Where fill is required (including backfilling of excavations to remove trees), only use **Approved Fill**, moisture conditioned, placed and compacted in layers of no greater than 300 mm loose thickness. Test moisture and compaction as specified in Section GDR7.1.
Grade completed clayey surface	Surface water control is essential for clayey sites. This also applies to control of infiltrated water into sand topping layers or the like. The surface of clayey ground must be graded at a minimum of 1% crossfall to drain. This is a general recommendation and an appropriate civil design must be done to account for surface and subsoil drainage.
Install sand topping layer	Where a sand topping layer is proposed, this should be done as outlined in Section GDR6.2.5.

These measures do not take into account the objectives of the civil design for the site, particularly with regard to surface water drainage and groundwater control (including clay grading, subsoil drainage, thickness and composition of a sand topping layer and the like). This must be taken into account by the civil designer. General commentary on drainage control measures is presented in Section GDR14.

GDR6.2.5 Sand Topping Layer

Where a sand topping layer is required:

Unless specified otherwise in the report, the **Approved Fill** to be used is outlined in Section GDR8 (**Permeable Sand** where permeable fill is required, else **General Sand**). The specific selection is subject to the requirements of the civil designer.

Table GDR 6: Sand Topping Layer Measures

Measure	Commentary
Prepare Substrate	Prepare the clayey or other substrate as separately outlined prior to installing the topping layer.
Build up sand topping layer	Build up level to the required level with **Approved Fill**, placed and compacted in layers of no greater than 300 mm loose thickness to achieve the density specified in Section GDR7.1.

For the purposes of achieving the allowable bearing pressures and site classification discussed in the report, it is not necessary to have the bases of slabs and footings in the sand topping layer, i.e. if required, they may extend through the sand topping layer into clayey soil below.

GDR6.2.6 Limestone Sites

The preparation measures outlined below are provided for sites underlain by limestone (refer to Section GDR4.1), meeting the following criteria:

- Site underlain by sand overlying limestone.
- Compaction of a loose upper horizon to maximum 1 m depth, with localised deeper treatments between pinnacles if required.
- No shallow groundwater (<1 m deep)
- “Common Measures” outlined in Section GDR6.2.1 have been completed.

The site preparation measures outlined below are aimed at improvement of the site in preparation for construction of the structures including on-ground slabs, shallow footings, retaining walls and pavements.

Unless specified otherwise in the report, the **Approved Fill** may comprise one of the following as specified in Section GDR8 (the specific selection is subject to the requirements of the civil designer):

- **Permeable Sand** where permeable fill is required
- **General Sand** where permeable fill is not required
- **Mixed Sand/Limestone Fill** where permeable fill is not required

The re-use of any limestone for fill is subject to the requirements of the civil design and discussions in the report text. The use of **Mixed Sand/Limestone Fill** is discussed in Section GDR6.2.7. The preparation measures outlined in Table GDR 7 assume sand fill.

Table GDR 7: Standard Limestone Site Measures (Bulk Earthworks)

Measure	Commentary
Treat zones of loose sand	Where deep loose sand is present (particularly, but not exclusively, between limestone pinnacles), over-excavate to the depth as noted in the report . Sand should be retained for re-use as fill if recommended in the report. Limestone debris and pinnacles should be separated and only re-used if recommended in the report.
Moisture condition and proof compact.	Moisture condition and compact the exposed sandy ground to achieve the density specified in Section GDR7.1 (“sand”) to a depth of at least 900 mm. Proof compaction of intact limestone is not required.
Test proof compaction	Check that the density specified in Section GDR7.1 (“sand”) has been achieved to a depth of at least 900 mm. We note that the applicability of the use of the PSP for compaction control is discussed in the report. Unless specifically approved for use on the subject site, the contractor must not assume that the use of the PSP is appropriate. If refusal to the test method is encountered within the target test depth on limestone and the results to the refusal depth are acceptable, it is not necessary to repeat compaction testing at that location. Compaction control of intact limestone is not required.
Treat areas of loose or unsuitable material	Any areas of loose sand or unsuitable material (including over-excavated areas of former trees and root balls) must be removed and replaced with compacted **Approved Fill** as outlined in the report or as noted above. The report will explain the suitability of site-derived materials for re-use as approved fill.
Carry out bulk filling	Where fill is required to build up levels, use **Approved Fill**, placed and compacted in layers of no greater than 300 mm loose thickness. Test compaction to achieve the density specified in Section GDR7.1.

These measures do not take into account the specifics of the civil design, including the requirement (if any) for excavatable and/or free draining layers to achieve construction and drainage objectives. The civil design must take precedence and is not specifically considered in this advice.

Soakwells can perform poorly in limestone and specific advice may apply to the installation of soakwells in limestone areas. If not discussed in our report, please contact us for further advice.

Without further consultation with the structural designer, footings for any one structure must not be founded on a mixture of sand and intact limestone. This is due to potential differential settlements between limestone zones (relatively stiff) and soil zones (relatively soft). Where this is the case, the measures outlined in Table GDR 8 must be followed, only with guidance from the structural designer and Galt.

Table GDR 8: Standard Limestone Site Measures (Footing and Slab Preparation)

Measure	Commentary
Excavate and compact for subgrades, pad or strip footings	Excavate for pad and strip footings. Where a mix of soil and limestone is present below any one structure, one of the following must be done (to be agreed with structural designer and us): ▪ **Over-excavate limestone and replace with compacted soil:** Typically where the foundation largely comprises soil and a relatively small amount of limestone is present. Where footings and slabs are founded partly on soil and partly on limestone, over-excavate the limestone by at least 300 mm below the base of footing or slab and replace the excavated material with compacted **Approved Fill**. ▪ **Remove soil from over limestone and replace with concrete**: Typically where the foundation largely comprises limestone and a relatively small amount of soil is present. Localised zones of sand and mixed sand/limestone rubble must be removed and replaced with lean-mix concrete, e.g. 10 MPa blinding concrete. ▪ **Design the structure to accommodate differential foundation movements:** For example, include construction joints or use a more heavily reinforced footing (subject to the structural designer’s requirements).
Test compaction of footing bases, slabs or subgrades.	Compact the exposed bases to achieve the density specified in Section GDR7.1 (“sand”), to a depth of at least 900 mm, or to the depth where limestone is intersected. If refusal to the test method is encountered within the target test depth on limestone and the results to the refusal depth are acceptable, it is not necessary to repeat compaction testing at that location. Compaction control of intact limestone is not required. Remove, replace and compact as required with approved fill any zone not achieving the density specified in Section GDR7.1 (“sand”)

GDR6.2.7 Mixed Sand/Limestone Filling

On sites where deemed appropriate by the Civil Design, **Approved Fill** may comprise limestone rubble fill (**Mixed Sand/Limestone**, as specified in Section GDR8).

The preparation measures outlined below are provided for sites meeting the following criteria:

- No shallow groundwater (<1 m deep)
- “Common Measures” outlined in Section GDR GDR6.2.1 have been completed.
- Substrate preparation for the relevant site type has been done in preparation for further filling (as relevant for sand, limestone or clayey sites discussed in the preceding sections).

The site preparation measures outlined below are required prior to construction of structures including on-ground slabs, shallow footings, retaining walls and pavements.

Table GDR 9: Mixed Sand/Limestone Fill Measures

Measure	Commentary
Develop a method specification for the filling	A performance specification is not appropriate for compaction control in **Mixed Sand/Limestone** fill, due to oversize limestone particles and the limitations of test methods. Therefore, a method specification is required. Development of a method specification is discussed in Section GDR7.5. A tentative method specification for **Mixed Sand/Limestone** Fill preparation is also provided.
Carry out bulk filling	Where fill is required to build up levels, use **Approved Fill**, placed and compacted in accordance with the developed method specification.
Maintain Construction Records	As performance testing cannot be done, quality assurance records are limited. Therefore, the parameters mentioned in Section GDR7.5.1 must be kept in a comprehensive record of the earthworks done to the developed method specification. The use of the PSP is possible only to check for loose sand zones between limestone particles. High PSP blow counts, where limestone particles are intersected, are meaningless in terms of assessing density of the prepared fill. The primary means of validation of the earthworks is conformance with the developed method specification.
Install sand topping layer	Where a sand topping layer is proposed, this should be done as outlined in Section GDR6.2.5.

