REPORT 11210

OPUS

Watercare Services Limited

Woodlands Park Road Reservoirs

Geotechnical Factual Report

GS13/424

Watercare Services Limited

Woodlands Park Road Reservoirs

Geotechnical Investigation Report

GS13/424

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Contents

Appendices

1 Introduction

Opus International Consultants Limited were commissioned by Watercare Services Limited to undertake a geotechnical investigation for the proposed Woodlands Park Road Reservoirs project.

The results of our geotechnical investigation are included in this factual report.

2 Site Location

The site is located west of Titirangi, Auckland as shown on the site plan included in Appendix A.

3 Investigations

3.1 Boreholes

Our geotechnical site investigation consisted of twelve fully cored HQ size machine boreholes at the locations briefed. Likewise as briefed, standard penetrometer tests (SPT's) were undertaken at 1.5 m intervals and push tube samples were taken for laboratory testing.

The drilling was undertaken by DrillForce Limited from the 16th of October to the 8th of November 2013.

The target depth of the boreholes as briefed was 15 m beneath ground level. Before the investigation commenced, it was agreed that BH13/08 be extended to 30 m+ depth to provide an indication of the site's deeper underlying geology. Piezometers were installed in BH13/02, 13/04, 13/07, 13/08 and 13/09.

All of the boreholes were logged in accordance with the NZGS *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes*, December 2005.

The borehole locations are shown in the plan presented in Appendix A, borehole logs and corresponding core photographs are presented in Appendix B.

3.2 Dutch Cone Penetrometer's

Ten Dutch cone penetrometer's (CPT's) were undertaken at the locations briefed. The CPT's were undertaken by Ground Investigation Limited on the 5th and 6th of November 2013.

The CPT locations are shown in the plan presented in Appendix A, CPT plots are presented in Appendix C.

3.3 Test Pits

Six geotechnical test pits were carried out by DrillForce Limited on the 21st to the 23rd of November 2013 at the locations briefed.

The test pits were undertaken to simulate potential excavation conditions during construction of the proposed reservoir structures. Bulk samples were taken from each pit for laboratory testing if required.

The test pit locations are shown in the plan presented in Appendix A, test pit logs and corresponding photographs are presented in Appendix D.

3.4 Hand Augers

Three hand augers were undertaken by the Opus Geotechnical Section on the 4th of November 2013. The hand auger locations were positioned in the centre of proposed reservoir footprints and were primarily undertaken to collect soil samples to be tested for contamination.

The hand auger locations are shown in the plan presented in Appendix A, hand auger logs are presented in Appendix E.

3.5 Laboratory Testing

Laboratory testing has been carried by Opus International Consultants Auckland Laboratory. Various core samples obtained from boreholes BH13/01, 13/03, 13/07 and 13/09 were tested.

Borehole	Depth	Test
BH 13/01	3.0 m 3.3 m 3.35 m 4.0 m 6.7 m 7.2 m 9.4 m 11.55 m	Plasticity Index One Dimensional Consolidation Consolidated Undrained Triaxial Particle Size Distribution Unconfined Compressive Strength Unconfined Compressive Strength Unconfined Compressive Strength Unconfined Compressive Strength
BH 13/03	3.0 m 3.25 m 3.4 m 4.2 m 6.0 m 6.35 m 10.5 m	Plasticity Index Consolidated Undrained Triaxial One Dimensional Consolidation Plasticity Index Plasticity Index Consolidated Undrained Triaxial Plasticity Index
BH 13/07	3.0 m 3.25 m 3.35 m 6.15 m	Plasticity Index One Dimensional Consolidation Consolidated Undrained Triaxial UCS

Borehole	Depth	Test
BH 13/09	3.0 m 3.3 m 3.38 m 6.0 m 6.3 m 6.35 m 9.45 m	Plasticity Index One Dimensional Consolidation Consolidated Undrained Triaxial Plasticity Index One Dimensional Consolidation Consolidated Undrained Triaxial Plasticity Index

The results are presented in Appendix F.

3.6 Contamination Testing

Contamination testing was undertaken on six soil samples collected from the hand auger investigation. The testing was carried out by Hill Laboratories Limited on the 7th of November 2013. The soil samples were tested for hydrocarbons and heavy metals.

The results of the contamination testing are presented in Appendix G.

3.7 Groundwater Levels

The groundwater levels in boreholes BH13/02, 13/04, 13/07, 13/08 and 13/09 were measured by Opus on the 19th of November 2013.

The groundwater levels are presented on each respective borehole logs in Appendix B.

4 Limitations

The results presented in this report are taken from tests undertaken at discreet locations. Ground conditions may change suddenly over short distances resulting in variations between positions or across the site.

This report has been prepared for the benefit of the Watercare Services Limited, for the purpose of providing geotechnical factual information for the proposed Woodlands Park Road Reservoirs. It is not to be relied upon or used out of context by any other person without further reference to the Auckland Geotechnical Section of Opus International Consultants.

Appendix A
Geotechnical Site Plan

Manuka Road Reservoirs- Proposed Investigations

(Revision 2: CPT added at rectangular tank site, BH13/12 moved south)

Key

BH = Borehole (nominally 15 m deep, except BH 13/08 at 30 m)

CPT = Cone penetration test (to refusal)

TP = Trial pit (2 m to 4 m deep depending on requirements)

Note

All investigation sites approximate only- to be located on site by measurement. Test sites that are inaccessible (e.g. due to terrain or water) will be relocated nearby.

Appendix B
Borehole Logs & Core Photographs

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/01**			
PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746085 E 5910825 N	R.L.: 124.69 m	SHEET: 1 of 2
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	HOLE LENGTH: 15.19 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Colluvium	Clayey SILT; greyish brown streaked orange, firm, plastic. Trace manganese staining from 0.30m.																			
	CLAY; with trace silt, light grey streaked orange, stiff, plastic. Some silt and trace manganese staining from 1.10m.	124	1										100	HA	Hand Auger					
	Occasional lenses of fine sandy silt and fine angular gravel from 1.60m.				6	1//1/1/2/2							100	SPT	HQ Triple Tube Wireline					
			2										67	HQ						
	CLAY; with trace silt, brownish grey streaked orange, stiff, plastic, some fine angular silt fragments, some lenses of sandy silt.	122	3										100	PT						
Nihotupu Formation	Silty fine SAND; greyish brown streaked orange, medium dense, brittle, occasional 1-3mmØ angular mudstone fragments.				10	3//1/3/3/3							100	SPT						
	Fine to medium sand and some sub-rounded gravels from 4.20m.		4										100	HQ						
		120			30	5//4/5/8/13							82	SPT						
	Becomes weakly cemented to 5.80m with 0.5-1cmØ angular silt fragments from 4.95m.		5										69	HQ						
			6		50+	17//17/20/13 for 30mm					Relict fracture, very steeply inclined dip; undulating, rough, clay coating from 5.60m to 5.70m.		100	SPT						
	Fine to coarse SANDSTONE; brownish grey, very weak, moderately weathered, some 1-3mmØ sub-rounded to angular gravel.	118	7		50+	50 for 150mm	VW	MW			Fracture, steeply inclined dip; planar, rough, manganese coating from 6.40m to 6.50m. Fracture, moderately inclined dip; undulating, rough, clay coating at 6.65m. Fracture, steeply inclined dip; stepped, rough, manganese coating at 6.90m. Fracture zone, multiple moderately inclined dips; rough, manganese coating from 7.00m to 7.25m. Two fractures, moderately inclined dips; planar, rough, manganese coating at 7.30m and 7.50m.	84	100	HQ						
													100	SPT						
	Fine to coarse SANDSTONE; light grey, very weak, slightly weathered, some 1-3mmØ sub-rounded to angular gravel.		8				VW	SW			Fracture, steeply inclined dip; planar, rough, limonite staining at 7.80m. Fracture, steeply inclined dip; planar, rough, limonite staining at 7.80m.	86	100	HQ						
	Becomes fine to medium grained with occasional 1-3mmØ sub-rounded to angular gravel. Becomes moderately weathered and brownish grey from 8.70m.	116	9		50+	28//38/12 for 15mm N=50+	VW	MW			Six closely spaced fractures, moderately inclined dips; planar, rough, limonite coating from 8.70m to 9.00m.			SC						
	Fine SANDSTONE; light bluish grey, very weak, slightly weathered.						VW	SW			Fracture, gently inclined dip; planar, rough, limonite staining.	62	100	HQ						
	CLAY; greenish grey, hard, plastic.										Bedding plane, gently inclined dip; planar at 9.80m.									

NOTES
Borehole was backfilled upon completion.

STARTED: 29/10/2013	FINISHED: 29/10/2013
DRILLER: Glen	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/01

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/01**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746085 E 5910825 N**	R.L.: **124.69 m**	SHEET: **2 of 2**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **15.19 m**

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Nihotupu Formation	Fine SAND; greenish grey, dense, brittle, moderately cemented.	114	11		50+	18//14/15/12/9 for 55mm					Multiple relict fractures, gently to steeply inclined dips; planar, rough, trace clay and limonite coating from 9.85m to 11.00m.	62	100	HQ	HQ Triple Tube Wireline					
													SC	SPT						
	Fine to medium SANDSTONE; greenish grey, very weak, unweathered to slightly weathered, occasional 1-2mmØ angular gravel.										Fracture, gently inclined dip; planar, rough, trace silt and limonite coating at 11.00m.	84	100	HQ						
		112	12		50+	26//50 for 25mm							SC	SPT						
	Progressively grades into some 1-4mmØ angular gravel by 13.00m.											100	100	HQ						
	Fine SANDSTONE; dark grey, very weak, unweathered.		13				VW	UW												
					50+	50 for 125mm							SC	SPT						
	Progressively grades into a fine to medium grained sandstone with some 1-2mmØ angular gravel by 14.40m.		14									98	100	HQ						
		110									Two fractures, moderately inclined dips; planar, rough, dark greenish grey coatings at 14.40m.									
			15		50+	20//50 for 40mm					Fracture, gently inclined dip; undulating, rough, dark greenish grey coating at 14.80m.		SC	SPT						
	End of Borehole at 15.19m.		16																	
		108	17																	
			18																	
		106	19																	

NOTES
Borehole was backfilled upon completion.

STARTED: 29/10/2013		FINISHED: 29/10/2013	
DRILLER: Glen		DRILLING CO.: Drillforce Ltd	
INCLINATION/ AZIMUTH: -90°		DRILLING RIG: Tractor	
LOGGED: T Van Deelen		CHECKED: A George	BH13/01
CLIENT: Watercare Services Limited		JOB NO.: 1-C0935.25	

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES — SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

Manuka Reservoirs
Watercare Services Limited
Borehole 13/01

0.00m – 3.00m **Box 1 of 5**

3.00m – 6.10m **Box 2 of 5**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/01

6.10m – 8.90m **Box 3 of 5**

8.90m – 12.50m **Box 4 of 5**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/01

12.50m – 15.19m (E.O.H)	**Box 5 of 5**

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/02**				
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746091 E 5910813 N**	R.L.: **127.10 m**	SHEET: **1 of 2**	
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **15.45 m**	

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Fill	Silty CLAY; brown streaked greyish brown and orange, firm, plastic, inclusions of 3cmØ angular, grey, gravel.																		P1	
Colluvium	CLAY; with trace silt, brownish grey streaked dark orange, firm, plastic.												100	HA	Hand Auger					
	Clayey SILT; light brownish grey streaked orange, firm, plastic.	126	1																	
	SILT; with trace fine sand, brownish grey, firm, brittle, trace fine angular silt fragments.				2	1//0/1/0/1							53	SPT	HQ Triple Tube Wireline					
			2										76	HQ						
	Trace limonite staining, trace clay, becomes slightly plastic from 2.40m.																			
	Some lenses of grey and pink fine sandy silt, and brownish orange silty fine to medium sand from 2.70m.	124	3										100	PT						
	SILT; with some clay, brownish grey streaked orange, very stiff, slightly plastic, some pockets of orange brown fine to medium sandy silt, trace limonite and manganese streaks.				8	3/2/1/2/3							69	SPT					19/11/2013 19/11/2013	
			4										100	HQ						
	Silty fine SAND; with trace fine angular gravels, dark brown, loose, brittle.																			
	Fine sandy SILT; with trace clay, yellowish brown, firm to stiff, slightly plastic,				4	1//0/1/2/1							58	SPT						
		122	5										58	HQ						
			6		8	1//1/2/3/2							0	SPT						
		120	7										100	HQ						
	SILT; with trace fine sand and trace clay, greyish brown streaked orange, hard, slightly plastic, grading into a silty fine SAND; loose, brittle by 7.85m.				14	4//5/3/3/3							100	SPT						
	SILT; with some clay, light grey, hard, slightly plastic, with trace fine to medium angular gravel and lenses of silty fine to medium sand.		8										100	HQ						
		118	9								Relict fracture, very steeply inclined dip; undulating, smooth, no coating from 8.70m to 9.00m.									
					21	6//4/5/5/7							100	SPT						
	SILT; with trace fine sand, light grey, hard, brittle, moderately cemented, some very closely spaced incipient fractures.												100	HQ						

NOTES

Single piezometer installed upon completion.

STARTED: 23/10/2013	FINISHED: 24/10/2013
DRILLER: Glen	DRILLING CO.: Drillforce Ltd
INCLINATION/AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/02

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/02**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746091 E 5910813 N**	R.L.: **127.10 m**	SHEET: **2 of 2**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **15.45 m**

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Colluvium	SILT; with trace fine sand, light grey, hard, brittle, moderately cemented, some very closely spaced incipient fractures. Thin layer of fine to medium SAND; medium dense, brittle, weakly cemented.				30	16//7/8/7/8					Bedding plane(?), steeply inclined dip; undulating.		100	HQ	HQ Triple Tube Wireline				P1	
													62	SPT						
	SILT; with trace fine sand, light grey, hard, brittle, 50% moderately cemented, some 1-2cmØ angular mudstone fragments.	116	11										100	HQ						
	Fine sandy SILT; light grey, hard, brittle, 50% moderately cemented, some 1-2cmØ angular mudstone fragments.		12		50+	11//7/11/19/13 for 55mm							58	SPT						
	Fine SANDSTONE; with some silt, dark grey, extremely weak, slightly weathered, massive, occasional fine angular gravel.	114	13				EW	SW					100	HQ						
	SILT; with trace fine sand, light grey, hard, brittle, occasional fine angular to sub-rounded mudstone fragments.				50+	11//11/15/11/13 for 70mm							44	SPT						
			14										81	HQ						
		112	15		27	7//5/6/7/9							100	SPT						
	End of Borehole at 15.45m.		16																	
		110	17																	
			18																	
		108	19																	

NOTES
Single piezometer installed upon completion.

STARTED: 23/10/2013	FINISHED: 24/10/2013
DRILLER: Glen	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/02

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

Manuka Reservoirs
Watercare Services Limited
Borehole 13/02

0.00m – 3.00m **Box 1 of 5**

3.00m – 6.45m **Box 2 of 5**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/02

6.45m – 9.10m **Box 3 of 5**

9.10m – 12.00m **Box 4 of 5**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/02

12.00m – 15.45m (E.O.H)	**Box 5 of 5**

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/03**			
PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746105 E 5910797 N	R.L.: 127.65 m	SHEET: 1 of 2
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	HOLE LENGTH: 15.45 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: DRILLING METHOD	DRILLING: DRILLING FLUID LOSS	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Fill	SILT; with some clay, greyish brown blotched orange, firm, slightly plastic, some rootlets, occasional 4cmØ angular concrete fragments.																			
	CLAY; with some silt, brownish grey mottled orange, firm, slightly plastic, some rootlets.												100	HA	Hand Auger					
	Silty CLAY; grey mottled orange, firm, plastic, occasional fine angular silt fragments.		1																	
	Clayey SILT; brownish grey, firm, plastic, some lenses of orangish brown silty fine to medium sand.	126			4	1//1/1/1/1							100	SPT						
	Silty fine to medium SAND; brown, very loose, brittle, some fine angular mudstone fragments.		2										100	HQ						
	SILT; with some clay, light yellowish grey, firm, plastic, some horizons of pinkish grey silty sand, occasional 1-2mmØ angular silt fragments.																			
			3										100	PT						
	Trace clay and slightly plastic from 3.50m.	124			3	1//0/1/1/1							100	SPT						
	SILT; with trace clay, brownish grey streaked orange, firm, slightly plastic, trace fine angular gravels.		4										100	HQ						
	Some manganese streaks from 4.30m.				4	1//1/1/1/1							100	SPT						
Colluvium	Some limonite streaks and larger 1-2cmØ silt fragments from 5.00m.		5										100	HQ	HQ Triple Tube Wireline					
	Progressively grades into a fine sandy SILT; firm, brittle, weakly cemented from 5.70m to 6.00m.	122																		
			6										100	PT						
	Fine sandy SILT; greyish brown, very stiff to hard, brittle, occasional 1-3cmØ mudstone fragments, occasional lenses of silty fine to coarse sand; some weakly cemented.				9	3//1/2/3/3							100	SPT						
	Some fine to medium angular gravel from 7.00m.		7										100	HQ						
		120			10	3//2/2/4/2							100	SPT						
	Heavy limonite staining from 7.80m to 7.90m.		8																	
	Poor recovery from 7.95m to 9.00m. Fragments of silty fine SAND; brownish grey, loose, brittle, weakly cemented. Suspected fine grained matrix washed away during drilling.												54	HQ						
	SILT; with trace fine sand and trace clay, brownish grey streaked orange, hard, slightly plastic, trace 1-5mmØ angular mudstone fragments, some limonite and manganese staining.		9		18	5//3/3/5/7							82	SPT						
	Fine sandy SILT; greenish grey, hard, brittle, weakly cemented, trace 1-2cmØ angular gravels, some limonite staining.	118											100	HQ						

NOTES

Borehole was backfilled upon completion.

STARTED: 22/10/2013	FINISHED: 23/10/2013
DRILLER: Glen	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/03

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746105 E 5910797 N	R.L.: 127.65 m	HOLE NO.: BH13/03	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 2 of 2	HOLE LENGTH: 15.45 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Colluvium	Fine sandy SILT; greenish grey, hard, brittle, weakly cemented, trace 1-2cmØ angular gravels, some limonite staining.												100	HQ	HQ Triple Tube Wireline					
	Some 1-3mmØ angular gravels from 10.50m.				12	3//3/3/3/3							100	SPT						
	Poor recovery from 10.95m to 12.00m. Suspected hard fragments of sand in a fine grained matrix washed away during drilling.	116	11										13	HQ						
	SILT; with trace clay, dark grey, hard, plastic, some streaks of fibrous organics, occasional 1cmØ mudstone fragments.		12		15	5//3/4/3/5							100	SPT						
	Fine sandy SILT; with trace clay, greenish grey, hard, brittle to slightly plastic, some weakly cemented material, occasional 1-4cmØ angular mudstone fragments.		13								Weakly cemented from 12.90m to 13.00m.		67	HQ						
		114			14	4//4/4/3/3							67	SPT						
	Becomes greenish grey mottled yellowish brown from 14.00m.		14								Weakly cemented from 14.10m to 14.25m.	0	100	HQ						
	MUDSTONE; greenish grey, extremely weak, moderately weathered, multiple very closely spaced incipient fractures.						EW	MW												
	Fine to medium SAND; dark greenish grey, medium dense, brittle, weakly cemented.		15		23	16//9/5/5/4							68	SPT						
	End of Borehole at 15.45m.	112	16																	
			17																	
		110																		
			18																	
			19																	
		108																		

NOTES
Borehole was backfilled upon completion.

STARTED: 22/10/2013	FINISHED: 23/10/2013		
DRILLER: Glen	DRILLING CO.: Drillforce Ltd		
INCLINATION/AZIMUTH: -90°	DRILLING RIG: Tractor		
LOGGED: T Van Deelen	CHECKED: A George	BH13/03	
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25		

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES — SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

Manuka Reservoirs
Watercare Services Limited
Borehole 13/03

0.00m – 2.65m **Box 1 of 6**

2.65m – 5.10m **Box 2 of 6**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/03

5.10m – 7.60m **Box 3 of 6**

7.60m – 12.00m **Box 4 of 6**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/03

12.00m – 14.50m **Box 5 of 6**

14.50m – 15.45m (E.O.H) **Box 6 of 6**

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/04**				
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746065 E 5910805 N**	R.L.: **122.39 m**	SHEET: **1 of 2**	
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **15.45 m**	

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Fill	SILT; with some clay, brown mottled dark brown, firm, plastic, some 1-2cmØ angular gravel, some rootlets.	122											100	HQ	Hand Auger				P1	
	Some 2-5cmØ angular concrete fragments from 0.50m.																			
	Silty CLAY; grey mottled brownish grey and streaked orange, firm, plastic, occasional 0.5-1cmØ angular gravel.		1																	
	Some lenses of clay with trace silt from 1.10m.																			
Colluvium	CLAY; with some silt, grey streaked orange, firm, plastic.				4	1//1/1/1/1							100	SPT	HQ Triple Tube Wireline					
	No recovery from 1.95m to 3.00m. Suspected gravel in the core barrel, fine grained material washed away.	120	2										0	HQ						
			3										100	PT						
	SILT; with some clay, trace fine sand and trace fine angular gravel, light brownish grey streaked orange, firm, slightly plastic.				3	1//1/0/1/1							100	SPT						
	Progressively grading into a silty fine SAND; loose, brittle, trace 1cmØ angular mudstone fragments, trace limonite staining by 4.50m.	118	4										49	HQ						
	Fine sandy SILT; with trace fine angular gravel, brownish grey, firm, brittle.				2	1//1/1/0/0							100	SPT						
	Fine sandy SILT; firm to hard, brittle, occasional weakly cemented 1-2mmØ lenses of sand.		5										58	HQ						
	Becomes weakly cemented with some limonite staining from 4.80m.												100	PT						
	Fine to medium sandy SILT; grey mottled orange, hard, brittle, weakly cemented from 6.80m to 6.95m.	116	6		10	2//1/2/3/4							100	SPT						
	Clayey SILT; with trace fine to medium sand and occasional fine angular gravel, grey, very stiff, plastic.		7										100	HQ						
					8	2//2/1/2/3							0	SPT						
	Fine sandy SILT; grey, hard, brittle, some 1-3cmØ angular mudstone fragments and lenses of weakly cemented material. Becomes a silty fine sand from 8.30m.	114	8										100	HQ						
			9		17	9//4/3/4/6							100	SPT						
	Fine sandy SILT; grey, hard, brittle, moderately to completely cemented, some 1-3cmØ angular mudstone and silt fragments.												69	HQ						

19/11/2013
19/11/2013

NOTES

Single piezometer installed upon completion.

STARTED: 30/10/2013	FINISHED: 30/10/2013
DRILLER: Glen	DRILLING CO.: Drillforce Ltd
INCLINATION/AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/04

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746065 E 5910805 N	R.L.: 122.39 m	HOLE NO.: BH13/04	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 2 of 2	HOLE LENGTH: 15.45 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Colluvium	Fine sandy SILT; grey, hard, brittle, moderately to completely cemented, some 1-3cmØ angular mudstone and silt fragments.	112	11		18	5//3/4/6/5							69	HQ	HQ Triple Tube Wireline				P1	
													100	SPT						
											Relict fracture, steeply inclined dip; planar, rough, no coating at 11.70m.		100	HQ						
		110	12		16	5//4/3/4/5							100	SPT						
			13										100	HQ						
	Clayey SILT; brownish grey, hard, slightly plastic, moderately to completely cemented, some 1-3cmØ angular mudstone and silt fragments.				19	6//3/5/5/6							100	SPT						
		108	14								Two relict fractures, steeply inclined dips; planar, smooth, no coating at 14.10m and 14.40m.		100	HQ						
	Some lenses of dark greenish grey fine to medium sand from 15.00m.		15		21	6//5/5/5/6							100	SPT						
	End of Borehole at 15.45m.	106	16																	
			17																	
		104	18																	
			19																	

NOTES
Single piezometer installed upon completion.

STARTED: 30/10/2013	FINISHED: 30/10/2013
DRILLER: Glen	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/04

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

Manuka Reservoirs
Watercare Services Limited
Borehole 13/04

0.00m – 3.50m **Box 1 of 6**

3.50m – 6.50m **Box 2 of 6**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/04

6.50m – 9.45m **Box 3 of 6**

9.45m – 12.45m **Box 4 of 6**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/04

12.45m – 15.45m (E.O.H)	**Box 5 of 5**

BOREHOLE LOG

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746014 E 5910793 N	R.L.: 121.35 m	HOLE NO.: BH13/05	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 1 of 2	HOLE LENGTH: 15.45 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Topsoil	SILT; with trace clay, brown, firm, slightly plastic, abundant rootlets.																			
	SILT; with some clay, brownish grey, firm, slightly plastic.																			
	Clayey SILT; brownish grey streaked orange, firm, plastic.		1										100	HA	Hand Auger					
		120																		
	SILT; with trace clay, brownish grey with limonite streaks, firm, slightly plastic, occasional grey silt streaks.				4	0//1/1/1/1							100	SPT						
	Silty fine to medium SAND; with trace fine angular gravel, brownish orange, very loose, brittle, some limonite staining. Becomes weakly cemented from 2.20m.		2										100	HQ						
	SILT; with trace fine sand, brownish grey streaked orange, firm to stiff, brittle, some 1-5cmØ weakly cemented angular fine sand with some manganese and limonite staining.		3										100	PT						
		118																		
	Silty CLAY; greenish grey mottled brown, stiff, slightly plastic, trace 1-2mmØ angular hard silt fragments.				5	1/1/1/1/2							100	SPT						
	Fine to medium SAND; with trace fine angular gravels, dark grey, brittle, moderately cemented. Completely cemented from 4.20m to 4.40m.		4										100	HQ						
	CLAY; with trace silt, firm, plastic, occasional fibrous wood organics.																			
Colluvium	SILT; with trace clay, light grey, very stiff, brittle. Pockets of hard greyish pink silt from 4.80m.				8	2//2/2/2/2							100	SPT						
	Some 1-10mmØ angular mudstone fragments and occasional 5cm long segments of weakly cemented fine to medium sand.		5										100	HQ	HQ Triple Tube Wireline					
		116																		
	Becomes weakly cemented from 5.60m.																			
			6		9	4//2/3/2/2							100	SPT						
	Abundant weakly cemented fine to medium sand fragments from 6.60m to 6.80m.		7										100	HQ						
	Clayey SILT; grey, hard, slightly plastic, trace 1-3mmØ angular gravel.	114																		
	SILT; with trace fine sand, grey mottled orangish brown, hard, brittle, some limonite staining.				34	8//6/9/8/11							100	SPT						
	Fine to medium SAND; grey mottle orangish brown, medium dense, brittle, weakly cemented.		8										100	HQ						
	SILT; with trace fine sand, grey mottled orangish brown, hard, brittle, some limonite staining. Lenses of greyish pink silt and dark grey fine to medium sand from 8.80m.																			
			9		35	7//9/9/6/11							100	SPT						
		112																		
	Fine to medium SANDSTONE; extremely weak, moderately weathered, limonite staining.						EW	MW				26	58	HQ						

NOTES
Borehole was backfilled upon completion.
T. = Topsoil.

STARTED: 31/10/2013	FINISHED: 31/10/2013		
DRILLER: Glen	DRILLING CO.: Drillforce Ltd		
INCLINATION/AZIMUTH: -90°	DRILLING RIG: Tractor		
LOGGED: T Van Deelen	CHECKED: A George	BH13/05	
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25		

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES — SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746014 E 5910793 N	R.L.: 121.35 m	HOLE NO.: BH13/05	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 2 of 2	HOLE LENGTH: 15.45 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Colluvium	SILT; with trace clay, light grey, hard, slightly plastic, some 1-2mmØ lenses of dark grey silt.											26	58	HQ	HQ Triple Tube Wireline					
					17	3//1/2/6/6							100	SPT						
	Silty fine SAND; light grey, loose to medium dense, brittle, weakly cemented. Streaked purple and brown from 10.90m. Occasional 5cm thick layers of clayey silt from 11.00m.	110	11										100	HQ						
	Fragments of moderately cemented fine to coarse SAND; with some silt, light grey streaked brown, medium dense, brittle, some limonite staining.		12		25	7//6/6/7							100	SPT						
		108	13										100	HQ						
					22	7//5/6/5/6							49	SPT						
	Some 1-3cmØ angular fragments of sandstone from 13.95m.		14										43	HQ						
	Poor recovery from 14.20m to 15.00m. Fine SANDSTONE; extremely weak, slightly weathered, suspected fine grained materials washed away during drilling.																			
	Fine to medium SAND; grey, dense, brittle, weakly cemented.	106	15		50	6//9/16/19/6							100	SPT						
	End of Borehole from 15.45m.	104	16 17 18 19																	
		102																		

NOTES
Borehole was backfilled upon completion.
T. = Topsoil.

STARTED: 31/10/2013	FINISHED: 31/10/2013		
DRILLER: Glen	DRILLING CO.: Drillforce Ltd		
INCLINATION/AZIMUTH: -90°	DRILLING RIG: Tractor		
LOGGED: T Van Deelen	CHECKED: A George	BH13/05	
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25		

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES — SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

Manuka Reservoirs
Watercare Services Limited
Borehole 13/05

0.00m – 3.00m **Box 1 of 6**

3.00m – 5.60m **Box 2 of 6**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/05

5.60m – 8.30m **Box 3 of 6**

8.30m – 11.30m **Box 4 of 6**

Manuka Reservoirs	
Watercare Services Limited	
Borehole 13/05	

12.50m – 14.30m **Box 5 of 6**

14.30m – 15.45m (E.O.H) **Box 6 of 6**

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/06**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1745990 E 5910831 N**	R.L.: **120.96 m**	SHEET: **1 of 2**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **15.45 m**

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Topsoil	SILT; with trace clay, brown, firm, slightly plastic, abundant rootlets.																			
	CLAY; with some silt, brownish grey streaked orange and grey, firm, plastic.	120	1										100	HA	Hand Auger					
	CLAY; with trace silt, grey streaked orange, firm, plastic, occasional specks of white silt.				4	1//1/1/1/1							100	SPT						
	Some lenses of orangish brown silty fine sand with trace clay from 1.80m.		2										100	HQ						
	Some limonite streaks from 2.10m.																			
	Clayey SILT; brownish grey, firm, slightly plastic, some lenses of non to weakly cemented silty fine to medium sand with manganese staining.	118	3										100	PT						
	SILT; with some clay and minor fine sand, light bluish grey, stiff, slightly plastic, some 1-5mmØ angular silt fragments.				7	2//2/1/2/2							87	SPT						
	SILT; with trace fine to medium sand, light grey, firm, brittle, some 1-5mmØ angular silt fragments.		4										100	HQ						
	Occasional pink and purple streaks of clayey silt from 4.40m.				4	1//1/1/1/1							100	SPT						
Colluvium	SILT; with some clay, firm, light bluish grey, slightly plastic, occasional 1-5mmØ angular silt fragments.	116	5										93	HQ	HQ Triple Tube Wireline					
	Clayey SILT; light bluish grey, stiff, plastic.		6																	
	SILT; with trace clay, stiff, slightly plastic, occasional 2-3cmØ hard silt fragments and purple streaks.				8	3//1/2/3/2							100	SPT						
		114	7										77	HQ						
					8	2//2/2/2/2							0	SPT						
	Some 2-5mmØ angular silt fragments from 7.95m.		8										100	HQ						
	SILT; with trace fine sand, light bluish grey, stiff, brittle. Some 1-2cmØ angular weakly cemented sand fragments from 8.40m to 8.50m.	112	9																	
	Silty CLAY; light bluish grey, stiff, plastic.				8	4//2/2/2/2							100	SPT						
	SILT; with trace clay, bluish grey, stiff, slightly plastic, 1-3mmØ angular mudstone fragments.												68	HQ						

NOTES

Borehole was backfilled upon completion.

STARTED: 5/11/2013		FINISHED: 5/11/2013	
DRILLER: Glen		DRILLING CO.: Drillforce Ltd	
INCLINATION/ AZIMUTH: -90°		DRILLING RIG: Tractor	
LOGGED: T Van Deelen		CHECKED: A George	**BH13/06**
CLIENT: Watercare Services Limited		JOB NO.: 1-C0935.25	

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES — SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1745990 E 5910831 N	R.L.: 120.96 m	HOLE NO.: BH13/06	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 2 of 2	HOLE LENGTH: 15.45 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Colluvium	SILT; with trace clay, bluish grey, stiff, slightly plastic, 1-3mmØ angular mudstone fragments. Some moderately cemented fine to mediums sand lenses from 10.30m to 10.50m. Occasional 1-4mmØ angular silt fragments.				7	3//1/2/2/2							68	HQ	HQ Triple Tube Wireline					
													100	SPT						
	CLAY; with some silt, brown, stiff, plastic.	110	11																	
	SILT; with trace clay, stiff, slightly plastic, occasional weakly cemented fine to medium sand lenses.												100	HQ						
			12		9	3//3/2/2/2							100	SPT						
	Some 1-3cmØ angular mudstone fragments from 12.50m.	108	13										57	HQ						
					6	2//1/2/1/2							62	SPT						
	Some moderately cemented fine to medium sand fragments from 14.10m.		14										100	HQ						
	SILT; with trace fine sand, hard, brittle, some 1-2cmØ angular mudstone fragments.	106	15		16	3//1/3/3/9							100	SPT						
	End of Borehole at 15.45m.		16																	
		104	17																	
			18																	
		102	19																	

NOTES
Borehole was backfilled upon completion.

STARTED: 5/11/2013	FINISHED: 5/11/2013		
DRILLER: Glen	DRILLING CO.: Drillforce Ltd		
INCLINATION/AZIMUTH: -90°	DRILLING RIG: Tractor		
LOGGED: T Van Deelen	CHECKED: A George	BH13/06	
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25		

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES — SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

Manuka Reservoirs
Watercare Services Limited
Borehole 13/06

0.00m – 2.80m **Box 1 of 5**

2.80m – 5.20m **Box 2 of 5**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/06

5.20m – 8.80m **Box 3 of 5**

8.80m – 11.95m **Box 4 of 5**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/06

11.95m – 15.45m (E.O.H)	**Box 5 of 5**

BOREHOLE LOG

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746025 E 5910818 N	R.L.: 119.20 m	HOLE NO.: BH13/07	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 1 of 2	HOLE LENGTH: 15.45 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING METHOD	DRILLING FLUID LOSS	CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Topsoil	SILT; with trace clay, brown, firm, slightly plastic, some rootlets.																			
Colluvium	Fine sandy CLAY; with some silt and trace angular fine gravel, greyish brown mottled grey and streaked orange, firm, plastic, trace limonite staining.																			
Colluvium	CLAY; with trace silt, grey mottled orange, firm, plastic, trace limonite streaks, trace grey silt specks.		1										100	HA	Hand Auger					
Colluvium	CLAY; with some silt, grey streaked orange, firm, plastic, trace limonite staining.	118																		
					2	1//0/1/0/1							44	SPT						
Alluvium	CLAY; with trace silt, bluish grey, firm, plastic, trace fibrous organics.		2																	
Alluvium	Fine sandy SILT; with trace clay, bluish grey, very stiff, slightly plastic, occasional 1-2cmØ angular gravel, occasional fibrous organics.												100	HQ						
Colluvium	SILT; with trace fine sand, bluish grey mottled yellowish brown, hard, brittle.	116	3										100	PT						
					9	3//1/2/3/3							100	SPT						
Colluvium	Silty fine SAND; bluish grey, medium dense, brittle, 50% weakly cemented.		4										100	HQ						
					16	6//4/4/3/5							100	SPT						
Colluvium	SILT; with trace clay, bluish grey, hard, brittle, 1-2cmØ angular mudstone fragments.	114	5																	
Colluvium	Fine SANDSTONE; dark grey, very weak, slightly weathered, massive.		6		50+	50 for 150mm	VW	SW				57	100	HQ	HQ Triple Tube Wireline					
													100	SPT						
												100	100	HQ						
		112	7																	
	Poor recovery from 7.50m to 9.45m. Fragments of 1-4cmØ angular SANDSTONE; dark grey, in a suspected fine grained matrix that has been washed away during drilling.				23	7//6/6/5/6							0	SPT						
			8										10	HQ						
		110	9		7	3/2/2/1/2							11	SPT						
	Fine sandy SILT; bluish grey, stiff, brittle, 1-3cmØ angular lenses of weakly cemented material.												100	HQ						

P1 P2

19/11/2013

19/11/2013

NOTES

Multi-level piezometer installed upon completion.
T. = Topsoil

STARTED: 6/11/2013	FINISHED: 6/11/2013		
DRILLER: Glen	DRILLING CO.: Drillforce Ltd		
INCLINATION/AZIMUTH: -90°	DRILLING RIG: Tractor		
LOGGED: T Van Deelen	CHECKED: A George	BH13/07	
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25		

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746025 E 5910818 N	R.L.: 119.20 m	HOLE NO.: BH13/07	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 2 of 2	HOLE LENGTH: 15.45 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Colluvium	Silty fine SAND; bluish grey, medium dense, brittle.												100	HQ	HQ Triple Tube Wireline				P1, P2	
	Becomes weakly cemented from 10.40m to 10.50m.				16	8//5/5/3/3							60	SPT						
	Becomes moderately cemented from 10.95m to 11.20m.	108	11										77	HQ						
	Clayey fine SAND; with trace silt, bluish grey, medium dense, slightly plastic, some 1-5cmØ angular sandstone fragments.																			
	SILT; with some fine sand, some 1-6mmØ fine angular gravel and trace clay, bluish grey, hard, slightly plastic, occasional 1-3cmØ sandstone fragments.		12		14	4//3/3/4/4							53	SPT						
	Becomes moderately cemented from 12.70m to 12.80m.												100	HQ						
	SILT; with some clay and trace fine sand, bluish grey, stiff, slightly plastic, occasional 1-2cmØ moderately cemented sand fragments.	106	13																	
					7	4//1/1/3/2							0	SPT						
			14										57	HQ						
	Silty fine SAND; dark grey, medium dense, brittle, weakly cemented.	104	15		11	5//2/3/2/4							100	SPT						
	End of Borehole at 15.45m.		16																	
		102	17																	
			18																	
		100	19																	

NOTES
Multi-level piezometer installed upon completion.
T. = Topsoil

STARTED: 6/11/2013	FINISHED: 6/11/2013
DRILLER: Glen	DRILLING CO.: Drillforce Ltd
INCLINATION/AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/07

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

Manuka Reservoirs
Watercare Services Limited
Borehole 13/07

0.00m – 2.80m **Box 1 of 5**

2.80m – 6.00m **Box 2 of 5**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/07

6.00m – 10.50m **Box 3 of 5**

10.50m – 13.95m **Box 4 of 5**

Manuka Reservoirs	OPUS
Watercare Services Limited	
Borehole 13/07	

13.95m – 15.45m (E.O.H)	**Box 5 of 5**

BOREHOLE LOG

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746063 E 5910827 N	R.L.: 122.56 m	HOLE NO.: BH13/08	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 1 of 5	HOLE LENGTH: 40.58 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Topsoil	Silty CLAY; brown mottled light brown, firm, plastic, abundant rootlets.																			
	CLAY; with some silt, greyish brown streaked orange, firm, plastic, occasional 2mm lenses of brown, "hard" angular silt fragments.	122	1										100	HA	Hand Auger					
					4	1//1/1/1/1							69	SPT						
	CLAY; with trace silt, greyish brown, soft, plastic with very low remoulded strength.		2										77	HQ						
	CLAY; with some silt, light greyish brown, stiff, plastic, trace 4cmØ lenses of dark reddish brown, brittle silty fine to medium sand.	120																		
	Silty fine to coarse SAND; greyish brown mottled orangish brown, medium dense, brittle.		3		20	5/3/4/5/8							78	SPT						
	Poor recovery from 3.45m to 4.95m. Fragments of 10-15cmØ, angular, weakly cemented fine to coarse SAND; in a suspected fine grained matrix that has been washed away during drilling.		4										42	HQ						
		118			23	8//6/5/6/6							56	SPT						
	Clayey SILT; greyish brown, hard, plastic, some 2-5cmØ angular mudstone fragments and fine angular and rounded, grey and green gravels, some limonite and manganese streaks.		5										100	HQ	HQ Triple Tube Wireline					
	Becomes grey with trace fine sand and no manganese staining from 5.70m.		6		13	3//3/3/3/4							56	SPT						
	SILT; with some fine sand and trace clay, grey, hard, slightly plastic, some fine to medium angular, red and green, gravels and occasional 2-5cmØ weakly cemented sand lenses.	116	7										90	HQ						
					14	4//4/5/4/5							100	SPT						
	Fine sandy SILT; dark grey, hard, brittle, with some fine to medium angular, grey, green and red, silt gravels.	114	8										95	HQ						
			9		19	4//4/5/4/6							100	SPT						
	Poor recovery from 9.45m to 10.5m. Fragments of moderately cemented fine to coarse SAND; dark grey, in a suspected fine grained matrix that has been washed away during drilling.												25	HQ						

P1
19/11/2013
19/11/2013

NOTES

Single piezometer installed upon completion.

STARTED: 16/10/2013	FINISHED: 22/10/2013
DRILLER: Billy	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/08

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746063 E 5910827 N	R.L.: 122.56 m	HOLE NO.: BH13/08	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 2 of 5	HOLE LENGTH: 40.58 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
	Fine to medium sandy SILT; dark grey, hard, brittle, some fine to medium angular, grey and green, gravels and occasional 3cmØ weakly cemented sand lenses.	112	11		13	3//3/3/3/4							25	HQ	HQ Triple Tube Wireline				P1	
													82	SPT						
	Becomes a silt with some fine to medium sand from 11.50m.												100	HQ						
			12		10	3/2/2/3/3							76	SPT						
	Becomes mottled brown from 12.45m to 12.70m with fine to medium angular, dark grey, gravel from 12.45m.	110											100	HQ						
			13																	
	Fine to medium SAND; dark grey, medium dense, brittle.				15	4//4/3/4/4							71	SPT						
	SILT; with some clay and trace fine sand, hard, slightly plastic, some 1-4cmØ angular mudstone fragments.		14																	
	SILT; with trace fine sand, hard, brittle, some 3-5cmØ angular mudstone fragments.	108											100	HQ						
	Some fine to medium angular to rounded, grey and green, gravel from 15.00m.		15		18	4//3/4/6/5							70	SPT						
													100	HQ						
	Becomes mottled brown from 16.20m.		16																	
	Clayey SILT; dark grey, hard, plastic.	106			20	6//3/5/6/6							42	SPT						
			17																	
	SILT; with trace clay, hard, slightly plastic, with some weakly cemented fine to coarse sand lenses and fine angular grey silt fragments.												90	HQ						
			18		32	10//8/8/7/9							44	SPT						
	SILT; with some fine sand, hard, brittle, some 2-6cm long core segments of mudstone and sandstone, trace 1-3cmØ angular mudstone fragments.	104																		
			19										71	HQ						
					20	10//4/5/6/5							38	SPT						

NOTES

Single piezometer installed upon completion.

STARTED: 16/10/2013	FINISHED: 22/10/2013
DRILLER: Billy	DRILLING CO.: Drillforce Ltd
INCLINATION/AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/08

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/08**				
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746063 E 5910827 N**	R.L.: **122.56 m**	SHEET: **3 of 5**	
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **40.58 m**	

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
	SILT; with some fine sand, hard, brittle, some 2-6cm long core segments of mudstone and sandstone, trace 1-3cmØ angular mudstone fragments.	102 / 21										57	HQ					P1	
	Fine sandy SILT; hard, brittle, some 1-4cmØ angular mudstone fragments.	21		26	10//7/7/7/5							57	HQ						
	Silty fine to medium SAND; medium dense, brittle, some 1-5cm Øweakly cemented lenses, trace fine to medium angular, grey, green and red, gravel.	100 / 22		18	6//4/4/5/5							47	SPT						
	Segment of fine to medium SANDSTONE; slightly weathered, massive, with some fine to medium angular gravel. No recovery from 23.60m to 24.50m, "softer material" beneath segment of sandstone.	23										100	HQ						
	Poor recovery from 24.50m to 26.00m. Fragments of moderately cemented fine to coarse SAND; grey with fine to coarse angular gravels in a suspected fine grained matrix that has been washed away during drilling.	24 / 98 / 25		3	0//1/0/2/0							67	SPT						
	SILT; with trace clay and trace fine sand, dark grey, hard, slightly plastic, some lenses of weakly cemented fine to coarse sand, trace fine angular, red, grey and green, gravels, trace 0.5cm to 2cmØ angular mudstone fragments.	26 / 96 / 27		23	7//3/4/7/9							30	HQ						
	Fine sandy SILT; with trace clay, dark grey, hard, slightly plastic, some lenses of weakly cemented fine to coarse sand, trace fine angular, red, grey and green, gravels, trace 0.5cm to 2cmØ angular mudstone fragments. Some 5-10cm segments of weakly cemented fine sand and sandstone from 28.50m.	28 / 94 / 29		50+	22//43/7 for 15mm							60	SPT						
					??							100	HQ						
												36	SPT						
												69	HQ						
												42	SPT						
												100	HQ						

NOTES
Single piezometer installed upon completion.

STARTED: 16/10/2013	FINISHED: 22/10/2013
DRILLER: Billy	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/08

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/08**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746063 E 5910827 N**	R.L.: **122.56 m**	SHEET: **4 of 5**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **40.58 m**

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
					35	13//7/8/8/12							31	SPT						
	MUDSTONE; extremely weak, slightly weathered, massive, bluish grey.	92									Fracture, steeply inclined dip; planar, smooth, clay coating at 30.60m. Fracture, moderately inclined dip; planar, smooth, silt coating at 30.85m.	38	100	HQ						
	SILT; with some fine sand, greenish grey, hard, brittle, some 1-2mmØ sub-rounded mudstone gravels.		31																	
					15	7//4/4/4/3							27	SPT						
			32																	
	Fine SAND; with trace silt, grey, loose, brittle. Becomes weakly cemented from 32.80m.	90											100	HQ						
	Fine to medium sub-rounded gravelly fine to medium SAND; with trace silt, grey mottled greenish grey, medium dense, brittle, 50% weakly cemented.		33		40	18//8/9/11/12							28	SPT						
											Relict fracture(?), sub-vertical dip; undulating, rough.		100	HQ						
			34																	
		88			27	6//4/5/8/10							47	SPT						
			35																	
	Becomes moderately cemented from 35.50m.										Relict fracture(?), sub-vertical dip; undulating, rough.		58	HQ						
			36		50+	15//18/22/10 for 20mm							63	SPT						
	Fine to medium SANDSTONE; with fine to medium sub-angular to angular gravel, grey, extremely weak, slightly weathered.	86					W	SW			Three fractures, gently to moderately inclined dips; undulating, rough, no coating from 36.40m to 36.80m.	31	100	HQ						
			37																	
	Silty fine SAND; dense, brittle, weakly cemented.																			
	Fine to medium SANDSTONE; with fine to medium sub-angular to angular gravel, grey, extremely weak, slightly weathered.				50+	25//28/22 for 70mm	W	SW			Fracture, sub-vertical dip; wavy, undulating, rough, no coating from 37.35m to 37.50m.		100	SPT						
			38								Two fractures, steeply inclined dips; undulating, rough, no coating.	68	100	HQ						
	Fine to coarse SANDSTONE; with some fine to 3mmØ angular gravel, very weak, slightly weathered, progressively grading into a 1-3cmØ sub-rounded to angular CONGLOMERATE; with some fine to coarse sand, very weak, slightly weathered. Broken segment of core from 38.60 to 39.00m. Suspected very steeply inclined fracture.	84																		
			39		50+	50 for 140mm	VW	SW					SC	SPT						
												100	100	HQ						

NOTES

Single piezometer installed upon completion.

STARTED: 16/10/2013	FINISHED: 22/10/2013
DRILLER: Billy	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/08

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/08**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746063 E 5910827 N**	R.L.: **122.56 m**	SHEET: **5 of 5**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **40.58 m**

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: DRILLING METHOD	DRILLING: DRILLING FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
							VW	SW				100	100	HQ					P1	
		82			50+	50 for 80mm							SC	SPT						
	End of Borehole at 40.58m.		41																	
			42																	
		80																		
			43																	
			44																	
		78																		
			45																	
			46																	
		76																		
			47																	
			48																	
		74																		
			49																	

NOTES

Single piezometer installed upon completion.

STARTED: 16/10/2013	FINISHED: 22/10/2013
DRILLER: Billy	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/08

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

Manuka Reservoirs
Watercare Services Limited
Borehole 13/08

0.00m – 3.45m **Box 1 of 11**

3.45m – 7.50m **Box 2 of 11**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/08

7.50m – 11.50m **Box 3 of 11**

11.5m – 14.65m **Box 4 of 11**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/08

14.65m – 18.00m **Box 5 of 11**

18.00m – 22.50m **Box 6 of 11**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/08

22.50m – 27.00m **Box 7 of 11**

27.00m – 31.00m **Box 8 of 11**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/08

31.00m – 34.50m **Box 9 of 11**

34.50m – 38.10m **Box 10 of 11**

Manuka Reservoirs	OPUS
Watercare Services Limited	
Borehole 13/08	

38.10m – 40.58m (E.O.H)	**Box 11 of 11**

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/09**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1745933 E 5910849 N**	R.L.: **123.61 m**	SHEET: **1 of 2**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **15.45 m**

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Topsoil	SILT; with trace clay, brown, firm, slightly plastic, some rootlets.																		P1	
	CLAY; with trace silt, light brownish grey streaked orange, firm, plastic.																			
	Trace fine to coarse sand from 0.70m.												100	HA	Hand Auger					
	Silty CLAY; with trace fine to coarse sand, grey mottled orangish brown, firm, plastic.		1																	
	CLAY; with trace silt, grey, firm, plastic, limonite streaks.	122			4	1//1/1/1/1							100	SPT						
	No recovery from 1.95m to 3.00m. Inferred soft material washed away during drilling.		2										0	HQ						
	Fine to medium sandy SILT; with trace clay, stiff, slightly plastic, occasional 1-4mmØ angular silt fragments.		3										100	PT						
		120			5	1//1/2/1/1							100	SPT						
			4										100	HQ						
Colluvium	Clayey SILT; with trace fine to medium sand, firm, plastic.				4	1//0/1/2/1							100	SPT						
	Silty fine to medium SAND; with some fine sub-rounded to angular gravel, dark grey, loose, brittle.		5										100	HQ	HQ Triple Tube Wireline					
	Fine to medium sandy SILT; with trace clay and occasional fine angular gravel, bluish grey, firm, slightly plastic.	118																	19/11/2013	
			6										100	PT					19/11/2013	
	Silty fine SAND; bluish grey, loose, brittle, trace 1-5mmØ silt fragments.				6	1//1/1/2/2							100	SPT						
	SILT; with trace clay, bluish grey, stiff, plastic.		7										100	HQ						
	SILT; with some clay and trace fine to medium sand, dark bluish grey, stiff, slightly plastic, some 1-2mmØ angular gravels and mudstone fragments.	116			6	1//1/1/2/2							100	SPT						
			8										100	HQ						
	SILT; with some fine to medium sand, bluish grey, hard, brittle, occasional 1-3cmØ angular sandstone fragments.																			
	Fine sandy SILT; bluish grey, hard, brittle.		9		11	3//2/2/3/4							100	SPT						
		114									Two relict fractures, steeply inclined dips; undulating, rough at 9.50m and 9.60m.		100	HQ						

NOTES

Single piezometer installed upon completion.
T. = Topsoil.

STARTED: 4/11/2013	FINISHED: 4/11/2013
DRILLER: Glen	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/09

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/09**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1745933 E 5910849 N**	R.L.: **123.61 m**	SHEET: **2 of 2**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **15.45 m**

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Colluvium	Fine sandy SILT; bluish grey, hard, brittle.											100	HQ	HQ Triple Tube Wireline				P1	
	Some 3-5cmØ angular mudstone fragments at 10.50m.	11		11	3//2/3/3/3							31	SPT						
		112										100	HQ						
	Fine to medium SAND; dark grey, medium dense, brittle.																		
	Fine sandy SILT; bluish grey, hard, trace fine to medium angular mudstone fragments.	12		19	6//3/5/5/6							100	SPT						
	SILT; with trace fine sand, dark greyish brown, hard, brittle, weakly cemented.																		
	Thin carbonaceous streak at 12.90m.	13										100	HQ						
	SILT; with trace clay, light bluish grey, hard, slightly plastic.	110		17	5//3/4/4/6							100	SPT						
	MUDSTONE; yellowish brown, extremely weak, highly weathered.	14				EW	HW			Relict fracture surfaces, planar, smooth from 13.95m to 14.10m.									
	SILT; with trace fine sand, light bluish grey, hard, brittle.										0	100	HQ						
		15		35	9//7/8/11/9							100	SPT						
	End of Borehole at 15.45m.	108																	
		16																	
		17																	
		106																	
		18																	
		19																	
		104																	

NOTES
Single piezometer installed upon completion.
T. = Topsoil.

STARTED: 4/11/2013	FINISHED: 4/11/2013
DRILLER: Glen	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/09

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

Manuka Reservoirs
Watercare Services Limited
Borehole 13/09

0.00m – 3.50m **Box 1 of 5**

3.50m – 6.00m **Box 2 of 5**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/09

6.00m – 9.00m **Box 3 of 5**

9.00m – 12.45m **Box 4 of 5**

Manuka Reservoirs	OPUS
Watercare Services Limited	
Borehole 13/08	

12.45m – 15.45m (E.O.H)	**Box 5 of 5**

BOREHOLE LOG

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1745918 E 5910806 N	R.L.: 122.95 m	HOLE NO.: BH13/10	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 1 of 2	HOLE LENGTH: 15.42 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Colluvium	CLAY; with trace silt, orangish brown, stiff, plastic, trace rootlets.												100	HA	Hand Auger					
	CLAY; with some silt, orangish brown mottled light brownish grey, stiff, plastic, trace white silt specks. Minor limonite staining from 1.00m.	122	1																	
	CLAY; with trace silt, light brownish grey streaked orange, stiff, plastic, occasional 1-3cmØ angular mudstone fragments and lenses of silty sand.				6	1//1/2/1/2							100	SPT	HQ Triple Tube Wireline					
	Trace fine sand and becomes weakly cemented from 2.10m.		2										100	HQ						
		120	3										100	PT						
	Fine to medium sandy CLAY; with some silt, yellowish brown mottled grey				6	2//1/1/2/2							100	SPT						
			4										100	HQ						
					6	3//2/1/2/1							60	SPT						
		118	5										67	HQ						
	MUDSTONE; light orangish brown, extremely weak, highly weathered. No recovery from 5.50m to 6.00m. Suspected fine grained material washed away during drilling.						EW	HW			Relict fracture surfaces; planar to undulating, rough, limonite coatings from 5.20m to 5.50m.									
			6		17	4//3/3/4/7							100	PT						
	Silty fine SAND; greyish brown streaked orange, medium dense, brittle, trace limonite staining.												100	SPT						
	CLAY; with trace silt, brown, hard, plastic, blocky/ lensmoidal, some manganese streaks.	116	7																	
	Fine to medium SAND; with some silt and some fine angular gravel, light yellowish brown mottled greyish brown, medium dense, brittle.												100	HQ						
	SILT; with some clay and trace fine sand, greyish brown streaked orange, hard, slightly plastic, some 1-3cmØ angular silt fragments.				12	4//3/2/4/3							100	SPT						
	Fine sandy SILT; greyish brown, hard, brittle, weakly cemented.		8								Relict fracture surfaces, heavy limonite staining from 8.00m to 8.40m.									
	Silty CLAY; brown, hard, plastic, blocky/ lensmoidal.												43	HQ						
	Silty fine to medium SAND; with some fine angular gravel, light brown mottled dark greyish brown, medium dense, brittle, trace limonite staining. Occasional streaks of white clay from 9.00m.	114	9		15	2//3/3/3/6							100	SPT						
	Becomes weakly cemented from 9.50m.												78	HQ						

NOTES

Borehole was backfilled upon completion.

STARTED: 1/11/2013	FINISHED: 1/11/2013
DRILLER: Glen	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/10

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1745918 E 5910806 N	R.L.: 122.95 m	HOLE NO.: BH13/10	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 2 of 2	HOLE LENGTH: 15.42 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Colluvium	Silty fine to medium SAND; with some fine angular gravel, light brown mottled dark greyish brown, medium dense, brittle, trace limonite staining. Becomes non-cemented from 10.50m.	112	11		12	3//2/3/3/4							78	HQ	HQ Triple Tube Wireline					
													100	SPT						
	Silty fine to medium SAND; dark greyish brown, medium dense, brittle, some weakly cemented lenses of material with manganese coatings, occasional pockets of grey clay. Fine grained material washed away from 11.50m to 12.00m.												100	HQ						
	Fine sub-rounded to angular GRAVEL; with trace fine sand and trace silt, yellowish brown, medium dense, brittle.		12		25	4//5/5/7/8							100	SPT						
	Fine sub-rounded to angular gravelly fine to medium SAND; with trace silt, yellowish brown, medium dense, brittle.	110											100	HQ						
	Fine to medium SAND; with trace fine angular gravel, bluish grey mottled brown, medium dense, brittle, weakly cemented.		13								Very closely spaced relict fractures; undulating, smooth, clay coating from 12.90m to 13.00m.									
					10	1//1/2/3/4							33	SPT						
			14										78	HQ						
	Silty fine to medium SAND; with trace fine angular gravel, bluish grey, medium dense, brittle, moderately cemented.																			
	Clayey SILT; bluish grey, hard, slightly plastic.																			
	Silty fine to medium SAND; with trace fine angular gravel, bluish grey, dense, brittle, moderately cemented.	108	15		50+	8//5/14/16/16 for 45mm							100	SPT						
	End of Borehole at 15.42m.		16																	
		106	17																	
			18																	
		104	19																	

NOTES
Borehole was backfilled upon completion.

STARTED: 1/11/2013	FINISHED: 1/11/2013		
DRILLER: Glen	DRILLING CO.: Drillforce Ltd		
INCLINATION/AZIMUTH: -90°	DRILLING RIG: Tractor		
LOGGED: T Van Deelen	CHECKED: A George	BH13/10	
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25		

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES — SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

Manuka Reservoirs	OPUS
Watercare Services Limited	
Borehole 13/10	

0.00m – 3.00m **Box 1 of 6**

3.00m – 6.00m **Box 2 of 6**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/10

6.00m – 8.20m **Box 3 of 6**

8.20m – 11.65m **Box 4 of 6**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/10

11.65m – 15.00m **Box 5 of 6**

15.00m – 15.45m (E.O.H) **Box 6 of 6**

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/11**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746226 E 5910756 N**	R.L.: **126.49 m**	SHEET: **1 of 2**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **12 m**

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	CPT qc (MPa) 0 10 20 30	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Fill	CLAY; with some 1-10cmØ angular gravel, trace silt and trace fine sand, brownish orange, firm, plastic. Becomes mottled grey with trace silt and occasional 1-2cmØ angular gravel.	126 / 0												
	CLAY; with trace silt, brownish grey streaked orange, firm, plastic.	1					100	HA	Hand Auger					
Nihotupu Formation	Clayey SILT; with trace fine sand, brownish grey mottled orange, firm, plastic. Becomes greyish brown with trace medium sand from 2.00m.	2		3	1//0/1/1/1		100	SPT						
	Progressively grading into a silty fine SAND; loose, brittle by 3.00m.	124 / 3					100	HQ						
	Fine SAND; with trace silt, greyish brown, medium dense, brittle, trace manganese staining.						100	PT						
				10	3//2/2/3/3		100	SPT						
		4					100	HQ						
	Limonite staining from 4.50m to 4.70m.	122 / 5		20	5//4/4/6/6		100	SPT						
	Some manganese streaks from 4.95m. Becomes yellowish brown with trace limonite staining from 5.50m.						100	HQ	HQ Triple Tube Wireline					
	Fine to medium SAND; with trace silt, yellowish brown, medium dense, brittle. Relict fracture, gently inclined dip; planar, rough, limonite staining at 5.90m.	6												
	Fine to coarse SAND; with some 1-5mmØ sub-rounded to angular gravel, yellowish brown, medium dense, brittle, some weakly cemented zones.			38	12//11/8/9/10		100	SPT						
	Poor recovery from 6.45m to 7.50m. Fragments of 1-4cmØ angular weakly cemented SAND; in a suspected fine grained matrix that has been washed away during drilling.	120 / 7					27	HQ						
	Intense zone of limonite staining from 7.70m.			37	23//13/8/8/8		100	SPT						
	Thin streaks of whitish brown clay from 8.00m to 8.50m.	8					100	HQ						
	Intense zone of limonite from 8.70m to 8.80m. Becomes brownish grey and weakly cemented from 8.80m. Relict fracture, moderately inclined dip; undulating, rough, limonite coating at 8.90m.	118 / 9		3	3//1/0/1/1		100	SPT						
	Poor recovery from 9.45m to 10.50m. Fragments of 1-4cmØ angular weakly cemented SAND; in a suspected fine grained matrix that has been washed away during drilling.						29	HQ						

NOTES

Borehole was backfilled upon completion.

STARTED: 8/11/2013	FINISHED: 8/11/2013		
DRILLER: Glen	DRILLING CO.: Drillforce Ltd		
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor		
LOGGED: T Van Deelen	CHECKED: A George	**BH13/11**	
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25		

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES — SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

Scale 1:33.33

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/11**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746226 E 5910756 N**	R.L.: **126.49 m**	SHEET: **2 of 2**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	HOLE LENGTH: **12 m**

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	CPT qc (MPa) 0 10 20 30	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
	Fine to coarse SAND; with some 1-5mmØ sub-rounded to angular gravel, yellowish brown, medium dense, brittle, some weakly cemented zones.	116					29	HQ						
Fill / Concrete (Aqueduct)	Fragments of hard angular CONCRETE.			50+	50 for 75mm		100	SPT						
		11												
		12					20	HQ	HQ Triple Tube Wireline					
	End of Borehole at 12.00m. Underground service struck.	114												
		13												
		14												
		112												
		15												
		16												
		110												
		17												
		18												
		108												
		19												

NOTES

Borehole was backfilled upon completion.

STARTED: 8/11/2013		FINISHED: 8/11/2013	
DRILLER: Glen		DRILLING CO.: Drillforce Ltd	
INCLINATION/ AZIMUTH: -90°		DRILLING RIG: Tractor	
LOGGED: T Van Deelen		CHECKED: A George	**BH13/11**
CLIENT: Watercare Services Limited		JOB NO.: 1-C0935.25	

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

Scale 1:33.33

BOREHOLE_LOG_A3_SOILS (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Manuka Reservoirs
Watercare Services Limited
Borehole 13/11

0.00m – 3.00m **Box 1 of 4**

3.00m – 5.80m **Box 2 of 4**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/11

5.80m – 9.45m **Box 3 of 4**

9.45m – 12.00m (E.O.H) **Box 4 of 4**

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/12**				
PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746229 E 5910719 N	R.L.: 130.04 m	SHEET: 1 of 2	
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	HOLE LENGTH: 15.4 m	

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Nihotupu Formation	CLAY; with some silt, brown streaked orange, firm, plastic, some rootlets.												100	HA	Hand Auger					
	CLAY; with trace silt, brownish grey mottled orange, stiff, plastic, some 1-4mmØ angular hard silt fragments.		1																	
	Becomes grey mottled orange from 1.20m.																			
	Trace manganese staining from 1.50m.				5	2//1/1/1/2							100	SPT						
	Silty CLAY; with trace fine to coarse sand, brown mottled yellowish brown, firm, plastic, some 1-3mmØ angular silt fragments.	128	2										87	HQ						
	Silty fine to medium SAND; brown mottled yellowish brown, very loose, brittle, slightly dilatant in the core box, some 1-3mmØ angular gravel.		3										100	PT						
	Becomes yellowish brown with no dilatancy from 3.50m.				0	0//0/0/0/0							100	SPT						
	SILT; with some fine to medium sand and some clay, light brownish grey, soft, slightly plastic, trace 1-5mmØ angular silt fragments.	126	4										100	HQ						
	Fine to medium SAND; with trace silt, greyish brown, very loose, brittle, slightly dilatant in the core box from 4.95m to 5.20m. Poor recovery from 4.95m to 6.00m.				0	0//0/0/0/0							71	SPT						
			5										33	HQ	HQ Triple Tube Wireline					
		124	6										100	PT						
	SILT; with some fine to medium sand, stiff, brittle, trace limonite staining.				5	2//1/1/1/2							100	SPT						
	Clayey fine SAND; with some silt, yellowish brown, loose, plastic.		7										100	HQ						
	Some limonite staining from 7.20m.																			
	Silty fine SAND; dense, brittle, weakly cemented.																			
	Laminae streaks of manganese from 7.60m.				50+	18//12/12/18/8 for 25mm					Relict fracture, very steeply inclined dip; undulating, rough, limonite coating at 7.40m.		100	SPT						
	Fine to coarse SANDSTONE; some 1-2cmØ sub-rounded to angular gravel, brownish grey, extremely weak, moderately cemented, limonite staining.	122	8				EW	MW			Fracture, moderately inclined dip; undulating, rough, trace limonite coating at 8.30m.	78	100	HQ						
	Fine to medium SANDSTONE; with trace 0.5m-2cmØ angular gravel, brownish grey, extremely weak, moderately weathered.		9		50+	28//35/15 for 35mm					Broken core due to drilling from 8.80m to 9.00m.		SC	SPT						
							EW	MW			Three closely spaced fractures, very steeply inclined dips; undulating, rough, trace manganese coating from 9.30m to 10.05m.	54	100	HQ						

NOTES

Borehole was backfilled upon completion.

STARTED: 7/11/2013	FINISHED: 8/11/2013
DRILLER: Glen	DRILLING CO.: Drillforce Ltd
INCLINATION/ AZIMUTH: -90°	DRILLING RIG: Tractor
LOGGED: T Van Deelen	CHECKED: A George
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25

BH13/12

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES

SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE LOG

OPUS GEOTECHNICAL

HOLE NO. **BH13/12**			
PROJECT: Manuka Road Reservoirs	CO-ORD.: 1746229 E 5910719 N	R.L.: 130.04 m	SHEET: 2 of 2
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	HOLE LENGTH: 15.4 m

GEOLOGY/UNIT	MAIN DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	DEFECT SPACING	DIP (degrees 0–90)	DETAILED DESCRIPTION	CORE: RQD (%)	CORE: TOTAL CORE RECOVERY (%)	CORE: SAMPLE TYPE	DRILLING: METHOD	DRILLING: FLUID LOSS	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	PIEZOMETER DETAILS	OTHER INSTRUMENTATION
Nihotupu Formation	Silty fine SAND; light grey, loose, brittle, weakly cemented, abundant 1-3mmØ angular gravel down to 10.30m.				4	2//1/1/1/1						54	100	HQ	HQ Triple Tube Wireline					
													0	SPT						
	Fine to 3mmØ GRAVEL; with some silt and some fine sand, grey, loose, brittle.		11																	
	Progressively grading into a silty GRAVEL; brown mottled orange, loose, brittle by 11.40m.												100	HQ						
	SILT; with some 1-3mmØ angular gravel and trace clay, brownish orange, firm, slightly plastic. No gravel and trace limonite and manganese staining from 11.40m.	118	12																	
	Silty fine SAND; light grey, medium dense, brittle, weakly to moderately cemented.				31	9//8/7/8/8							SC	SPT						
											Relict fracture, very steeply inclined dip; undulating, rough, trace limonite coating from 12.60m to 12.95m.										
	Occasional 2cm thick horizons of some fine angular gravel from 13.00m to 13.50m. Becomes completely cemented from 13.20m to 13.40m.		13								Relict fracture, very steeply inclined dip; undulating, rough, trace clay coating from 13.10m to 13.40m. Relict fracture, steeply inclined dip; undulating, rough, trace limonite coating at 13.45m.		100	HQ						
					50+	16//17/13/14/6 for 35mm							SC	SPT						
	FIne to coarse SAND; with some silt and some fine angular gravel, brownish grey, dense, brittle, weakly cemented.	116	14									55	85	HQ						
	Silty CLAY; brownish grey, hard, plastic.																			
	Fine SANDSTONE; brownish grey, very weak, slightly weathered, massive.		15		50+	16//13/17/14/6 for 25mm	VW	SW					SC	SPT						
	End of Borehole at 15.40m.	114	16																	
			17																	
		112	18																	
			19																	

NOTES
Borehole was backfilled upon completion.

STARTED: 7/11/2013		FINISHED: 8/11/2013	
DRILLER: Glen		DRILLING CO.: Drillforce Ltd	
INCLINATION/ AZIMUTH: -90°		DRILLING RIG: Tractor	
LOGGED: T Van Deelen		CHECKED: A George	BH13/12
CLIENT: Watercare Services Limited		JOB NO.: 1-C0935.25	

LOGGED IN ACCORDANCE WITH NZ GEOTECHNICAL SOCIETY (2005) GUIDELINES — SEE ATTACHED KEY SHEET FOR EXPLANATION OF SYMBOLS

BOREHOLE_LOG_A3 (&PHOTO PAGE) 1-C0935.25 MANUKA ROAD RESERVOIRS GEOTECHNICAL TESTING.GPJ OPUS CHCH DEC12.GDT 13/12/13

Scale 1:33.33

Manuka Reservoirs
Watercare Services Limited
Borehole 13/12

0.00m – 3.00m **Box 1 of 5**

3.00m – 6.30m **Box 2 of 5**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/12

6.30m – 9.26m **Box 3 of 5**

9.26m – 13.00m **Box 4 of 5**

Manuka Reservoirs
Watercare Services Limited
Borehole 13/12

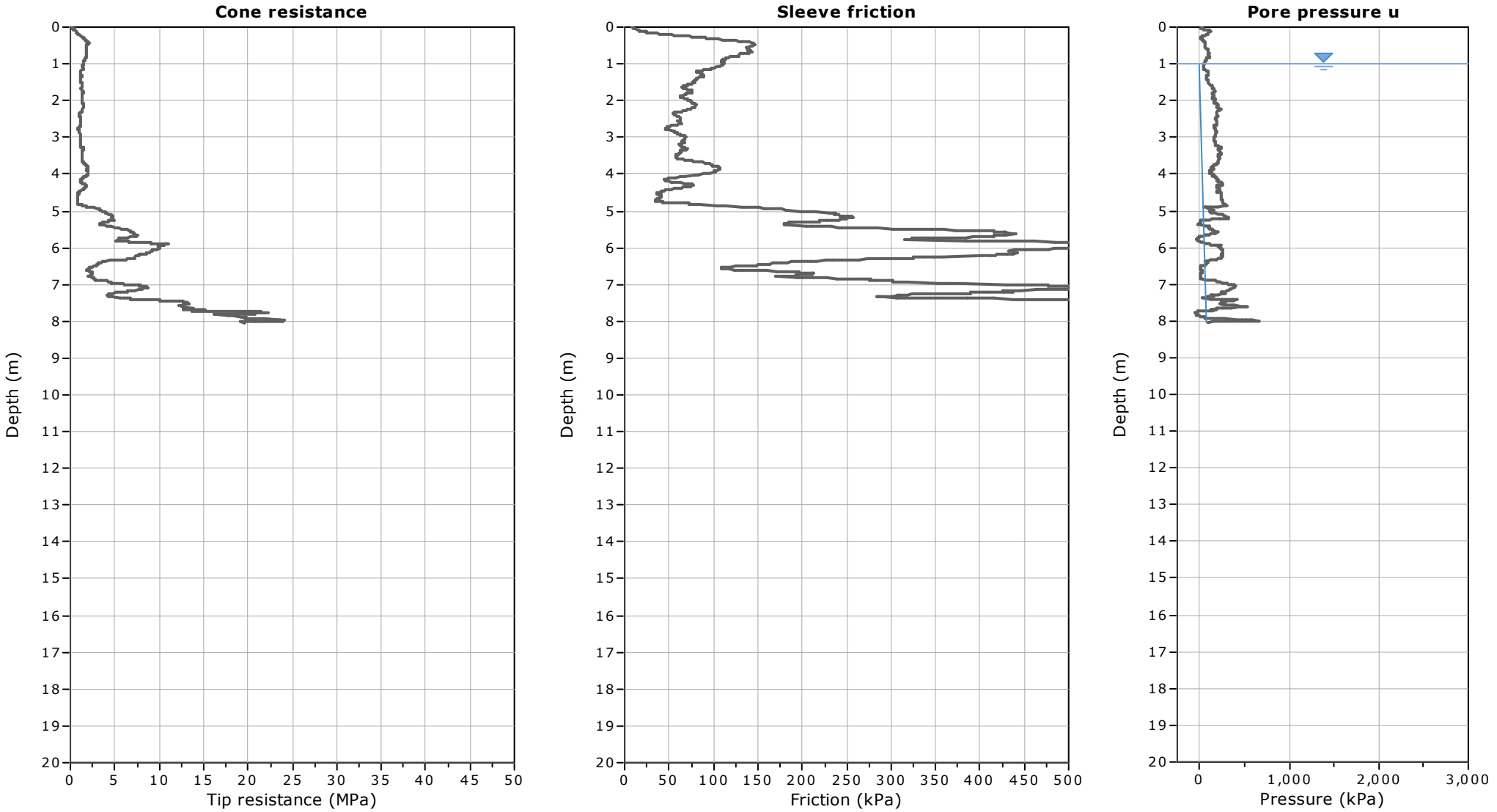
13.00m – 15.40m (E.O.H)	**Box 5 of 5**

Appendix C
CPT Plots

Ground Investigation
PO Box 21-956, Henderson, Auckland 0650
Ph: (09) 950 1919, (021) 191 6000
http://www.g-i.co.nz

CPT: CPT01
Total depth: 8.04 m, Date: 6/11/2013
Cone Type: 10 cm2, 50 MPa, Piezocone
Cone Operator: SP&TP

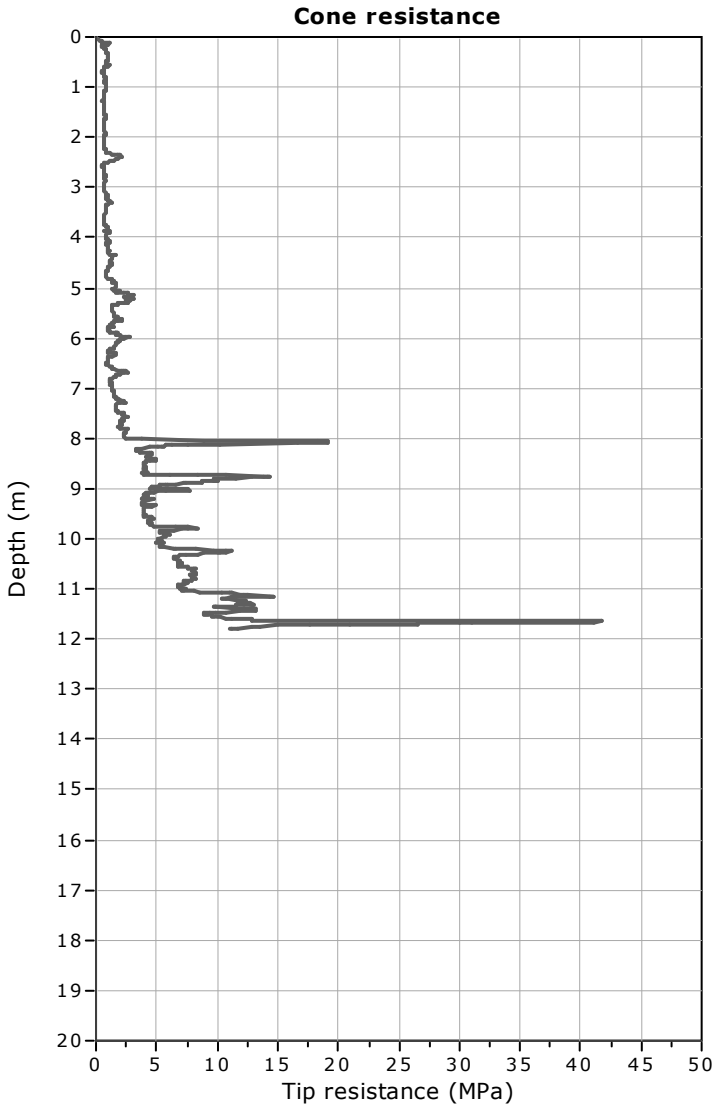
Project: **13-101 - Woodlands Park**
Location: **Titirangi**

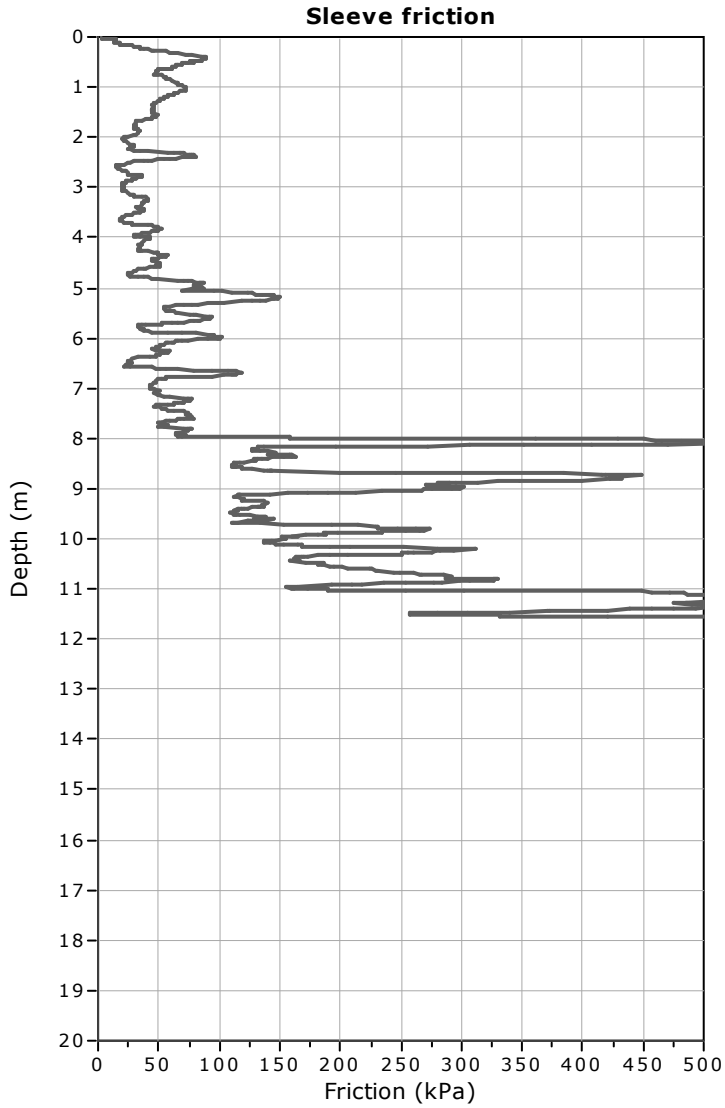


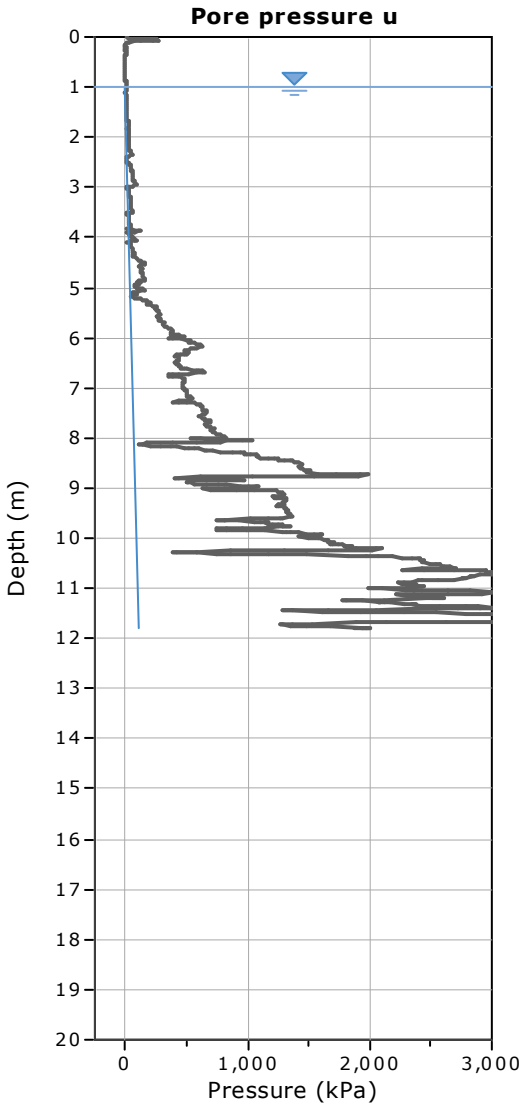
Ground Investigation
PO Box 21-956, Henderson, Auckland 0650
Ph: (09) 950 1919, (021) 191 6000
http://www.g-i.co.nz

CPT: CPT02
Total depth: 11.81 m, Date: 6/11/2013
Cone Type: 10 cm2, 50 MPa, Piezocone
Cone Operator: SP&TP

Project: **13-101 - Woodlands Park**
Location: **Titirangi**



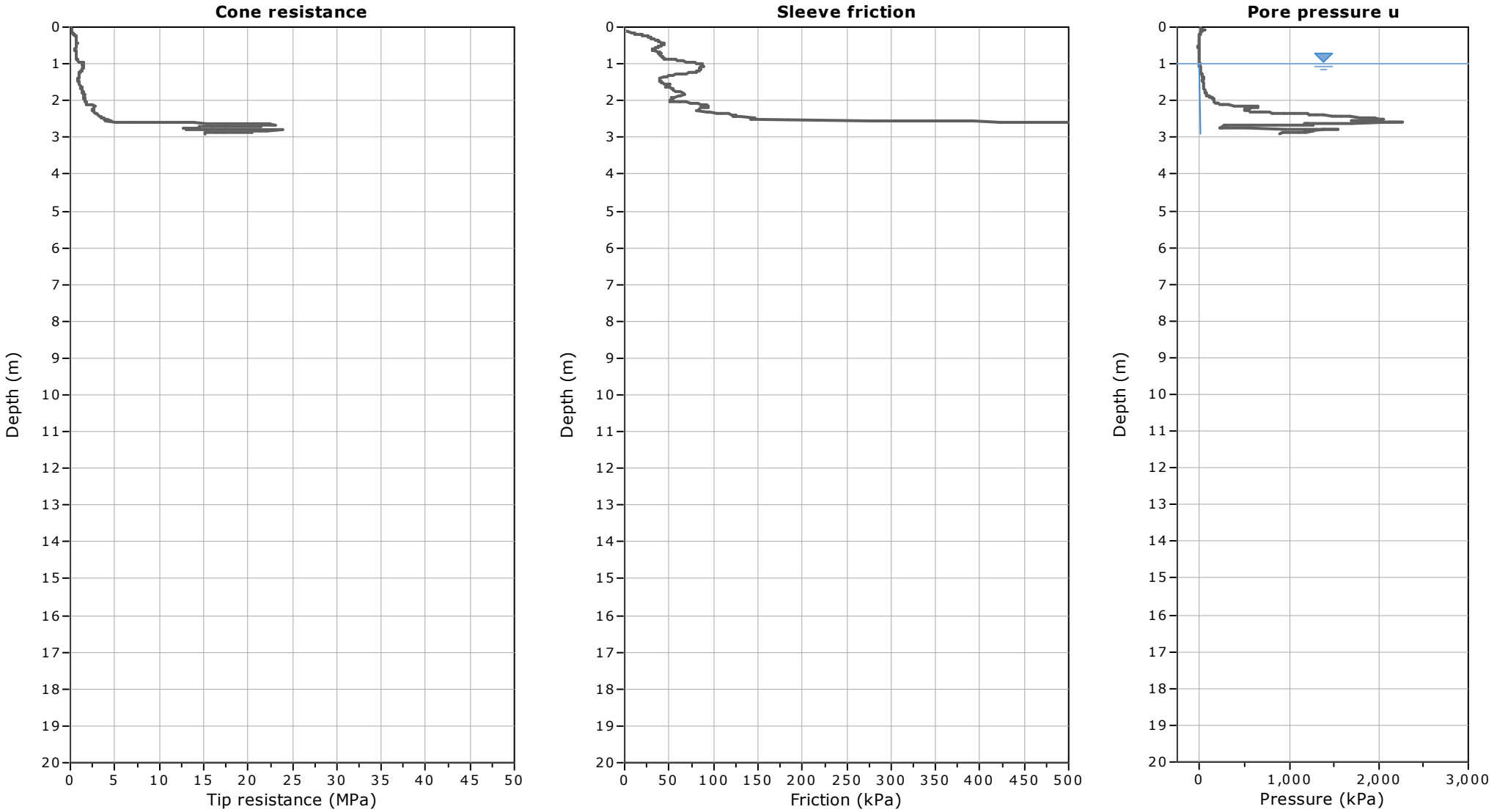




Ground Investigation
PO Box 21-956, Henderson, Auckland 0650
Ph: (09) 950 1919, (021) 191 6000
http://www.g-i.co.nz

CPT: CPT03
Total depth: 2.89 m, Date: 6/11/2013
Cone Type: 10 cm2, 50 MPa, Piezocone
Cone Operator: SP&TP