These measures do not take into account the specifics of the civil design, including the requirement (if any) for excavatable and/or free draining layers to achieve construction and drainage objectives. The civil design must take precedence and is not specifically considered in this advice.

Soakwells can perform poorly in limestone fill and specific advice may apply to the installation of soakwells in limestone fill areas. If not discussed in our report, please contact us for further advice.

GDR6.3 Guidance on Sites with Cohesive Soils

Cohesive soils (most commonly, “clayey” soils) require careful moisture conditioning to facilitate compaction. We recommend that the moisture content of the material is between optimum moisture content (OMC) and 2% wet of OMC at the time of placement and compaction. We note that compaction to the densities specified in Section GDR7.1 can be difficult to achieve for clayey material when not appropriately moisture conditioned.

Vibratory padfoot rollers are preferred for compacting cohesive fill to promote proper kneading and interlocking of subsequent layers.

Clayey soils will drain poorly when inundated following rain events and result in saturated conditions that may inhibit compaction of the soil. In general, it is preferable to avoid trying to re-work clayey sites within several days of any substantial rainfall.

We recommend that the surfaces of clayey sites are sealed by compaction (i.e., final compaction should be with a smooth drum roller) and graded to drain (to avoid low spots where water can pond and cause softening) prior to any rain events. Stripping back of softened materials to expose competent natural or compacted clayey soil is required before continuing earthworks.

If difficulties are experienced during compaction due to water, further advice should be sought from a geotechnical engineer.

GDR6.4 Preparation and Testing of Shallow Footings

It is preferable to dig all footing excavations carefully with a flat-edged bucket to minimise the disturbance of underlying foundation soil.

Where the footing base is disturbed, or compaction is required, this must be done using appropriate compaction equipment particular to the task (as evaluated by the contractor) – typically a ‘jumping jack’, self-propelled plate compactor or an excavator-mounted plate compactor.

All footing bases must be tested to achieve the density requirements of Section GDR7.1. PSP testing of sand foundations is only applicable where the use of the PSP is specifically approved in the report, otherwise all testing is to be done using the NDG.

Sand Topping Layer - Where a sand topping layer is present over a different soil (i.e., clay, limestone etc.), testing of the density of the sand topping layer is only necessary within the thickness of the sand topping layer. Testing does not need to extend into the underlying compacted substrate, which is separately subjected to compaction control.

Mixed Sand/Limestone Fill – Where mixed sand/limestone fill has been installed to a method specification, no compaction control testing is required, however re-compaction of the base must be done as noted above.

In situ limestone – where in situ limestone (weakly or more cemented limestone, with no sand zones or voids) is present at a footing base and no over-excavation has been done (refer to Section GDR6.2.6 regarding over-excavation of footing bases in limestone), then no compaction control testing is required.

Where loose or soft material is encountered, one of the following actions must be taken:

- Over-excavate the loose / soft layer to expose a suitable layer that does meet the required density (Section GDR7.1) and either:
    - Place and compact Approved Fill (relevant to the appropriate preparation measures outlined in Section GDR6.2) to achieve the required density (Section GDR7.1); or
    - Pouring blinding concrete (f'_c>15 MPa at 28 days) from the competent layer up to the underside of the footing.

All foundations must be assessed by a competent person prior to blinding.

Measures must be taken to minimise moisture changes in clayey foundation soils at the base of footing excavations. Concrete footings are to be poured soon after excavation to minimise the potential for excessive moisture change. The use of a concrete blinding layer following foundation preparation should be considered.

GDR7 COMPACTION AND MOISTURE CONDITIONING

GDR7.1 Requirements

Any soil within the significant founding zone of structures (buildings, slabs, pavements, etc.) must be suitably moisture conditioned and compacted. These soils must be compacted to the requirements as outlined below.

Table GDR 10: Compaction and Moisture Requirements

Soil Description	Soil Particle Limits	Moisture Requirement	Density Requirement (DDR)	Possible QA/QC Test Methods
Sand	<5% fines <5% gravel *Maximum particle size 9.5 mm*	MOMC ±2%	95% MMDD	PSP NDG
Gravel	<5% fines >50% gravel *Maximum particle size 19.0 mm*	MOMC ±2%	95% MMDD	NDG
Clayey/Silty Gravel	5-35% fines >50% gravel *Maximum particle size 19.0 mm*	MOMC ±2%	95% MMDD	NDG
Sand with fines or gravel	5-35% fines; and/or 5-50% gravel *Maximum particle size 19.0 mm*	MOMC ±2%	95% MMDD	NDG Method Specification
Fine grained soils (Clayey or Silty)	>35% fines *Maximum particle size 19.0 mm*	MOMC ±2%; or SOMC ±2%^{2}	92% MMDD; or 95% SMDD	NDG Method Specification
Oversize/rubbly soil	Any soils with particles >19.0 mm	MOMC ±2%	95% MMDD (Or equivalent to)	Method Specification Detailed Assessment Based on Specific Material

NOTES: ***1.*** *DDR – Dry Density Ratio*
MMDD – Modified maximum dry density (AS1289.5.2.1)
MOMC – Modified optimum moisture content (AS1289.5.2.1)
SMDD – Standard maximum dry density (AS1289.5.1.1)
SOMC – Standard optimum moisture content (AS1289.5.1.1)
PSP – Perth Sand Penetrometer
NDG – Nuclear Density Gauge
2. *Preferably OMC to OMC +2%, for ease of compaction and producing a homogenous fill*
3. *Test frequencies are specified in Section GDR7.6.*

The soil groups and definitions outlined above are generally based on AS1726-2017. Test methods are discussed in subsequent sections.

GDR7.2 Construction Recommendations

Over-excavation and replacement of loose material must be done where the minimum DDR cannot be achieved.

Fill must be placed in horizontal layers of not greater than 300 mm loose thickness. Each layer must be compacted by suitable compaction equipment, and carefully controlled to ensure even compaction over the full area and depth of each layer.

Care will need to be taken if compacting in the vicinity of existing structures, such as the adjacent properties. This is particularly important if vibratory compaction is being carried out.

- Tynan (1973), “Ground Vibration and Damage Effects on Buildings”, Australia Road Research Board, Special Report No. 11.

Tynan (1973) provides guidance on the selection of compaction equipment for use adjacent to structures. The distance of influence (i.e., the definition of “vicinity”) will vary depending on the size of compaction plant proposed for use. Where there is concern regarding the impact on nearby structures, a dilapidation study should be done.

Care must be taken when compaction is undertaken when the site surface is within 1 m of the groundwater level, as compaction (particularly with vibration) can draw the water up to the surface. In this instance, consideration should be given to:

- Static rolling only;
- Using a pioneering layer (if possible); or
- Dewatering to keep the water at least 1 m below the surface being compacted.

GDR7.3 Nuclear Density Gauge

Where applicable, a nuclear density gauge (NDG) must be used in accordance with AS1289.5.8.1. NDG tests must be done to a depth of 300 mm or as otherwise indicated in the text of the attached report.

GDR7.4 Perth Sand Penetrometer

Where clean sand is used (<5% fines and <5% gravel), a Perth sand penetrometer (PSP) may be used for compaction control in accordance with AS1289.6.3.3. Refer to the report for recommended blow counts correlating to the specified density.

Where the fines or gravel contents of a sand soil exceed the maximum contents noted above, a PSP must not be used exclusively for compaction control. As a minimum, ongoing confirmation testing with an NDG is required. If not specified in our report, please contact us for further advice regarding test frequencies.