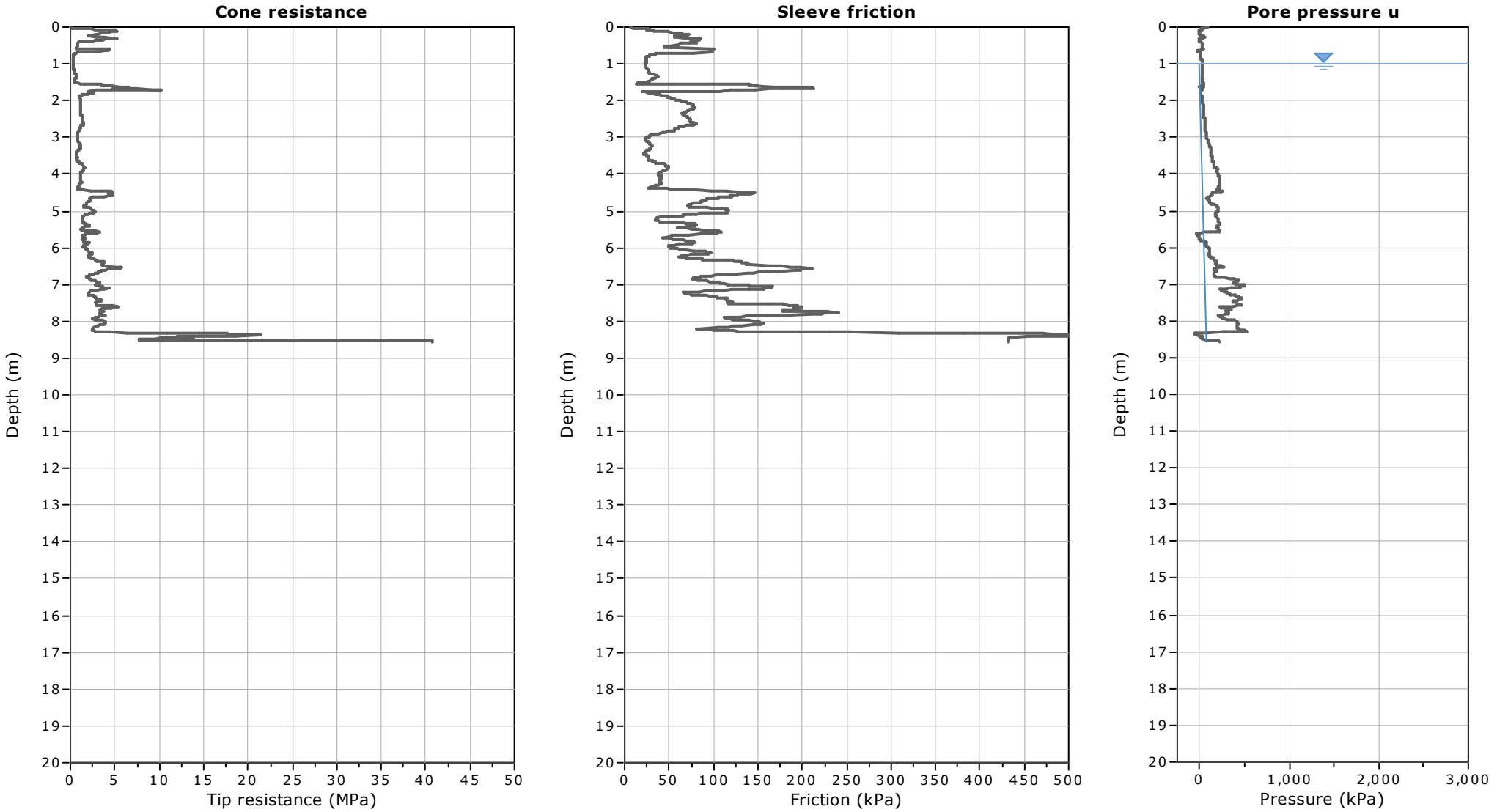
Project: **13-101 - Woodlands Park**
Location: **Titirangi**



Ground Investigation
PO Box 21-956, Henderson, Auckland 0650
Ph: (09) 950 1919, (021) 191 6000
http://www.g-i.co.nz

CPT: CPT04
Total depth: 8.55 m, Date: 6/11/2013
Cone Type: 10 cm2, 50 MPa, Piezocone
Cone Operator: SP&TP

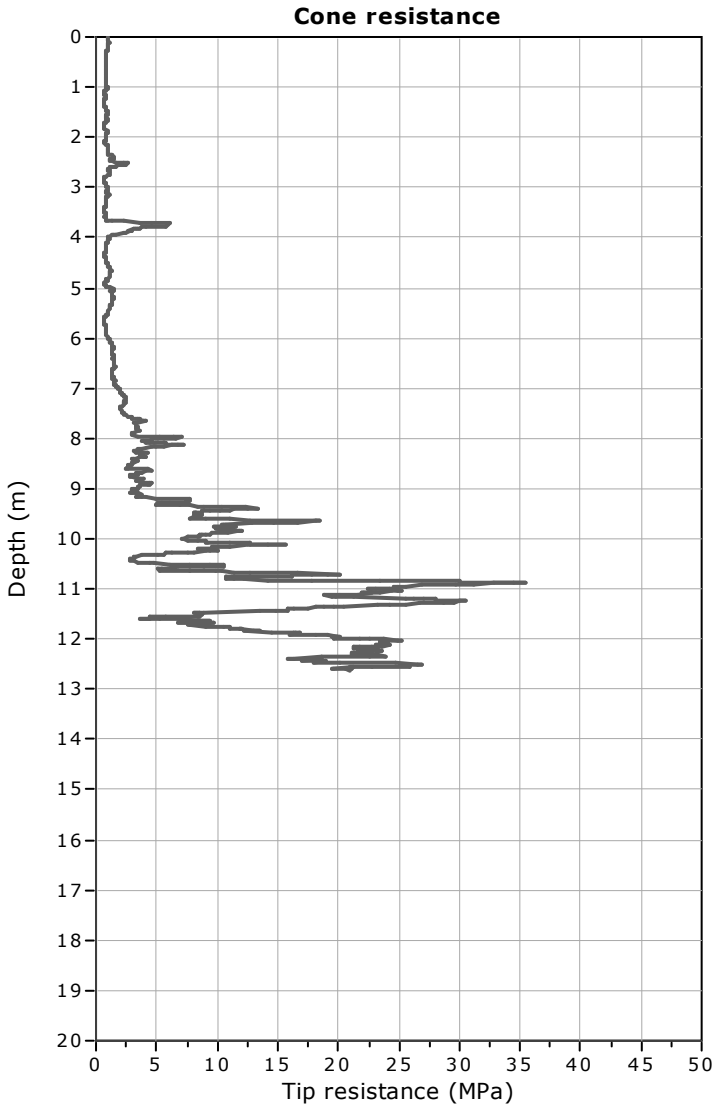
Project: **13-101 - Woodlands Park**
Location: **Titirangi**

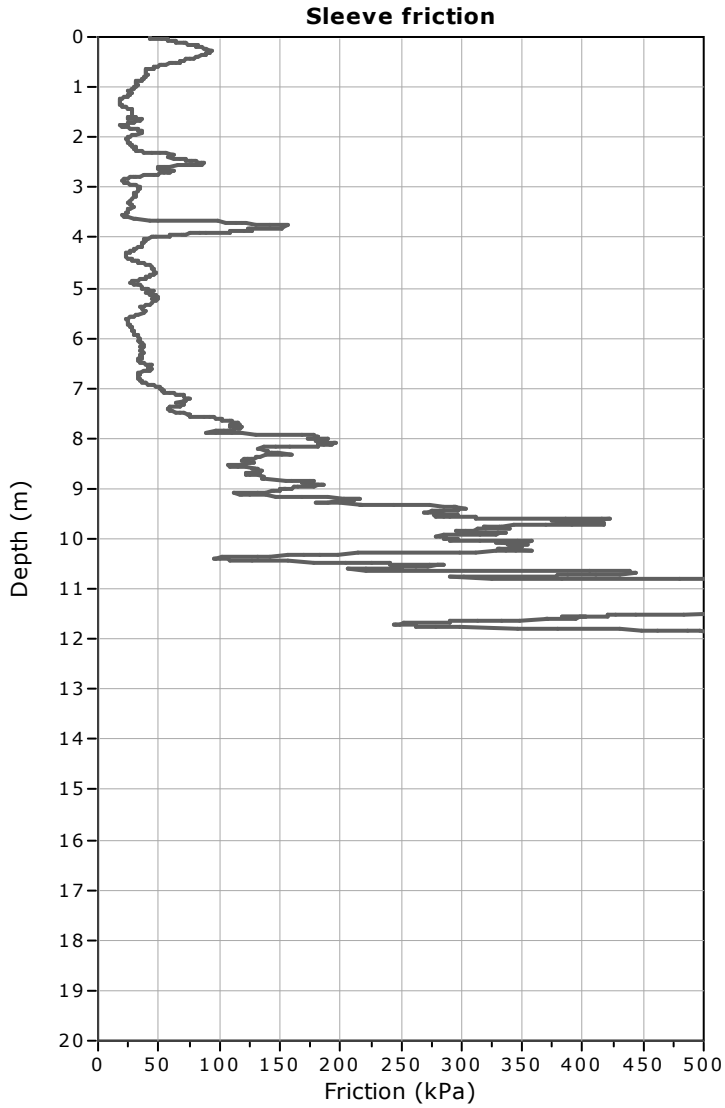


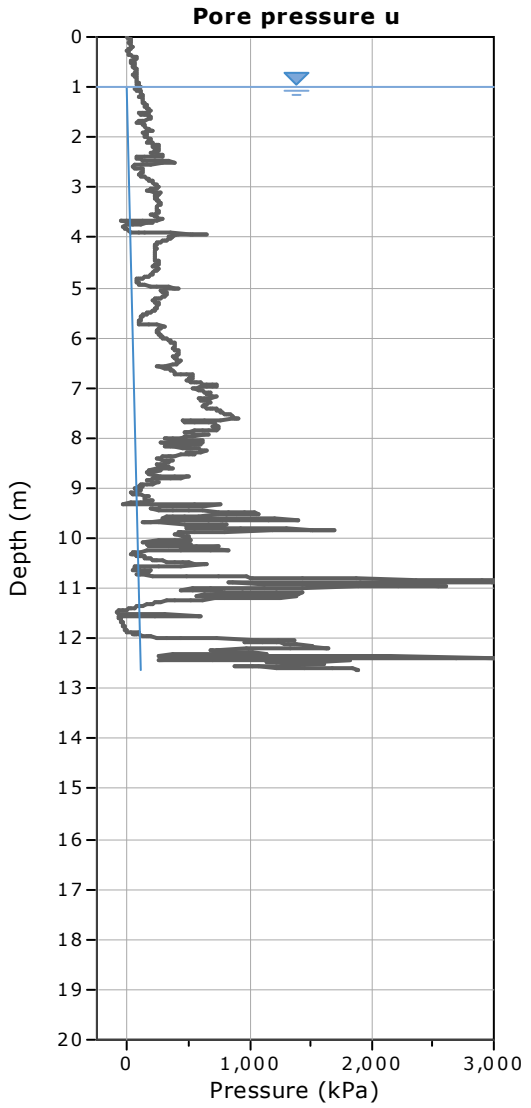
Ground Investigation
PO Box 21-956, Henderson, Auckland 0650
Ph: (09) 950 1919, (021) 191 6000
http://www.g-i.co.nz

CPT: CPT05
Total depth: 12.62 m, Date: 5/11/2013
Cone Type: 10 cm2, 50 MPa, Piezocone
Cone Operator: SP&TP

Project: **13-101 - Woodlands Park**
Location: **Titirangi**



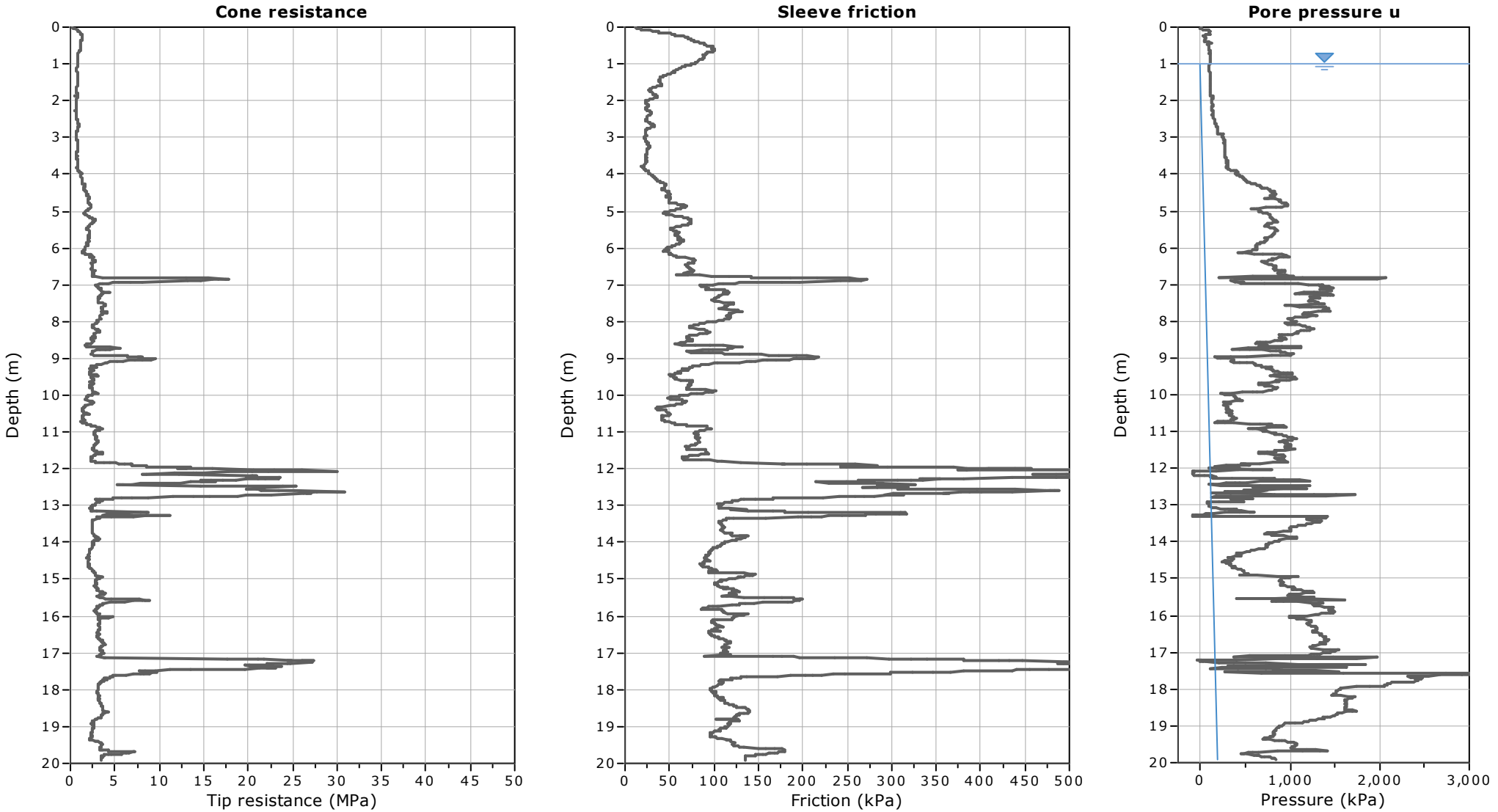




Ground Investigation
PO Box 21-956, Henderson, Auckland 0650
Ph: (09) 950 1919, (021) 191 6000
http://www.g-i.co.nz

CPT: CPT06
Total depth: 19.92 m, Date: 5/11/2013
Cone Type: 10 cm2, 50 MPa, Piezocone
Cone Operator: SP&TP

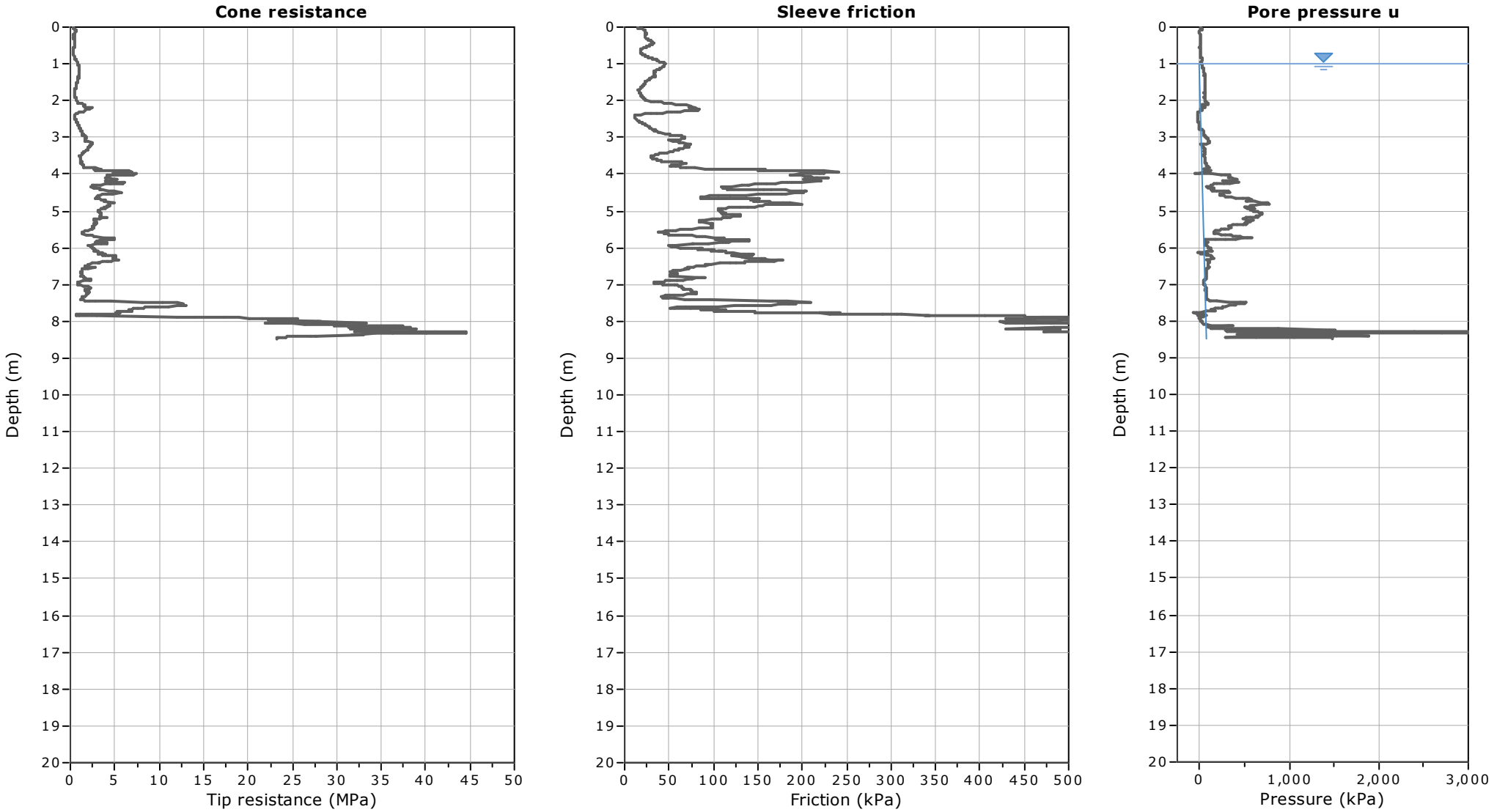
Project: **13-101 - Woodlands Park**
Location: **Titirangi**



Ground Investigation
PO Box 21-956, Henderson, Auckland 0650
Ph: (09) 950 1919, (021) 191 6000
http://www.g-i.co.nz

CPT: CPT07
Total depth: 8.47 m, Date: 5/11/2013
Cone Type: 10 cm2, 50 MPa, Piezocone
Cone Operator: SP&TP

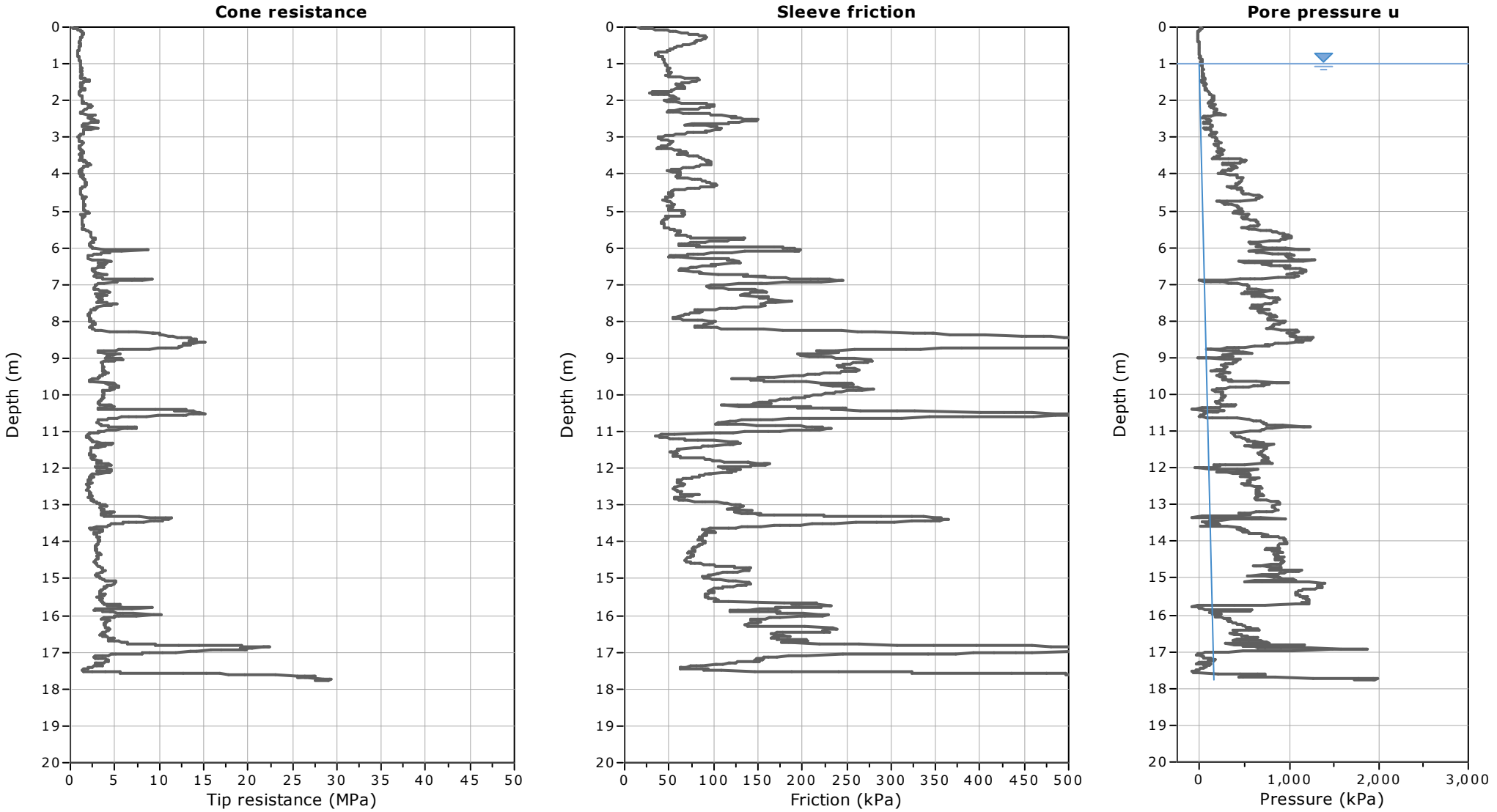
Project: **13-101 - Woodlands Park**
Location: **Titirangi**



Ground Investigation
PO Box 21-956, Henderson, Auckland 0650
Ph: (09) 950 1919, (021) 191 6000
http://www.g-i.co.nz

CPT: CPT08
Total depth: 17.77 m, Date: 6/11/2013
Cone Type: 10 cm2, 50 MPa, Piezocone
Cone Operator: SP&TP

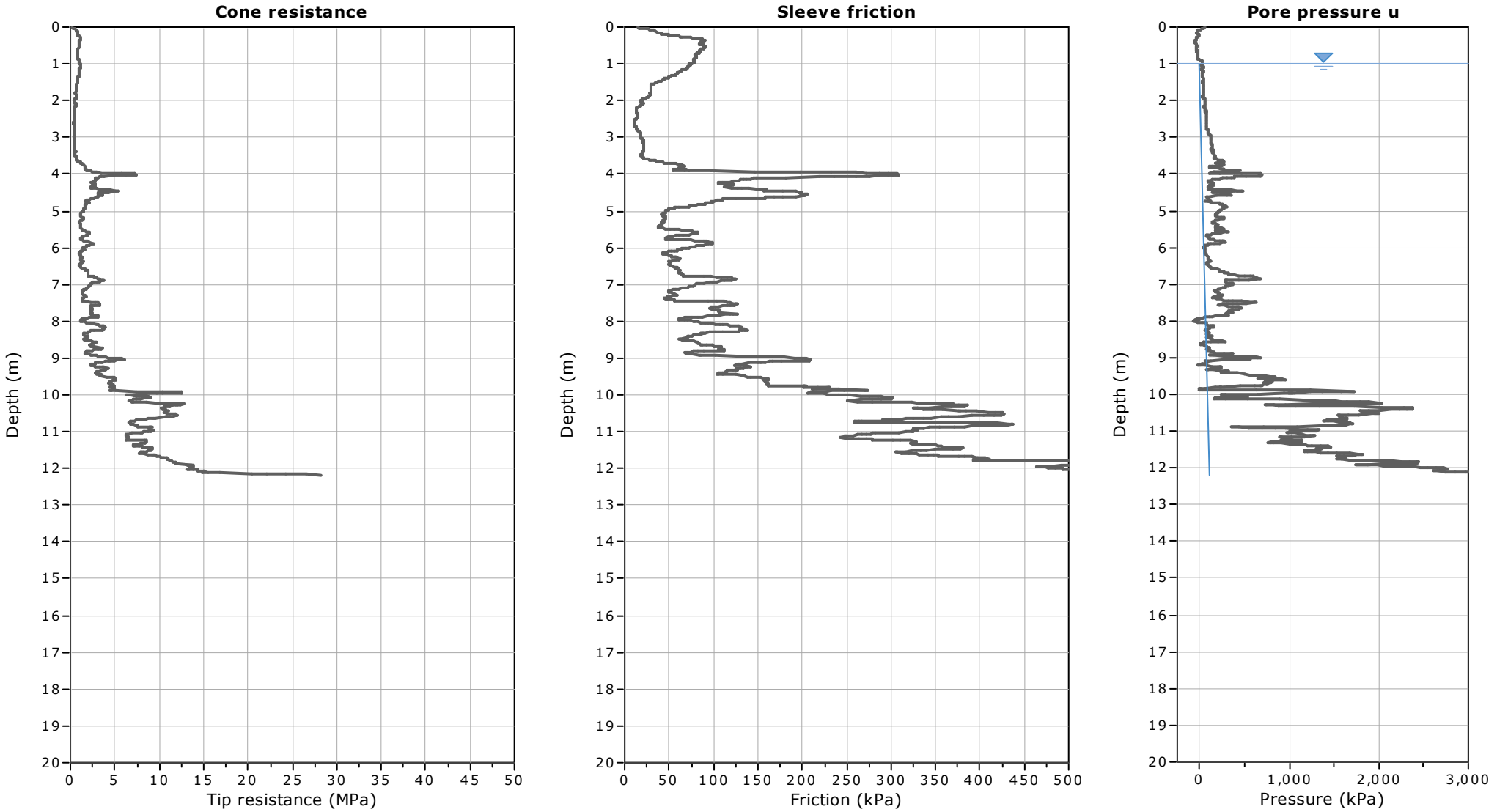
Project: **13-101 - Woodlands Park**
Location: **Titirangi**



Ground Investigation
PO Box 21-956, Henderson, Auckland 0650
Ph: (09) 950 1919, (021) 191 6000
http://www.g-i.co.nz

CPT: CPT09
Total depth: 12.20 m, Date: 5/11/2013
Cone Type: 10 cm2, 50 MPa, Piezocone
Cone Operator: SP&TP

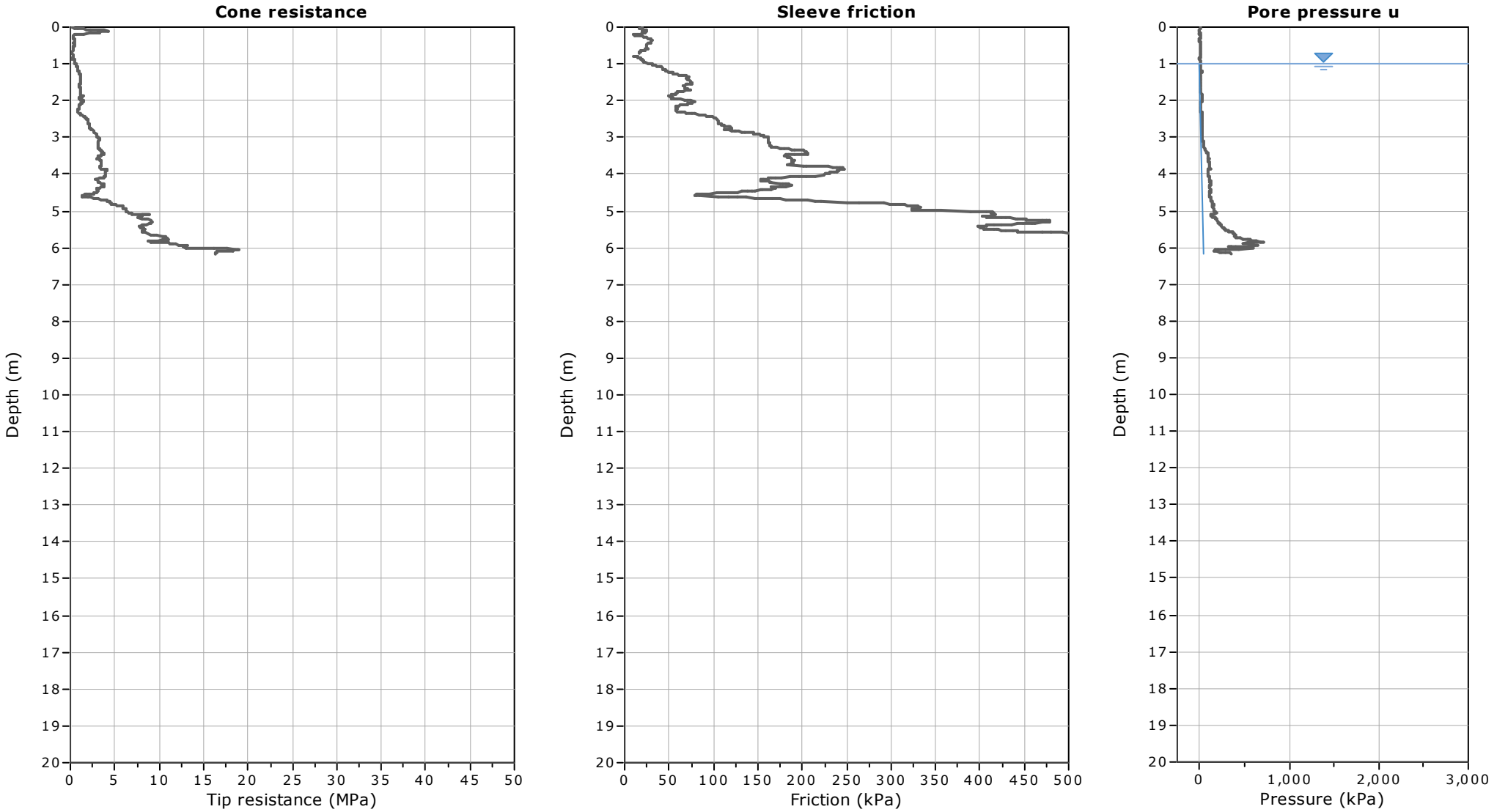
Project: **13-101 - Woodlands Park**
Location: **Titirangi**



Ground Investigation
PO Box 21-956, Henderson, Auckland 0650
Ph: (09) 950 1919, (021) 191 6000
http://www.g-i.co.nz

CPT: CPT10
Total depth: 6.18 m, Date: 6/11/2013
Cone Type: 10 cm2, 50 MPa, Piezocone
Cone Operator: SP&TP

Project: **13-101 - Woodlands Park**
Location: **Titirangi**



Appendix D
Test Pit Logs & Photographs

LOG OF TRIAL PIT

OPUS GEOTECHNICAL

HOLE NO. **TP13/01**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746118 E 5910826 N**	R.L.: **127.55 m**	SHEET: **1 of 1**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	TOTAL DEPTH: **2.4 m**

GEOLOGY/UNIT	DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION	SOIL TESTS: SCALA PENETROMETER Blows per 100 mm (0 2 4 6 8 10 12 14 16 18 20)	SHEAR STRENGTH kPa	OTHER TESTS	SAMPLES
T.	SILT; with some clay, dark brown, stiff, moist, plastic, some rootlets.							
Colluvium	SILT; with trace clay, brownish grey, stiff, moist, slightly plastic, some rootlets.							
	CLAY; with some silt, grey mottled orange, stiff, moist, plastic, some limonite streaks.					92/32		
		1				83/33		
	Occasional lenses of brownish orange clayey silt with trace fine sand from 1.20m.	126				158/56		
	Silty CLAY; grey mottled orange, very stiff, moist, plastic, some lenses of yellowish brown sandy silt and purple clay.							
	Fine sandy SILT; with some clay, yellowish brown mottle purplish grey, hard, moist, slightly plastic.	2				UTP		Bulk Sample
	Fine to medium SAND; with some silt, brownish grey, loose, moist, slightly plastic, weakly cemented.							
	End of Test Pit at 2.40m. Material too hard to excavate. One bulk soil sample taken at 2.0m.	3 124 4						

SKETCH OF EXPOSURE

TP13/01 - Excavation

TP13/01 - Stockpile

NOTES

Test pit was backfilled upon completion.
SV S23B, Correction Factor 1.337.
T. = Topsoil

LOGGED: T Van Deelen	DATE EXCAVATED: 23/10/2013		
OPERATOR: Drillforce Ltd	EXCAVATOR:		
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25	**TP13/01**	

Guideline for the field classification of soil and rock for engineering purposes: NZ Geotechnical Society (2005)
Determination of penetration resistance of a soil, NZS 4402 : 1988, Test 6.5.2
Shear strength using a hand held shear vane: NZ Geotechnical Society (8/2001)

LOG OF TRIAL PIT

OPUS GEOTECHNICAL

HOLE NO. **TP13/02**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746095 E 5910773 N**	R.L.: **125.43 m**	SHEET: **1 of 1**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	TOTAL DEPTH: **4 m**

GEOLOGY/UNIT	DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION	SCALA PENETROMETER Blows per 100 mm (0 2 4 6 8 10 12 14 16 18 20)	SHEAR STRENGTH kPa	OTHER TESTS	SAMPLES
T.	Clayey SILT; brown, firm, moist, slightly plastic, abundant rootlets.							
Fill	SILT; with some clay, brown, stiff, dry, plastic, some 10-30cmØ angular grey boulders.					87/33		
Colluvium	CLAY; with trace silt, grey mottled orange, very stiff, dry, plastic, trace limonite.	1				112/60		
	Occasional lenses of brown silt from 1.50m.	124				120/64		
	SILT; with some clay, greyish brown mottled orange, stiff, moist, slightly plastic, trace limonite staining.	2				74/33		Bulk Sample
						74/28		
	Clayey SILT; brownish grey streaked orange, stiff, moist, slightly plastic.	3				69/27		
	Occasional lenses of weakly cemented fine sand and trace limonite staining from 3.20m.	122				N/A		
		4				70/20		Bulk Sample
	End of Test Pit at 4.0m. Target depth reached. Two bulk soil samples taken at 2.0m and 4.0m.							

SKETCH OF EXPOSURE

TP13/02 - Excavation

TP13/02 - Stockpile

NOTES

Test pit was backfilled upon completion.
SV S23B, Correction Factor 1.337.
T. = Topsoil

Guideline for the field classification of soil and rock for engineering purposes: NZ Geotechnical Society (2005)
Determination of penetration resistance of a soil, NZS 4402 : 1988, Test 6.5.2
Shear strength using a hand held shear vane: NZ Geotechnical Society (8/2001)

LOGGED: T Van Deelen	DATE EXCAVATED: 23/10/2013		
OPERATOR: Drillforce Ltd	EXCAVATOR:		
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25	**TP13/02**	

LOG OF TRIAL PIT

OPUS GEOTECHNICAL

HOLE NO. **TP13/03**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746040 E 5910779 N**	R.L.: **119.83 m**	SHEET: **1 of 1**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	TOTAL DEPTH: **3 m**

GEOLOGY/UNIT	DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION	SOIL TESTS: SCALA PENETROMETER Blows per 100 mm (0 2 4 6 8 10 12 14 16 18 20)	SOIL TESTS: SHEAR STRENGTH kPa	SOIL TESTS: OTHER TESTS	SAMPLES
T.	Clayey SILT; brown, stiff, moist, plastic, abundant rootlets.								
Colluvium	CLAY; with some silt, grey mottled orange, stiff, moist, plastic, occasional limonite streaks.						86/38		
	Some 1-3mmØ grey clay fragments from 1.00m.		1				96/43		Bulk Sample
	Clayey SILT; with trace fine sand, light greyish brown streaked orange, stiff, moist, slightly plastic, occasional fine angular grey clayey silt fragments.	118					104/37		
	Clayey SILT; with trace fine sand, greyish brown streaked orange, very stiff, moist, plastic, some limonite streaks.		2				158/48		Bulk Sample
	Fine SAND; with fine to medium gravel, brown, loose, moist, brittle, moderately cemented.						187+		
	End of Test Pit at 3.00m. Material too hard to excavate. Two bulk soil samples taken at 1.0m and 2.0m.	116	3 4				UTP		

SKETCH OF EXPOSURE

TP13/03 - Excavation

TP13/03 - Stockpile

NOTES

Test pit was backfilled upon completion.
SV S23B, Correction Factor 1.337.
T. = Topsoil.

LOGGED: T Van Deelen	DATE EXCAVATED: 21/10/2013		
OPERATOR: Drillforce Ltd	EXCAVATOR:		
Guideline for the field classification of soil and rock for engineering purposes: NZ Geotechnical Society (2005) Determination of penetration resistance of a soil, NZS 4402 : 1988, Test 6.5.2 Shear strength using a hand held shear vane: NZ Geotechnical Society (8/2001)	CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25	**TP13/03**

LOG OF TRIAL PIT

OPUS GEOTECHNICAL

HOLE NO. **TP13/04**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746002 E 5910790 N**	R.L.: **123.12 m**	SHEET: **1 of 1**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	TOTAL DEPTH: **4 m**

GEOLOGY/UNIT	DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION	SOIL TESTS: SCALA PENETROMETER Blows per 100 mm (0 2 4 6 8 10 12 14 16 18 20)	SHEAR STRENGTH kPa	OTHER TESTS	SAMPLES
T.S	SILT; with trace clay, brown, stiff, moist, slightly plastic, some rootlets.							
	CLAY; with some silt, very stiff, moist, plastic, some limonite staining.					147/28		
	Silty CLAY; with trace fine sand, light brownish grey mottled orange, very stiff, moist, slightly plastic, trace 1-3mmØ grey clay fragments.	1 / 122				123/48		Bulk Sample
	SILT; with some clay, orange mottled grey, very stiff, moist, slightly plastic.					117/40		
	Some lenses of 1-5mmØ fine to coarse sandy clay from 2.00m.	2				131/45		Bulk Sample
	Silty CLAY; grey mottled orange, very stiff, moist, plastic.							
	Some limonite staining and some 1-3mmØ angular mudstone fragments from 2.50m.	3 / 120				158/56		
						140/48		
	CLAY; with some silt, light grey mottled orange, stiff, moist, plastic.					106/32		
	End of Test Pit at 4.0m. Target depth reached. Two bulk soil samples taken at 1.0m and 2.0m.	4				91/43		

SKETCH OF EXPOSURE

TP13/04 - Excavation

TP13/04 - Stockpile

NOTES

Test pit was backfilled upon completion.
SV S23B, Correction Factor 1.337.
T.S = Topsoil

LOGGED: T Van Deelen	DATE EXCAVATED: 21/10/2013		
OPERATOR: Drillforce Ltd	EXCAVATOR:		
Guideline for the field classification of soil and rock for engineering purposes: NZ Geotechnical Society (2005) Determination of penetration resistance of a soil, NZS 4402 : 1988, Test 6.5.2 Shear strength using a hand held shear vane: NZ Geotechnical Society (8/2001)	CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25	**TP13/04**

LOG OF TRIAL PIT

OPUS GEOTECHNICAL

HOLE NO. **TP13/05**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746016 E 5910837 N**	R.L.: **120.95 m**	SHEET: **1 of 1**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	TOTAL DEPTH: **4 m**

GEOLOGY/UNIT	DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION	SOIL TESTS: SCALA PENETROMETER Blows per 100 mm (0 2 4 6 8 10 12 14 16 18 20)	SHEAR STRENGTH kPa	OTHER TESTS	SAMPLES
T.S	Clayey SILT; brown, firm, moist, slightly plastic, abundant rootlets.							
Colluvium	Silty CLAY; grey streaked orange with limonite, stiff to very stiff, moist, plastic, some rootlets.	120 / 1				142/56		
						63/29		
	Silty CLAY; with trace fine sand, greyish brown mottled orange, stiff, wet, plastic, some 4mmØ max lenses of clay, silt and grey sandy clay, trace limonite and manganese streaks.					87/21		
	Clayey SILT; with trace fine sand, brownish grey, stiff, wet, plastic, some pockets of whitesh grey silty sand and trace 5mmØ max. "hard" angular silt fragments.	2				64/25		Bulk Sample
						N/A		
	Clayey SILT; with trace fine sand, greenish grey, very stiff, wet, slightly plastic, some 1-2cmØ lenses of weakly cemented pink and brown fine to coarse sand, trace limonite and manganese staining.	118 / 3				104/35		
	Some 4-5cmØ "hard" angular mudstone fragments from 3.50m.					91/33		
	End of Test Pit at 4.0m. Target depth reached. Scala-penetrometer test undertaken from 1.60m to 2.50m. Two bulk soil samples taken at 2.0m and 4.0m.	4 / 116				107/27		Bulk Sample

SKETCH OF EXPOSURE

TP13/05 - Excavation

NOTES

Test pit was backfilled upon completion.
SV S23B, Correction Factor 1.337.
T.S = Topsoil.

LOGGED: T Van Deelen	DATE EXCAVATED: 22/10/2013		
OPERATOR: Drillforce Ltd	EXCAVATOR:		
Guideline for the field classification of soil and rock for engineering purposes: NZ Geotechnical Society (2005) Determination of penetration resistance of a soil, NZS 4402 : 1988, Test 6.5.2 Shear strength using a hand held shear vane: NZ Geotechnical Society (8/2001)	CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25	**TP13/05**

LOG OF TRIAL PIT

OPUS GEOTECHNICAL

HOLE NO. **TP13/06**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746051 E 5910832 N**	R.L.: **122.03 m**	SHEET: **1 of 1**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	TOTAL DEPTH: **4 m**

GEOLOGY/UNIT	DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION	SOIL TESTS: SCALA PENETROMETER Blows per 100 mm (0 2 4 6 8 10 12 14 16 18 20)	SHEAR STRENGTH kPa	OTHER TESTS	SAMPLES
T.S	Clayey SILT; brown, firm, moist, slightly plastic, abundant rootlets.							
Colluvium	SILT; with some clay, greyish brown streaked orange, very stiff, moist, slightly plastic, some lenses of 1-4cmØ angular grey silt and "hard" mudstone fragments.					123/33		
	Clayey SILT; with trace fine sand, greyish brown streaked orange, stiff, moist, slightly plastic, some 0.5-1cmØ angular "hard" grey mudstone fragments.	1				62/20		
	Silty CLAY; with trace fine sand, brownish grey streaked orange, very stiff, moist, plastic, trace limonite and manganese staining.					124/38		
	CLAY; with trace silt, grey and brownish grey, very stiff, moist, plastic, occasional 1-2cmØ angular mudstone fragments, some limonite and manganese staining.	120 2				112/47		Bulk Sample
Recent Alluvium	Clayey SILT; with trace to medium sand, greenish grey, very stiff, moist, plastic, some fibrous wood organics, some limonite staining, trace white pumiceous specks.					130/48		
		3				115/28		
	Fine sandy CLAY; with some silt, greenish grey, stiff, wet, plastic, some lenses of pinkish brown silty fine sand and silt, trace white pumiceous specks.					N/A		
		118 4				60/N/A		Bulk Sample
	End of Test Pit at 4.0m. Target depth reached. Two bulk soil samples taken at 2.0m and 4.0m. Minimal seepage observed from 2.20m to 4.0m.							