If difficulties are experienced recording the required blow counts, a site-specific PSP correlation should be carried out to determine the PSP blow count correlating to a DDR of 95% MMDD. In addition, a particle size distribution (PSD) test should be carried out to verify that the use of a PSP is suitable for the sands being tested. A site-specific PSP correlation must:

- be done on site;
- use the nuclear density gauge (NDG) to determine density at a minimum of 5 points with varying density to a depth of 300 mm below surface;
- include at least 1 point where the dry density ratio is in excess of 95% MMDD;
- use a calibrated PSP to determine the PSP blow count from 150 mm to 450 mm at each NDG test point; and
- be plotted on a chart of PSP blow count vs DDR.

Only where specifically stated as applicable in the report and where the use of the PSP is relevant as noted above, the following values may be taken as deemed to conform to a dry density ratio of 95% MMDD for the relevant sand type.

Table GDR 11: Deemed-to-comply Values for PSP Results in Perth Sands

Depth Interval (mm)	Bassendean	Tamala	Calcareous
0-150	SET	SET	SET
150-450	7	8	12
450-750	9	10	14
750-1050	11	12	16

NOTES:

1. *Blows per 300 mm interval*
2. *Bassendean Sand is typically a white - grey, low-fines quartz sand found on the eastern part of the Perth coastal plain*
3. *Tamala / Spearwood sand is typically yellow or orange, low-fines quartz sand found on the western part of the Perth coastal plain*
4. *Calcareous sands are typically white or yellow, calcareous sand found in low-lying areas on the western fringe of the Perth coastal plain*

5. Values derived from Galt experience on PSP correlations done on sites across Perth for the 150-450 mm interval.

GDR7.5 Method Specifications

GDR7.5.1 General

Where proposed, a method specification should be developed by a geotechnical engineer or similarly qualified person and ratified by us (including a site visit by us). The method specification should be confirmed by the construction of a trial pad or trial area and the compaction methodology should be checked against either:

- density, as assessed using a nuclear density gauge; or
- settlement, as assessed using a dGPS.

Specific advice should be requested for the development of a method specification, taking into consideration the material being compacted.

Method specification compliance should be maintained for all areas on a minimum 20 m grid, with the compliance to include:

- Roller used (weight, style, vibration);
- Water application rate (per lift);
- Layer thickness placed; and
- Number of passes with roller.

GDR7.5.2 Indicative Method Specification – Sand/Limestone Rubble Mix

Where mixed sand/limestone is used as structural fill, a performance specification is not appropriate due to the inaccuracies of standard test methods (NDG/PSP etc.) in this type of material. A method specification can be used instead. The following indicative method specification is provided for evaluation and trial but must be trialled and ratified by us prior to widespread employment on site. The following would be typically adopted:

- Maximum particle size: 250 mm
- Maximum loose layer thickness: 350 mm
- Minimum watering rate: 10 L/m^2/100 mm thickness of loose material (e.g. 35 L/m^2 for a 350 mm thick layer)
- Minimum 8 passes with a vibrating padfoot roller, minimum static weight 10 tonnes.
- The compacted fill must comprise closely packed particles without any significant voids between the larger particles.

GDR7.6 Testing Frequency

After compaction, verify that the required density has been achieved by testing at the base of excavation and through the full depth of any fill, and to a minimum depth of:

- 900 mm where a PSP is used; or
- 300 mm where a NDG is used.

The frequency of testing (when a method specification is not used) should be as follows:

Table GDR 12: Compaction Testing Frequency Requirements

Area	Minimum Testing Frequency	Minimum Tests Per Lot
Proof Compacted Area	1 test per 1,000 m^2 (30 m grid)	2
Structural Fill Outside of Building and Pavement Footprints	1 test per 500 m^3 2 tests per layer *Whichever is greater*	2
Structural Fill Within Building and Pavement Footprints	1 test per 500 m^3 4 tests per layer *Whichever is greater*	4
Spread/Pad Footings	1 test per 9 m^2 per footing	1
Strip Footings/Retaining Wall Foundations	Minimum 2 tests At 5 m centres *Whichever is greater*	2
On-ground slabs, pavements and rafts	Minimum 2 tests At 10 m centres 1 test per 100 m^2 *Whichever is greater*	2

NOTES:

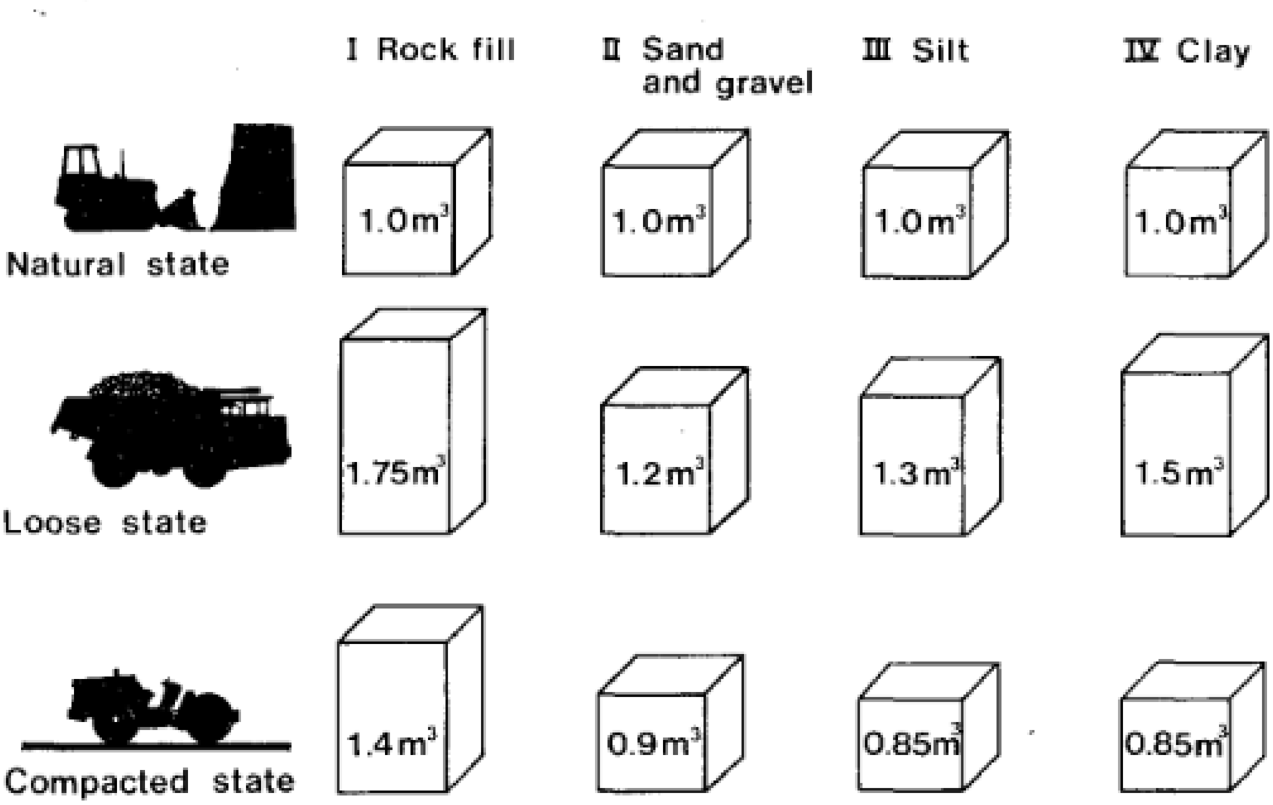
1. *A 'lot' is defined in the context of this section as a section of earthworks that is undertaken in one operation where the equipment, personnel, materials and methodology are consistent throughout the entire process. This would typically be limited to operations done in one day, but this is not mandatory.*
2. *There will frequently be multiple 'lots' in an earthworks process, therefore the number of tests must be adjusted according to the minimum number per lot in this table (where this is more than the frequency specified in 'testing requirements').*

GDR7.7 Bulking and Compaction Factors

All soils will "bulk" when excavated to stockpile, and "compact" when placed from stockpile to earthworks layers. Published bulk and compaction factors are presented below for conventional materials, taken from:

- Forssblad, L (1981), "Vibratory Soil and Rock Fill Compaction", Dynapac Maskin AB

Inline Image GDR 3: Volumes of Different Types of Fill Materials in Natural, Loose and Compacted State



These values are indicative only and will vary according to site specific conditions. The values provided here must not be used for commercial volume estimates or settling disputes regarding volumes.

GDR8 APPROVED FILL AND CONFORMANCE TESTING

Imported fill must comply with the material requirements as stated in AS 3798-2007, “Guidelines on Earthworks for Commercial and Residential Developments”.

Where doubt exists, a geotechnical engineer must be engaged to inspect and approve the use of potential fill materials.

The following table presents recommended material parameters for standard fill types. This does not take account of availability of materials either on site or in the local area. Refer to the report text for specific advice on fill at the subject site.

Table GDR 13: Standard Fill Recommendations

Soil Description	Application	Soil Particle Limits (%)[3]				k_{min}[1] (m/d)	OC[2] (%)	Atterberg Limits		CBR[6] (%)	Test Method[4]
		Fines	Sand	Gravel	Max.			LL (%)	PI (%)		
Permeable Sand	Permeable bulk fill Retaining wall backfill Permeable select fill	≤5	≥90	≤5	9.5	5	≤2	NP	NP	≥12	PSP NDG
General Sand	Bulk fill Select fill (permeability not required)	≤5	≥90	≤5	9.5	N/A	≤2	NP	NP	≥12	PSP NDG
Silty Sand	Bulk fill Select fill	≤35	≥55	≤10	9.5	N/A	≤2	<35	<11	≥12	NDG
Clayey Sand	Bulk fill Select fill	≤35	≥55	≤10	9.5	N/A	≤2	<40	N/A	≥12	NDG
Mixed Sand/Limestone	Bulk fill (permeability not required)	≤5	≥20	≤80	250	N/A	≤2	NP	NP	N/A	NDG Method
Blue Metal Gravel[8]	Retaining wall backfill Drainage trench backfill	≤3	≤5	≥90	37.5	5	≤1	NP	NP	N/A	NDG
Clay[7]	Reinstatement of localised excavations in clay Bulk fill	≥12	Varies	≤30	19	N/A	≤2	Varies			NDG

NOTES:

1. *k_{min} – minimum saturated hydraulic conductivity (AS1289.6.7.1, remoulded to minimum DDR 100% MMDD).*
2. *OC – organic content (Walkley-Black method recommended, AS1289.4.1.1 – not loss on ignition methods)*
3. *% by mass.*
4. *Test method indicates possible compaction control methods for this material.*
    - *PSP – Perth sand penetrometer (AS1289.6.3.3). Where a PSP is used, a site-specific correlation must be done unless otherwise noted in the report.*
    - *NDG – Nuclear density gauge (AS1289.5.8.1)*
    - *Method – method specification*
5. *Atterberg Limits: LL – liquid limit PI – plasticity index NP – non-plastic*
6. *CBR: California bearing ratio (for sand - remoulded to DDR 95% MMDD @ OMC, 4.5 kg surcharge). CBR values may be changed depending on the design pavement requirements.*
7. *"Clay" fill type is included for broad reference only and to illustrate preferred applications, particle size limits and recommended test method. Specific discussion on the use of clayey fills is included in the report text if applicable. Atterberg limit and CBR testing of clayey fills may be required and advice must be sought from us if not stated in the report.*
8. *"Blue metal" gravel refers to single sized, crushed, washed igneous rock gravel used for drainage purposes.*
9. *In the absence of specific test frequencies by the civil designer, the testing shown in Table GDR 14 must be done (highlights in Table GDR 13 show where the test is required).*

Table GDR 14: Conformance Testing Frequency Requirements

Parameter	Frequency (m^3)	Minimum Tests per Source	AS1289 Reference
Particle size distribution	5,000	1	3.6.1
Hydraulic conductivity (permeability)	10,000	2	6.7.1
Organic content	5,000	1	4.1.1
Atterberg limits	5,000	1	3.1.1, 3.2.1, 3.3.1
CBR	10,000	2	6.1.1

NOTES:

1. *Frequency is for the nominal number of cubic metres of compacted fill.*
2. *Unless stated otherwise in the report text, the conformance testing must also be carried out on site-derived materials to confirm suitability.*

GDR9 SHALLOW FOUNDATIONS

GDR9.1 Design

Footings and slabs may be designed in accordance with the assigned site classification in accordance with AS2870-2011. We note that AS2870-2011 is limited to single and double storey residential and commercial developments and may not be strictly applicable.

Where the report provides tables for shallow footing design, custom footings may be designed by the structural engineer using the data provided therein.

GDR9.2 Interpretation of Provided Values

BEARING PRESSURES

All settlement and bearing pressures estimates are provided on the assumption that the site preparation requirements outlined in the report are completed below all structures plus a minimum distance of 1 m beyond the outside edge of any footing or slab. It is essential that the soil below all foundations is appropriately prepared as outlined and meets the relevant compaction requirements.

Allowable bearing pressures for footings of intermediate plan dimensions (to any tabulated) can be interpolated. Footings that have a plan dimension either smaller or larger than those presented in the report will need to be considered individually along with other embedment depths.

Allowable bearing pressures, where provided, are considered to be the upper limit for shallow footings to limit total and differential settlements. Footings carrying eccentric loading, such as below retaining walls, must be assessed separately.

SETTLEMENTS

The reporting of settlements to any precision level is not intended to imply a high accuracy of settlement prediction. Settlements as reported should be considered ‘order of magnitude’.

Estimated settlements represent vertical downwards movement due to loading and do not take into account potential additional movement associated with the characteristic surface movement of the soil (which must be taken in addition to these settlements from loading, refer Section GDR5). The site classification is discussed in the report.

The actual settlement of any proposed structure will depend upon a number of factors including the applied pressures, footing size and base preparation. The estimated settlement(s) provided in this report are for the working bearing pressures as indicated. Differential settlements are likely between footings of similar sizes, loads and elevations (as stated in the report text). A proportion of the settlement is expected to occur during construction (i.e., during initial loading.

The provided settlement estimates (unless otherwise stated) do not include interaction effects from footings founded near other footings (i.e., groups of footings). Interaction effects will need to be considered if the spacing between adjacent footings is smaller than the dimension of the footings (i.e., the centre-to-centre spacing between footings is less than twice the width of the footing). This could act to double provided settlements, dependent on the footing configuration. Where an assessment of footing groups is required, a more detailed numerical or finite-element modelling analysis would need to be undertaken.

CREEP AND CONSOLIDATION

Creep settlement is an irreversible component of long-term soil settlement caused by sustained vertical stress. Consolidation is a time-dependent irreversible compression in a soil layer caused by a reduction in pore pressure between soil particles. Both creep and consolidation can occur in natural materials as a result of earthworks or the placement of loads on to soil layers. The settlements as presented for short-term loading do not include consideration for creep and consolidation settlements unless specifically stated.

GDR9.3 Raft Foundations

Where moduli of subgrade reactions are provided for the design of raft foundations, we highlight that these are an estimate of the elastic reaction of the soil. The values are provided based on an expected load and loaded area size. Soils are typically non-linear in their response and will have different stiffnesses at different levels of strain and load repetitions. This is due to the physical interaction of soil particles under different levels of stress.

The possibility of a non-linear response must be considered by the designer of any raft foundation.