SKETCH OF EXPOSURE

TP13/06 - Excavation

TP13/06 - Stockpile

NOTES

Test pit was backfilled upon completion.
SV S23B, Correction Factor 1.337.
T.S = Topsoil.

LOGGED: T Van Deelen	DATE EXCAVATED: 22/10/2013		
OPERATOR: Drillforce Ltd	EXCAVATOR:		
Guideline for the field classification of soil and rock for engineering purposes: NZ Geotechnical Society (2005) Determination of penetration resistance of a soil, NZS 4402 : 1988, Test 6.5.2 Shear strength using a hand held shear vane: NZ Geotechnical Society (8/2001)	CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25	**TP13/06**

Appendix E
Hand Auger Logs

LOG OF AUGER HOLE

OPUS GEOTECHNICAL

PROJECT: Manuka Road Reservoirs	CO-ORD.: 1745935 E 5910829 N	R.L.: 122.30 m	HOLE NO.: HA13/01
LOCATION: See Site Plan	REF. GRID: SM 6472 SO 61159	DATUM: MSL Akld. 1946	SHEET: 1 of 1
			TOTAL DEPTH: 3 m

GEOLOGY/UNIT	DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION	SOIL TESTS: SCALA PENETROMETER Blows per 100 mm (0 2 4 6 8 10 12 14 16 18 20)	SHEAR STRENGTH kPa	OTHER TESTS	SAMPLES
T.	Clayey SILT; brown, stiff, moist, plastic.								
Colluvium	CLAY; with some silt, brownish grey streaked orange, stiff, wet, plastic, trace limonite staining.	122					80/18		
	Silty CLAY; brownish grey streaked orange, stiff, wet, plastic, trace limonite staining.		1				90/44		Contam. Sample
	CLAY; with some silt, grey streaked orange, stiff, wet, plastic. Trace limonite specks from 1.75m.						95/41		
	CLAY; with some silt and occasional fine sand, greyish brown, stiff, wet, plastic. Some limonite staining.		2				89/44		
	Silty CLAY; with some fine sand, greenish grey, stiff, wet, plastic, trace fine silt fragments.	120					65/45		
	End of Hand Auger at 3.00m. Two contamination samples obtained from depths of 1.0m and 3.0m.		3				77/35		Contam. Sample
		118	4						

SKETCH OF EXPOSURE

NOTES

Hand auger was backfilled upon completion.
SV Geo954, Correction Factor 1.478.
T. = Topsoil.

LOGGED: T Van Deelen	DATE EXCAVATED: 4/11/2013		
CHECKED BY: Opus International Consltants Ltd	EXCAVATOR:		
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25	HA13/01	

Guideline for the field classification of soil and rock for engineering purposes: NZ Geotechnical Society (2005)
Determination of penetration resistance of a soil, NZS 4402 : 1988, Test 6.5.2
Shear strength using a hand held shear vane: NZ Geotechnical Society (8/2001)

LOG OF AUGER HOLE

OPUS GEOTECHNICAL

HOLE NO. **HA13/02**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746024 E 5910817 N**	R.L.: **119.15 m**	SHEET: **1 of 1**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	TOTAL DEPTH: **2 m**

GEOLOGY/UNIT	DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION	SOIL TESTS: SCALA PENETROMETER Blows per 100 mm (0 2 4 6 8 10 12 14 16 18 20)	SHEAR STRENGTH kPa	OTHER TESTS	SAMPLES
T.	SILT; with some clay, brown, firm, moist, slightly plastic.							
Colluvium	Clayey SILT; brownish grey streaked orange, stiff, wet, slightly plastic.							
	CLAY; with some silt and trace fine to medium sand, grey mottled brown, very stiff, wet, plastic.					N/A		Contam. Sample
		1				124/46		
		118						
	Clayey SILT; brownish grey, stiff, wet, slightly plastic, trace limonite streaks.					77/31		
	Silty CLAY; greenish grey, stiff, wet, plastic.							
		2				59/12		Contam. Sample
	End of Hand Auger at 2.00m. Two contamination samples obtained from depths of 0.5m and 2.0m.							
		3						
		116						
		4						

SKETCH OF EXPOSURE

NOTES

Hand auger was backfilled upon completion.
SV Geo954, Correction Factor 1.478.
T. = Topsoil.

LOGGED: T Van Deelen	DATE EXCAVATED: 4/11/2013		
CHECKED BY: Opus International Consltants Ltd	EXCAVATOR:		
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25	**HA13/02**	

Guideline for the field classification of soil and rock for engineering purposes: NZ Geotechnical Society (2005)
Determination of penetration resistance of a soil, NZS 4402 : 1988, Test 6.5.2
Shear strength using a hand held shear vane: NZ Geotechnical Society (8/2001)

LOG OF AUGER HOLE

OPUS GEOTECHNICAL

HOLE NO. **HA13/03**			
PROJECT: **Manuka Road Reservoirs**	CO-ORD.: **1746091 E 5910812 N**	R.L.: **127.62 m**	SHEET: **1 of 1**
LOCATION: **See Site Plan**	REF. GRID: **SM 6472 SO 61159**	DATUM: **MSL Akld. 1946**	TOTAL DEPTH: **3 m**

GEOLOGY/UNIT	DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION	SOIL TESTS: SCALA PENETROMETER Blows per 100 mm (0 2 4 6 8 10 12 14 16 18 20)	SOIL TESTS: SHEAR STRENGTH kPa	SOIL TESTS: OTHER TESTS	SAMPLES
Colluvium	Silty CLAY; brownish grey, stiff, moist, plastic.							
	CLAY; with some silt, dark brownish grey streaked orange, firm to stiff, moist, plastic.					80/27		
		1				47/15		Contam. Sample
	Fine sandy CLAY; with some silt, brownish grey streaked orange, stiff, wet, plastic.	126				95/34		
	Fine sandy SILT; with some clay and trace coarse sand, brown, stiff to very stiff, wet, slightly plastic, trace fine angular gravels.	2				130/22		
						90/43		
		3				124/43		Contam. Sample
	End of Hand Auger at 3.00m. Two contamination samples obtained from depths of 1.0m and 3.0m.	124						
		4						

SKETCH OF EXPOSURE

NOTES

Hand auger was backfilled upon completion.
SV Geo954, Correction Factor 1.478.

LOGGED: T Van Deelen	DATE EXCAVATED: 4/11/2013		
CHECKED BY: Opus International Consltants Ltd	EXCAVATOR:		
CLIENT: Watercare Services Limited	JOB NO.: 1-C0935.25	**HA13/03**	

Guideline for the field classification of soil and rock for engineering purposes: NZ Geotechnical Society (2005)
Determination of penetration resistance of a soil, NZS 4402 : 1988, Test 6.5.2
Shear strength using a hand held shear vane: NZ Geotechnical Society (8/2001)

Appendix F
Laboratory Testing Results

PLASTICITY INDEX TEST REPORT

OPUS

Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Sampled by:	**Tom Van Deelen**
Date sampled:	**21/11/13**
Sampling method:	**Pushtube**
Sample description:	**Weathered Sandstone**
Sample condition:	**As received**
Sample reference:	**BH13/01**
Sample depth:	**3.0 - 3.5m**

Project number:	**1-C0935.25**
Lab ref number:	**001/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test Results

As rec'd water content:	**48.7%**
Liquid limit:	**84**
Plastic limit:	**35**
Plasticity Index:	**49**

Test methods	
Water Content:	NZS 4402 : 1986, Test 2.1
Liquid Limit:	NZS 4402 : 1986, Test 2.2
Plastic Limit:	NZS 4402 : 1986, Test 2.3
Plasticity Index:	NZS 4402 : 1986, Test 2.4

Notes

Test performed on: Fraction passing 0.425mm test sieve

Sample descriptions are not covered by IANZ accreditation.

Date tested: 04 - 05/12/13
Date reported: 10/12/2013

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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IANZ Approved Signatory
Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 10/12/2013

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ONE DIMENSIONAL CONSOLIDATION PROPERTIES
TEST RESULT REPORT

OPUS

Project : **Manuka Reservoirs**
Location: **Manuka Reservoirs**
Client : **Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor: **Not Stated**
Subcontractor: **Not Stated**
Sample reference: **BH13/01, 3.0 - 3.5m** Specimen depth: **3.30 - 3.35 metres**
Sampled by : **Tom Van Deelen** Date: **21/11/13**
Date received : **21/11/13**
Sampling method : **Push Tube**
Sample description : **Weathered Sandstone**

Sample condition : **As received**
OEDOMETER APPARATUS No: S17C

Project No:	**1-C0935.25**
Lab Ref No:	**001b/13**
Folder No:	**SEC13/AU/050**

SOIL PROPERTIES

Specimen Dimensions:		
Diameter	(mm):	50.53
Initial height	(mm):	16.08
Final height	(mm):	14.26
Initial mass of sample (g):		51.88

Initial Wet Density	pbi (t/m³)	1.61
Initial Dry Density	pdi (t/m³)	1.13
Final Dry Density	pdf (t/m³)	1.27
Initial Void Ratio	eo	1.39
Final Void Ratio	ef	1.12
Initial Degree of Saturation	Si (%)	82
Final Degree of Saturation	Sf (%)	100
Solid Particle Density	*Gs (t/m³)	2.70
INITIAL Water Content	Wi (%)	42.5
FINAL Water Content	Wf (%)	42.7

*Gs is Assumed

CONSOLIDATION PROPERTIES

PRESSURE RANGE (kPa)	Pressure Increment (dp)	Void Ratio (e)	Intercept t90 (min)	Volume Compressibilty Mv=m²/MN	Coefficient of Consolidation Cv=m²/year	Coeff. of Permeability k=m/year	
0 - 12.5	12.5	1.367	0.4489	-	-	-	
12.5 - 25	12.5	1.347	0.14	0.68	200.0	1.3	
25 - 50	25	1.327	1.96	0.34	14.0	0.047	
50 - 100	50	1.295	0.69	0.28	39.0	0.11	
100 - 200	100	1.251	0.72	0.19	37.0	0.069	
200 - 400	200	1.181	0.84	0.16	30.0	0.046	
400 - 800	400	1.067	1.00	0.13	24.0	0.03	
800 - 200	-	1.082	-	-	-	-	
200 - 50	-	1.103	-	-	-	-	
50 - 12.5	-	1.121	-	-	-	-	
-	-	-	-	-	-	-	
-	-	-	-	-	-	-	

Test Methods:		Notes:
One Dimensional Consolidation Test.	NZS 4402:1986 Test 7.1	Sample is saturated during test.
Water Content	NZS 4402:1986 Test 2.1	Load Increments applied at 1.35hr intervals

Testing is covered by IANZ Accreditation

Date tested : 02- 03/12/13
Date reported : 11/12/13

IANZ Approved Signatory
Thirushen Pillay
Designation : *Senior Civil Engineering Technician*
Date : 11/12/13

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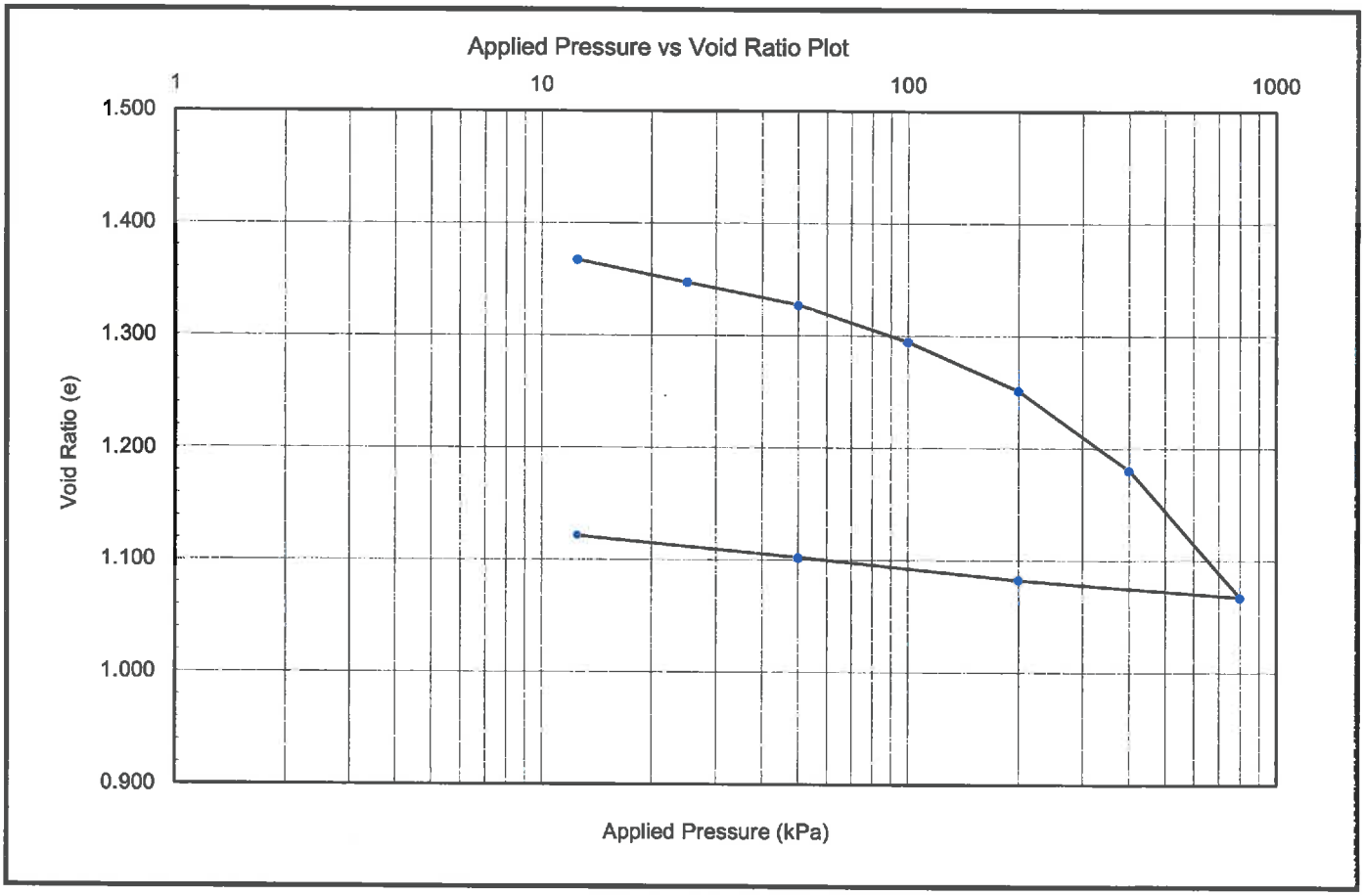
ONE DIMENSIONAL CONSOLIDATION PROPERTIES
Applied Pressure vs Void Ratio TEST REPORT

OPUS

Project :	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Subcontractor:	**Not Stated**
Sample reference:	**BH13/01, 3.0 - 3.5m**
Specimen depth:	**3.30 - 3.35 metres**
Sampled by :	**Tom Van Deelen**
Date:	**21/11/13**
Date received :	**21/11/13**
Sample description :	**Weathered Sandstone**

Sampling method : **Push Tube**
Sample condition : **As received**
OEDOMETER APPARATUS No: S17C

Project No:	**1-C0935.25**
Lab Ref No:	**001b/13**
Folder No:	**SEC13/AU/050**



Test Method:		Notes:
One Dimensional Consolidation Test:	NZS 4402:1986 Test 7.1	Load Increments applied at 1.35hr intervals
Water Content:	NZS 4402:1986 Test 2.1	

Date tested : 02- 03/12/13
Date reported : 11/12/13

Testing is covered by IANZ Accreditation
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IANZ Approved Signatory
Thirushen Pillay
Designation : *Senior Civil Engineering Technician*
Date : 11/12/13

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Result Summary

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/01**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Weathered Sandstone (Brown)**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**001a/13**
Client Ref No:	**Tom Van Deelen**

Result at Maximum Stress Ratio — **Back Pressure saturated at 450 kPa**

Specimen Stage No	Effective Confining Pressure (kPa)	INITIAL PROPERTIES Densities (t/m³) Wet (t/m³)	INITIAL PROPERTIES Densities (t/m³) Dry (t/m³)	INITIAL PROPERTIES Water Content (%)	Solid Particle Density (t/m³)	FINAL PROPERTIES Densities (t/m³) Wet (t/m³)	FINAL PROPERTIES Densities (t/m³) Dry (t/m³)	FINAL PROPERTIES Water Content (%)
1	75	1.71	1.21	41.6				
2	150				2.70 (assumed)			
3	300					1.83	1.29	42.3

Specimen Stage No	Effective Confining Pressure (kPa)	Void Ratio (e)	Deg of Saturation(Sr) Sr before Consolid. (%)	Deg of Saturation(Sr) Sr after Consolid. (%)	Values at Maximum Stress Ratio s_1-s_3 (kPa)	m (kPa)	Strain (%)
1	75	1.23	91	100	143.7	32	4.35
2	150				222.9	70	3.18
3	300				276.7	157	4.97

Specimen Stage No	Effective Confining Pressure (kPa)	Coefficient *of* Consolidation Cv (m^2/year)	Volume Compressibility Mv (m^2/MN)	Coefficient *of* Permeability k (m/s)	B at the start of test
1	75	6	0.30	4.6E-10	
2	150	4.2	0.20	3.1E-10	96.00
3	300	2.7	0.170	1.4E-10	

IANZ endorsement does not include the Cv, Mv and k values reported herein.
Mv & Cv calculated for the following conditions:-
L/D=2, RADIAL+TOP+BOTTOM Drainage
Side Filter drains Used
(L/D= Sample Length/Diameter.)

TOTAL STRESS RESULT				EFFECTIVE STRESS RESULT			
Intercept d	**44.70**	(kPa)		Intercept d'	**29.58**	(kPa)	
Beta b	**12.49**	(deg)		Beta b'	**21.62**	(deg)	
Cohesion c	**46**	(kPa)		Cohesion c'	**32**	(kPa)	
Phi Æ	**13**	(deg)		Phi Æ '	**23**	(deg)	
Correl coeff	**0.9467**	r^2		Correl coeff	**0.9758**	r^2	

Test Methods		Notes:
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	Cv and Mv have been rounded to 2 significant figures. L/D= Sample Length/Diameter.

Date Tested: 02-05/12/13

Date Reported: 10/12/13

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IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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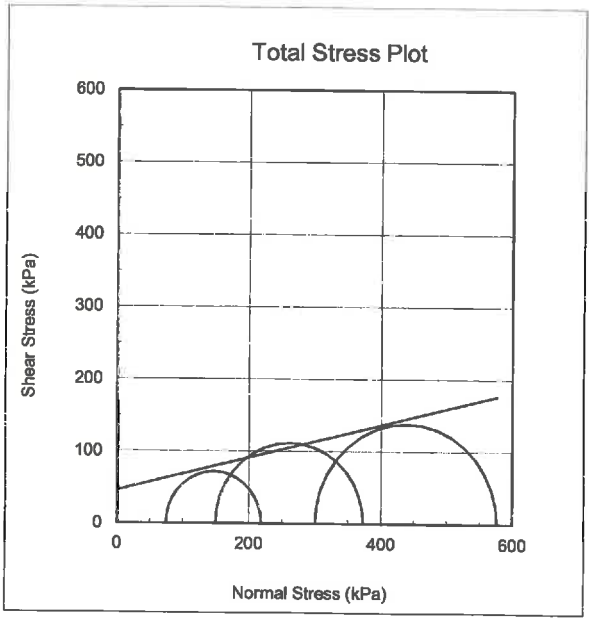
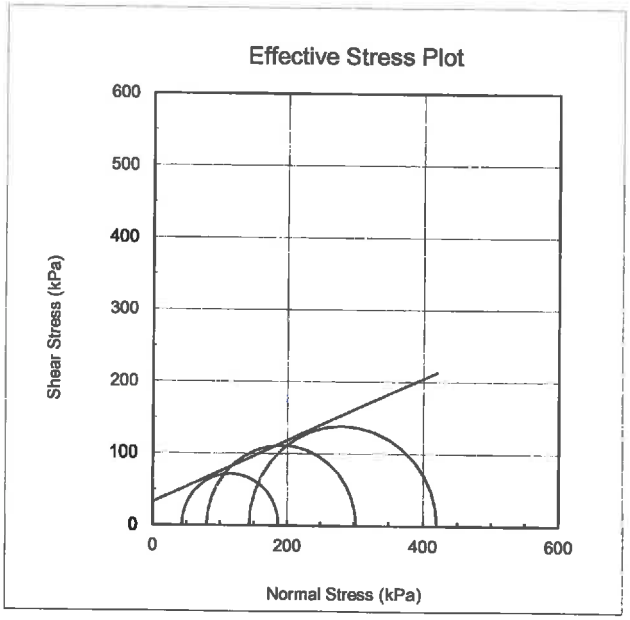
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Mohr Coulomb Envelope Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/01**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Weathered Sandstone (Brown)**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**001a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Mohr-Coulomb envelope plots Result at Maximum Stress Ratio
Back Pressure Saturated at 450 kPa





TOTAL STRESS RESULT		
Intercept d	**44.70**	(kPa)
Beta b	**12.49**	(deg)
Cohesion c	**46**	(kPa)
Phi Æ	**13**	(deg)
Correl coeff	**0.9467**	r^2

EFFECTIVE STRESS RESULT		
Intercept d'	**29.58**	(kPa)
Beta b'	**21.62**	(deg)
Cohesion c'	**32**	(kPa)
Phi Æ '	**23**	(deg)
Correl coeff	**0.9758**	r^2

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 02-05/12/13

Date Reported: 10/12/13

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IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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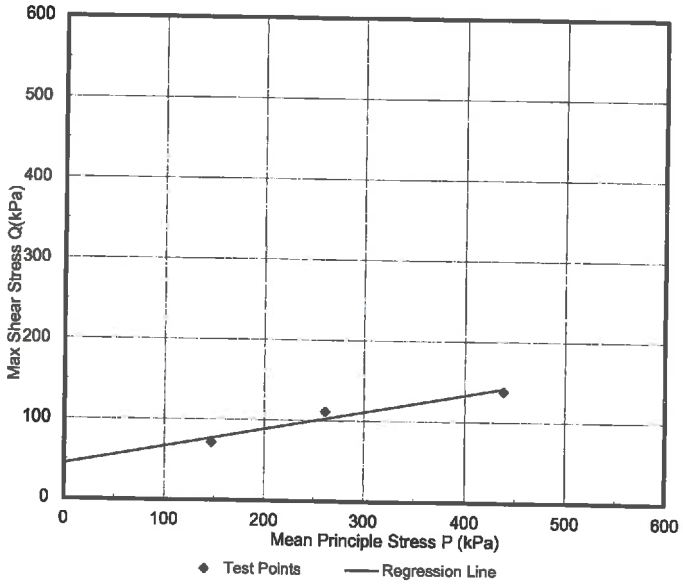
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P vs Q Total Stress Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/01**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Weathered Sandstone (Brown)**
Comments:	**Multistage Test.**

Depth (m): **3.0 - 3.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**001a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P vs Q Total Stress Plot- Back Pressure saturated at 450 kPa



TOTAL STRESS RESULT		
Intercept d	**44.70**	(kPa)
Beta b	**12.49**	(deg)
Correl coeff	**0.9467**	r^2
Cohesion c	**46**	(kPa)
Phi Æ	**13**	(deg)

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 02-05/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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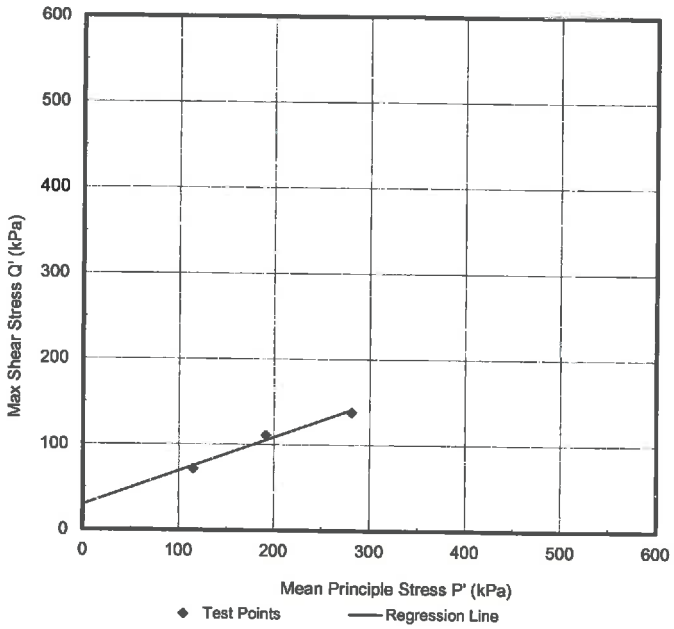
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P' vs Q' Effective Stress Plot

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/01**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Weathered Sandstone (Brown)**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**001a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Effective Stress Plot-Back Pressure saturated at 450 kPa



EFFECTIVE STRESS RESULT		
Intercept d'	**29.58**	(kPa)
Beta b'	**21.62**	(deg)
Correl coeff	**0.9758**	r^2
Cohesion c'	**32**	(kPa)
Phi Æ'	**23**	(deg)

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 02-05/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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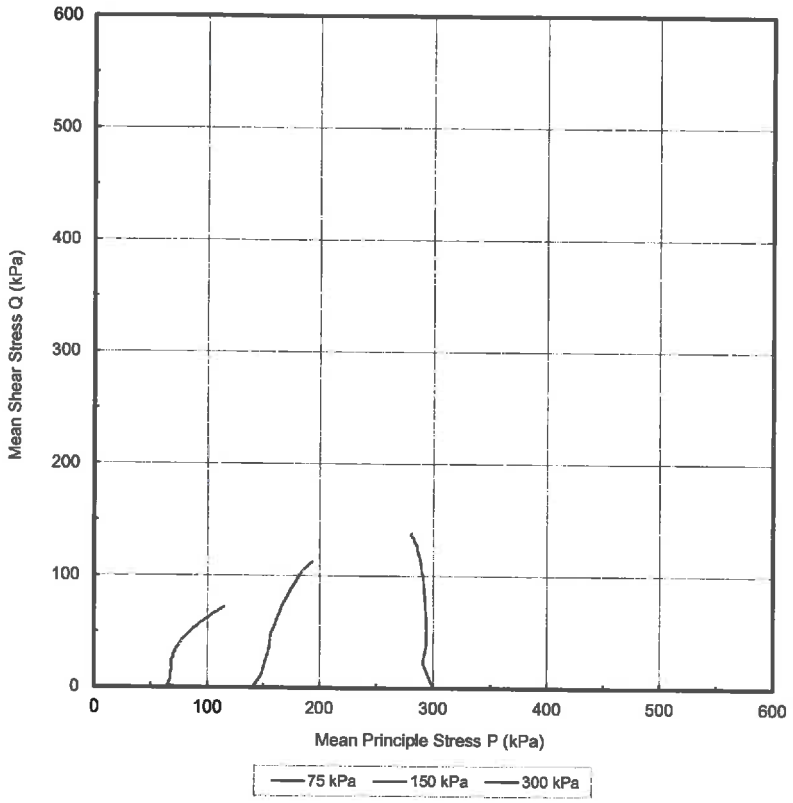
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - PvsQ Stress Path Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/01**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Weathered Sandstone (Brown)**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**001a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Stress Path (Effective Stress Plot) - Back Pressure saturated at 450 kPa



Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 02-05/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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Quality Management Systems Certified to ISO 9001

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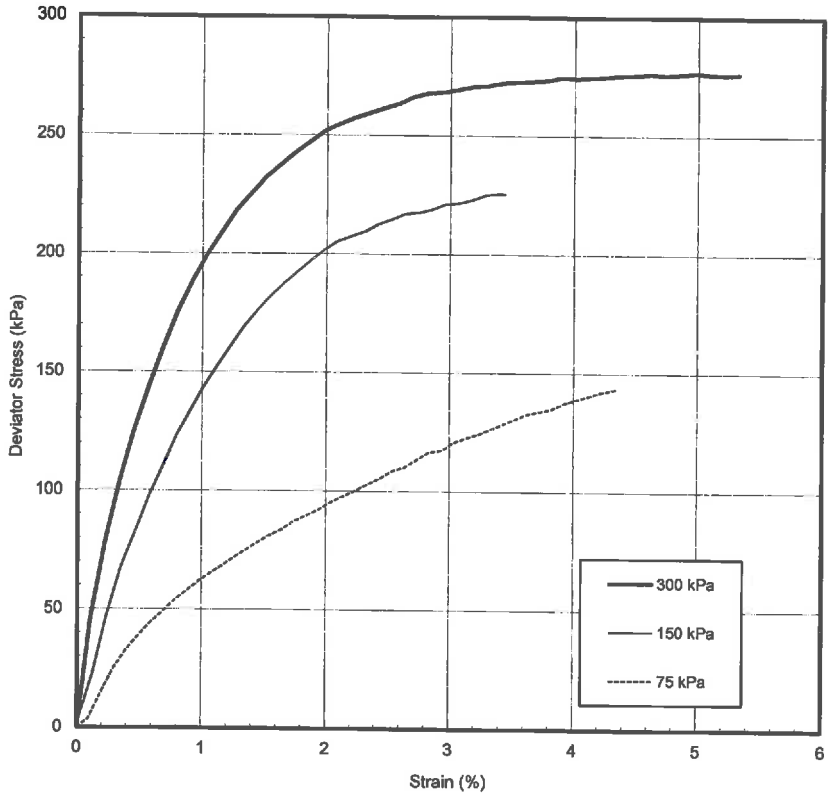
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Deviator StressPlot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/01**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Weathered Sandstone (Brown)**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**001a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Deviator Stress Plot- Back Pressure saturated at 450 kPa



Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 02-05/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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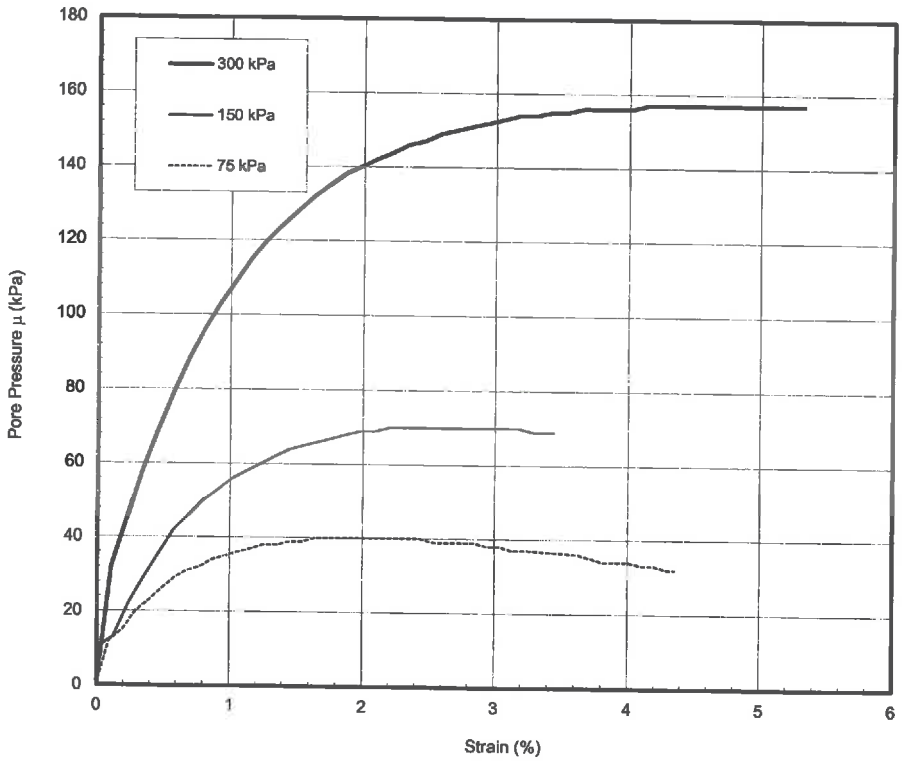
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Pore Pressure Plot

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/01**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Weathered Sandstone (Brown)**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**001a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Pore Pressure Plot- Back Pressure saturated at 450 kPa



Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 02-05/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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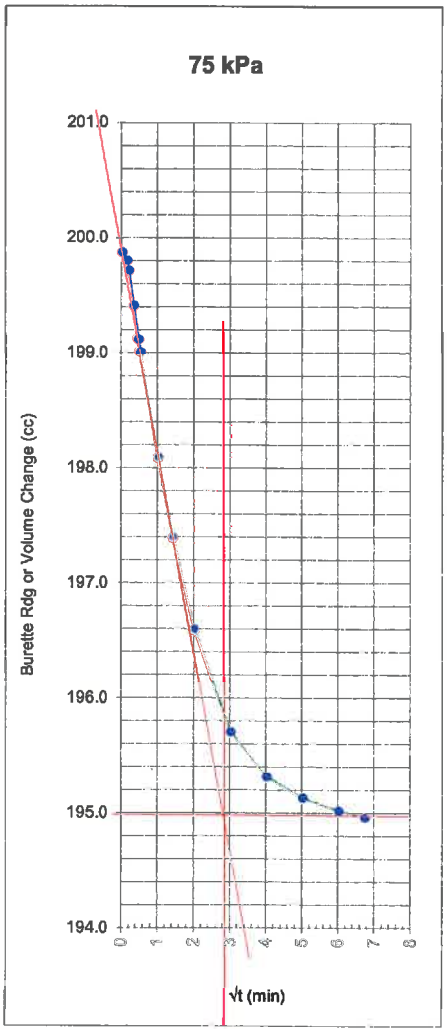
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Displacement *vs* Öt Plot (Consolidation stage)

OPUS

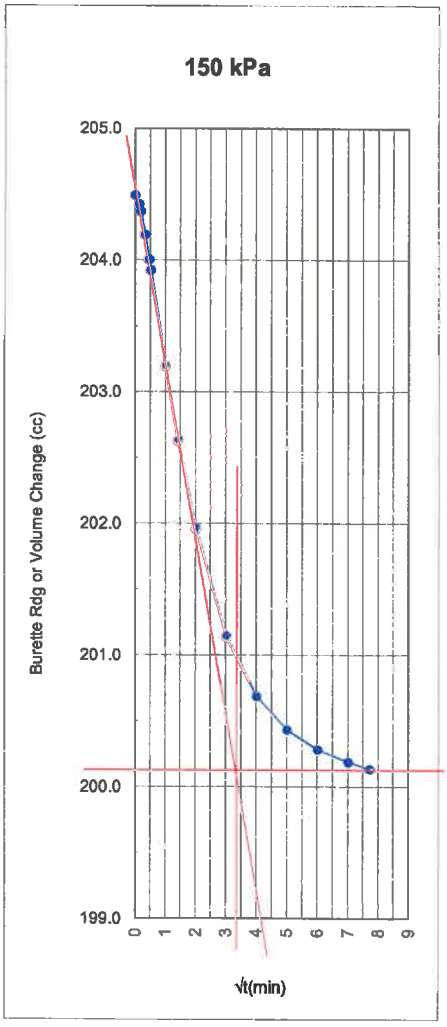
Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/01**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Weathered Sandstone (Brown)**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**001a/13**
Client Ref No:	**Tom Van Deelen**

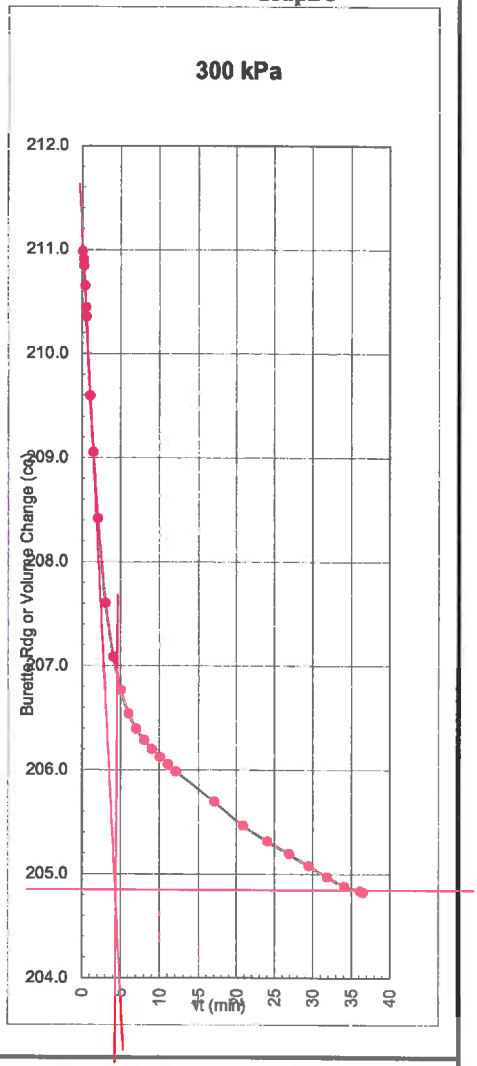
Graph 1



Graph 2



Graph 3



Test Methods		Result			
Triaxial Test	In House	**Confining Pressure (kPa)=**	**75**	**150**	**300**
Based On:	NZS 4402:1986 Test 6.2.1	**Cv (m^2/yr)=**	5.74	4.17	2.74
		Mv (m^2/MN)=	0.26	0.24	0.17
		k (m/s)=	4.64E-10	3.06E-10	1.44E-10
		t_{100}=	8.4	11.6	17.6

Date Tested: 02-05/12/13

Date Reported: 10/12/13

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IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

TEST REPORT

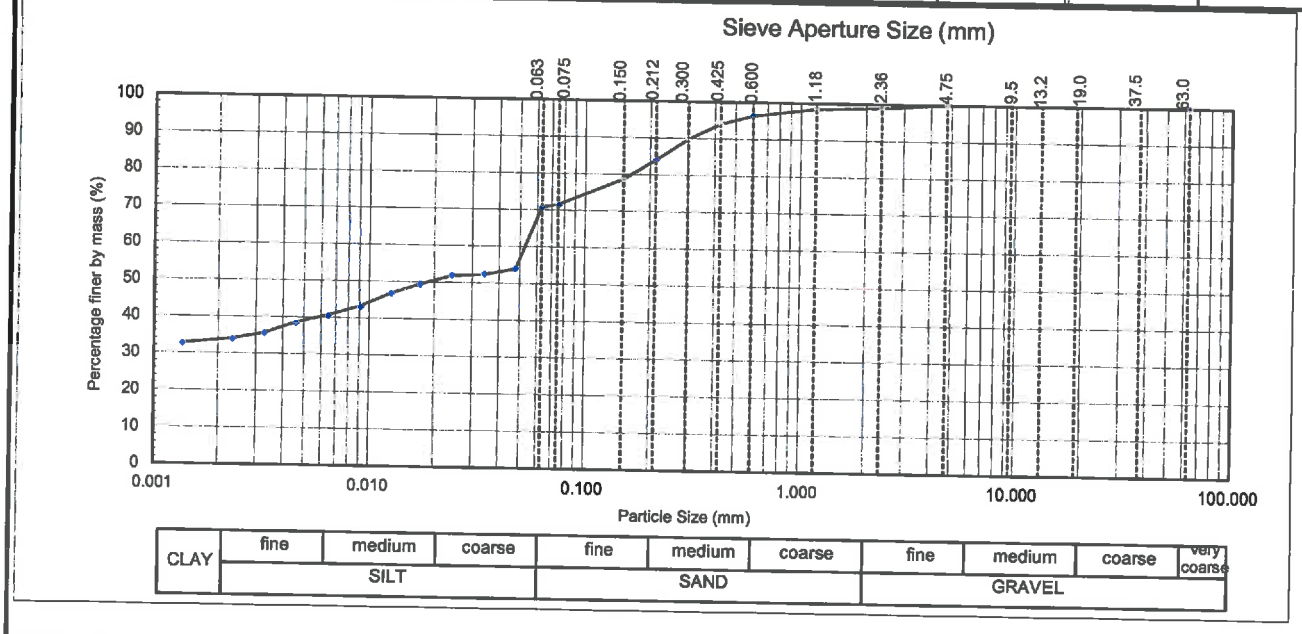
OPUS

Project :	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Sampled by :	**Tom Van Deelen**
Date sampled :	**21/11/13**
Sampling method :	**Not Stated**
Sample condition :	**As Received**
Sample description :	**Brown; slightly clayey sandy SILT; weathered**
Solid Particle Density (t/m^3)	**2.75** **Assumed**
Water Content (as received)	**45.4** **%**
Sample Reference:	**BH13/01** Depth: **4.0 - 4.4 metres**

Project number:	**1-C0935.25**
Lab ref number:	**013/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	100	0.300	90	0.0479	54	0.0065	41
37.5	--	2.36	99	0.212	84	0.0340	52	0.0046	39
19.0	--	1.18	98	0.150	79	0.0241	52	0.0033	36
13.2	--	0.600	96	0.075	72	0.0172	49	0.0023	34
9.5	--	0.425	94	0.063	71	0.0127	47	0.0014	33
						0.0091	43		

Note: "--" denotes sieve not used and/or hydrometer analysis not tested



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 9.6 (Electrometric method was used)

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

Date Tested: 04 - 05/12/13

This report may only be reproduced in full

Date Reported: 10/12/13

IANZ Approved Signatory *Thirushen Pillay*

Designation : *Senior Civil Engineering Technician*

Date : 10/12/13

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UNCONFINED COMPRESSIVE STRENGTH WITH YOUNG'S MODULUS

OPUS

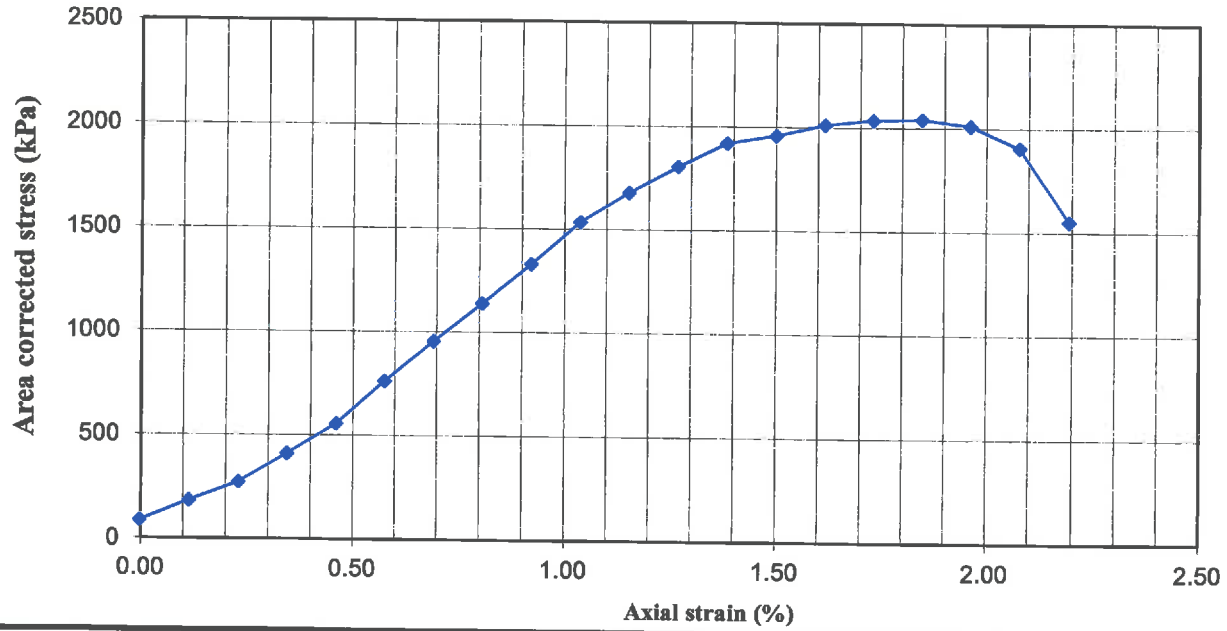
Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Sampled by:	**Opus - Tom Van Deelen**
Date sampled:	**21/11/13**
Sampling method:	**Not Stated**
Sample description:	**Very weak Sandstone**
Sample condition:	**As received**
Sample reference:	**BH13/01**
Sample depth (m):	**6.7 - 6.85**

Project number:	**1-C0935.25**
Lab ref number:	**010/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test results

Bulk density (t/m³)	**2.00**	Initial sample diameter (mm)	**60.7**
Water content (%)	**20.8**	Initial sample length (mm)	**86.6**
Dry density (t/m³)	**1.65**	Initial sample area (mm²)	**2890.5**
Maximum stress (kPa)	**2000**	Initial Length:Diameter ratio	**1.43:1**
Strain at failure (%)	**1.8**	Young's modulus (MPa)	**169**
Mode of failure:	**Sheared**	For strain range	**0.46 - 1.04%**

Area corrected Stress (kPa) Vs Axial strain (%)



Test Methods		Notes
UCS:	NZS 4402: 1986: Test 6.3.1	-Sample Descriptions are not covered by IANZ accreditation. -The strain rate for this test was kept constant at 0.4mm/min.