GDR10 PILED FOUNDATIONS

Piles must be designed and tested in accordance with AS2159-2009, “Piling – Design and Installation”. We use the following interpretation/design methods to provide pile design parameters:

- Franki Africa Pty Ltd (2008) “A Guide to Practical Geotechnical Engineering in South Africa”. 4th ed.
- AFNOR (2012) “NF P 94-262 – Justification des ouvrages géo-techniques, Normes d’application nationale de l’Eurocode 7”, Afnor, Paris, July 2012.
- Lehane, B. (2017) “CPT-Based Design of Foundations”. E.H Davis Memorial Lecture, Australian Geomechanics Vol 54. No. 4.
- Lehane, B. et al. (2020) “A New ‘Unified’ CPT-Based Axial Pile Capacity Design for Drivel Piles in Sand”. Proceedings of the Fourth International Symposium on Frontiers of Offshore Geotechnics.
- Doan., Lehane, B. (2021) “CPT-Based Design Method for Axial Capacities of Drilled Shafts and Cast-in-place Piles.” American Society of Civil Engineers (ASCE), Journal of Geotechnical and Geoenvironmental Engineering.

The pile designer must:

- consider the possible variation in subsurface conditions at each pile location;
- consider any pile group effects based on the final piling configuration;
- assume that the unit shaft resistance in tension is less than 80% of the unit shaft resistance in compression to account for Poisson’s effect in sand;
- ignore pile resistance in the surficial 0.5 m or 1 x pile diameter (whichever is greater), if relevant;

- consider the impact of weak layers underlying stiffer layers (or vice versa) on end bearing capacity; and
- reduce the pile capacity in tension to no greater than 0.8 of the pile capacity in compression.

The piling contractor must:

- make their own assessment on the suitability of their equipment to install any piles at the subject site; and
- carry out or appoint a suitably experienced contractor to test the piles in accordance with AS2159.

Where dynamic or static testing of the piles does not occur, we consider that a design geotechnical reduction factor (ϕg) of 0.4 is applicable for the pile design. If testing of the piles is proposed by the piling contractor, a higher ϕg could be adopted.

Unless otherwise stated, providing pile design parameters does not specifically indicate the driveability of any piles into soil units.

A separate driveability study may be required and must be considered by the pile designer and installer. The given pile design parameters must not be used for driveability assessments as these parameters are likely to be un-conservative.

GDR11 EARTH RETAINING STRUCTURES

GDR11.1 General

Retaining structures may be designed in accordance with AS4678 (2002) “Earth Retaining Structures”. Unless otherwise specifically stated, we recommend that all retaining walls are backfilled with free-draining soil (Permeable Sand or Blue Metal Gravel as defined in Section GDR8).

Where the cohesive soil is used as retaining wall backfill, a suitable, permanent drainage system must be placed behind the wall such that a build-up of pore pressure is prevented. A separator geotextile (Bidim A24, or similar, or heavier) must be used between the interface of any granular backfill and the cohesive soil.

Where drainage is not provided, the retaining wall must be designed to accommodate water pressure behind the wall (10 kPa per metre height).

GDR11.2 Earth Pressure Coefficients and Strength Parameters

Where earth pressure coefficients are provided for retaining walls, the wall designer must make an independent assessment of the parameters appropriate to the construction method to be used, including alternative values of wall friction. Unless otherwise stated, we have assumed a horizontal ground surface behind and in front of the retaining wall for provided parameters.

GDR11.2.1 Cohesionless Soils

Where cross-referenced for suitability in the report, the following parameters may be adopted for design of earth retaining structures in cohesionless soils (sand and gravel).

Table GDR 15: Retaining Wall Geotechnical Parameters (Cohesionless Soils)

Density	γ (kN/m^3)	ϕ' (°)	k_0	Wall Friction=0		Wall Friction=0.5ϕ		Wall Friction=0.67ϕ	
				k_a	k_p	k_a	k_p	k_a	k_p
Very Loose	17	30	0.44	0.33	3.00	0.29	4.81	0.28	5.74
Loose	17	32	0.42	0.31	3.25	0.27	5.55	0.26	6.83
Medium Dense	18	34	0.39	0.28	3.54	0.25	6.47	0.23	8.26
Dense	19	36	0.36	0.26	3.85	0.22	7.63	0.21	10.18
Very Dense (1)	19	38	0.34	0.24	4.20	0.21	9.11	0.20	12.85
Very Dense (2)	19	40	0.31	0.22	4.60	0.19	11.06	0.18	16.73

NOTES:

1. *Earth pressure coefficients are provided in this table for conditions of zero friction between the wall and the soil and with wall friction of 0.5Φ' or 0.67Φ'.*

2. *A horizontal ground surface behind and in front of the wall has been assumed.*

3. *The retaining wall designer should make an independent assessment of the parameters appropriate to the construction method to be used, including alternative values of wall friction.*

4. γ *– bulk unit weight*
ϕ' *– effective friction angle*
k_a *– coefficient of active earth pressure (Coulomb – AS4678-2002, Appendix E)*
k_p *– coefficient of passive earth pressure (Coulomb – AS4678-2002, Appendix E)*
k_0 *– coefficient of at-rest earth pressure (Jaky)*

5. *Maximum fines content 12% for applicability of this table for design purposes.*

6. *Unit weights based on Table D1 of AS4678-2002, for moist bulk weight.*

7. *Friction angle based on Equation D1 and Table D2 of AS4678-2002, based on rounded, moderately graded siliceous sand.*

GDR11.2.2 Cohesive Soils

Where cohesive soils (i.e. clayey or silty soils) are proposed for backfill, geotechnical design parameters may be provided in the form of effective strength and undrained strength parameters. We note that:

- Undrained strength parameters should be used for analysis of short-term stability, or stability under sudden loading of cohesive soils.
- The effective strength parameters should be used for analysis of free-draining soils and the long-term stability of cohesive soils.

Table GDR 16: Retaining Wall Geotechnical Design Parameters (Cohesive Soils – Undrained)

Consistency	γ_b (kN/m^3)	c_u (kPa)
Soft	17	12
Firm	18	25
Stiff	19	50
Very Stiff	20	100
Hard	20	200

NOTES:

1. γ_b *– bulk unit weight*
c_u *– undrained cohesion*
$\phi_u = 0^o$ *(undrained friction angle)*

2. *Unit weights based on Table D1 of AS4678-2002*

3. *Undrained cohesion based on lower end of shear strengths as define in AS1726-2017, Table 11*

Table GDR 17: Retaining Wall Geotechnical Design Parameters (Cohesive Soils – Drained)

Fines Content	PI (%)	γ_b (kN/m^3)	ϕ' (°)	c' (kPa)[5]
12-35%	All	19	32	0
>35%	10	20	30	0 – 5
>35%	20	20	26	0 – 5
>35%	30	20	23	0 – 5
>35%	40	20	21	0 – 5

NOTES:

1. *γ_b – bulk unit weight*
   c' – drained cohesion
   ϕ' – effective friction angle
   PI – plasticity index
2. *Unit weights based on Table D1 of AS4678-2002, assuming generally stiff to hard overconsolidated soils.*
3. *For fines contents <35% (silty sand and clayey sand), strength parameters based on:*
   - *Lehane, B. et al (2007) "A Laboratory Investigation of the Upper Horizons of the Perth/Guildford Formation in Perth CBD", Australian Geomechanics Vol 42. No. 3.*
4. *For fines content >35% (sandy clay), strength parameters based on:*
   - *CIVL5503 course notes (2004), "Underground Construction", University of Western Australia*
5. *c' = 0 recommended for long-term design. Table D4 of AS4678 suggests c' up to 5 kPa for 'poor' fine grained soils and 10 kPa for 'average' fine-grained soils. The use of c' for design is subject to the designer's judgement but recommended by us only for temporary works.*

Per AS4678-2002 Appendix E, horizontal earth pressures for frictional-cohesive soils may be calculated in accordance with the Rankine-Bell design model (illustrated in Figure E2 of AS4678). The earth pressures are as follows (Z = depth, all other terms have the meanings given in the above tables):

- Active: $p_a = \gamma Z tan^2\left(45 - \frac{\emptyset}{2}\right) - 2ctan\left(45 - \frac{\emptyset}{2}\right)$
- Passive: $p_p = \gamma Z tan^2\left(45 + \frac{\emptyset}{2}\right) + 2ctan\left(45 + \frac{\emptyset}{2}\right)$

GDR11.3 Design and Construction Considerations

Compaction plant can augment the lateral earth pressure acting on retaining walls. Hand operated compaction equipment is recommended within 2 m of any retaining walls to minimise compaction pressures.

Retaining walls can move and rotate under imposed soil loading resulting in settlement behind the wall. This must be considered in the design and during construction of the retaining walls in order that adjacent infrastructure is not adversely affected.

It is important to note that some ground movement will occur behind any soil retaining system, including gravity retaining walls.

GDR12 EXCAVATIONS, BATTERS AND SLOPES

GDR12.1 Excavatability

Our assessment of the excavatability of rock is based on a combination of:

- Our experience on earthworks and construction projects across Australia; and
- Figure 10 of the revised graphical method of assessing excavatability of rock by:
- Pettifer, G.S. & Fookes, P.G., "A revision of the graphical method for assessing the excavatability of rock", Quarterly Journal of Engineering Geology, 27, pp145-164, 1994.

GDR12.2 Safety

All excavations must be carried out in accordance with:

- Commission for Occupational Safety and Health (2022). “Excavation: Code of Practice”, Department of Mines, Industry Regulation and Safety, 89pp, Perth.

Excavations in cohesionless soils are particularly prone to instability unless support is provided. Care must be exercised in such excavations and appropriate safety measures adopted where necessary, particularly in the vicinity of existing buildings, structures and infrastructure.

The toe of any batter must be at least 500 mm above groundwater (including perched groundwater).

Unless a specific slope stability assessment or retention design has been done, the toe of any excavation should not encroach within a line of 1V:3H to any nearby footings, pavements or other settlement-sensitive structures.

Surcharges (such as structures, plant and soil stockpiles) must not be placed at or close to the crest of unsupported excavations, without a specific slope stability assessment.

A geotechnical engineer must be consulted where there is any doubt regarding the stability or safety of unsupported excavations.

GDR12.3 Batters

Temporary batter slopes provided in the report are subject to the following conditions, unless otherwise stated:

- The maximum slope height is 2 m without specific advice and slope stability analysis.
- The groundwater level for the duration of the excavation must be at least 500 mm below the toe of the slope.
- No surcharges are present in the vicinity of the slope (i.e. must be outside a line of 1V:3H from the toe of the slope).

Unless noted specifically in the report, the following batters may be adopted (maximum height: 2 m):

Table GDR 18: Default Batter Angles

Situation	Material	Batter
Temporary	Cohesionless Soils (Sand/Gravel)	1V:2H
Temporary	Cohesive Soils – Soft	1V:2H
Temporary	Cohesive Soils – Firm, Stiff, Very Stiff or Hard	1V:1H
Temporary	Limestone – Variably Cemented	1V:1H
Temporary	Limestone – Well Cemented	1V:0.5H
Permanent	All Soils	1V:3H
Permanent	Limestone – Variably Cemented	1V:2H
Permanent	Limestone – Well Cemented	1V:1H

Where specified batters cannot be accommodated in the vicinity of existing footings, roads and services, temporary or permanent lateral support will be required.

Specific advice is required for batters higher than 2 m.

Erosion control must be considered for permanent slopes.

Rock slopes must be inspected, and all loose cobbles / boulders removed. Permanent rock slopes may require dentition works or possibly rock catch drains.

GDR12.4 Grouting

Permeation or jet grouting involves injecting a microfine cement into soil to form a grouted soil block (soilcrete) to support excavation and structures. Grouting is typically only effective where the soil has the capacity to "take" the grout and form a uniformly cemented soil mass. Permeation grouting is generally limited to relatively permeable, coarse-grained cohesionless soils (sands and gravels with <5% fines).

If grouting is proposed, we recommend the following:

- Grouting must be carried out by a suitably experienced contractor.
- Only microfine cement grout should be used (not GP or coarse cement blends) to ensure adequate penetration into the soil matrix.
- Grouting should be done on a grid of not greater than 300 m.
- Application rates must be discussed with the contractor.
- The grouted soil mass must have intimate contact with any structures it is intended to support.
- The contractor must satisfy themselves that the proposed grouting can be installed with their equipment and into the subsurface conditions encountered at the site, considering possible obstructions, groundwater, cemented layers, loose sands etc.
- Testing of the grouted soil mass must be done to ensure that the grout has adequately permeated through the soil matrix. This can be done by drilling into the soil mass to ensure the cementation is continuous.

Grouting is most effective on permeable, relatively loose natural sand. Where historical filling or other ground disturbances have occurred, the grouting process can be less effective due to the tendency of grout (or other liquids) to follow more permeable paths / zones through the disturbed soil.

GDR13 STORMWATER DISPOSAL AND DRAINAGE DESIGN

GDR13.1 Groundwater Separation – Controlled Groundwater

These recommendations ONLY apply to where regional controls on groundwater (primarily: subsoil drainage, but also surficial 'main drains') exist, i.e. only to areas where groundwater is actively controlled.

The following reference:

- IPWEA (2016), "Specification: Separation Distances for Groundwater Controlled Urban Development", Institute of Public Works Engineering Australasia

recommends the following separation distances from drainage infrastructure to groundwater:

- Underground infiltration systems: 0 mm from the 50% AEP (annual exceedance probability) phreatic surface.
- Surface infiltration systems (vegetated): 300 mm from the 50% AEP phreatic surface.

The above IPWEA reference also states that performance measures for underground infiltration systems are to have a: *demonstration of acceptable volumetric capacity when groundwater is elevated above base of system and that the groundwater recedes below the invert of the system during mosquito breeding seasons (grated or partially open systems)*.

GDR13.2 Groundwater Separation – Uncontrolled Groundwater

These recommendations apply where regional controls on groundwater levels are not present. For infiltration into soakwells and soakage basins to be the full theoretical value, an adequate separation to groundwater must be achieved, because otherwise performance is hindered by inadequate separation to groundwater or partial submergence of the infiltrative element.

We recommend a minimum separation of 500 mm from the underside of infiltrative elements to maximum groundwater level.

- To average annual maximum groundwater level (AAMGL), where this has been defined for the site; or
- To historical maximum groundwater level, where this has been defined to the site.

GDR13.3 Design Hydraulic Conductivity Values

Where provided, the values of hydraulic conductivity (k) should be considered the maximum/upper limit design values. As discussed in Section GDR3.7, the inverse auger hole test is an unsaturated field test carried out above the groundwater table and, as such, presents the best-case conditions for drainage.

For soak wells in sand, we provide the design value taking into consideration the variability in materials and reduced permeability as a result of:

- Densification of sand during site preparation works; and
- Natural variation in sands.

Design k_{unsat} values provided for soak wells are only appropriate for the design of unsaturated soils where the base of disposal area is at least 500 mm above groundwater and 500 mm above any impermeable layer.

Where design values of k_{unsat} have been provided, clogging of the base of the soakwell / drainage basin has not been considered. Clogging will need to be controlled with maintenance over the life of the soakwell / drainage basin.

For the design of subsoil drains or modelling of saturated soil performance, a k_{sat} value must be given (in the report text) or assessed by laboratory testing (or a combination of field and laboratory testing). Unless specifically stated, k_{unsat} values presented in our report are for unsaturated conditions and intended for design of stormwater disposal elements above groundwater. If no k_{sat} value has been provided, do not use the provided k_{unsat} value for saturated drainage design. Please contact us for further advice.

For saturated or semi-saturated sands, the hydraulic conductivity must be assessed by testing of representative soil samples at a NATA accredited laboratory to determine:

- The modified maximum dry density (MMDD); and
- The constant-head permeability (AS1289.6.7.1) on a sample remoulded to at least 5% greater than the proposed specification density (i.e., sample should be remoulded to 100% MMDD if the earthworks specification requires a density ratio of 95% MMDD).