Tested by: AJ

Date tested: 22/11/13

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

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IANZ Approved Signatory Date : 09/12/13

Thirushen Pillay

Senior Civil Engineering Technician

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UNCONFINED COMPRESSIVE STRENGTH WITH YOUNG'S MODULUS

OPUS

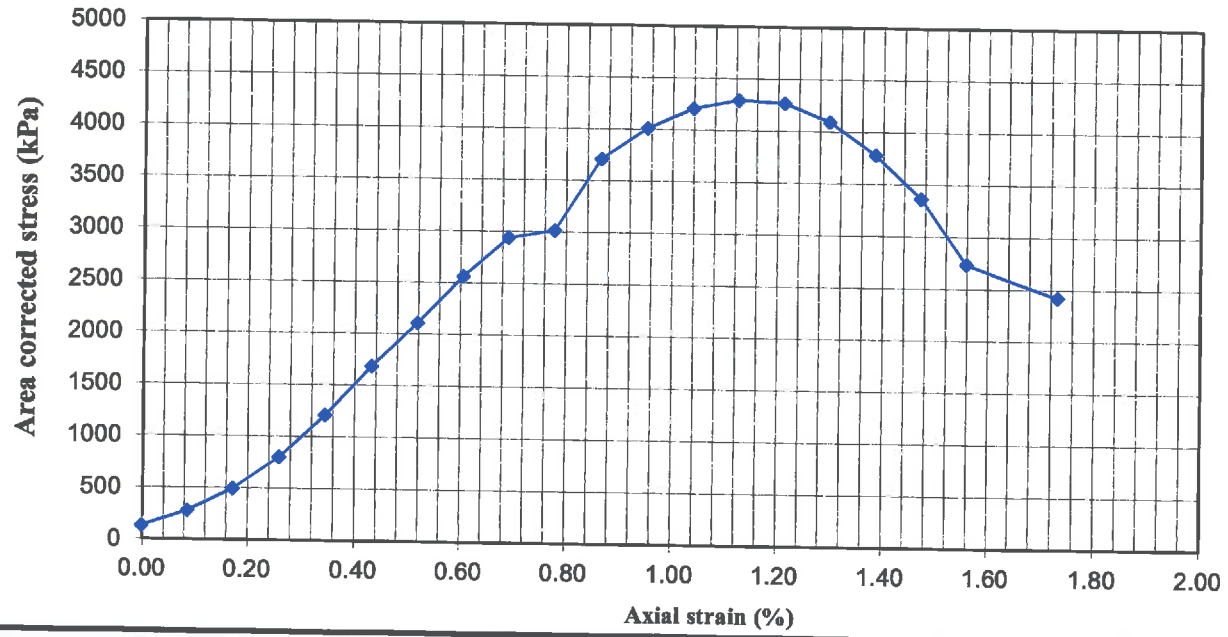
Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Sampled by:	**Opus - Tom Van Deelen**
Date sampled:	**21/11/13**
Sampling method:	**Not Stated**
Sample description:	**Very weak Sandstone**
Sample condition:	**As received**
Sample reference:	**BH13/01**
Sample depth (m):	**7.2 - 7.4**

Project number:	**1-C0935.25**
Lab ref number:	**011/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test results

Bulk density (t/m³)	**2.05**	Initial sample diameter (mm)	**60.5**
Water content (%)	**21.3**	Initial sample length (mm)	**115.5**
Dry density (t/m³)	**1.65**	Initial sample area (mm²)	**2878.6**
Maximum stress (kPa)	**4300**	Initial Length:Diameter ratio	**1.91:1**
Strain at failure (%)	**1.1**	Young's modulus (MPa)	**470**
Mode of failure:	**Sheared**	For strain range	**0.17 - 0.69%**

Area corrected Stress (kPa) Vs Axial strain (%)



Test Methods		Notes
UCS:	NZS 4402: 1986: Test 6.3.1	-Sample Descriptions are not covered by IANZ accreditation. -The strain rate for this test was kept constant at 0.3mm/min.

Tested by: AJ

Date tested: 22/11/13

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

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IANZ Approved Signatory

Thirushen Pillay

Senior Civil Engineering Technician

Date : 09/12/13

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UNCONFINED COMPRESSIVE STRENGTH WITH YOUNG'S MODULUS

OPUS

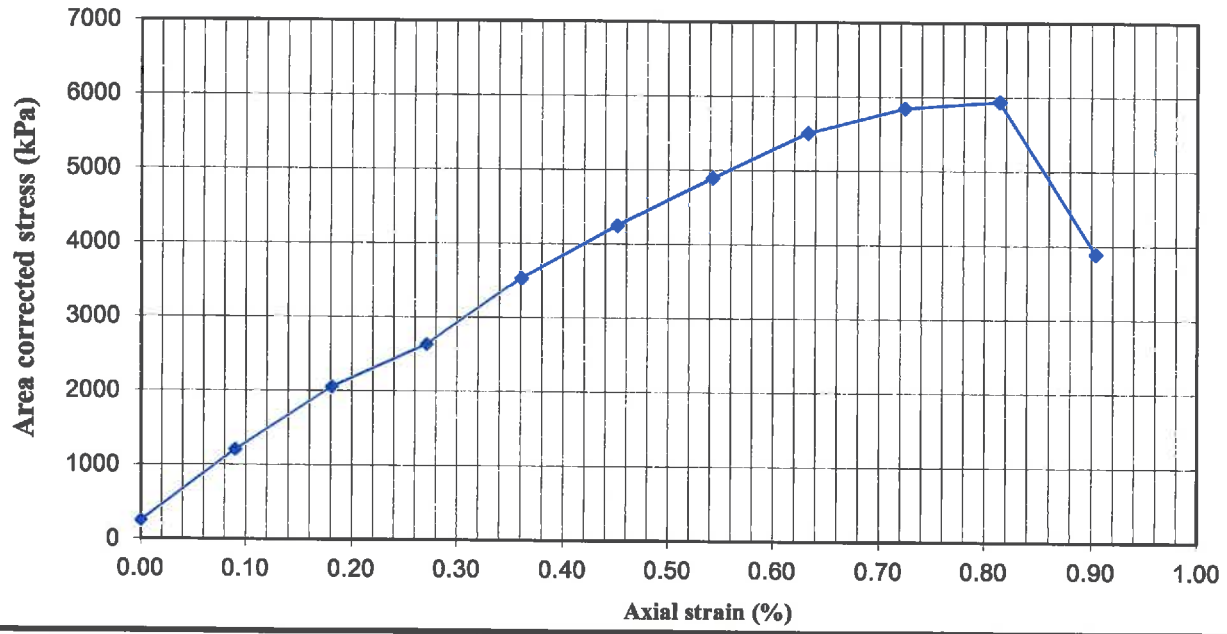
Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Sampled by:	**Opus - Tom Van Deelen**
Date sampled:	**10/12/13**
Sampling method:	**Not Stated**
Sample description:	**Weak Sandstone**
Sample condition:	**As received**
Sample reference:	**BH13/01**
Sample depth (m):	**9.4 - 9.5**

Project number:	**1-C0935.25**
Lab ref number:	**015/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test results

Bulk density (t/m³)	**2.05**	Initial sample diameter (mm)	**61.0**
Water content (%)	**20.6**	Initial sample length (mm)	**110.6**
Dry density (t/m³)	**1.70**	Initial sample area (mm²)	**2922.0**
Maximum stress (kPa)	**5900**	Initial Length:Diameter ratio	**1.81:1**
Strain at failure (%)	**0.81**	Young's modulus (MPa)	**1000**
Mode of failure:	**Sheared**	For strain range	**0.00 - 0.18%**

Area corrected Stress (kPa) Vs Axial strain (%)



Test Methods		Notes
UCS:	NZS 4402: 1986: Test 6.3.1	-Sample Descriptions are not covered by IANZ accreditation. -The strain rate for this test was kept constant at 0.5mm/min.

Tested by: TPI/AOD

Date tested: 11/12/13

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

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IANZ Approved Signatory Date : 12/12/13

Thirushen Pillay

Senior Civil Engineering Technician

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UNCONFINED COMPRESSIVE STRENGTH WITH YOUNG'S MODULUS

OPUS

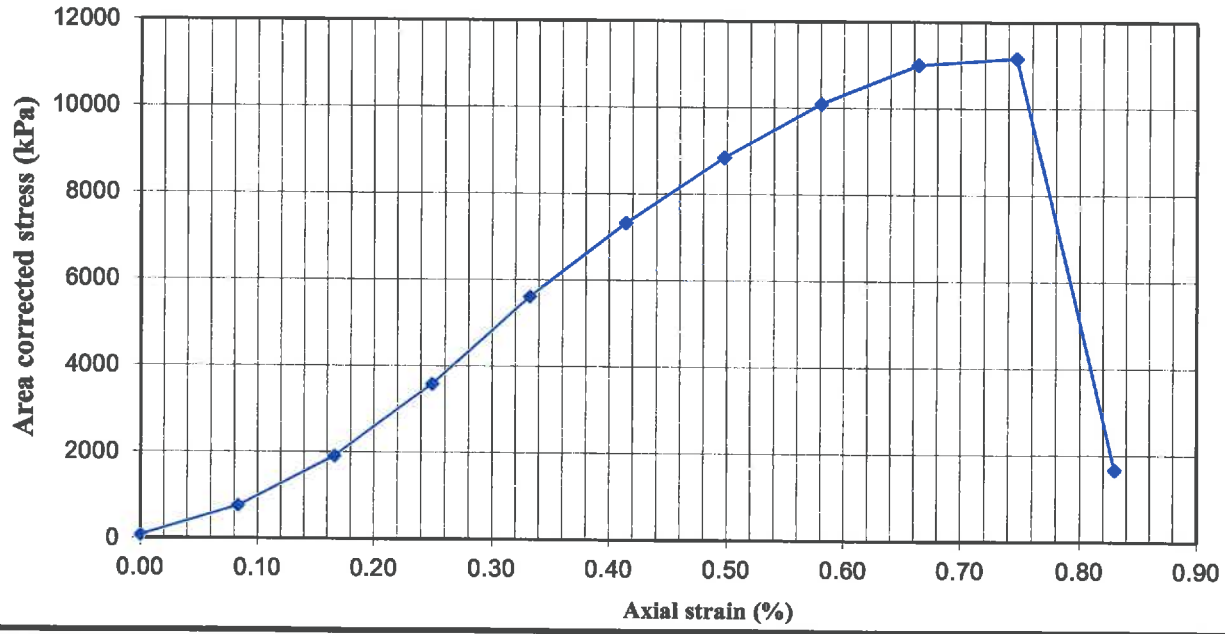
Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Sampled by:	**Opus - Tom Van Deelen**
Date sampled:	**10/12/13**
Sampling method:	**Not Stated**
Sample description:	**Weak Sandstone**
Sample condition:	**As received**
Sample reference:	**BH13/01**
Sample depth (m):	**11.55 - 11.7**

Project number:	**1-C0935.25**
Lab ref number:	**014/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test results

Bulk density (t/m³)	**2.10**	Initial sample diameter (mm)	**61.1**
Water content (%)	**18.0**	Initial sample length (mm)	**120.5**
Dry density (t/m³)	**1.80**	Initial sample area (mm²)	**2932.5**
Maximum stress (kPa)	**11000**	Initial Length:Diameter ratio	**1.97:1**
Strain at failure (%)	**0.75**	Young's modulus (MPa)	**2180**
Mode of failure:	**Sheared**	For strain range	**0.17 - 0.42%**

Area corrected Stress (kPa) Vs Axial strain (%)



Test Methods		Notes
UCS:	NZS 4402: 1986: Test 6.3.1	-Sample Descriptions are not covered by IANZ accreditation. -The strain rate for this test was kept constant at 0.4mm/min.

Tested by: TPI/AOD

Date tested: 11/12/13

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

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IANZ Approved Signatory Date : 12/12/13

Thirushen Pillay

Senior Civil Engineering Technician

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PLASTICITY INDEX TEST REPORT

OPUS

Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Sampled by:	**Tom Van Deelen**
Date sampled:	**21/11/13**
Sampling method:	**Pushtube**
Sample description:	**Brown; clayey SILT with clasts**
Sample condition:	**As received**
Sample reference:	**BH13/03**
Sample depth:	**3.0 - 3.5m**

Project number:	**1-C0935.25**
Lab ref number:	**002/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test Results

As rec'd water content:	**67.8%**
Liquid limit:	**83**
Plastic limit:	**34**
Plasticity Index:	**49**

Test methods		Notes
Water Content:	NZS 4402 : 1986, Test 2.1	Test performed on: Fraction passing 0.425mm test sieve
Liquid Limit:	NZS 4402 : 1986, Test 2.2	Sample descriptions are not covered by IANZ accreditation.
Plastic Limit:	NZS 4402 : 1986, Test 2.3	
Plasticity Index:	NZS 4402 : 1986, Test 2.4	

Date tested: 06-09/12/13
Date reported: 10/12/2013

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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IANZ Approved Signatory
Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 10/12/2013

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Result Summary

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.25 - 3.4m**
Sample Reference:	**BH13/03** Depth (m): **3.0 - 3.5**
Sampled by:	**Tom Van Deelen** Date Sampled: **21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; with clasts**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**002a/13**
Client Ref No:	**Tom Van Deelen**

Result at Maximum Stress Ratio — **Back Pressure saturated at 350 kPa**

Specimen Stage No	Effective Confining Pressure (kPa)	INITIAL PROPERTIES Densities (t/m³) Wet (t/m³)	INITIAL PROPERTIES Densities (t/m³) Dry (t/m³)	INITIAL PROPERTIES Water Content (%)	Solid Particle Density (t/m³)	FINAL PROPERTIES Densities (t/m³) Wet (t/m³)	FINAL PROPERTIES Densities (t/m³) Dry (t/m³)	FINAL PROPERTIES Water Content (%)
1	75	1.62	0.97	67.4				
2	150				2.70			
3	300				(assumed)	1.75	1.11	57.2

Specimen Stage No	Effective Confining Pressure (kPa)	Void Ratio (e)	Deg of Saturation(Sr) Sr before Consolid. (%)	Deg of Saturation(Sr) Sr after Consolid. (%)	Values at Maximum Stress Ratio s_1-s_3 (kPa)	m (kPa)	Strain (%)
1	75	1.79	100	100	85.4	40	4.33
2	150				124.3	86	3.17
3	300				264.3	173	1.61

Specimen Stage No	Effective Confining Pressure (kPa)	Coefficient *of* Consolidation Cv (m^2/year)	Volume Compressibility Mv (m^2/MN)	Coefficient *of* Permeability k (m/s)	B at the start of test
1	75	2	0.40	2.4E-10	
2	150	1.1	0.60	2.0E-10	95.00
3	300	0.2	0.400	3.0E-11	

IANZ endorsement does not include the Cv, Mv and k values reported herein.
Mv & Cv calculated for the following conditions:-
L/D=2, RADIAL+TOP+BOTTOM Drainage
Side Filter drains Used
(L/D= Sample Length/Diameter.)

TOTAL STRESS RESULT				EFFECTIVE STRESS RESULT			
Intercept d	**5.23**	(kPa)		Intercept d'	**1.82**	(kPa)	
Beta b	**16.20**	(deg)		Beta b'	**26.57**	(deg)	
Cohesion c	**5**	(kPa)		Cohesion c'	**2**	(kPa)	
Phi Æ	**17**	(deg)		Phi Æ '	**30**	(deg)	
Correl coeff	**0.9921**	r^2		Correl coeff	**0.9972**	r^2	

Test Methods		Notes:
Triaxial Test	In House	Cv and Mv have been rounded to 2 significant figures.
Based On:	NZS 4402:1986 Test 6.2.1	L/D= Sample Length/Diameter.

Date Tested: 04-11/12/13

Date Reported: 12/12/13

IANZ ACCREDITED LABORATORY — All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

IANZ Approved Signatory: Date: 12/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

CSF 2130 (6/99)

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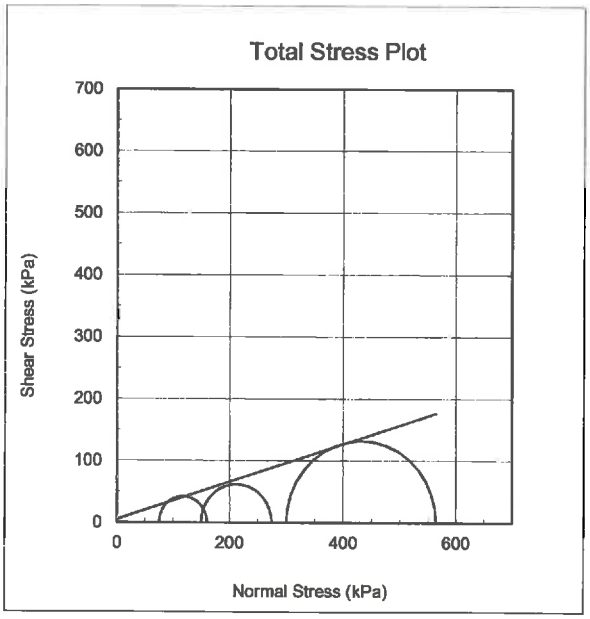
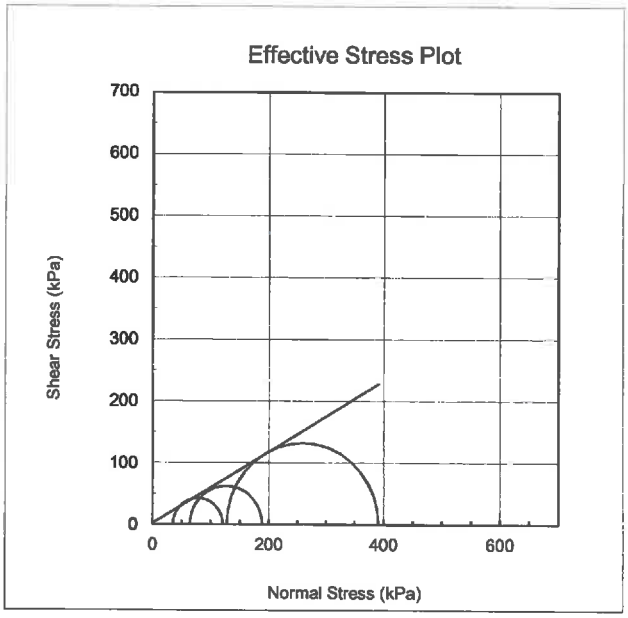
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Mohr Coulomb Envelope Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.25 - 3.4m**
Sample Reference:	**BH13/03** Depth (m): **3.0 - 3.5**
Sampled by:	**Tom Van Deelen** Date Sampled: **21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; with clasts**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**002a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Mohr-Coulomb envelope plots Result at Maximum Stress Ratio
Back Pressure Saturated at 350 kPa





TOTAL STRESS RESULT		
Intercept d	**5.23**	(kPa)
Beta b	**16.20**	(deg)
Cohesion c	**5**	(kPa)
Phi Æ	**17**	(deg)
Correl coeff	**0.9921**	r^2

EFFECTIVE STRESS RESULT		
Intercept d'	**1.82**	(kPa)
Beta b'	**26.57**	(deg)
Cohesion c'	**2**	(kPa)
Phi Æ '	**30**	(deg)
Correl coeff	**0.9972**	r^2

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 04-11/12/13

Date Reported: 12/12/13

IANZ ACCREDITED LABORATORY — All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

IANZ Approved Signatory: Date: 12/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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Telephone +64 9 415 4660
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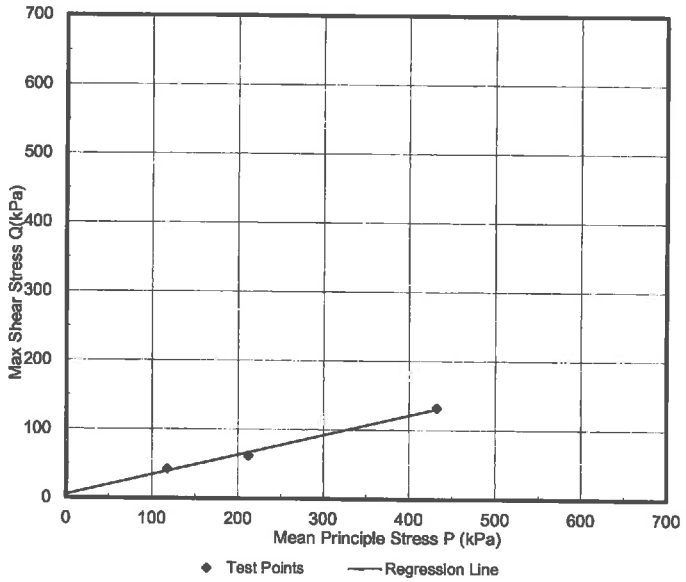
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P vs Q Total Stress Plot

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.25 - 3.4m**
Sample Reference:	**BH13/03**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; with clasts**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**002a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P vs Q Total Stress Plot- Back Pressure saturated at 350 kPa



TOTAL STRESS RESULT		
Intercept d	**5.23**	(kPa)
Beta b	**16.20**	(deg)
Correl coeff	**0.9921**	r^2
Cohesion c	**5**	(kPa)
Phi Æ	**17**	(deg)

Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 04-11/12/13

Date Reported: 12/12/13

IANZ Approved Signatory: Date: 12/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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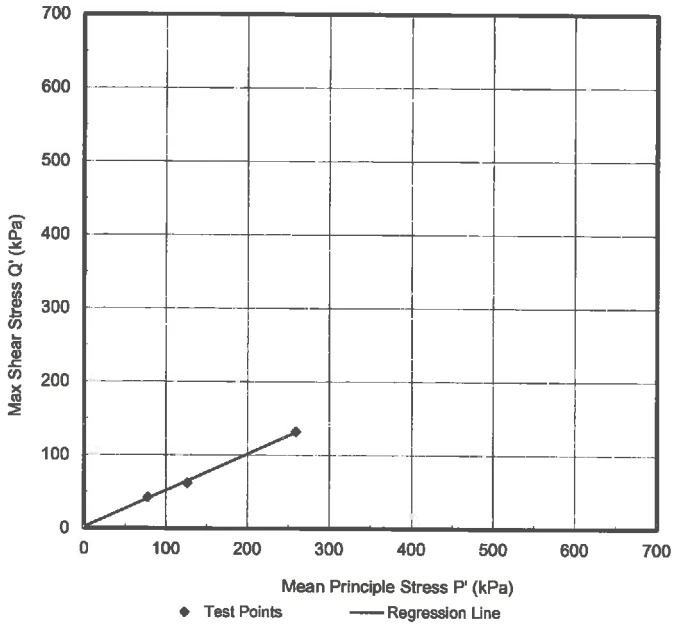
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P' vs Q' Effective Stress Plot

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.25 - 3.4m**
Sample Reference:	**BH13/03** Depth (m): **3.0 - 3.5**
Sampled by:	**Tom Van Deelen** Date Sampled: **21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; with clasts**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**002a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Effective Stress Plot-Back Pressure saturated at 350 kPa



EFFECTIVE STRESS RESULT		
Intercept d'	**1.82**	(kPa)
Beta b'	**26.57**	(deg)
Correl coeff	**0.9972**	r^2
Cohesion c'	**2**	(kPa)
Phi Æ'	**30**	(deg)

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 04-11/12/13

Date Reported: 12/12/13

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IANZ Approved Signatory: Date: 12/12/13

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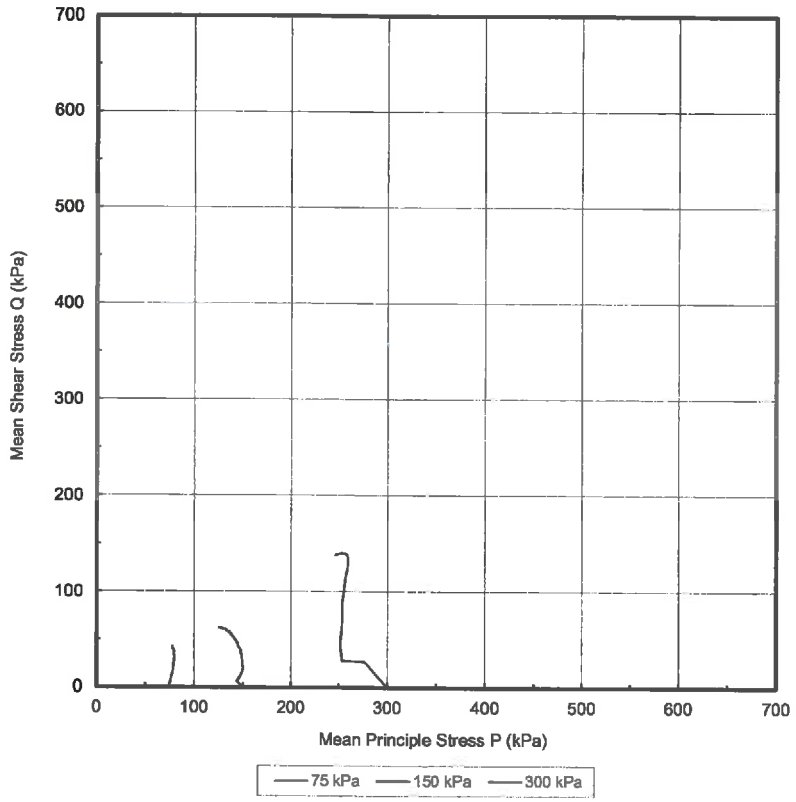
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - PvsQ Stress Path Plot

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.25 - 3.4m**
Sample Reference:	**BH13/03**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; with clasts**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**002a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Stress Path (Effective Stress Plot) - Back Pressure saturated at 350 kPa



Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 04-11/12/13

Date Reported: 12/12/13

IANZ Approved Signatory: Date: 12/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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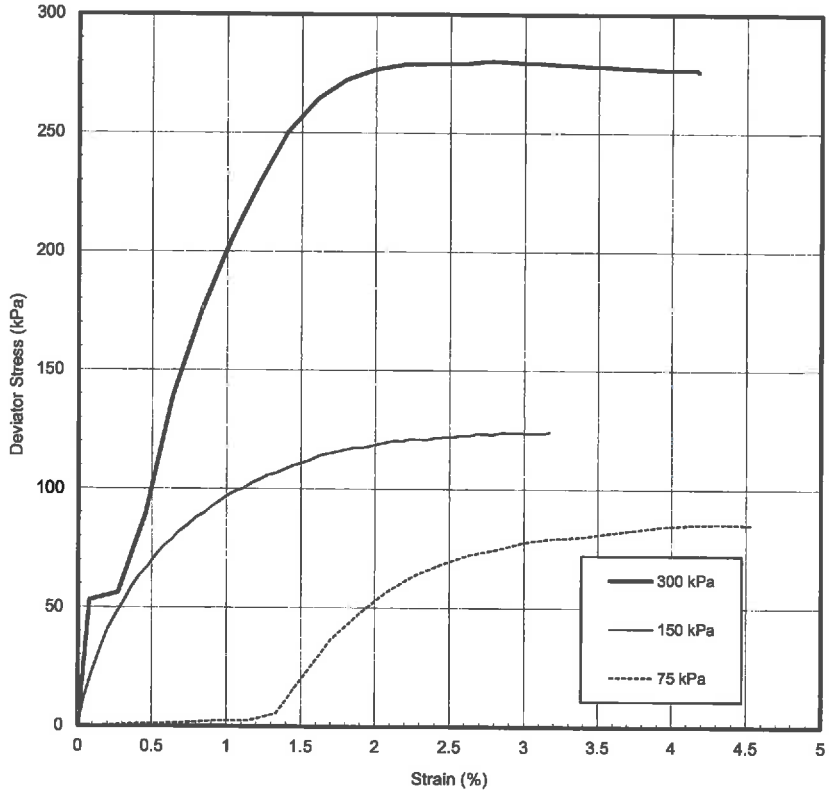
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Deviator StressPlot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.25 - 3.4m**
Sample Reference:	**BH13/03** Depth (m): **3.0 - 3.5**
Sampled by:	**Tom Van Deelen** Date Sampled: **21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; with clasts**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**002a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Deviator Stress Plot- Back Pressure saturated at 350 kPa



Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 04-11/12/13

Date Reported: 12/12/13

IANZ Approved Signatory: Date: 12/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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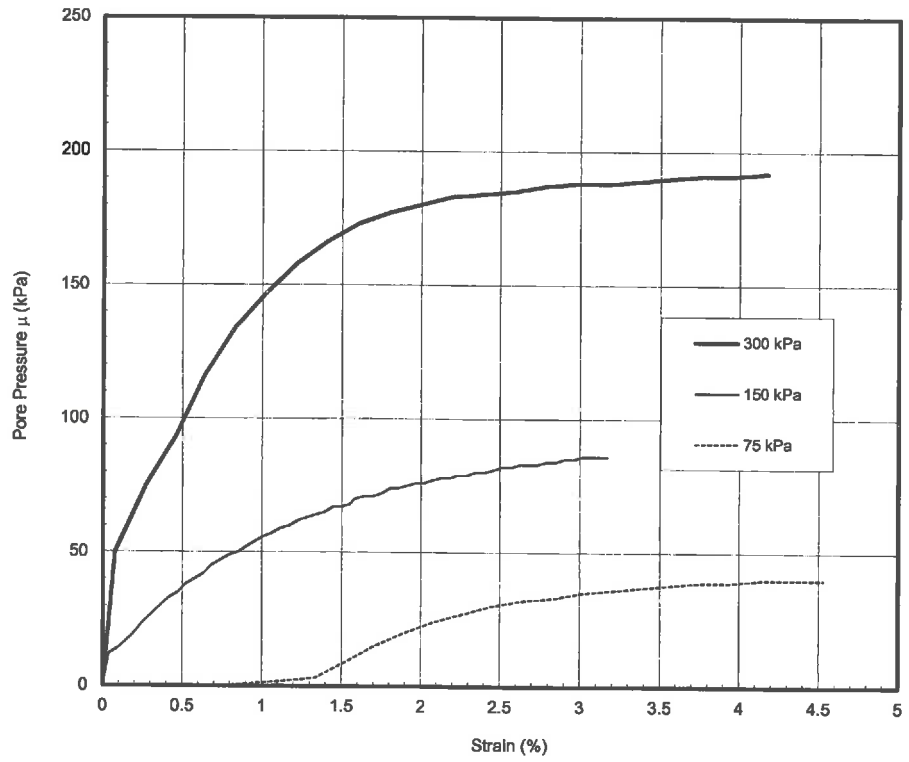
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Pore Pressure Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.25 - 3.4m**
Sample Reference:	**BH13/03** Depth (m): **3.0 - 3.5**
Sampled by:	**Tom Van Deelen** Date Sampled: **21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; with clasts**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**002a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Pore Pressure Plot- Back Pressure saturated at 350 kPa



Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 04-11/12/13

Date Reported: 12/12/13

IANZ Approved Signatory: Date: 12/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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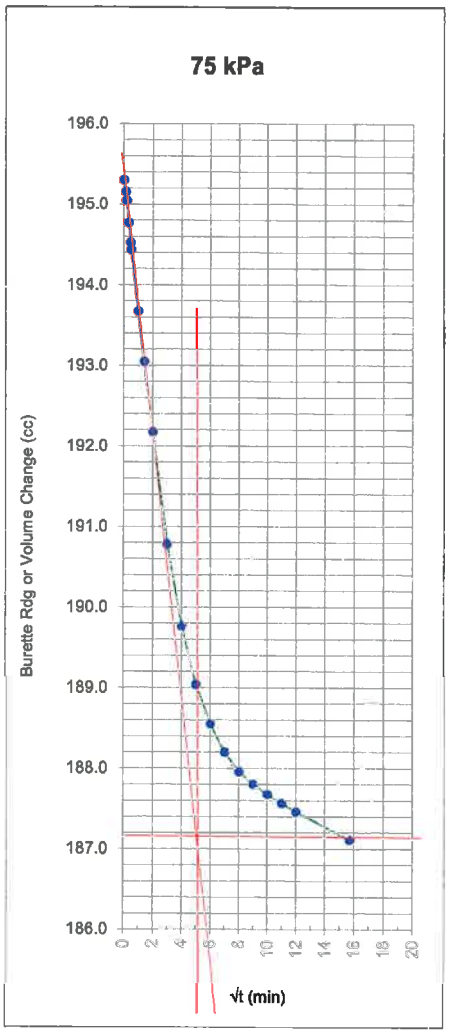
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Displacement vs Öt Plot (Consolidation stage)

OPUS

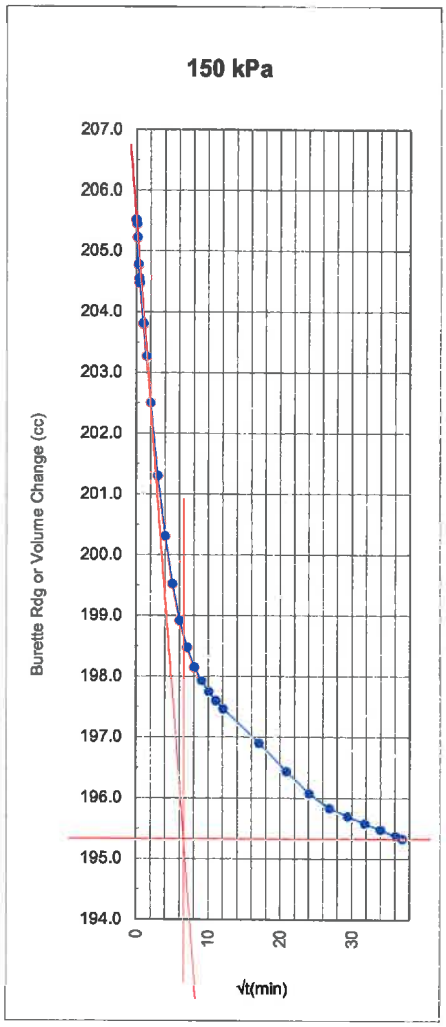
Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.25 - 3.4m**
Sample Reference:	**BH13/03**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; with clasts**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**002a/13**
Client Ref No:	**Tom Van Deelen**

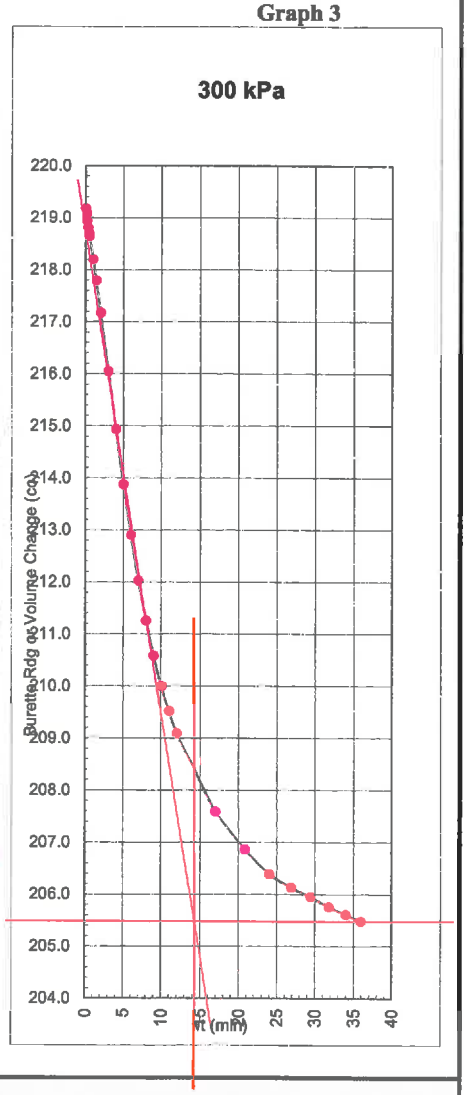
Graph 1



Graph 2



Graph 3



Test Methods		Result			
Triaxial Test	In House	**Confining Pressure (kPa)=**	**75**	**150**	**300**
Based On:	NZS 4402:1986 Test 6.2.1	**Cv (m^2/yr)=**	1.73	1.11	0.24
		Mv (m^2/MN)=	0.45	0.58	0.40
		k (m/s)=	2.40E-10	1.98E-10	2.98E-11
		t_{100}=	27.0	42.3	196.0

Date Tested: 04-11/12/13

Date Reported: 12/12/13

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IANZ Approved Signatory: Date: 12/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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ONE DIMENSIONAL CONSOLIDATION PROPERTIES
TEST RESULT REPORT

OPUS

Project : **Manuka Reservoirs**
Location: **Manuka Reservoirs**
Client : **Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor: **Not Stated**
Subcontractor: **Not Stated**
Sample reference: **BH13/03, 3.0 - 3.5m** Specimen depth: **3.4 - 3.5 metres**
Sampled by : **Tom Van Deelen** Date: **21/11/13**
Date received : **21/11/13**
Sampling method : **Push Tube**
Sample description : **Brown; clayey SILT with clasts**

Sample condition : **As received**
OEDOMETER APPARATUS No: S17C

Project No:	**1-C0935.25**
Lab Ref No:	**002b/13**
Folder No:	**SEC13/AU/050**

SOIL PROPERTIES

Specimen Dimensions:

Diameter	(mm):	50.53
Initial height	(mm):	16.08
Final height	(mm):	13.20
Initial mass of sample (g):		50.62

Initial Wet Density	pbi (t/m³)	1.57
Initial Dry Density	pdi (t/m³)	0.93
Final Dry Density	pdf (t/m³)	1.13
Initial Void Ratio	eo	1.91
Final Void Ratio	ef	1.38
Initial Degree of Saturation	Si (%)	98
Final Degree of Saturation	Sf (%)	100
Solid Particle Density	*Gs (t/m³)	2.70
INITIAL Water Content	Wi (%)	68.9
FINAL Water Content	Wf (%)	54.4

*Gs is Assumed

CONSOLIDATION PROPERTIES

PRESSURE RANGE (kPa)	Pressure Increment (dp)	Void Ratio (e)	Intercept t90 (min)	Volume Compressibilty Mv=m²/MN	Coefficient of Consolidation Cv=m²/year	Coeff. of Permeability k=m/year	
0 - 12.5	12.5	1.889	0.724201	-	-	-	
12.5 - 25	12.5	1.863	0.86	0.71	33.0	0.23	
25 - 50	25	1.834	0.81	0.41	34.0	0.14	
50 - 100	50	1.775	1.00	0.42	27.0	0.11	
100 - 200	100	1.652	1.21	0.44	22.0	0.094	
200 - 400	200	1.466	1.77	0.35	14.0	0.047	
400 - 800	400	1.255	4.00	0.21	5.2	0.011	
800 - 200	-	1.300	-	-	-	-	
200 - 50	-	1.351	-	-	-	-	
50 - 12.5	-	1.385	-	-	-	-	
-	-	-	-	-	-	-	
-	-	-	-	-	-	-	

Test Methods:		Notes:
One Dimensional Consolidation Test.	NZS 4402:1986 Test 7.1	Sample is saturated during test.
Water Content	NZS 4402:1986 Test 2.1	Load Increments applied at 1.06hr intervals

Testing is covered by IANZ Accreditation

This report may only be reproduced in full

Date tested : 04- 05/12/13
Date reported : 11/12/13

IANZ Approved Signatory
Thirushen Pillay
Designation : *Senior Civil Engineering Technician*
Date : 11/12/13

IANZ ACCREDITED LABORATORY

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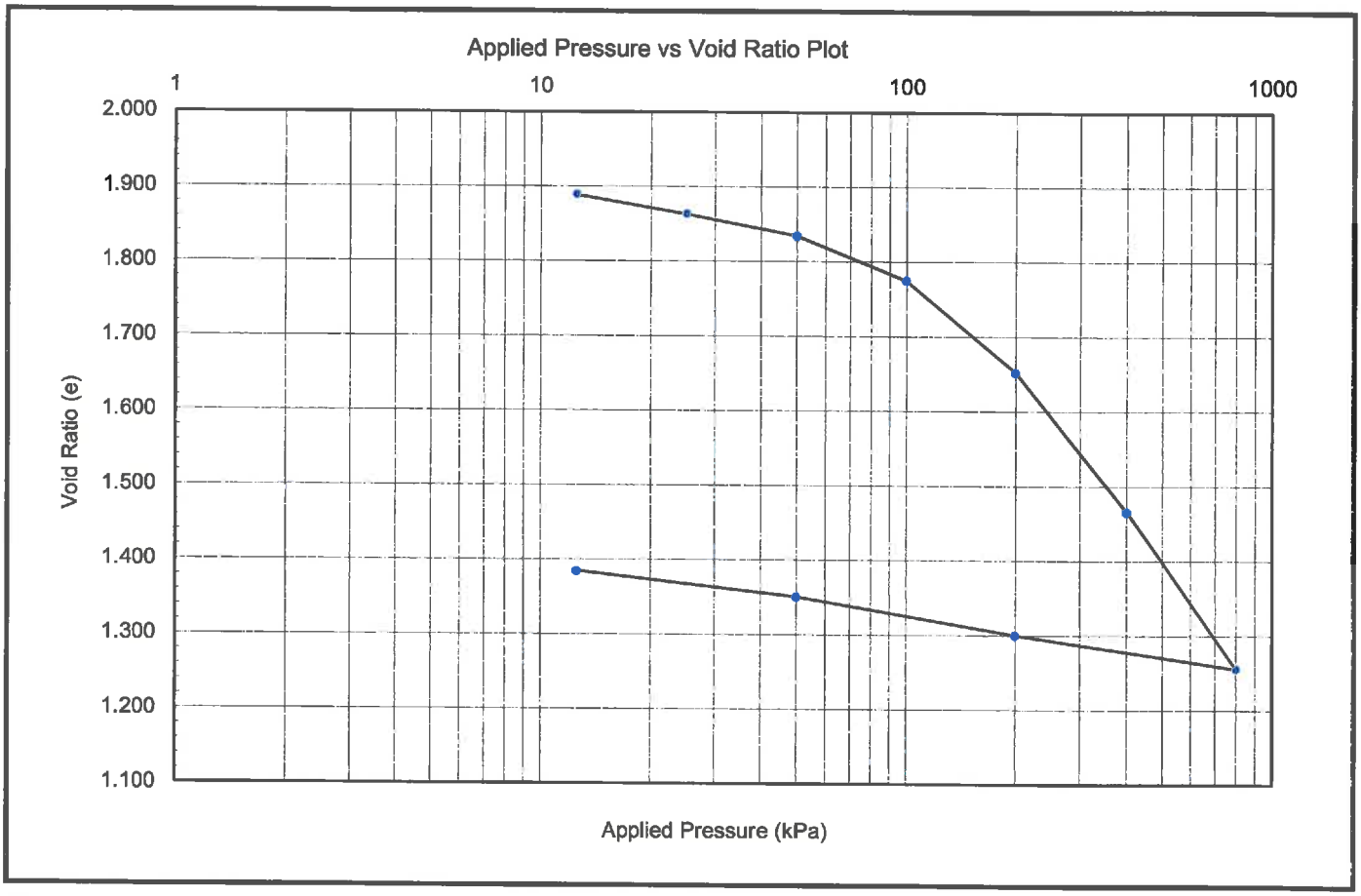
ONE DIMENSIONAL CONSOLIDATION PROPERTIES
Applied Pressure vs Void Ratio TEST REPORT

OPUS

Project :	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Subcontractor:	**Not Stated**
Sample reference:	**BH13/03, 3.0 - 3.5m**
Specimen depth:	**3.4 - 3.5 metres**
Sampled by :	**Tom Van Deelen**
Date:	**21/11/13**
Date received :	**21/11/13**
Sample description :	**Brown; clayey SILT with clasts**

Sampling method : **Push Tube**
Sample condition : **As received**
OEDOMETER APPARATUS No: S17C

Project No:	**1-C0935.25**
Lab Ref No:	**002b/13**
Folder No:	**SEC13/AU/050**



Test Method:		Notes:
One Dimensional Consolidation Test:	NZS 4402:1986 Test 7.1	Load Increments applied at 1.06hr intervals
Water Content:	NZS 4402:1986 Test 2.1	

Date tested : 04- 05/12/13
Date reported : 11/12/13

Testing is covered by IANZ Accreditation
This report may only be reproduced in full

IANZ Approved Signatory
Thirushen Pillay
Designation : *Senior Civil Engineering Technician*
Date : 11/12/13

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CSF 2120 (8/02)

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PLASTICITY INDEX TEST REPORT

OPUS

Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Sampled by:	**Tom Van Deelen**
Date sampled:	**21/11/13**
Sampling method:	**Core Sample**
Sample description:	**Brown; clayey SILT**
Sample condition:	**As received**
Sample reference:	**BH13/03**
Sample depth:	**4.2 - 4.4m**

Project number:	**1-C0935.25**
Lab ref number:	**004/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test Results

As rec'd water content:	**53.6%**
Liquid limit:	**67**
Plastic limit:	**32**
Plasticity Index:	**35**

Test methods	
Water Content:	NZS 4402 : 1986, Test 2.1
Liquid Limit:	NZS 4402 : 1986, Test 2.2
Plastic Limit:	NZS 4402 : 1986, Test 2.3
Plasticity Index:	NZS 4402 : 1986, Test 2.4

Notes

Test performed on: Fraction passing 0.425mm test sieve

Sample descriptions are not covered by IANZ accreditation.