For saturated or semi-saturated clayey or silty soils, the hydraulic conductivity must be assessed by testing of representative soil samples at a NATA accredited laboratory to determine:

- The standard maximum dry density (SMDD); and
- The falling-head permeability (AS1289.6.7.2) on a sample remoulded to at least 3% greater than the proposed specification density (i.e., sample should be remoulded to 101% SMDD if the earthworks specification requires a density ratio of 98% SMDD).

GDR13.4 Soakwells

In uncontrolled groundwater environments, the base of any soakwell must be the higher of:

- At least 500 mm above the average annual maximum groundwater level (AAMGL).
- At least 500 mm above any low permeability/impermeable layers (clay, rock or otherwise).

In controlled groundwater environments (refer to Section GDR13.1), the base of any soakwell may be 0 mm above the controlled groundwater level at the location of the soakwell (as determined by the civil engineer).

Soak wells must be placed outside a line of 1V:2H extending below the edge of the nearest footing, subject to local council regulations. Discharge from soak wells has been known to promote densification of loose sandy soils, leading to settlements of footings and slabs. Soak wells should be carefully wrapped with geotextile to prevent migration of sand and fines into the soak well.

Where soak wells are proposed to dispose of water within a line of 1V:2H from any basement walls or similar, the walls must be waterproofed to prevent seepage or damp within the basement wall.

In potentially karstic terrain or areas of potentially collapsible soils, soakwells should typically be located 10 m from the nearest footing, slab or pavement.

GDR13.5 Design Groundwater Elevation

Where applicable, a recommended design groundwater elevation will be provided in the report and will be identified as such.

In the absence of a specific statement on design groundwater elevation, **do not assume** that:

- Absence of comments about groundwater indicates an absence of groundwater (in particular, sites that are dry in the dry season to the investigated depth may well become waterlogged in the rainy season).
- Where groundwater depths/levels are noted, that these are fixed (groundwater fluctuations occur over the course of the year and between wetter and drier years).

Where groundwater elevations are likely to be critical for a development (particularly where large-scale subdivision or large developments are proposed with substantial channelling of stormwater into on-site disposal by infiltration), a site-specific hydrology study is likely to be required to confirm design groundwater elevations.

GDR14 DRAINAGE CONTROL

In addition to the site preparation measures outlined for cohesive soils (refer Section GDR6.2.4), careful control of surface water and stormwater is essential to minimise the likelihood of cohesive soils decreasing in strength and affecting the installed infrastructure. These measures include:

- The ground surface of clayey soils should be graded to drain any seepage away from structures and prevent standing water over the cohesive soils. A grade of at least 1% is recommended.
- Pavements should be sealed to minimise water ingress.
- Stormwater disposal swales should be located at least 10 m away from buildings, retaining walls and pavements.
- Runoff from hardstandings and pavements must either be collected and discharged via pipes into discrete locations (via swales or soakage basins) at least 10 m away from structures and pavements or, alternatively, discharged over a wide area, but not allowed to collect and discharge into concentrated areas, particularly near structures and pavements.

- Spoon drains should be used to collect water at the crest of slopes to capture surface runoff and direct it away from running directly down slopes or seeping into the ground behind slopes.

These measures are general in nature only and do not take into account the civil design objectives, which must be addressed separately by the civil designer.

GDR15 DEWATERING

Dewatering may be required for excavations and construction below groundwater or perched groundwater tables. Common dewatering methods are summarised below:

Table GDR 19: Dewatering Recommendations

Material	Recommended Methods
Sandy Soils	Spears Deep Well Point
Impermeable Clay	Sump Pumping

Dewatering spears are typically suitable for small scale excavations below groundwater, with a typical recommendation for spears to be installed at 1 m below the base of any excavation. Dewatering spears may not be suitable where there are impermeable/cemented/strong transition layers, i.e., it may not be possible to extract water near an impermeable layer (rock/clay), or the spear may not be readily driven through a hard clay/cemented layer (i.e., coffee rock).

Sump pumping can be done by grading a clayey excavation to drain (i.e., by using spoon drains), and excavating a sump in the excavation. A sump can typically be backfilled with a blue metal gravel, with a pump wrapped in a geofabric (i.e., Bidim A14 or similar), with disposal of water away from the excavation.

Deep well point dewatering is typically suitable for larger excavations, where there are transitional layers or where the aquifer is confined. It may not be suitable where there are impermeable layers within the profile. It involves the installation of a deep filtered well to a depth required to draw down the groundwater level at the entire site. A deep well dewatering system must be designed by a suitable designer to provide design flow rates, draw down depths etc.

GDR16 PAVEMENT SUBGRADES

Unless otherwise specified, the provided subgrade California bearing ratio (CBR) is not a pavement design, but an assessment of the subgrade as an input into any required pavement designs.

Provided design values are based on the assumption that the relevant site preparation measures are completed for all pavement subgrades, including the use of appropriate approved fill and adequate compaction. We highlight that specific requirements such as those outlined by Main Roads WA (MRWA) or the local council in their construction specifications may have different requirements.

The provided design value is based on laboratory testing (where done), local experience, and the advice as outlined in:

- Main Roads Western Australia (2013). “Engineering Road Note 9 – Procedure for the Design of Road Pavements”. Western Australia Supplement to the Austroads Guide to Pavement Technology Part 2: Pavement Structural Design, East Perth.

Where the subgrade differs from that described in the text, the subgrade CBR must be confirmed.

The performance of any pavement is highly dependent on the surface and subsurface drainage provided (also considering factors like capillary rise from seasonally high groundwater tables). Adequate drainage must be provided to any pavements, and capillary rise must be considered by the designer.

GDR17 SOIL CORROSIVITY AND AGGRESSIVITY

The relevant exposure classifications for concrete and steel piles in soils based on the exposure conditions are presented in Table GDR 20 and Table GDR 21 respectively.

The relevant exposure classifications for concrete in sulfate soils based on the exposure conditions are presented in Table GDR 22.

Table GDR 20: Exposure Classification for Concrete Piles in Soil

Exposure Conditions				Exposure Classification	
Sulfates (expressed as SO_4)[1]		pH	Chlorides in Groundwater (ppm)	Soil Conditions A[2]	Soil Conditions B[3]
In Soil (ppm)	In Groundwater (ppm)				
< 5,000	< 1,000	> 5.5	<6000	Mild	Non-aggressive
5,000 – 10,000	1,000 – 3,000	4.5 – 5.5	6,000-12,000	Moderate	Mild
10, 000 – 20,000	3,000 – 10,000	4 – 4.5	12,000-30,000	Severe	Moderate
> 20,000	> 10,000	< 4	>30,000	Very Severe	Severe

NOTES:

1. *Approximately 100 ppm SO_4 = 80 ppm SO_3*
2. *Soil Conditions A – high permeability soils (e.g. sands and gravels) which are in groundwater*
3. *Soil Conditions B – low permeability soils (e.g. silts and clays) or all soils above groundwater*
4. *Table reproduced from Table 6.4.2(C) of AS2159-2009*

Table GDR 21: Exposure Classification for Steel Piles in Soil

pH	Chlorides		Resistivity (ohm.cm)	Exposure Classification	
	In Soil (ppm)	In Water (ppm)		Soil Conditions A[2]	Soil Conditions B[3]
> 5	< 5,000	< 1,000	> 5,000	Non-aggressive	Non-aggressive
4–5	5,000-20,000	1,000–10,000	2,000 – 5,000	Mildly aggressive	Non-aggressive
3–4	20,000-50,000	10,000–20,000	1,000 – 2,000	Moderately aggressive	Mildly aggressive
< 3	> 50,000	> 20,000	< 1,000	Severely aggressive	Moderately aggressive

NOTES:

1. *1 ppm (parts per million) is equivalent to 1 mg/kg*
2. *Soil Conditions A – high permeability soils (e.g. sands and gravels) which are in groundwater*
3. *Soil Conditions B – low permeability soils (e.g. silts and clays) or all soils above groundwater*
4. *Table reproduced from Table 6.5.2(C) of AS2159-2009*