Date tested: 02 - 03/12/13

Date reported: 10/12/2013

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

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IANZ Approved Signatory

Thirushen Pillay

Designation: *Senior Civil Engineering Technician*

Date: 10/12/2013

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PLASTICITY INDEX TEST REPORT

OPUS

Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Sampled by:	**Tom Van Deelen**
Date sampled:	**21/11/13**
Sampling method:	**Pushtube**
Sample description:	**Brown; clayey SILT; firm**
Sample condition:	**As received**
Sample reference:	**BH13/03**
Sample depth:	**6.0 - 6.5m**

Project number:	**1-C0935.25**
Lab ref number:	**003/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test Results

As rec'd water content:	**44.5%**
Liquid limit:	**57**
Plastic limit:	**25**
Plasticity Index:	**32**

Test methods	
Water Content:	NZS 4402 : 1986, Test 2.1
Liquid Limit:	NZS 4402 : 1986, Test 2.2
Plastic Limit:	NZS 4402 : 1986, Test 2.3
Plasticity Index:	NZS 4402 : 1986, Test 2.4

Notes

Test performed on: Fraction passing 0.425mm test sieve

Sample descriptions are not covered by IANZ accreditation.

Date tested: 06/12/13
Date reported: 10/12/2013

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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IANZ Approved Signatory
Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 10/12/2013

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LAF-103 (19/02/13)

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Result Summary

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/03** Depth (m): **6.0 - 6.5**
Sampled by:	**Tom Van Deelen** Date Sampled: **21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; firm**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**003a/13**
Client Ref No:	**Tom Van Deelen**

Result at Maximum Stress Ratio — **Back Pressure saturated at 350 kPa**

Specimen Stage No	Effective Confining Pressure (kPa)	INITIAL PROPERTIES Densities (t/m³) Wet (t/m³)	INITIAL PROPERTIES Densities (t/m³) Dry (t/m³)	Water Content (%)	Solid Particle Density (t/m³)	FINAL PROPERTIES Densities (t/m³) Wet (t/m³)	FINAL PROPERTIES Densities (t/m³) Dry (t/m³)	Water Content (%)
1	75	1.79	1.27	40.5				
2	150				2.70			
3	300				(assumed)	1.89	1.36	39.1

Specimen Stage No	Effective Confining Pressure (kPa)	Void Ratio (e)	Deg of Saturation(Sr) Sr before Consolid. (%)	Sr after Consolid. (%)	Values at Maximum Stress Ratio s_1-s_3 (kPa)	m (kPa)	Strain (%)
1	75	1.12	98	100	141.7	29	2.32
2	150				164.7	70	2.31
3	300				310.5	169	3.59

Specimen Stage No	Effective Confining Pressure (kPa)	Coefficient *of* Consolidation Cv (m^2/year)	Volume Compressibility Mv (m^2/MN)	Coefficient *of* Permeability k (m/s)	B at the start of test
1	75	5	0.30	4.3E-10	
2	150	1.3	0.20	9.8E-11	98.00
3	300	1.5	0.150	7.1E-11	

IANZ endorsement does not include the Cv, Mv and k values reported herein.
Mv & Cv calculated for the following conditions:-
L/D=2, RADIAL+TOP+BOTTOM Drainage
Side Filter drains Used
(L/D= Sample Length/Diameter.)

TOTAL STRESS RESULT				EFFECTIVE STRESS RESULT			
Intercept d	**24.05**	(kPa)		Intercept d'	**5.35**	(kPa)	
Beta b	**15.83**	(deg)		Beta b'	**27.34**	(deg)	
Cohesion c	**25**	(kPa)		Cohesion c'	**6**	(kPa)	
Phi Æ	**16**	(deg)		Phi Æ '	**31**	(deg)	
Correl coeff	**0.9782**	r^2		Correl coeff	**0.9815**	r^2	

Test Methods		Notes:
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	Cv and Mv have been rounded to 2 significant figures. L/D= Sample Length/Diameter.

Date Tested: 04-10/12/13

Date Reported: 11/12/13

IANZ Approved Signatory: Date: 11/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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CSF 2130 (6/99)

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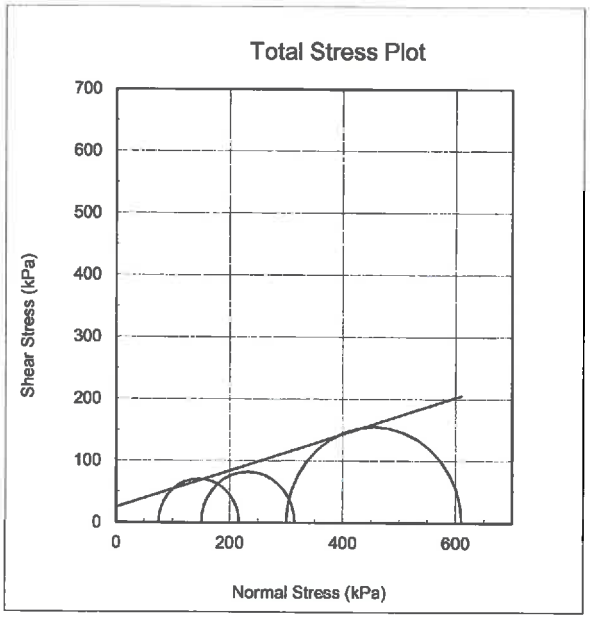
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Mohr Coulomb Envelope Plot

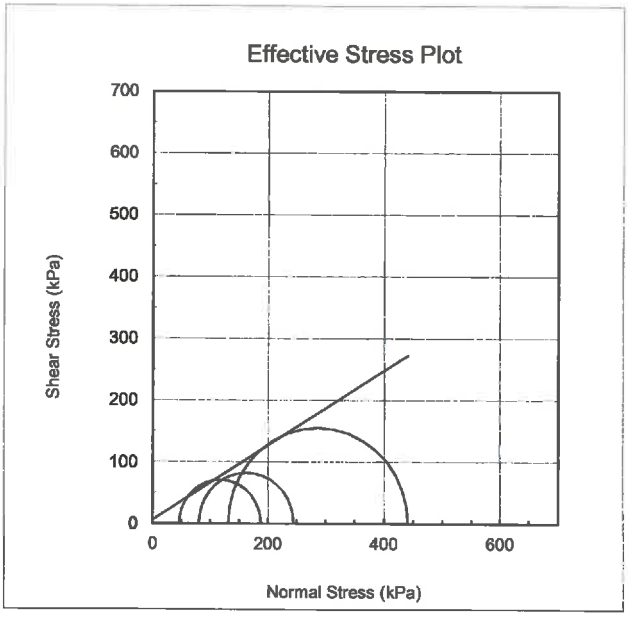
OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/03** Depth (m): **6.0 - 6.5**
Sampled by:	**Tom Van Deelen** Date Sampled: **21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; firm**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**003a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Mohr-Coulomb envelope plots Result at Maximum Stress Ratio
Back Pressure Saturated at 350 kPa





TOTAL STRESS RESULT		
Intercept d	**24.05**	(kPa)
Beta b	**15.83**	(deg)
Cohesion c	**25**	(kPa)
Phi Æ	**16**	(deg)
Correl coeff	**0.9782**	r^2

EFFECTIVE STRESS RESULT		
Intercept d'	**5.35**	(kPa)
Beta b'	**27.34**	(deg)
Cohesion c'	**6**	(kPa)
Phi Æ '	**31**	(deg)
Correl coeff	**0.9815**	r^2

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 04-10/12/13

Date Reported: 11/12/13

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IANZ Approved Signatory: Date: 11/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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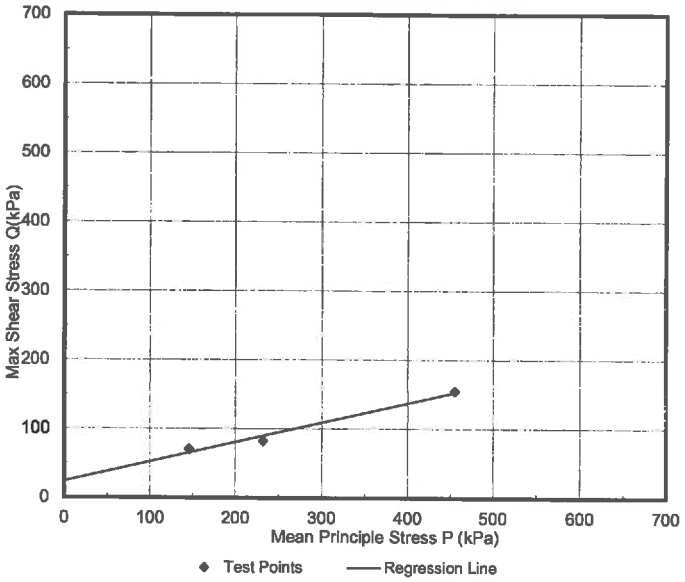
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P vs Q Total Stress Plot

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/03**
Depth (m):	**6.0 - 6.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; firm**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**003a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P vs Q Total Stress Plot- Back Pressure saturated at 350 kPa



TOTAL STRESS RESULT		
Intercept d	**24.05**	(kPa)
Beta b	**15.83**	(deg)
Correl coeff	**0.9782**	r^2
Cohesion c	**25**	(kPa)
Phi Æ	**16**	(deg)

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 04-10/12/13

Date Reported: 11/12/13

IANZ Approved Signatory: Date: 11/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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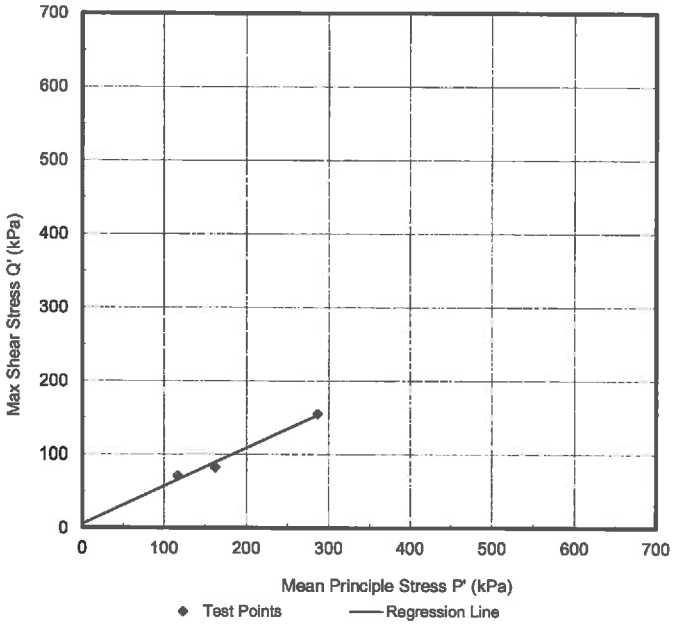
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P' vs Q' Effective Stress Plot

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/03**
Depth (m):	**6.0 - 6.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; firm**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**003a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Effective Stress Plot-Back Pressure saturated at 350 kPa



EFFECTIVE STRESS RESULT		
Intercept d'	**5.35**	(kPa)
Beta b'	**27.34**	(deg)
Correl coeff	**0.9815**	r^2
Cohesion c'	**6**	(kPa)
Phi Æ'	**31**	(deg)

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 04-10/12/13

Date Reported: 11/12/13

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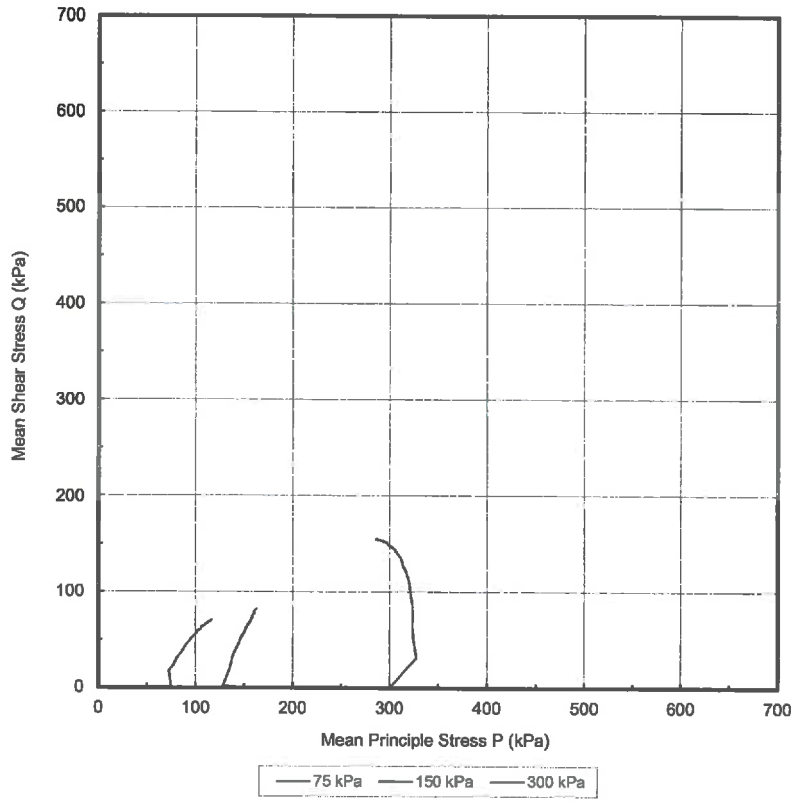
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - PvsQ Stress Path Plot

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/03** Depth (m): **6.0 - 6.5**
Sampled by:	**Tom Van Deelen** Date Sampled: **21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; firm**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**003a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Stress Path (Effective Stress Plot) - Back Pressure saturated at 350 kPa



Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 04-10/12/13

Date Reported: 11/12/13

IANZ Approved Signatory: Date: 11/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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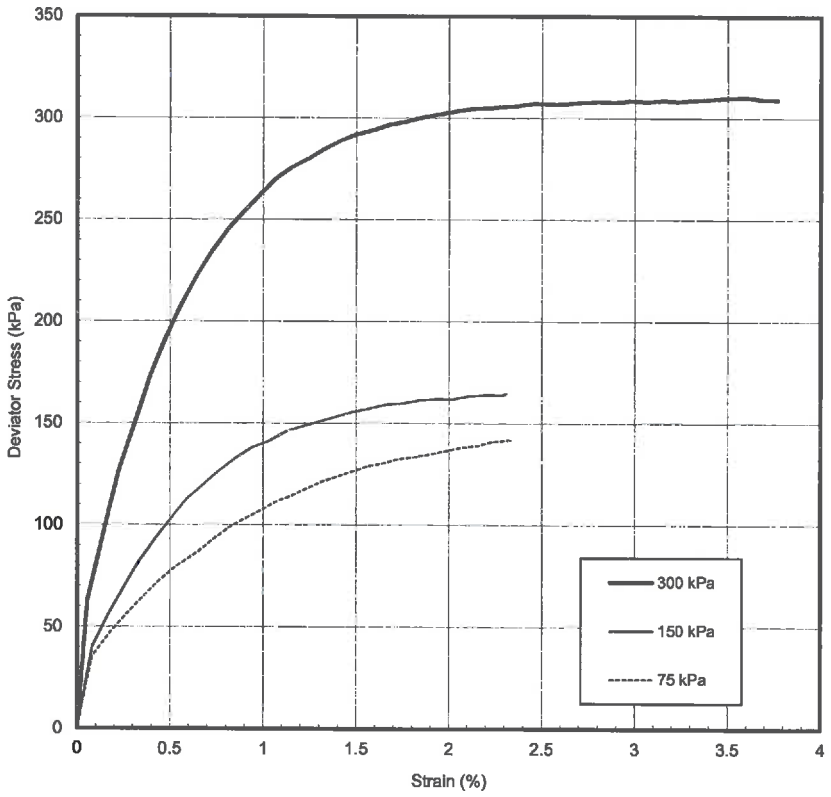
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Deviator StressPlot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/03** Depth (m): **6.0 - 6.5**
Sampled by:	**Tom Van Deelen** Date Sampled: **21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; firm**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**003a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Deviator Stress Plot- Back Pressure saturated at 350 kPa



Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 04-10/12/13

Date Reported: 11/12/13

IANZ Approved Signatory: Date: 11/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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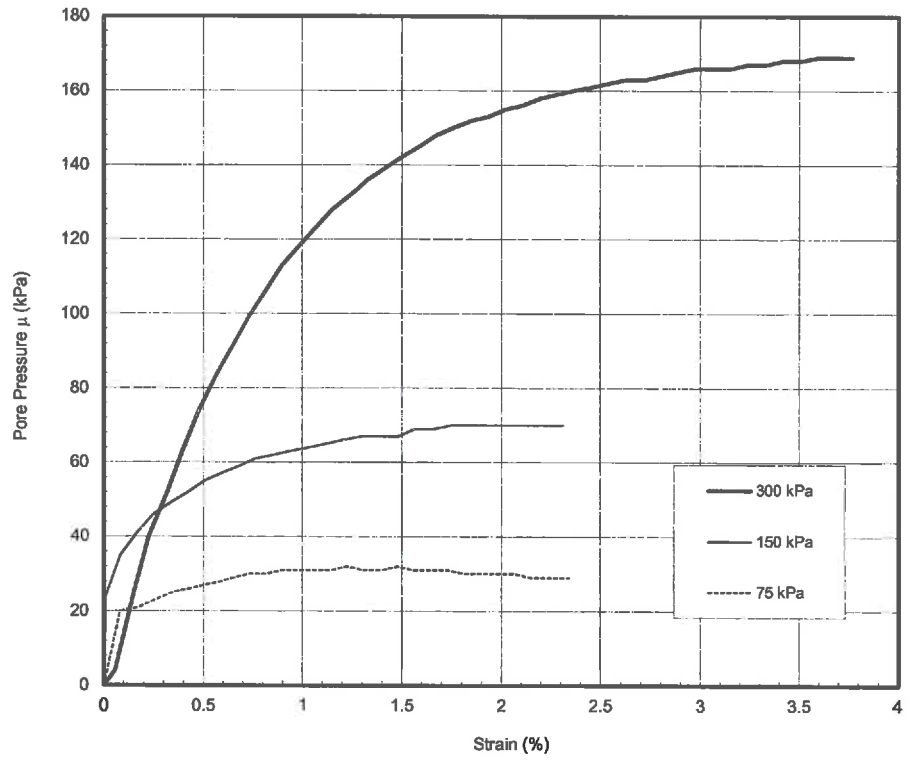
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Pore Pressure Plot

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/03** Depth (m): **6.0 - 6.5**
Sampled by:	**Tom Van Deelen** Date Sampled: **21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; firm**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**003a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Pore Pressure Plot- Back Pressure saturated at 350 kPa



Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 04-10/12/13

Date Reported: 11/12/13

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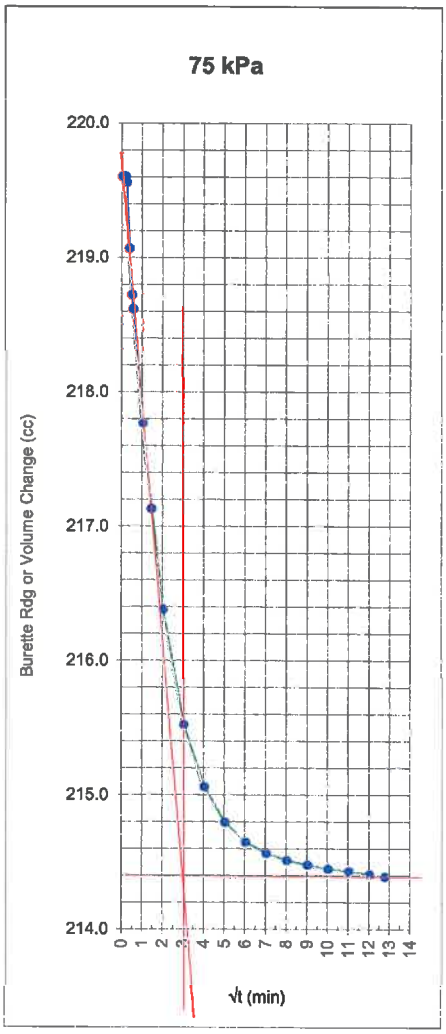
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Displacement *vs* Öt Plot (Consolidation stage)

OPUS

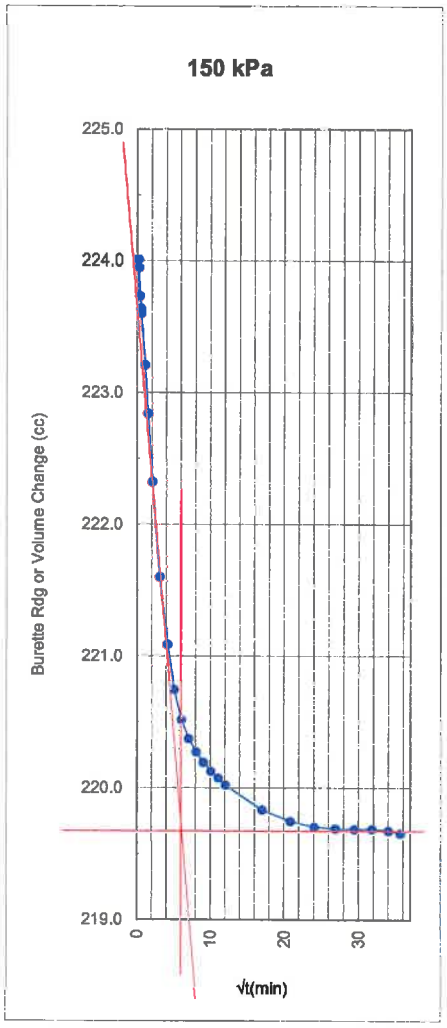
Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/03**
Depth (m):	**6.0 - 6.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; clayey SILT; firm**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**003a/13**
Client Ref No:	**Tom Van Deelen**

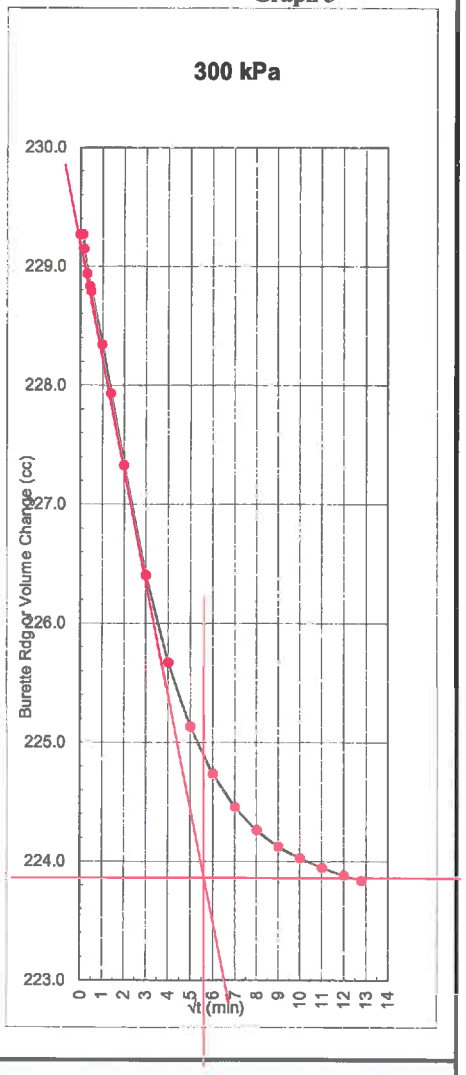
Graph 1



Graph 2



Graph 3



Test Methods		Result			
Triaxial Test	In House	**Confining Pressure (kPa)=**	**75**	**150**	**300**
Based On:	NZS 4402:1986 Test 6.2.1	**Cv (m^2/yr)=**	4.92	1.31	1.51
		Mv (m^2/MN)=	0.28	0.24	0.15
		k (m/s)=	4.28E-10	9.76E-11	7.10E-11
		t_{100}=	9.6	36.0	31.4

Date Tested: 04-10/12/13

Date Reported: 11/12/13

IANZ ACCREDITED LABORATORY — All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

IANZ Approved Signatory: Date: 11/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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PLASTICITY INDEX TEST REPORT

OPUS

Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Sampled by:	**Tom Van Deelen**
Date sampled:	**21/11/13**
Sampling method:	**Core Sample**
Sample description:	**Brownish grey; siltstone/sandstone**
Sample condition:	**As received**
Sample reference:	**BH13/03**
Sample depth:	**10.5 - 10.7m**

Project number:	**1-C0935.25**
Lab ref number:	**005/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test Results

As rec'd water content:	**42.9%**
Liquid limit:	**60**
Plastic limit:	**29**
Plasticity Index:	**31**

Test methods	
Water Content:	NZS 4402 : 1986, Test 2.1
Liquid Limit:	NZS 4402 : 1986, Test 2.2
Plastic Limit:	NZS 4402 : 1986, Test 2.3
Plasticity Index:	NZS 4402 : 1986, Test 2.4

Notes

Test performed on: Fraction passing 0.425mm test sieve

Sample descriptions are not covered by IANZ accreditation.

Date tested: 05/12/13
Date reported: 10/12/2013

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

IANZ Approved Signatory
Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 10/12/2013

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PLASTICITY INDEX TEST REPORT

OPUS

Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Sampled by:	**Tom Van Deelen**
Date sampled:	**21/11/13**
Sampling method:	**Pushtube**
Sample description:	**Grey; clayey SILT**
Sample condition:	**As received**
Sample reference:	**BH13/07**
Sample depth:	**3.0 - 3.5m**

Project number:	**1-C0935.25**
Lab ref number:	**006/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test Results

As rec'd water content:	**51.3%**
Liquid limit:	**76**
Plastic limit:	**33**
Plasticity Index:	**43**

Test methods		Notes
Water Content:	NZS 4402 : 1986, Test 2.1	Test performed on: Fraction passing 0.425mm test sieve
Liquid Limit:	NZS 4402 : 1986, Test 2.2	Sample descriptions are not covered by IANZ accreditation.
Plastic Limit:	NZS 4402 : 1986, Test 2.3	
Plasticity Index:	NZS 4402 : 1986, Test 2.4	

Date tested: 29/11/13 - 02/12/13
Date reported: 10/12/2013

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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IANZ Approved Signatory
Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 10/12/2013

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ONE DIMENSIONAL CONSOLIDATION PROPERTIES TEST RESULT REPORT

OPUS

Project :	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Subcontractor:	**Not Stated**
Sample reference:	**BH13/07, 3.0 - 3.5m**
Specimen depth:	**3.25 - 3.35 metres**
Sampled by :	**Tom Van Deelen**
Date:	**21/11/13**
Date received :	**21/11/13**
Sampling method :	**Push Tube**
Sample description :	**Grey; clayey SILT**
Sample condition :	**As received**

OEDOMETER APPARATUS No: S17D

Project No:	**1-C0935.25**
Lab Ref No:	**006b/13**
Client Ref:	**Tom Van Deelen**

SOIL PROPERTIES

Specimen Dimensions:		
Diameter	(mm):	50.51
Initial height	(mm):	19.76
Final height	(mm):	18.28
Initial mass of sample (g):		64.76

Initial Wet Density	pbi (t/m³)	1.64
Initial Dry Density	pdi (t/m³)	1.07
Final Dry Density	pdf (t/m³)	1.16
Initial Void Ratio	eo	1.52
Final Void Ratio	ef	1.34
Initial Degree of Saturation	Si (%)	94
Final Degree of Saturation	Sf (%)	100
Solid Particle Density	*Gs (t/m³)	2.70
INITIAL Water Content	Wi (%)	52.9
FINAL Water Content	Wf (%)	49.7

*Gs is Assumed

CONSOLIDATION PROPERTIES

PRESSURE RANGE (kPa)	Pressure Increment (dp)	Void Ratio (e)	Intercept t90 (min)	Volume Compressibilty Mv=m²/MN	Coefficient of Consolidation Cv=m²/year	Coeff. of Permeability k=m/year	
0 - 12.5	12.5	1.519	-	-	-	-	
12.5 - 25	12.5	1.518	-	-	-	-	
25 - 50	25	1.513	1.89	0.083	23.0	0.019	
50 - 100	50	1.496	1.77	0.13	24.0	0.032	
100 - 200	100	1.461	1.77	0.14	24.0	0.033	
200 - 400	200	1.387	3.49	0.15	12.0	0.017	
400 - 800	400	1.268	9.61	0.12	4.0	0.0049	
800 - 200	-	1.291	-	-	-	-	
200 - 50	-	1.317	-	-	-	-	
50 - 12.5	-	1.335	-	-	-	-	
-	-	-	-	-	-	-	
-	-	-	-	-	-	-	

Test Methods:		Notes:
One Dimensional Consolidation Test.	NZS 4402:1986 Test 7.1	Sample is saturated during test.
Water Content	NZS 4402:1986 Test 2.1	Load Increments applied at 2.02hr intervals
		Folder No: SEC13/AU/050

Testing is covered by IANZ Accreditation

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Date tested : 02-03/12/13

Date reported : 11/12/13

IANZ Approved Signatory

Thirushen Pillay

Designation : *Senior Civil Engineering Technician*

Date : 11/12/13

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ONE DIMENSIONAL CONSOLIDATION PROPERTIES
Applied Pressure vs Void Ratio TEST REPORT

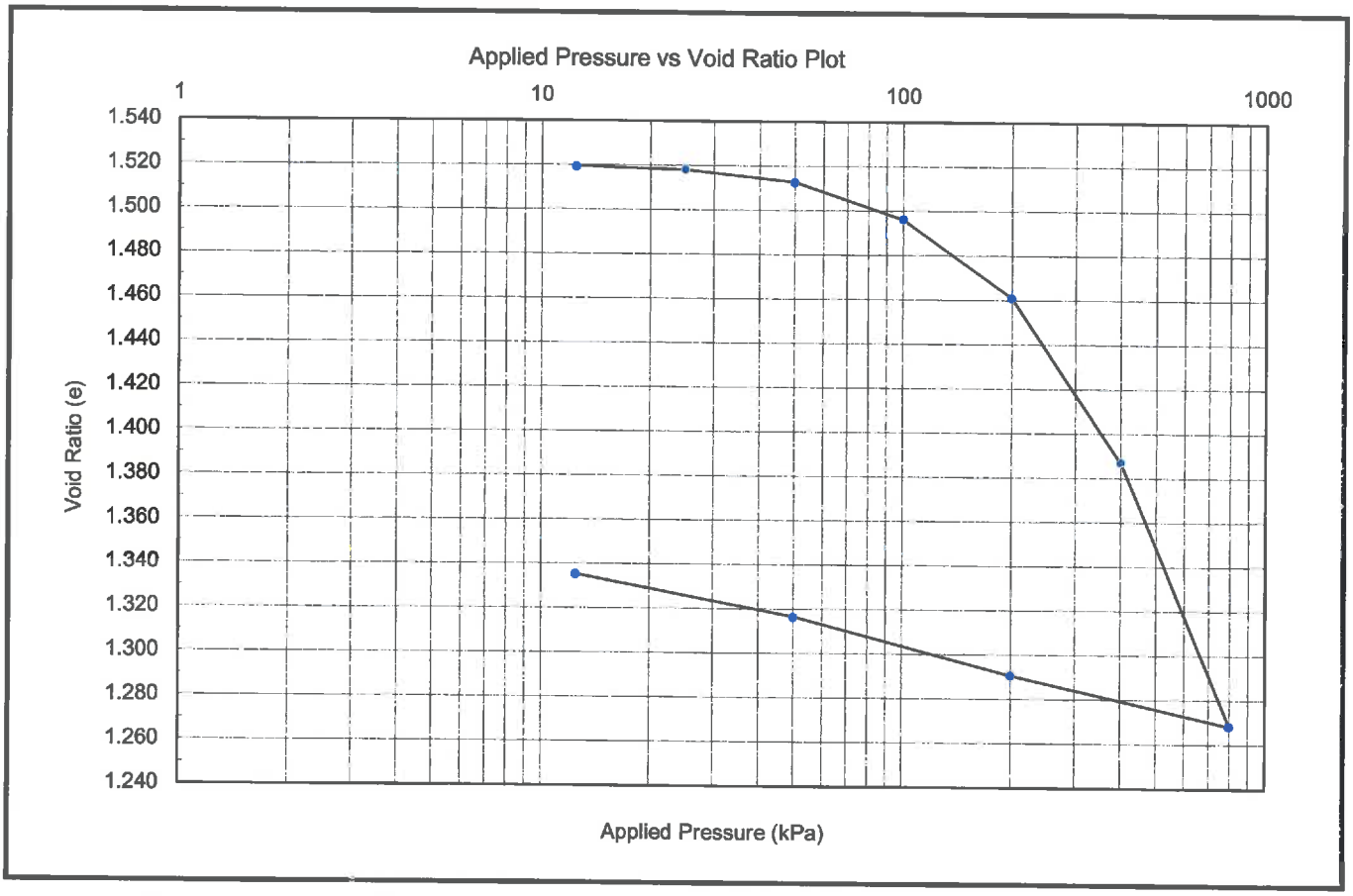
OPUS

Project :	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Subcontractor:	**Not Stated**
Sample reference:	**BH13/07, 3.0 - 3.5m**
Sampled by :	**Tom Van Deelen**
Date received :	**21/11/13**
Sample description :	**Grey; clayey SILT**

Specimen depth: **3.25 - 3.35 metres**
Date: **21/11/13**

Sampling method : **Push Tube**
Sample condition : **As received**
OEDOMETER APPARATUS No: S17D

Project No:	**1-C0935.25**
Lab Ref No:	**006b/13**
Client Ref:	**Tom Van Deelen**



Test Method:		Notes:
One Dimensional Consolidation Test:	NZS 4402:1986 Test 7.1	Load Increments applied at 2.02hr intervals
Water Content:	NZS 4402:1986 Test 2.1	Folder No: SEC13/AU/050

Date tested : 02-03/12/13
Date reported : 11/12/13

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IANZ Approved Signatory
Thirushen Pillay
Designation : *Senior Civil Engineering Technician*
Date : 11/12/13

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CSF 2120 (8/02)

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Result Summary

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/07**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; clayey SILT**
Comments:	**Multistage Test.**

Depth (m): **3.0 - 3.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**006a/13**
Client Ref No:	**Tom Van Deelen**

Result at Maximum Stress Ratio — **Back Pressure saturated at 400 kPa**

Specimen Stage No	Effective Confining Pressure (kPa)	INITIAL PROPERTIES Densities (t/m³) Wet (t/m³)	Dry (t/m³)	Water Content (%)	Solid Particle Density (t/m³)	FINAL PROPERTIES Densities (t/m³) Wet (t/m³)	Dry (t/m³)	Water Content (%)
1	75	1.70	1.12	51.3				
2	150				2.70 (assumed)			
3	300					1.80	1.20	49.7

Specimen Stage No	Effective Confining Pressure (kPa)	Void Ratio (e)	Deg of Saturation(Sr) Sr before Consolid. (%)	Sr after Consolid. (%)	Values at Maximum Stress Ratio s_1-s_3 (kPa)	m (kPa)	Strain (%)
1	75	1.40	99	100	154.4	36	3.41
2	150				239.4	67	2.82
3	300				338.9	134	2.58

Specimen Stage No	Effective Confining Pressure (kPa)	Coefficient *of* Consolidation Cv (m^2/year)	Volume Compressibility Mv (m^2/MN)	Coefficient *of* Permeability k (m/s)	B at the start of test	
1	75	4	0.20	2.7E-10		IANZ endorsement does not include the Cv, Mv and k values reported herein.
2	150	0.6	0.30	6.0E-11	95.00	Mv & Cv calculated for the following conditions:-
3	300	0.5	0.180	2.7E-11		L/D=2, RADIAL+TOP+BOTTOM Drainage Side Filter drains Used (L/D= Sample Length/Diameter.)

TOTAL STRESS RESULT			EFFECTIVE STRESS RESULT		
Intercept d	**37.06**	(kPa)	Intercept d'	**31.20**	(kPa)
Beta b	**15.97**	(deg)	Beta b'	**22.63**	(deg)
Cohesion c	**39**	(kPa)	Cohesion c'	**34**	(kPa)
Phi Æ	**17**	(deg)	Phi Æ '	**25**	(deg)
Correl coeff	**0.9894**	r^2	Correl coeff	**0.9943**	r^2

Test Methods		Notes:
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	Cv and Mv have been rounded to 2 significant figures. L/D= Sample Length/Diameter.