Table GDR 22: Exposure Classification for Concrete in Sulfate Soils

Exposure Conditions			Exposure Classification	
Sulfates (expressed as SO_4)[1]		pH	Soil Conditions A[2]	Soil Conditions B[3]
In Soil (ppm)	In Groundwater (ppm)			
< 5,000	< 1,000	> 5.5	Mild	Non-aggressive
5,000 – 10,000	1,000 – 3,000	4.5 – 5.5	Moderate	Mild
10, 000 – 20,000	3,000 – 10,000	4 – 4.5	Severe	Moderate
> 20,000	> 10,000	< 4	Very Severe	Severe

NOTES:

1. *Approximately 100 ppm SO_4 = 80 ppm SO_3*
2. *Soil Conditions A – high permeability soils (e.g. sands and gravels) which are in groundwater*
3. *Soil Conditions B – low permeability soils (e.g. silts and clays) or all soils above groundwater*
4. *For disturbed soils, the assumption of soil A conditions where accelerated corrosion is possible should be considered.*
5. *Table reproduced from Table 4.8.1 of AS3600-2018*

GDR18 LIQUEFACTION

Soil liquefaction can occur when loose, granular, Holocene age material below the groundwater table is subjected to a seismic event (typically within 15 m of the ground surface). This can cause a loss of strength and result in vertical and lateral movements of the site surface.

Where a liquefaction analysis is carried out and outlined in the report, this has been done in accordance with consideration to the design earthquake details as presented in AS1170.4-2007:

- The hazard factor is taken from Figure 3.2 (C) and Table 3.2. The Hazard Factor (Z) for Western Australia represents the 1 in 500-year annual probability of exceedance of ground motions measured in gravity (g).

- The probability factor (k_p) is taken from Table 3.1.

Unless otherwise stated, an earthquake magnitude of 7.5 for the south-west of WA is based on research by:

- Dhu T., Sinadinovski C., Edwards M., Robinson D., Jones T., Jones A. (2004) “Earthquake Risk Assessment for Perth, Western Australia”. 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada. Paper No. 2748.

GDR19 EXPECTATIONS OF THE REPORT

The following sections have been prepared to clarify what is and is not provided in your report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with the conditions on site.

Geotechnical engineering and environmental science are less exact than other engineering and scientific disciplines. We include this information to help you understand where our responsibilities begin and end. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of projects and we can help you to manage your risk.

GDR20 THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following:

- the project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the project team. Furthermore, we recommend that we be able to review work produced by other members of the project team that relies on information provided in our report.

GDR21 DATA PROVIDED BY THIRD PARTIES

Where data is provided by third parties, it will be identified as such in our reports. We necessarily rely on the completeness and accuracy of data provided by third parties in order to draw conclusions presented in our reports. We are not responsible for omissions, incomplete or inaccurate data associated with third party data, including where we have been requested to provide advice in relation to field investigation data provided by third parties.

GDR22 SOIL LOGS

Our reports often include logs of intrusive and non-intrusive investigation techniques prepared by Galt. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

GDR23 THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party because of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

GDR24 CHANGE IN SUBSURFACE CONDITIONS

The recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including anthropogenic events (such as construction or contaminating activities on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

GDR25 SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use professional judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from professional judgement and opinion.

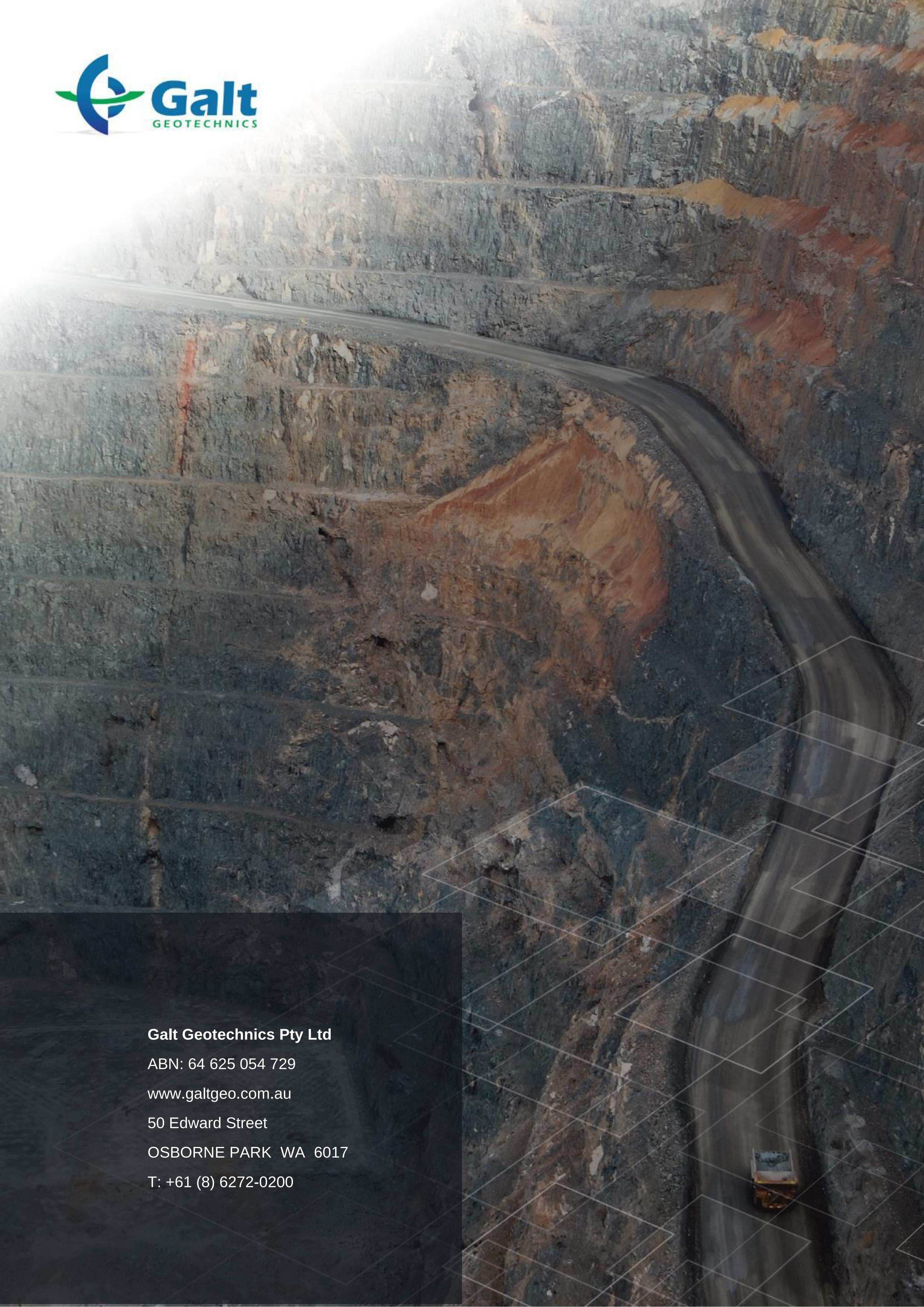
The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

GDR26 ENVIRONMENTAL AND GEOTECHNICAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not addressed in geotechnical reports. Similarly, geotechnical issues are not addressed in environmental reports. The investigation techniques used for geotechnical investigations can differ from those used for environmental investigations. It is the client's responsibility to satisfy themselves that geotechnical and environmental considerations have been taken into account for the site.

Geotechnical advice presented in a Galt Environmental report has been provided by Galt Geotechnics under a sub-contract agreement. Similarly, environmental advice presented in a Galt Geotechnics report has been provided by Galt Environmental under a sub-contract agreement.

Unless specifically noted otherwise, no parties shall draw any inferences about the applicability of the Western Australian state government landfill levy from the contents of this document.



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