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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CSF 2130 (6/99)

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Mohr Coulomb Envelope Plot

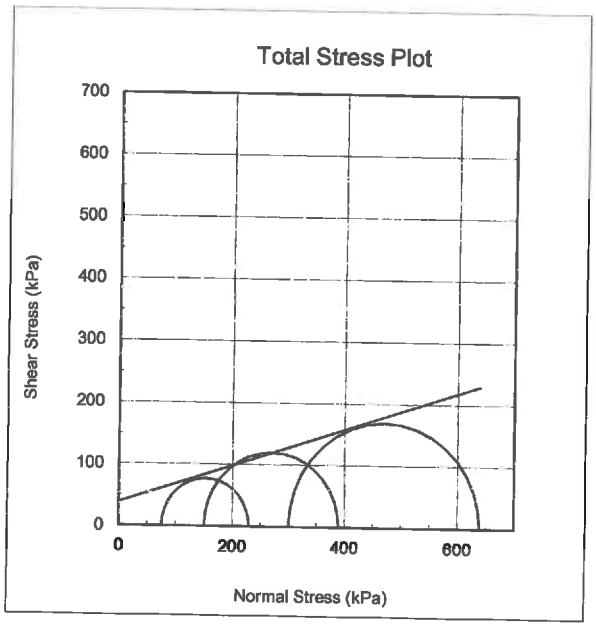
OPUS

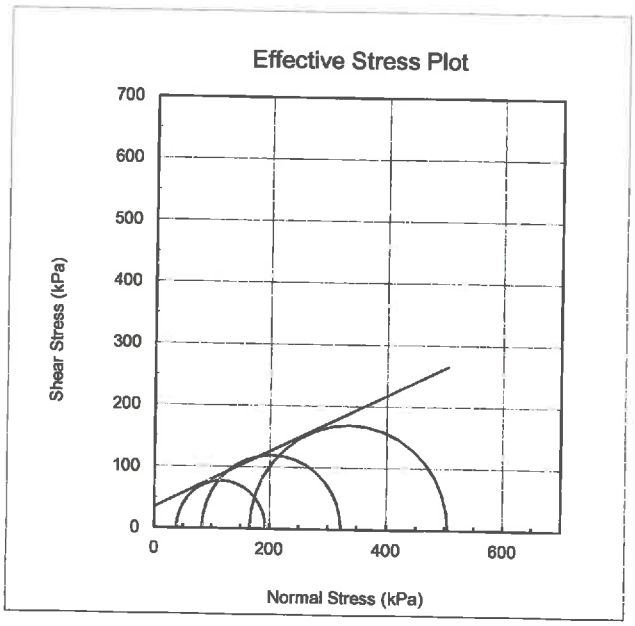
Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/07**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; clayey SILT**
Comments:	**Multistage Test.**

Depth (m): **3.0 - 3.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**006a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Mohr-Coulomb envelope plots Result at Maximum Stress Ratio
Back Pressure Saturated at 400 kPa





TOTAL STRESS RESULT		
Intercept d	**37.06**	(kPa)
Beta b	**15.97**	(deg)
Cohesion c	**39**	(kPa)
Phi Æ	**17**	(deg)
Correl coeff	**0.9894**	r^2

EFFECTIVE STRESS RESULT		
Intercept d'	**31.20**	(kPa)
Beta b'	**22.63**	(deg)
Cohesion c'	**34**	(kPa)
Phi Æ'	**25**	(deg)
Correl coeff	**0.9943**	r^2

Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

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IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P vs Q Total Stress Plot

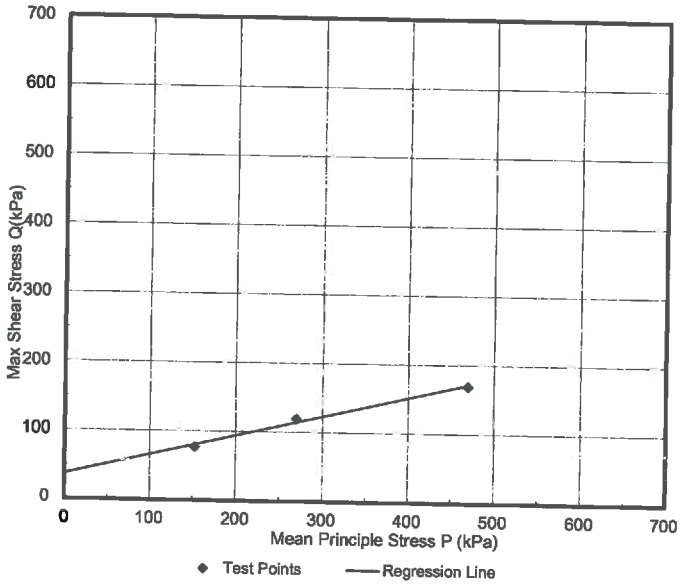
OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/07**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; clayey SILT**
Comments:	**Multistage Test.**

Depth (m): **3.0 - 3.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**006a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P vs Q Total Stress Plot- Back Pressure saturated at 400 kPa



TOTAL STRESS RESULT		
Intercept d	**37.06**	(kPa)
Beta b	**15.97**	(deg)
Correl coeff	**0.9894**	r^2
Cohesion c	**39**	(kPa)
Phi Æ	**17**	(deg)

Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13
Designation: Thirushen Pillay- Senior Civil Engineering Technician

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P' vs Q' Effective Stress Plot

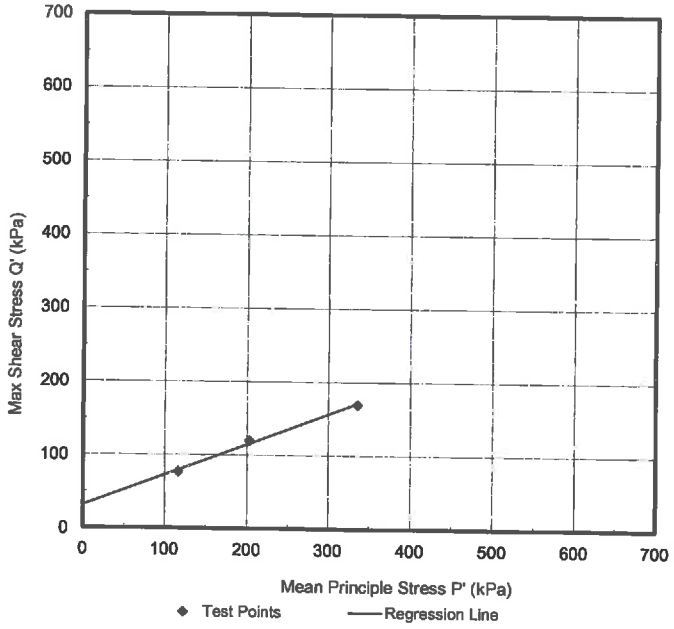
OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/07**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; clayey SILT**
Comments:	**Multistage Test.**

Depth (m): **3.0 - 3.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**006a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Effective Stress Plot-Back Pressure saturated at 400 kPa



EFFECTIVE STRESS RESULT		
Intercept d'	**31.20**	(kPa)
Beta b'	**22.63**	(deg)
Correl coeff	**0.9943**	r^2
Cohesion c'	**34**	(kPa)
Phi Æ'	**25**	(deg)

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

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IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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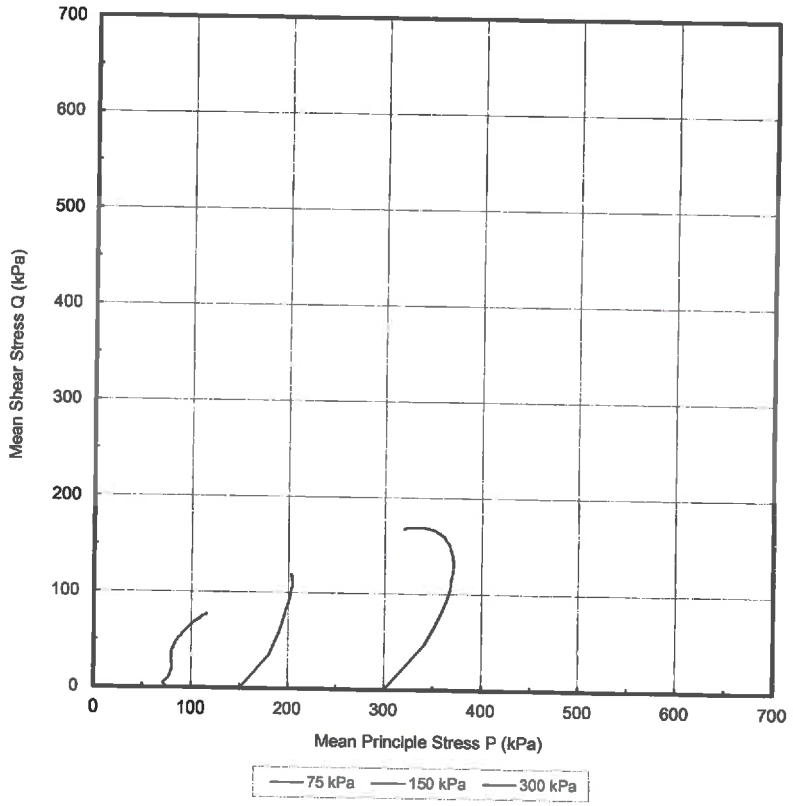
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - PvsQ Stress Path Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/07**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; clayey SILT**
Comments:	**Multistage Test.**

Depth (m): **3.0 - 3.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**006a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Stress Path (Effective Stress Plot) - Back Pressure saturated at 400 kPa



Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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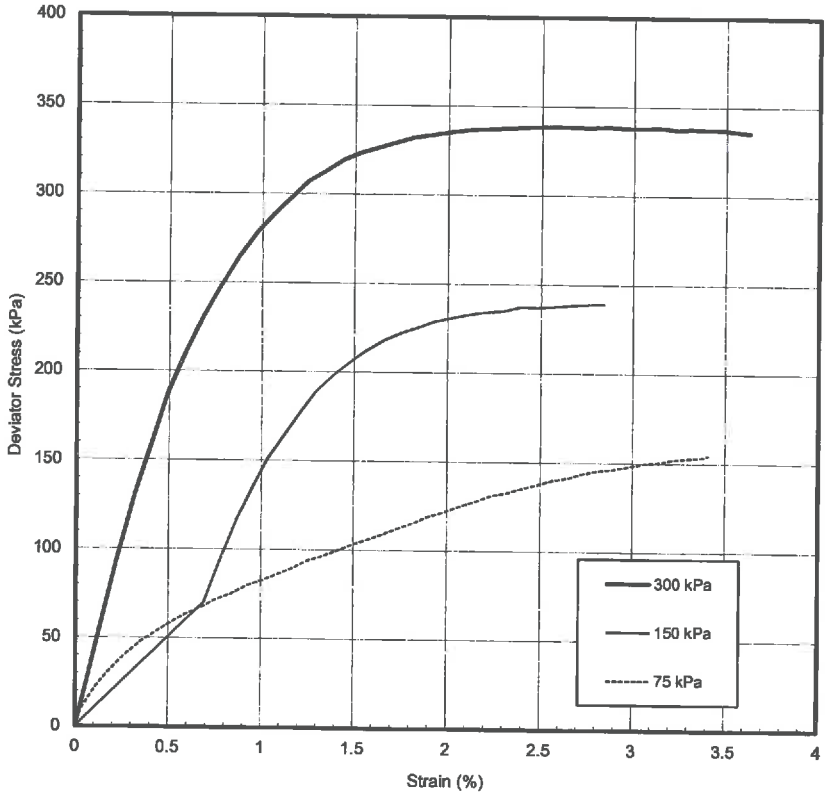
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Deviator StressPlot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/07**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Grey; clayey SILT**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**006a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Deviator Stress Plot- Back Pressure saturated at 400 kPa



Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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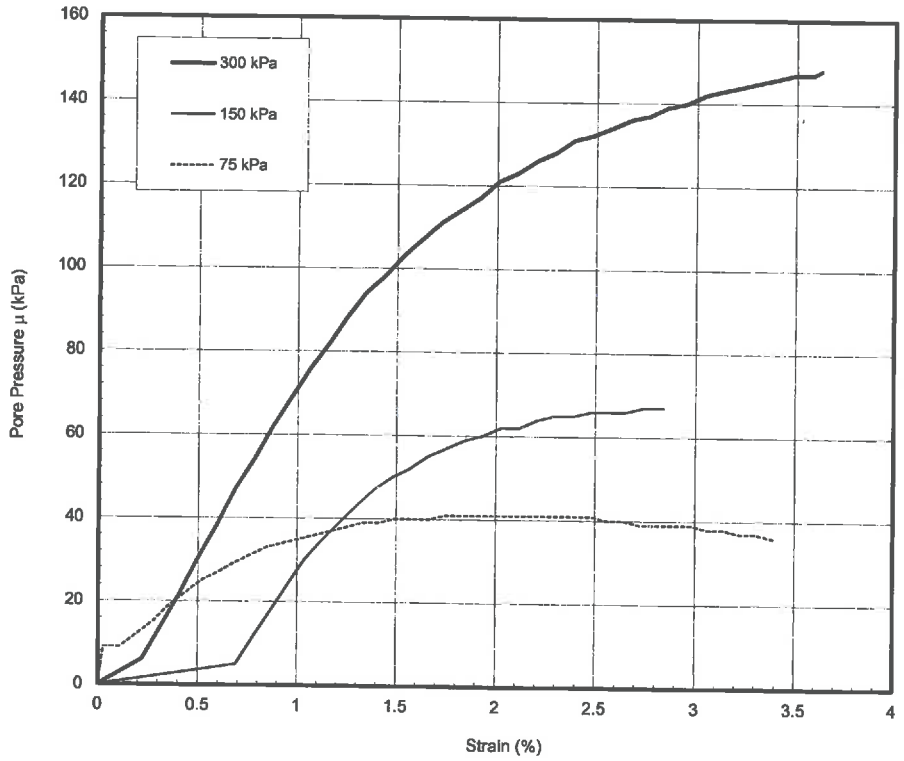
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Pore Pressure Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/07**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Grey; clayey SILT**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**006a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Pore Pressure Plot- Back Pressure saturated at 400 kPa



Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Displacement *vs* Öt Plot (Consolidation stage)

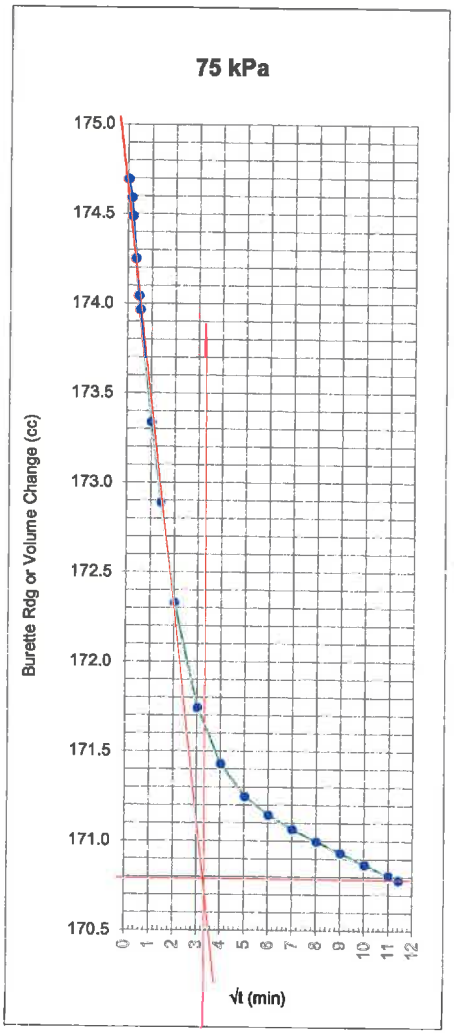
OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.35 - 3.5m**
Sample Reference:	**BH13/07**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; clayey SILT**
Comments:	**Multistage Test.**

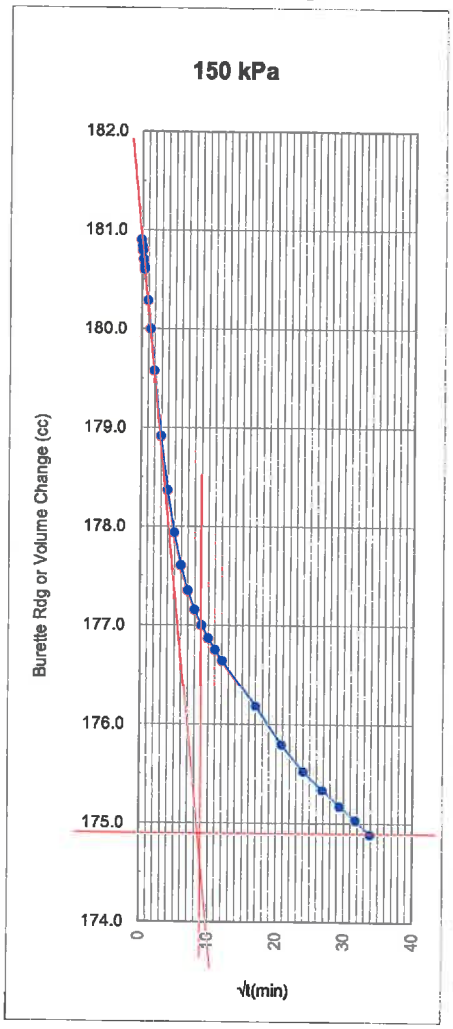
Depth (m): **3.0 - 3.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**006a/13**
Client Ref No:	**Tom Van Deelen**

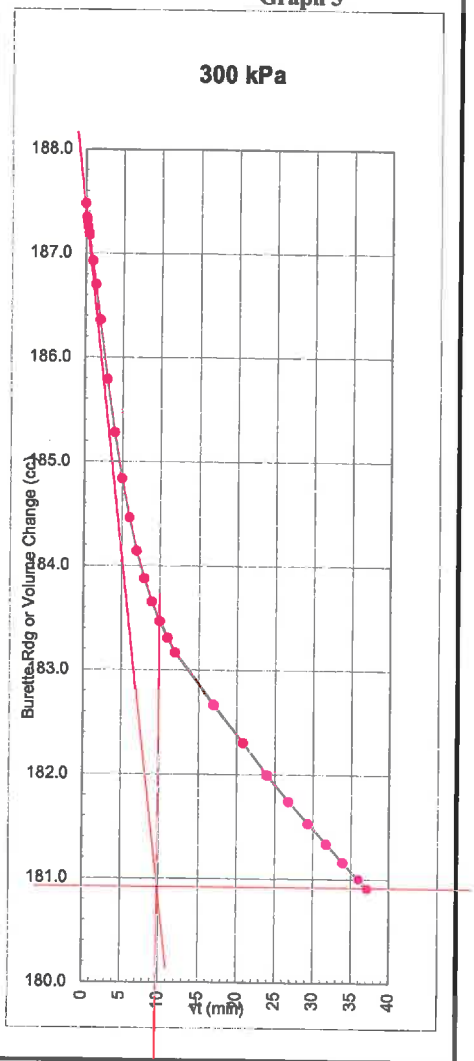
Graph 1



Graph 2



Graph 3



Test Methods		Result			
Triaxial Test	In House	**Confining Pressure (kPa)=**	**75**	**150**	**300**
Based On:	NZS 4402:1986 Test 6.2.1	**Cv (m^2/yr)=**	4.08	0.58	0.47
		Mv (m^2/MN)=	0.21	0.33	0.18
		k (m/s)=	2.68E-10	5.97E-11	2.70E-11
		t_{100}=	11.6	81.0	100.0

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

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IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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UNCONFINED COMPRESSIVE STRENGTH WITH YOUNG'S MODULUS

OPUS

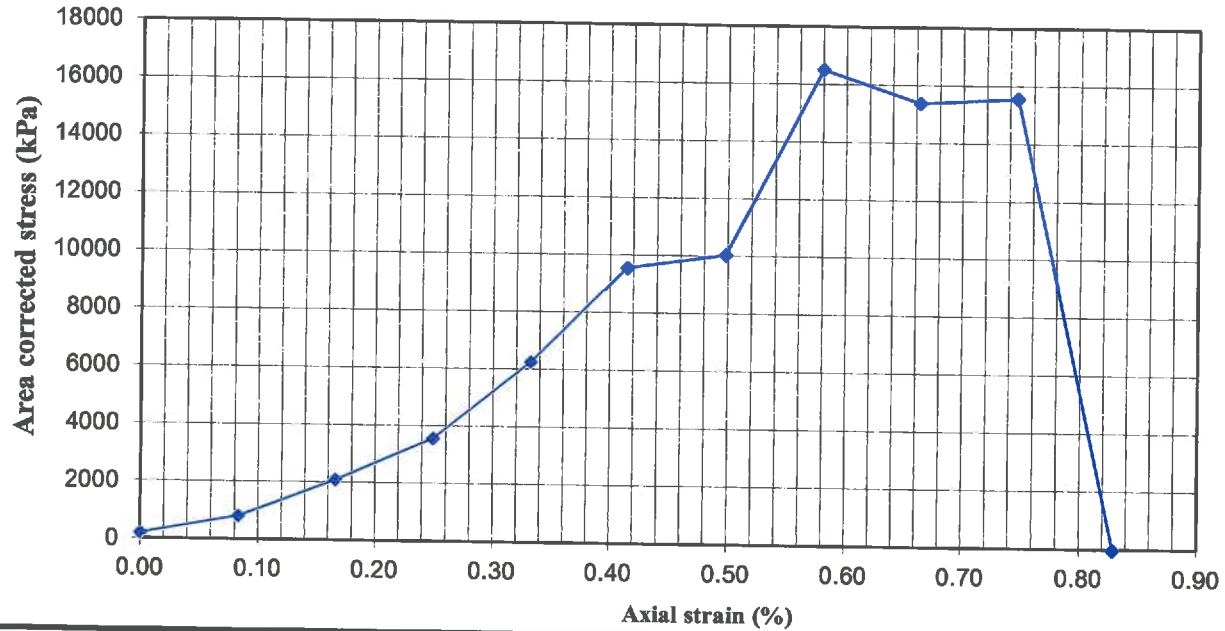
Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Sampled by:	**Opus - Tom Van Deelen**
Date sampled:	**21/11/13**
Sampling method:	**Not Stated**
Sample description:	**Weak Sandstone**
Sample condition:	**As received**
Sample reference:	**BH13/07**
Sample depth (m):	**6.15 - 6.30**

Project number:	**1-C0935.25**
Lab ref number:	**012/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test results

Bulk density (t/m³)	**2.05**	Initial sample diameter (mm)	**60.3**
Water content (%)	**17.6**	Initial sample length (mm)	**120.6**
Dry density (t/m³)	**1.75**	Initial sample area (mm²)	**2855.8**
Maximum stress (kPa)	**17000**	Initial Length:Diameter ratio	**2:1**
Strain at failure (%)	**0.58**	Young's modulus (MPa)	**7844**
Mode of failure:	**Sheared**	For strain range	**0.50 - 0.58%**

Area corrected Stress (kPa) Vs Axial strain (%)



Test Methods		Notes
UCS:	NZS 4402: 1986: Test 6.3.1	-Sample Descriptions are not covered by IANZ accreditation. -The strain rate for this test was kept constant at 0.1mm/min.

Tested by: AJ

Date tested: 22/11/13

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

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IANZ Approved Signatory Date : 09/12/13

Thirushen Pillay

Senior Civil Engineering Technician

IANZ ACCREDITED LABORATORY

Tests indicated as not accredited are outside the scope of the laboratory's accreditation

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PLASTICITY INDEX TEST REPORT

Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Sampled by:	**Tom Van Deelen**
Date sampled:	**21/11/13**
Sampling method:	**Pushtube**
Sample description:	**Brown; silty CLAY**
Sample condition:	**As received**
Sample reference:	**BH13/09**
Sample depth:	**3.0 - 3.5m**

Project number:	**1-C0935.25**
Lab ref number:	**007/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test Results

As rec'd water content:	**59.0%**
Liquid limit:	**73**
Plastic limit:	**40**
Plasticity Index:	**33**

Test methods		Notes
Water Content:	NZS 4402 : 1986, Test 2.1	Test performed on: Fraction passing 0.425mm test sieve
Liquid Limit:	NZS 4402 : 1986, Test 2.2	Sample descriptions are not covered by IANZ accreditation.
Plastic Limit:	NZS 4402 : 1986, Test 2.3	
Plasticity Index:	NZS 4402 : 1986, Test 2.4	

Date tested: 29/11/13 - 02/12/13
Date reported: 10/12/2013

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IANZ Approved Signatory
Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 10/12/2013

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ONE DIMENSIONAL CONSOLIDATION PROPERTIES
TEST RESULT REPORT

OPUS

Project :	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Subcontractor:	**Not Stated**
Sample reference:	**BH13/09, 3.0 - 3.5m**
Specimen depth:	**3.3 - 3.38 metres**
Sampled by :	**Tom Van Deelen**
Date:	**21/11/13**
Date received :	**21/11/13**
Sampling method :	**Push Tube**
Sample description :	**Brown; silty CLAY**
Sample condition :	**As received**

OEDOMETER APPARATUS No: S17D

Project No:	**1-C0935.25**
Lab Ref No:	**007b/13**
Client Ref:	**Tom Van Deelen**

SOIL PROPERTIES

Specimen Dimensions:	
Diameter (mm):	50.51
Initial height (mm):	19.76
Final height (mm):	17.07
Initial mass of sample (g):	59.81

Initial Wet Density	pbi (t/m³)	1.51
Initial Dry Density	pdi (t/m³)	0.97
Final Dry Density	pdf (t/m³)	1.12
Initial Void Ratio	eo	1.78
Final Void Ratio	ef	1.40
Initial Degree of Saturation	Si (%)	84
Final Degree of Saturation	Sf (%)	97
Solid Particle Density	*Gs (t/m³)	2.70
INITIAL Water Content	Wi (%)	55.7
FINAL Water Content	Wf (%)	50.4

*Gs is Assumed

CONSOLIDATION PROPERTIES

PRESSURE RANGE (kPa)	Pressure Increment (dp)	Void Ratio (e)	Intercept t90 (min)	Volume Compressibilty Mv=m²/MN	Coefficient of Consolidation Cv=m²/year	Coeff. of Permeability k=m/year	
0 - 12.5	12.5	1.771	-	-	-	-	
12.5 - 25	12.5	1.749	-	-	-	-	
25 - 50	25	1.728	0.81	0.3	52.0	0.15	
50 - 100	50	1.691	1.00	0.27	42.0	0.11	
100 - 200	100	1.620	1.00	0.26	41.0	0.11	
200 - 400	200	1.493	1.21	0.24	32.0	0.075	
400 - 800	400	1.337	2.25	0.16	15.0	0.024	
800 - 200	-	1.358	-	-	-	-	
200 - 50	-	1.383	-	-	-	-	
50 - 12.5	-	1.404	-	-	-	-	
-	-	-	-	-	-	-	
-	-	-	-	-	-	-	

Test Methods:		**Notes:**
One Dimensional Consolidation Test.	NZS 4402:1986 Test 7.1	Sample is saturated during test.
Water Content	NZS 4402:1986 Test 2.1	Load Increments applied at 1.667hr intervals
		Folder No: SEC13/AU/050

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Date tested : 28-29/11/13

Date reported : 12/12/13

IANZ Approved Signatory

Thirushen Pillay

Designation : *Senior Civil Engineering Technician*

Date : 12/12/13

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ONE DIMENSIONAL CONSOLIDATION PROPERTIES
Applied Pressure vs Void Ratio TEST REPORT

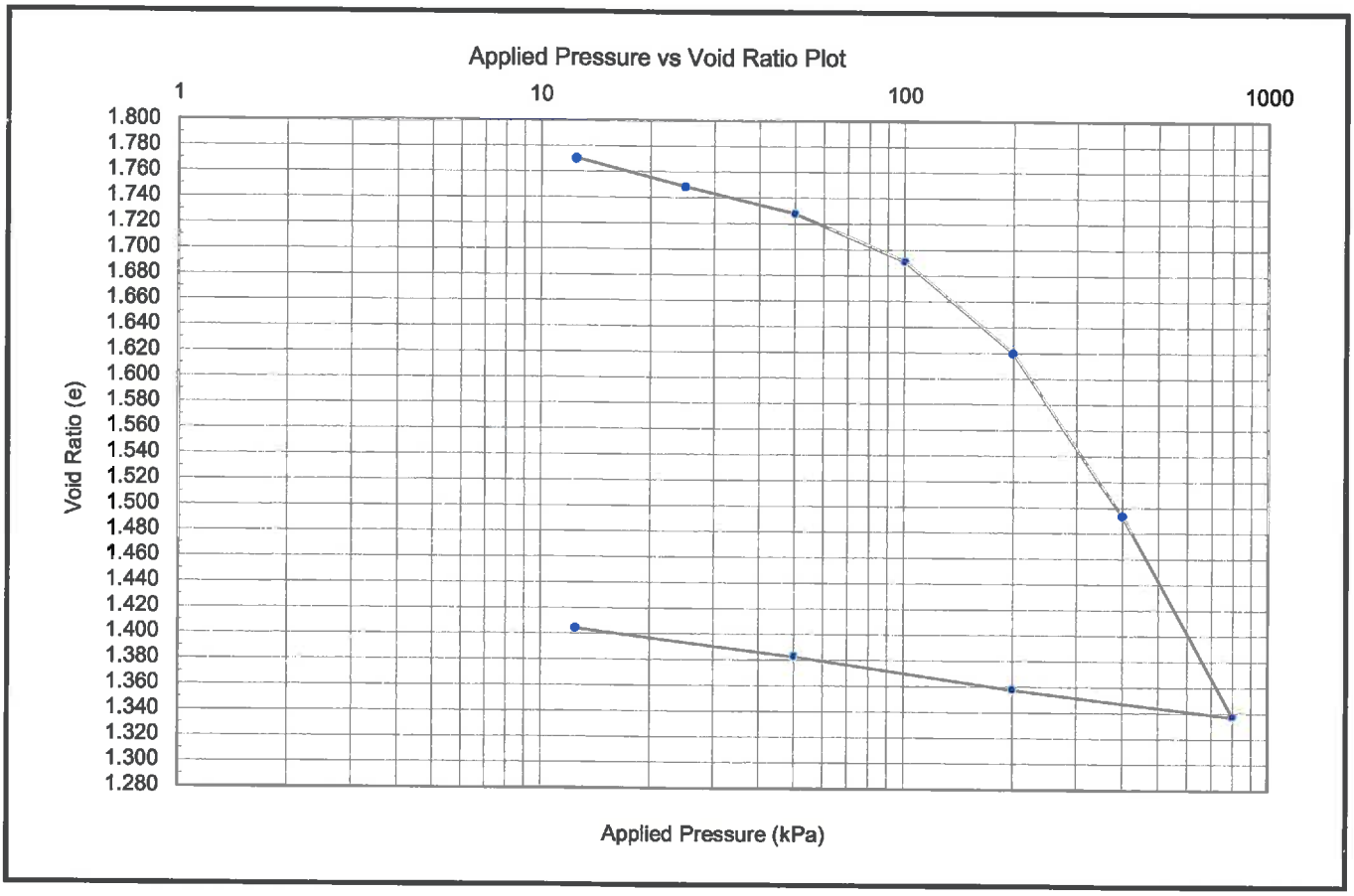
OPUS

Project :	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Subcontractor:	**Not Stated**
Sample reference:	**BH13/09, 3.0 - 3.5m**
Sampled by :	**Tom Van Deelen**
Date received :	**21/11/13**
Sample description :	**Brown; silty CLAY**

Specimen depth: **3.3 - 3.38 metres**
Date: **21/11/13**

Sampling method : **Push Tube**
Sample condition : **As received**
OEDOMETER APPARATUS No: S17D

Project No:	**1-C0935.25**
Lab Ref No:	**007b/13**
Client Ref:	**Tom Van Deelen**



Test Method:		Notes:
One Dimensional Consolidation Test:	NZS 4402:1986 Test 7.1	Load Increments applied at 1.667hr intervals
Water Content:	NZS 4402:1986 Test 2.1	Folder No: SEC13/AU/050

Date tested : 28-29/11/13
Date reported : 12/12/13

Testing is covered by IANZ Accreditation
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IANZ Approved Signatory
Thirushen Pillay
Designation : *Senior Civil Engineering Technician*
Date : 12/12/13

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Result Summary

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.38 - 3.5m**
Sample Reference:	**BH13/09**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Brown; silty CLAY**
Comments:	**Multistage Test.**

Depth (m): **3.0 - 3.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**007a/13**
Client Ref No:	**Tom Van Deelen**

Result at Maximum Stress Ratio — **Back Pressure saturated at 400 kPa**

Specimen Stage No	Effective Confining Pressure (kPa)	INITIAL PROPERTIES Densities (t/m³) Wet (t/m³)	Dry (t/m³)	Water Content (%)	Solid Particle Density (t/m³)	FINAL PROPERTIES Densities (t/m³) Wet (t/m³)	Dry (t/m³)	Water Content (%)
1	75	1.64	1.03	59.3				
2	150				2.70 (assumed)			
3	300					1.72	1.12	53.0

Specimen Stage No	Effective Confining Pressure (kPa)	Void Ratio (e)	Deg of Saturation(Sr) Sr before Consolid. (%)	Sr after Consolid. (%)	Values at Maximum Stress Ratio s_1-s_3 (kPa)	m (kPa)	Strain (%)
1	75	1.62	99	100	77.0	31	2.16
2	150				111.5	76	2.25
3	300				190.9	180	4.60

Specimen Stage No	Effective Confining Pressure (kPa)	Coefficient *of* Consolidation Cv (m²/year)	Volume Compressibility Mv (m²/MN)	Coefficient *of* Permeability k (m/s)	B at the start of test
1	75	1	0.20	8.6E-11	
2	150	0.6	0.30	6.2E-11	100.00
3	300	0.3	0.300	2.5E-11	

IANZ endorsement does not include the Cv, Mv and k values reported herein.
Mv & Cv calculated for the following conditions:-
L/D=2, RADIAL+TOP+BOTTOM Drainage
Side Filter drains Used
(L/D= Sample Length/Diameter.)

TOTAL STRESS RESULT				EFFECTIVE STRESS RESULT			
Intercept d	**14.86**	(kPa)		Intercept d'	**1.56**	(kPa)	
Beta b	**11.48**	(deg)		Beta b'	**23.39**	(deg)	
Cohesion c	**15**	(kPa)		Cohesion c'	**2**	(kPa)	
Phi Æ	**12**	(deg)		Phi Æ '	**26**	(deg)	
Correl coeff	**0.9993**	r^2		Correl coeff	**0.9966**	r^2	

Test Methods		Notes:
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	Cv and Mv have been rounded to 2 significant figures. L/D= Sample Length/Diameter.

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Mohr Coulomb Envelope Plot

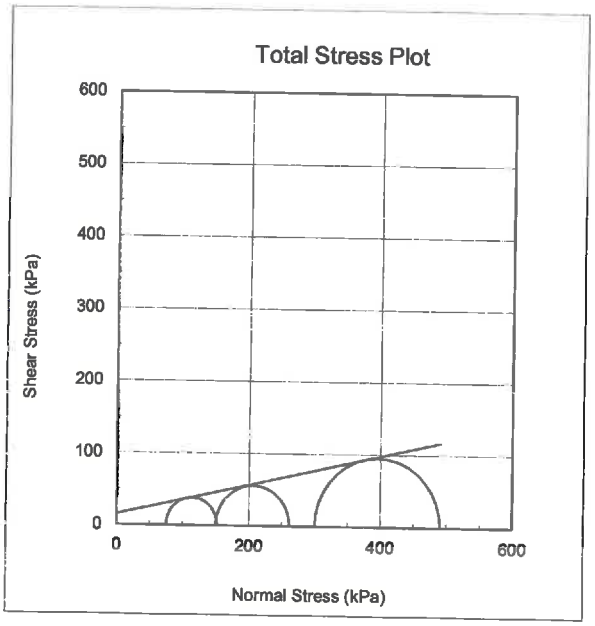
OPUS

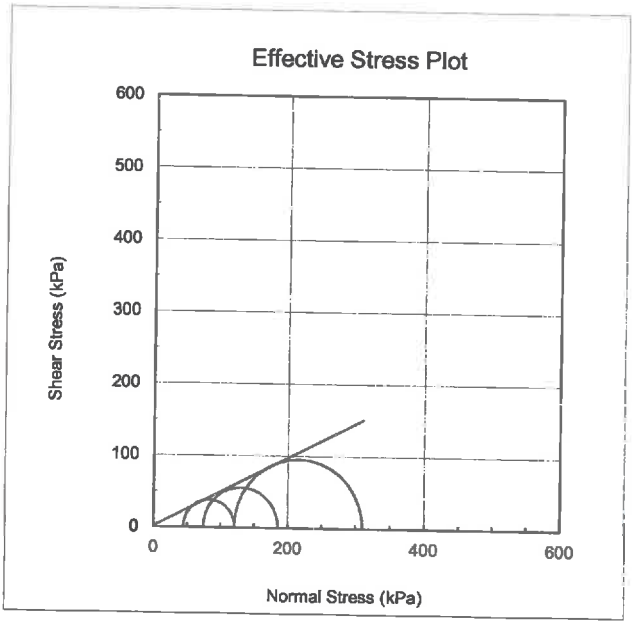
Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.38 - 3.5m**
Sample Reference:	**BH13/09**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Brown; silty CLAY**
Comments:	**Multistage Test.**

Depth (m): **3.0 - 3.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**007a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Mohr-Coulomb envelope plots Result at Maximum Stress Ratio
Back Pressure Saturated at 400 kPa





TOTAL STRESS RESULT		
Intercept d	**14.86**	(kPa)
Beta b	**11.48**	(deg)
Cohesion c	**15**	(kPa)
Phi Æ	**12**	(deg)
Correl coeff	**0.9993**	r^2

EFFECTIVE STRESS RESULT		
Intercept d'	**1.56**	(kPa)
Beta b'	**23.39**	(deg)
Cohesion c'	**2**	(kPa)
Phi Æ '	**26**	(deg)
Correl coeff	**0.9966**	r^2

Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

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IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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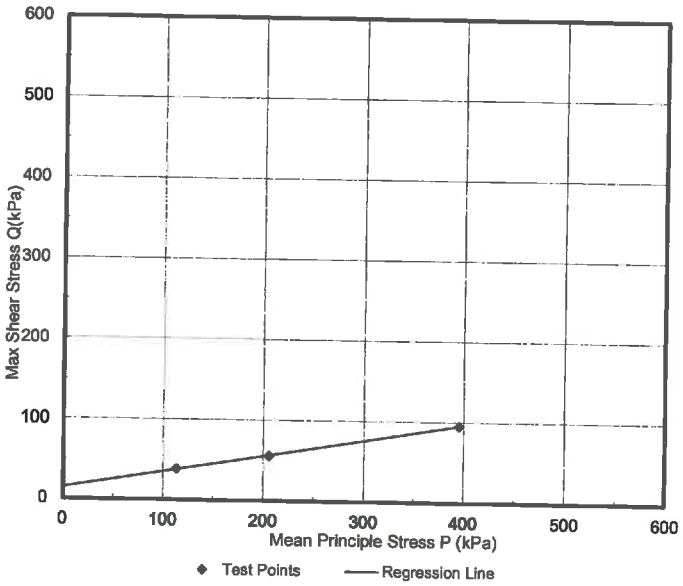
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P vs Q Total Stress Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.38 - 3.5m**
Sample Reference:	**BH13/09**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Brown; silty CLAY**
Comments:	**Multistage Test.**

Depth (m): **3.0 - 3.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**007a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P vs Q Total Stress Plot- Back Pressure saturated at 400 kPa



TOTAL STRESS RESULT		
Intercept d	**14.86**	(kPa)
Beta b	**11.48**	(deg)
Correl coeff	**0.9993**	r^2
Cohesion c	**15**	(kPa)
Phi Æ	**12**	(deg)

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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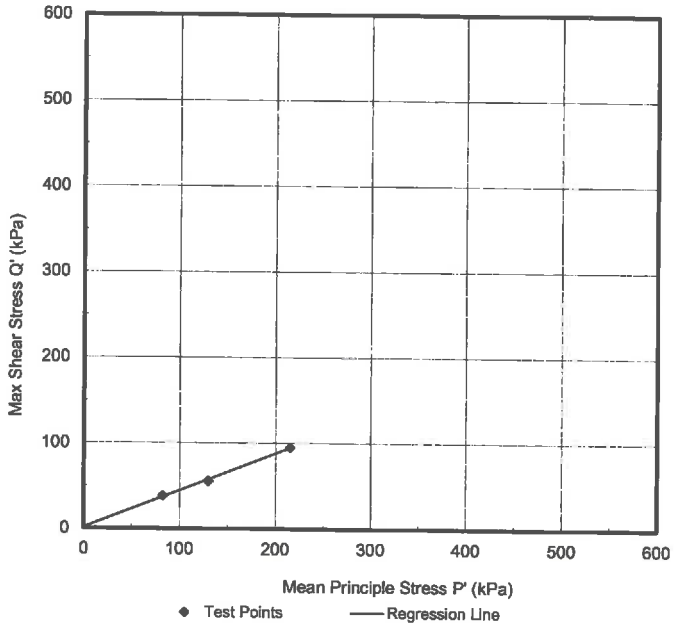
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P' vs Q' Effective Stress Plot

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.38 - 3.5m**
Sample Reference:	**BH13/09**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; silty CLAY**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**007a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Effective Stress Plot-Back Pressure saturated at 400 kPa



EFFECTIVE STRESS RESULT		
Intercept d'	**1.56**	(kPa)
Beta b'	**23.39**	(deg)
Correl coeff	**0.9966**	r^2
Cohesion c'	**2**	(kPa)
Phi Æ'	**26**	(deg)

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

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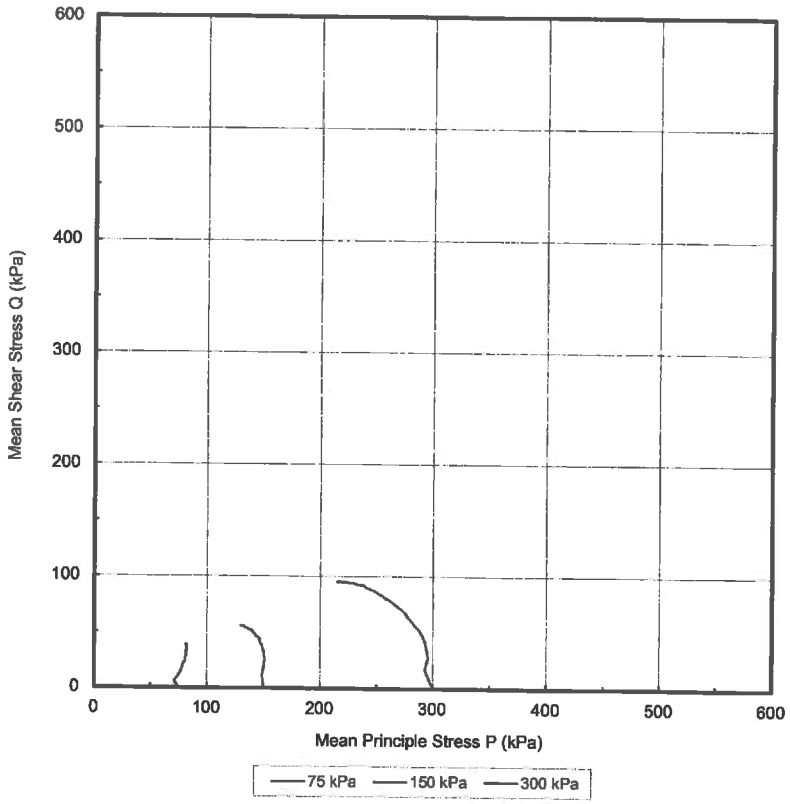
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - PvsQ Stress Path Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.38 - 3.5m**
Sample Reference:	**BH13/09**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; silty CLAY**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**007a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Stress Path (Effective Stress Plot) - Back Pressure saturated at 400 kPa



Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

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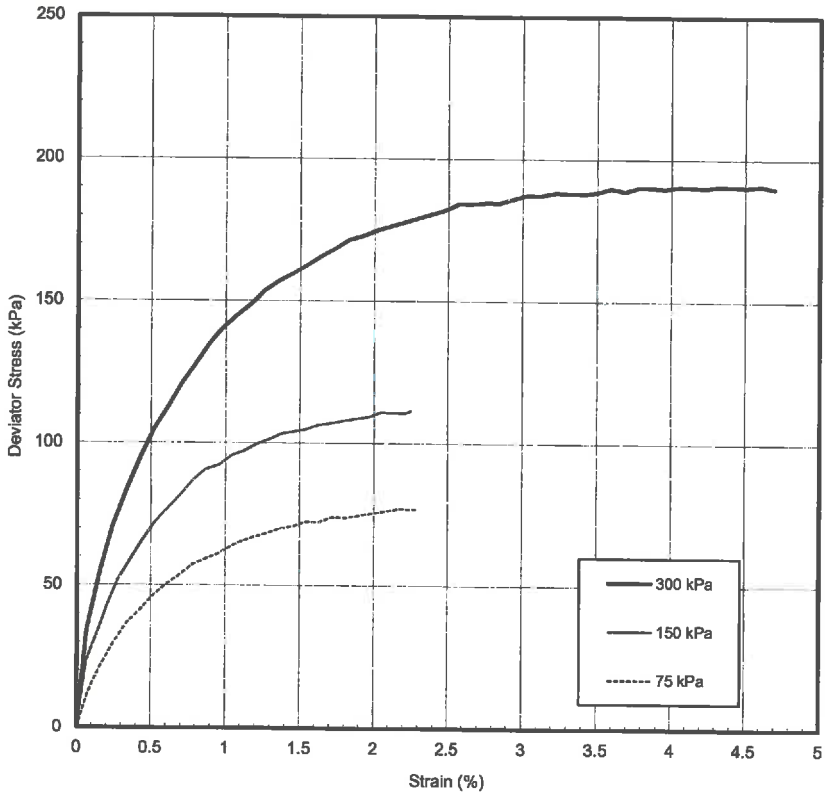
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Deviator StressPlot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.38 - 3.5m**
Sample Reference:	**BH13/09**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; silty CLAY**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**007a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Deviator Stress Plot- Back Pressure saturated at 400 kPa



Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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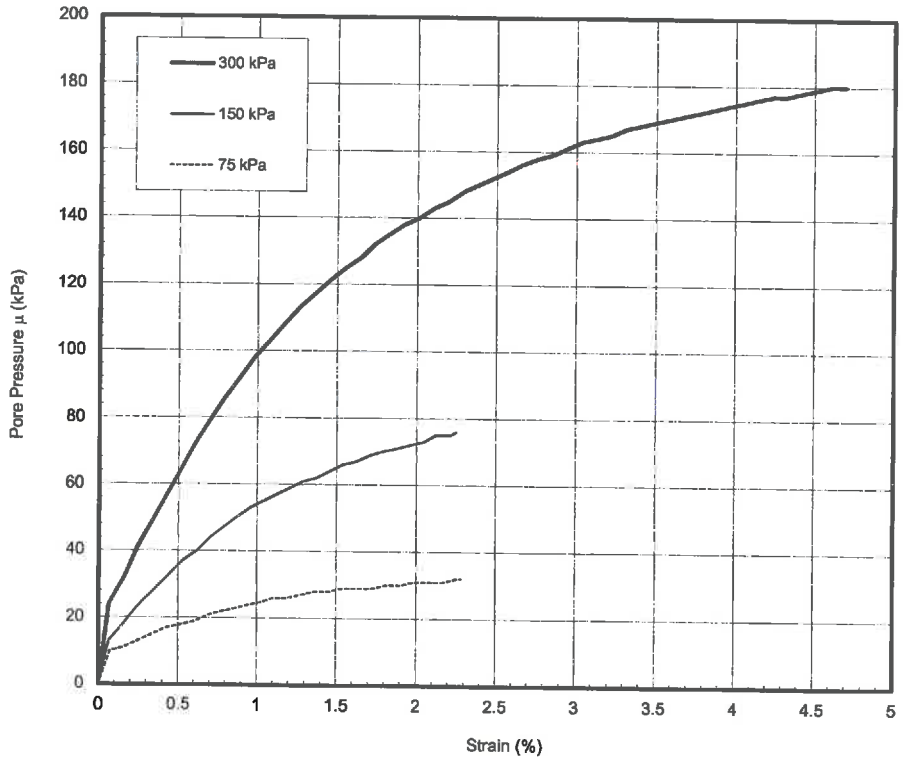
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Pore Pressure Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.38 - 3.5m**
Sample Reference:	**BH13/09**
Depth (m):	**3.0 - 3.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Brown; silty CLAY**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**007a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Pore Pressure Plot- Back Pressure saturated at 400 kPa



Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

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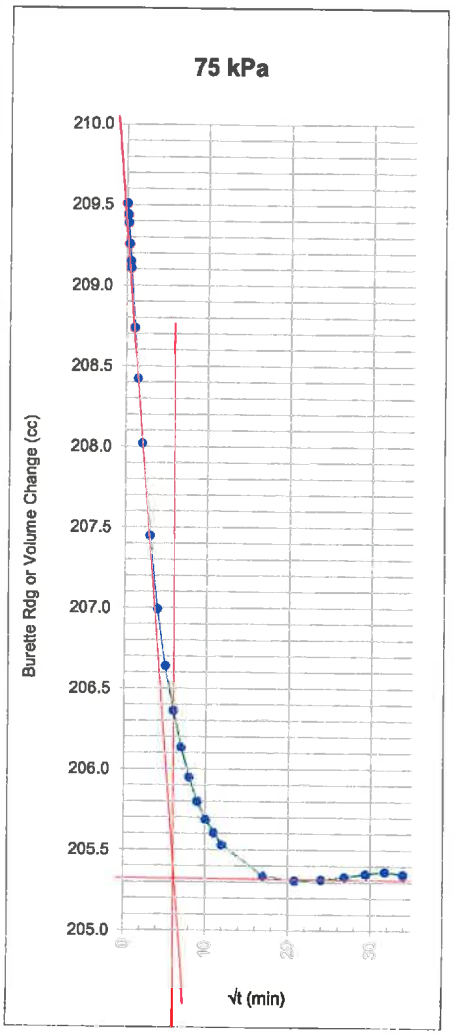
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Displacement vs Öt Plot (Consolidation stage)

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**3.38 - 3.5m**
Sample Reference:	**BH13/09**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Brown; silty CLAY**
Comments:	**Multistage Test.**

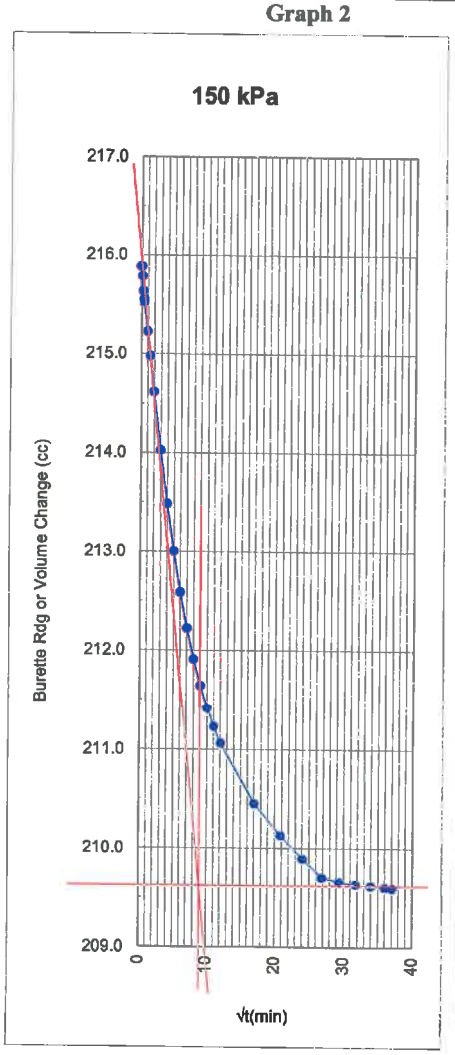
Depth (m): **3.0 - 3.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**007a/13**
Client Ref No:	**Tom Van Deelen**

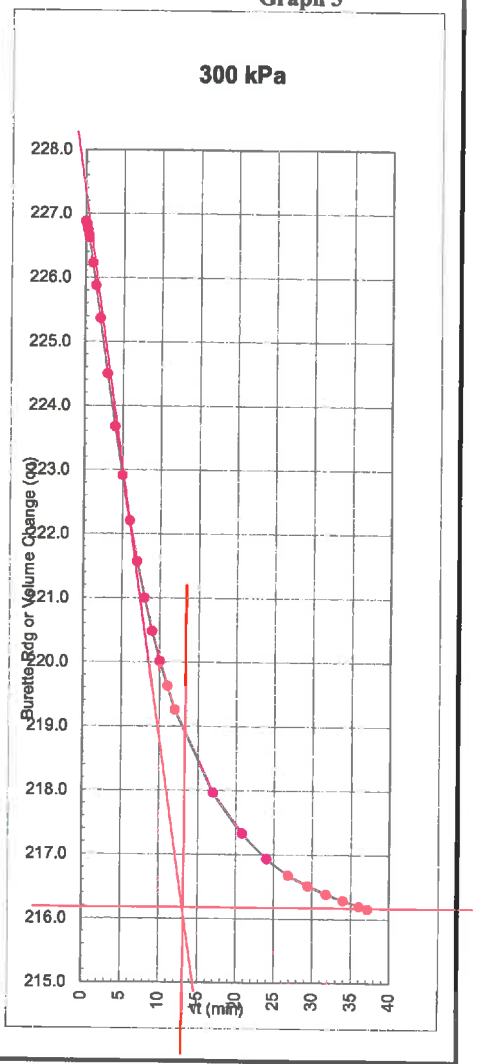
Graph 1



Graph 2



Graph 3



Test Methods	
Triaxial Test	In House
Based On:	NZS 4402:1986 Test 6.2.1

Result

Confining Pressure (kPa)=	75	150	300
Cv (m^2/yr)=	1.24	0.59	0.27
Mv (m^2/MN)=	0.23	0.34	0.30
k (m/s)=	8.64E-11	6.25E-11	2.53E-11
t_{100}=	38.4	81.0	174.2

Date Tested: 26/11/13 - 04/12/13

Date Reported: 10/12/13

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IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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PLASTICITY INDEX TEST REPORT

OPUS

Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Sampled by:	**Tom Van Deelen**
Sampling method:	**Pushtube**
Sample description:	**Grey; siltstone**
Sample condition:	**As received**
Sample reference:	**BH13/09**
Sample depth:	**6.0 - 6.5m**

Date sampled: **21/11/13**

Project number:	**1-C0935.25**
Lab ref number:	**008/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test Results

As rec'd water content:	**41.6%**
Liquid limit:	**58**
Plastic limit:	**36**
Plasticity Index:	**22**

Test methods		Notes
Water Content:	NZS 4402 : 1986, Test 2.1	Test performed on: Fraction passing 0.425mm test sieve
Liquid Limit:	NZS 4402 : 1986, Test 2.2	Sample descriptions are not covered by IANZ accreditation.
Plastic Limit:	NZS 4402 : 1986, Test 2.3	
Plasticity Index:	NZS 4402 : 1986, Test 2.4	

Date tested: 29/11/13
Date reported: 10/12/2013

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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IANZ Approved Signatory
Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 10/12/2013

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ONE DIMENSIONAL CONSOLIDATION PROPERTIES
TEST RESULT REPORT

OPUS

Project :	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Subcontractor:	**Not Stated**
Sample reference:	**BH13/09, 6.0 - 6.5m**
Specimen depth:	**6.3 - 6.35 metres**
Sampled by :	**Tom Van Deelen**
Date:	**21/11/13**
Date received :	**21/11/13**
Sampling method :	**Push Tube**
Sample description :	**Grey; Siltstone**
Sample condition :	**As received**
OEDOMETER APPARATUS No:	S17C

Project No:	**1-C0935.25**
Lab Ref No:	**008b/13**
Folder No:	**SEC13/AU/050**

SOIL PROPERTIES

Specimen Dimensions:	
Diameter (mm):	50.53
Initial height (mm):	16.08
Final height (mm):	14.87
Initial mass of sample (g):	54.15

Initial Wet Density	pbi (t/m³)	1.68
Initial Dry Density	pdi (t/m³)	1.20
Final Dry Density	pdf (t/m³)	1.30
Initial Void Ratio	eo	1.25
Final Void Ratio	ef	1.08
Initial Degree of Saturation	Si (%)	86
Final Degree of Saturation	Sf (%)	100
Solid Particle Density	*Gs (t/m³)	2.70
INITIAL Water Content	Wi (%)	40.1
FINAL Water Content	Wf (%)	40.9

*Gs is Assumed

CONSOLIDATION PROPERTIES

PRESSURE RANGE (kPa)	Pressure Increment (dp)	Void Ratio (e)	Intercept t90 (min)	Volume Compressibilty Mv=m²/MN	Coefficient of Consolidation Cv=m²/year	Coeff. of Permeability k=m/year	
0 - 12.5	12.5	1.242	1.21	-	-	-	
12.5 - 25	12.5	1.225	0.30	0.59	94.0	0.54	
25 - 50	25	1.212	1.69	0.25	17.0	0.041	
50 - 100	50	1.190	1.44	0.2	19.0	0.037	
100 - 200	100	1.161	0.77	0.13	35.0	0.045	
200 - 400	200	1.118	0.69	0.1	38.0	0.038	
400 - 800	400	1.039	1.00	0.093	25.0	0.023	
800 - 200	-	1.055	-	-	-	-	
200 - 50	-	1.072	-	-	-	-	
50 - 12.5	-	1.084	-	-	-	-	
-	-	-	-	-	-	-	
-	-	-	-	-	-	-	

Test Methods:		**Notes:**
One Dimensional Consolidation Test.	NZS 4402:1986 Test 7.1	Sample is saturated during test.
Water Content	NZS 4402:1986 Test 2.1	Load Increments applied at 1.66hr intervals

Testing is covered by IANZ Accreditation

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Date tested : 28 - 29/11/13

Date reported : 11/12/13

IANZ Approved Signatory

Thirushen Pillay

Designation : *Senior Civil Engineering Technician*

Date : 11/12/13

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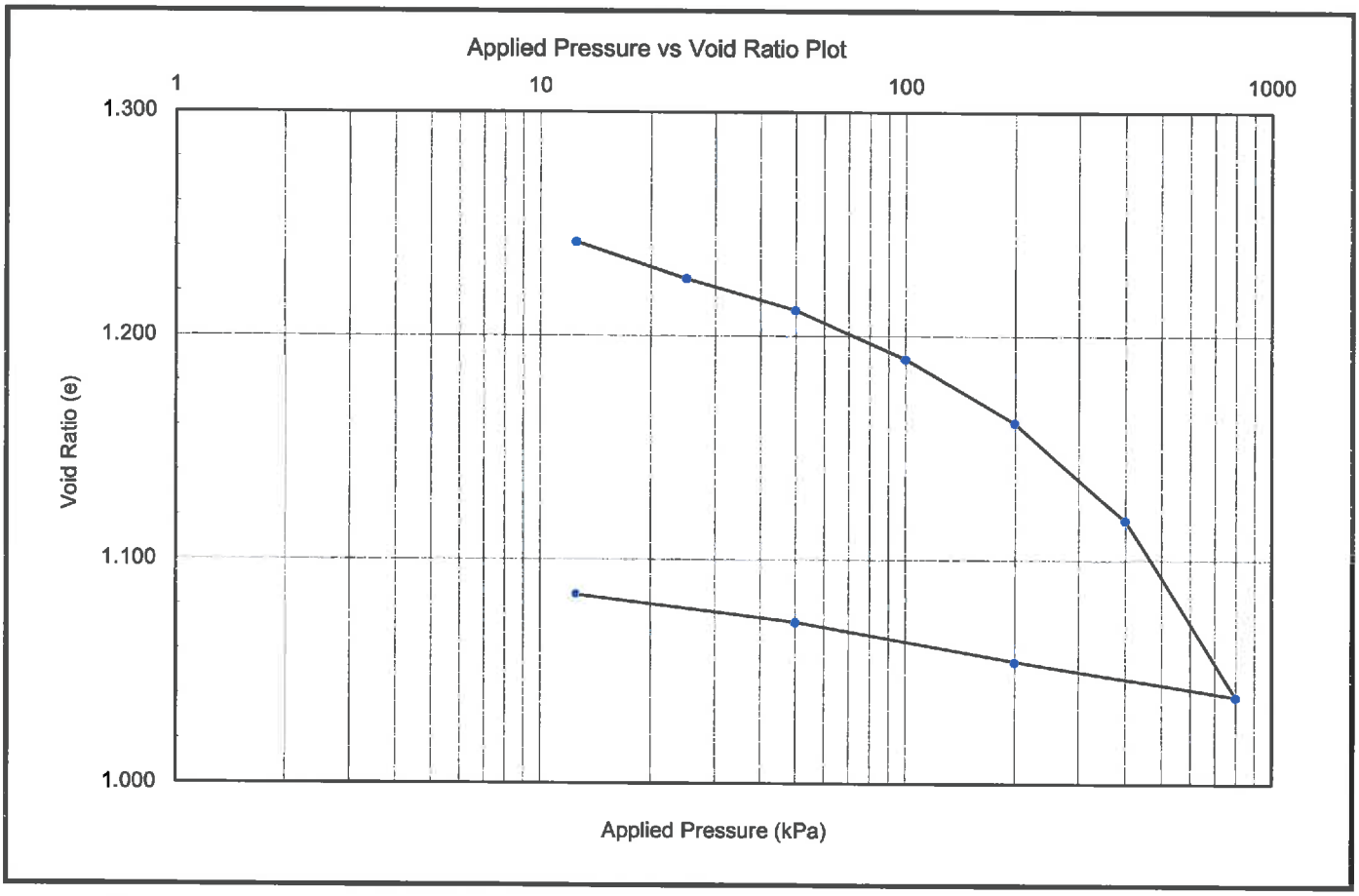
ONE DIMENSIONAL CONSOLIDATION PROPERTIES
Applied Pressure vs Void Ratio TEST REPORT

OPUS

Project :	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Subcontractor:	**Not Stated**
Sample reference:	**BH13/09, 6.0 - 6.5m**
Specimen depth:	**6.3 - 6.35 metres**
Sampled by :	**Tom Van Deelen**
Date:	**21/11/13**
Date received :	**21/11/13**
Sample description :	**Grey; Siltstone**

Sampling method : **Push Tube**
Sample condition : **As received**
OEDOMETER APPARATUS No: S17C

Project No:	**1-C0935.25**
Lab Ref No:	**008b/13**
Folder No:	**SEC13/AU/050**



Test Method:		Notes:
One Dimensional Consolidation Test:	NZS 4402:1986 Test 7.1	Load Increments applied at 1.66hr intervals
Water Content:	NZS 4402:1986 Test 2.1	

Date tested : 28 - 29/11/13
Date reported : 11/12/13

Testing is covered by IANZ Accreditation
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IANZ Approved Signatory
Thirushen Pillay
Designation : *Senior Civil Engineering Technician*
Date : 11/12/13

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Result Summary

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/09**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; siltstone**
Comments:	**Multistage Test.**

Depth (m): **6.0 - 6.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**008a/13**
Client Ref No:	**Tom Van Deelen**

Result at Maximum Stress Ratio — **Back Pressure saturated at 350 kPa**

Specimen Stage No	Effective Confining Pressure (kPa)	INITIAL PROPERTIES Densities (t/m³) Wet (t/m³)	INITIAL PROPERTIES Densities (t/m³) Dry (t/m³)	INITIAL PROPERTIES Water Content (%)	Solid Particle Density (t/m³)	FINAL PROPERTIES Densities (t/m³) Wet (t/m³)	FINAL PROPERTIES Densities (t/m³) Dry (t/m³)	FINAL PROPERTIES Water Content (%)
1	75	1.80	1.31	37.8				
2	150				2.70 (assumed)			
3	300					1.89	1.36	39.0

Specimen Stage No	Effective Confining Pressure (kPa)	Void Ratio (e)	Deg of Saturation(Sr) Sr before Consolid. (%)	Deg of Saturation(Sr) Sr after Consolid. (%)	Values at Maximum Stress Ratio s_1-s_3 (kPa)	Values at Maximum Stress Ratio m (kPa)	Values at Maximum Stress Ratio Strain (%)
1	75	1.06	96	100	263.3	7	3.25
2	150				370.9	40	2.18
3	300				439.1	50	2.21

Specimen Stage No	Effective Confining Pressure (kPa)	Coefficient *of* Consolidation Cv (m^2/year)	Volume Compressibility Mv (m^2/MN)	Coefficient *of* Permeability k (m/s)	B at the start of test
1	75	5	0.20	3.4E-10	
2	150	4.7	0.10	2.0E-10	96.00
3	300	6.6	0.080	1.7E-10	

IANZ endorsement does not include the Cv, Mv and k values reported herein.
Mv & Cv calculated for the following conditions:-
L/D=2, RADIAL+TOP+BOTTOM Drainage
Side Filter drains Used
(L/D= Sample Length/Diameter.)

TOTAL STRESS RESULT				EFFECTIVE STRESS RESULT			
Intercept d	**81.79**	(kPa)		Intercept d'	**79.23**	(kPa)	
Beta b	**15.34**	(deg)		Beta b'	**17.22**	(deg)	
Cohesion c	**85**	(kPa)		Cohesion c'	**83**	(kPa)	
Phi Æ	**16**	(deg)		Phi Æ'	**18**	(deg)	
Correl coeff	**0.9477**	r^2		Correl coeff	**0.9155**	r^2	

Test Methods		Notes:
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	Cv and Mv have been rounded to 2 significant figures. L/D= Sample Length/Diameter.

Date Tested: 26/11/13 - 29/11/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Mohr Coulomb Envelope Plot

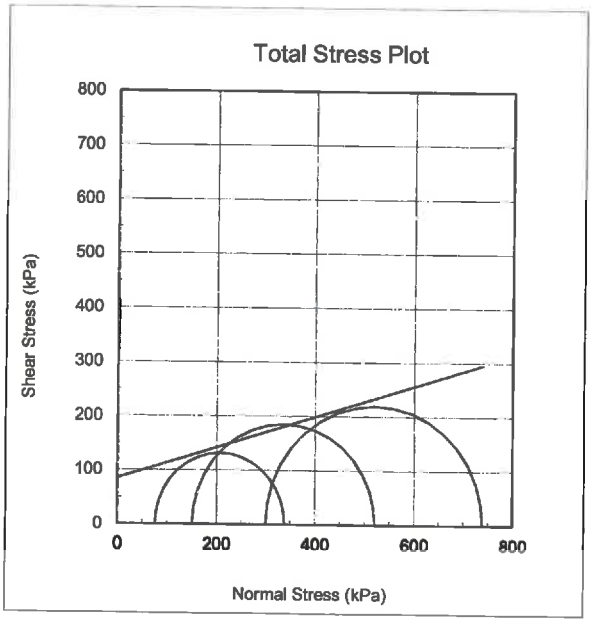
OPUS

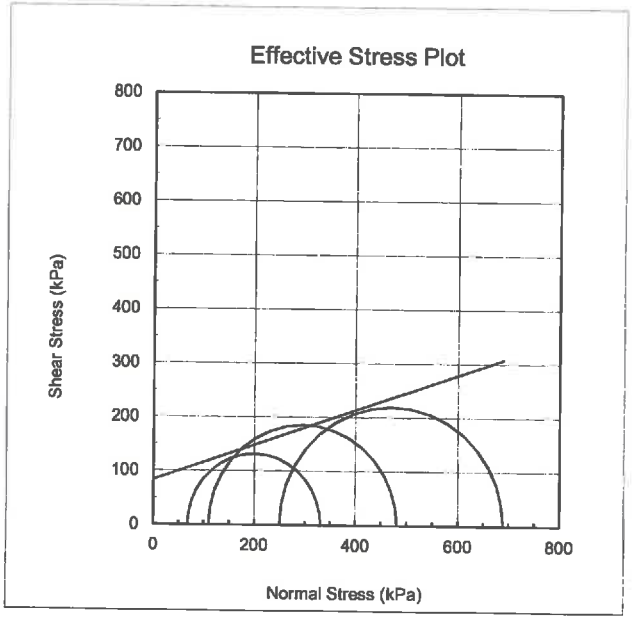
Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/09**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; siltstone**
Comments:	**Multistage Test.**

Depth (m): **6.0 - 6.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**008a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Mohr-Coulomb envelope plots Result at Maximum Stress Ratio
Back Pressure Saturated at 350 kPa





TOTAL STRESS RESULT		
Intercept d	**81.79**	(kPa)
Beta b	**15.34**	(deg)
Cohesion c	**85**	(kPa)
Phi Æ	**16**	(deg)
Correl coeff	**0.9477**	r^2

EFFECTIVE STRESS RESULT		
Intercept d'	**79.23**	(kPa)
Beta b'	**17.22**	(deg)
Cohesion c'	**83**	(kPa)
Phi Æ'	**18**	(deg)
Correl coeff	**0.9155**	r^2

Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 29/11/13

Date Reported: 10/12/13

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IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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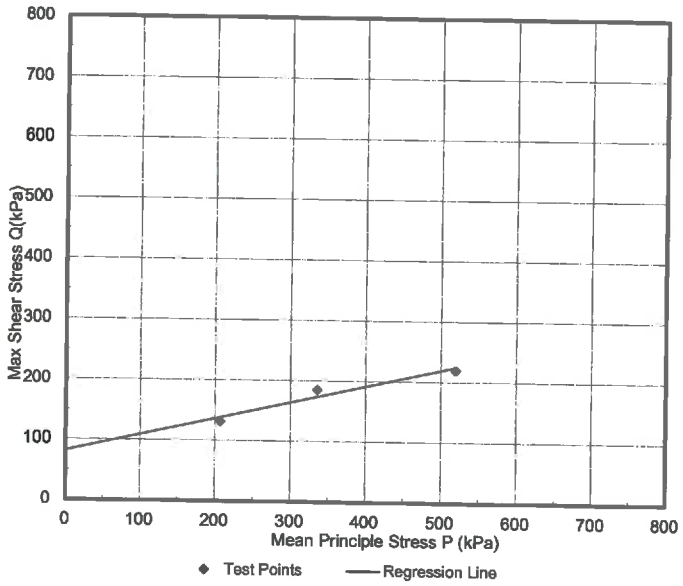
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P vs Q Total Stress Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/09**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; siltstone**
Comments:	**Multistage Test.**

Depth (m): **6.0 - 6.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**008a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P vs Q Total Stress Plot- Back Pressure saturated at 350 kPa



TOTAL STRESS RESULT		
Intercept d	**81.79**	(kPa)
Beta b	**15.34**	(deg)
Correl coeff	**0.9477**	r^2
Cohesion c	**85**	(kPa)
Phi Æ	**16**	(deg)

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 29/11/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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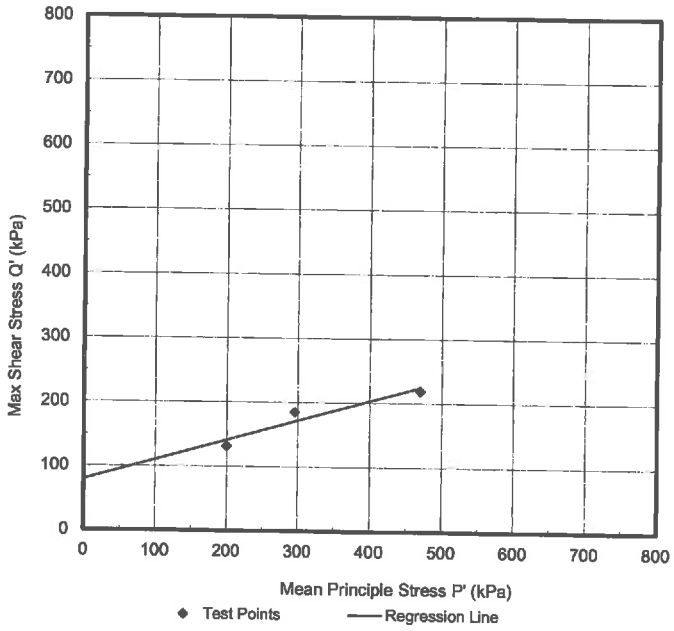
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - P' vs Q' Effective Stress Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/09**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; siltstone**
Comments:	**Multistage Test.**

Depth (m): **6.0 - 6.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**008a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Effective Stress Plot-Back Pressure saturated at 350 kPa



EFFECTIVE STRESS RESULT		
Intercept d'	**79.23**	(kPa)
Beta b'	**17.22**	(deg)
Correl coeff	**0.9155**	r^2
Cohesion c'	**83**	(kPa)
Phi Æ'	**18**	(deg)

Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 29/11/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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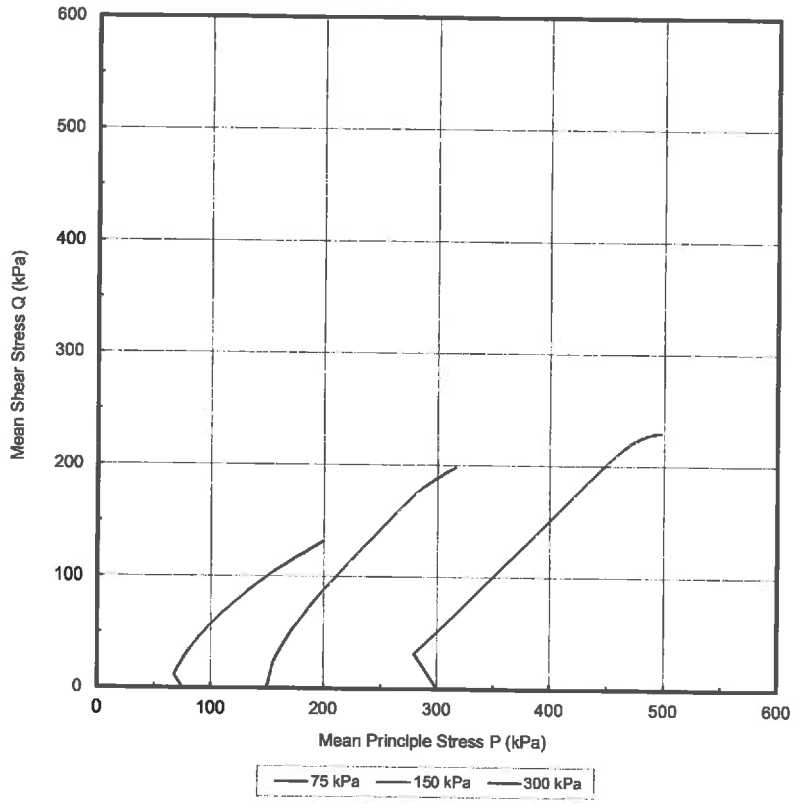
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - PvsQ Stress Path Plot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/09**
Depth (m):	**6.0 - 6.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Grey; siltstone**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**008a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
P' vs Q' Stress Path (Effective Stress Plot) - Back Pressure saturated at 350 kPa



Test Method		Notes
Triaxial Test	In House	
Based On:	NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 29/11/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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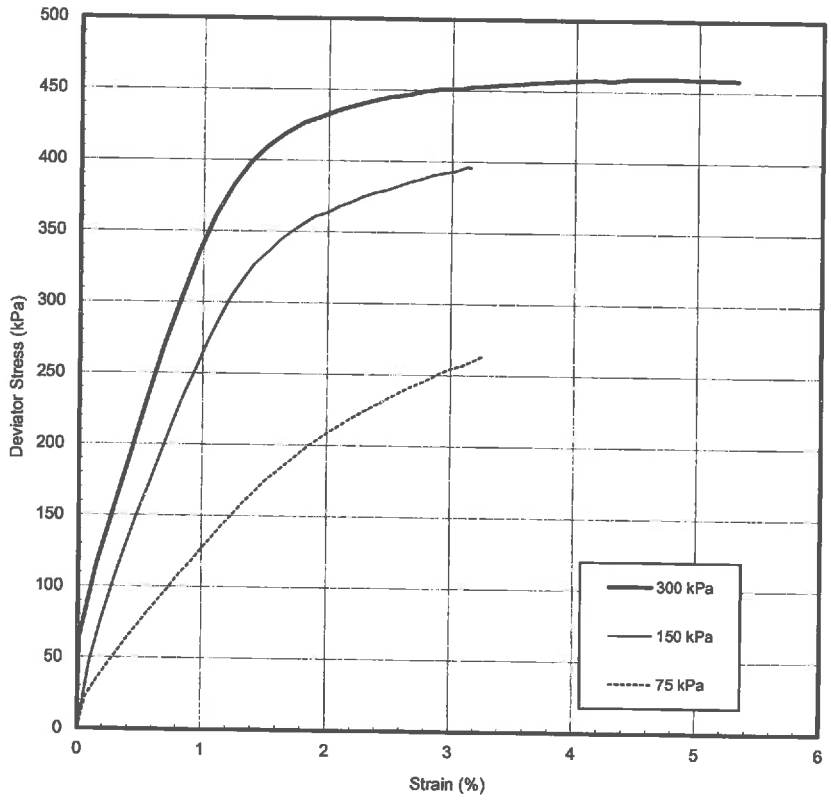
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Deviator StressPlot

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/09**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; siltstone**
Comments:	**Multistage Test.**

Depth (m): **6.0 - 6.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**008a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Deviator Stress Plot- Back Pressure saturated at 350 kPa



Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 29/11/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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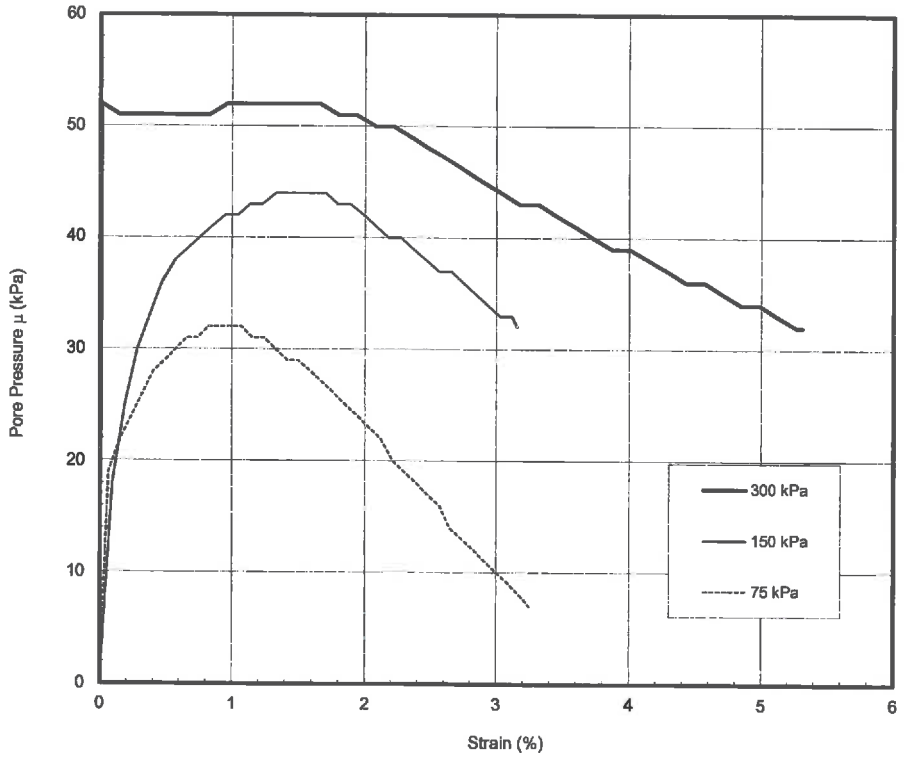
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Test Report - Strain vs Pore Pressure Plot

OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/09**
Depth (m):	**6.0 - 6.5**
Sampled by:	**Tom Van Deelen**
Date Sampled:	**21/11/13**
Sampling Method :	**Push Tube**
Description:	**Grey; siltstone**
Comments:	**Multistage Test.**

Project No:	**1-C0935.25**
Lab Ref No:	**008a/13**
Client Ref No:	**Tom Van Deelen**

Consolidated Undrained TRIAXIAL COMPRESSION TEST RESULT
Strain vs Pore Pressure Plot- Back Pressure saturated at 350 kPa



Test Method		Notes
Triaxial Test Based On:	In House NZS 4402:1986 Test 6.2.1	

Date Tested: 26/11/13 - 29/11/13

Date Reported: 10/12/13

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

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CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
Displacement vs Öt Plot (Consolidation stage)

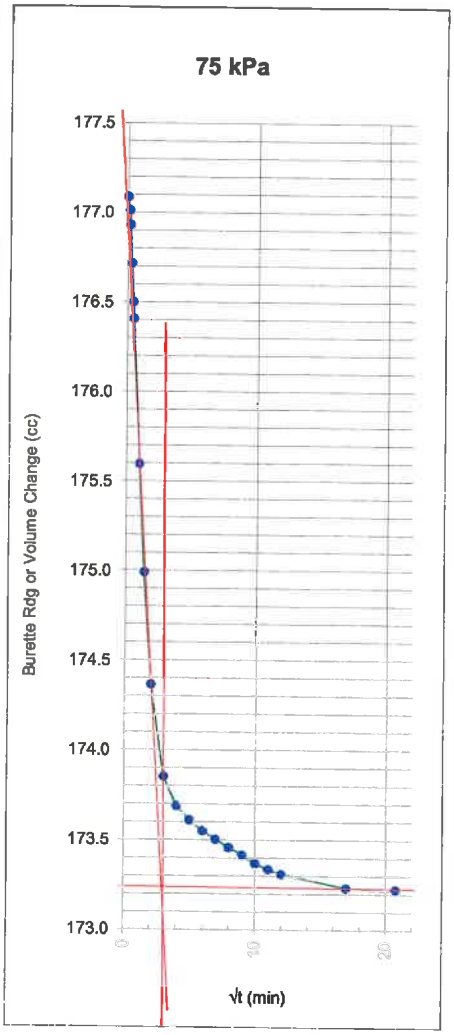
OPUS

Project:	**Manuka Reservoirs**
Location :	**Manuka Reservoirs**
Client :	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Specimen Depth(m):	**6.35 - 6.5m**
Sample Reference:	**BH13/09**
Sampled by:	**Tom Van Deelen**
Sampling Method :	**Push Tube**
Description:	**Grey; siltstone**
Comments:	**Multistage Test.**

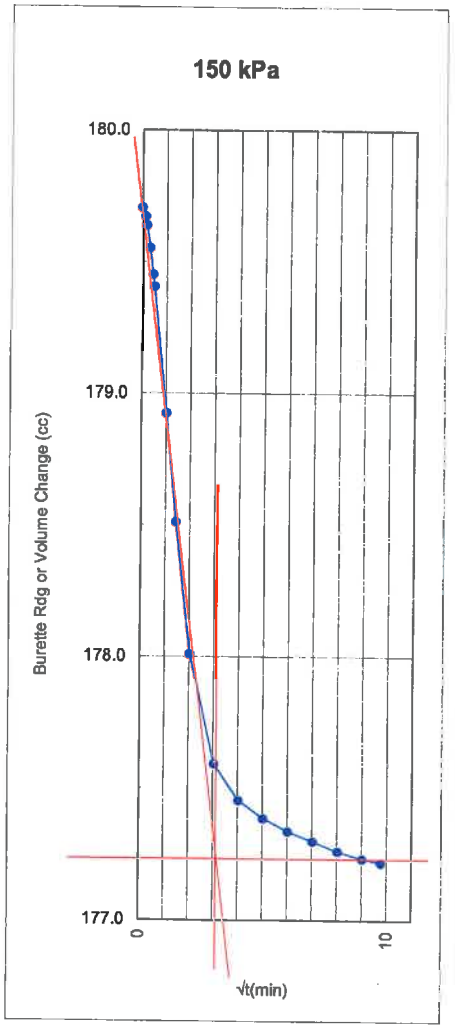
Depth (m): **6.0 - 6.5**
Date Sampled: **21/11/13**

Project No:	**1-C0935.25**
Lab Ref No:	**008a/13**
Client Ref No:	**Tom Van Deelen**

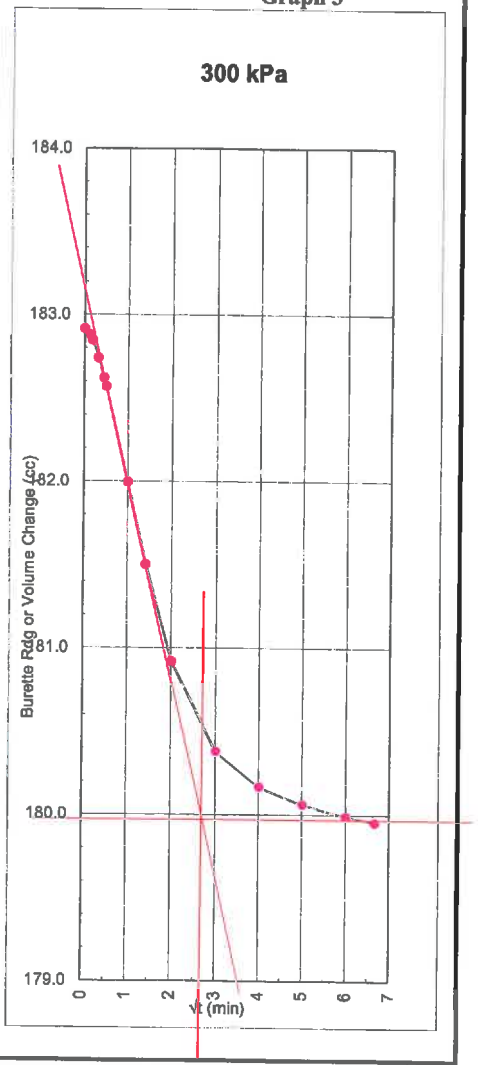
Graph 1



Graph 2



Graph 3



Test Methods		Result			
Triaxial Test	In House	**Confining Pressure (kPa)=**	**75**	**150**	**300**
Based On:	NZS 4402:1986 Test 6.2.1	**Cv (m^2/yr)=**	5.35	4.71	6.61
		Mv (m^2/MN)=	0.20	0.13	0.08
		k (m/s)=	3.40E-10	1.95E-10	1.65E-10
		t_{100}=	9.0	10.2	7.3

Date Tested: 26/11/13 - 29/11/13

Date Reported: 10/12/13

IANZ ACCREDITED LABORATORY — All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

IANZ Approved Signatory: Date: 10/12/13

Designation: Thirushen Pillay- Senior Civil Engineering Technician

Opus International Consultants Ltd
Auckland Laboratory
Quality Management Systems Certified to ISO 9001

7A Ride Way, Albany
Private Bag 101982, NS Mail Centre, North Shore City 0745, New Zealand

Telephone +64 9 415 4660
Facsimile +64 9 415 4661
Website www.opus.co.nz

PLASTICITY INDEX TEST REPORT

OPUS

Project:	**Manuka Reservoirs**
Location:	**Manuka Reservoirs**
Client:	**Watercare Services Ltd c/o Opus International Consultants Ltd**
Contractor:	**Not Stated**
Sampled by:	**Tom Van Deelen**
Date sampled:	**21/11/13**
Sampling method:	**Core Sample**
Sample description:	**Grey; siltstone**
Sample condition:	**As received**
Sample reference:	**BH13/09**
Sample depth:	**9.45 - 9.65m**

Project number:	**1-C0935.25**
Lab ref number:	**009/13**
Client ref:	**Tom Van Deelen**
Folder number:	**SEC13/AU/050**

Test Results

As rec'd water content:	**44.3%**
Liquid limit:	**60**
Plastic limit:	**43**
Plasticity Index:	**17**

Test methods		Notes
Water Content:	NZS 4402 : 1986, Test 2.1	Test performed on: Fraction passing 0.425mm test sieve
Liquid Limit:	NZS 4402 : 1986, Test 2.2	Sample descriptions are not covered by IANZ accreditation.
Plastic Limit:	NZS 4402 : 1986, Test 2.3	
Plasticity Index:	NZS 4402 : 1986, Test 2.4	

Date tested: 29/11/13
Date reported: 10/12/2013

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
This report may only be reproduced in full

IANZ Approved Signatory
Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 10/12/2013

IANZ ACCREDITED LABORATORY

Tests indicated as not accredited are outside the scope of the laboratory's accreditation

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Appendix G
Contamination Testing Results

Hill Laboratories
BETTER TESTING BETTER RESULTS

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	OPUS International Consultants	**Lab No:**	1200626 SPv1
Contact:	Tom Van Deelen	**Date Registered:**	07-Nov-2013
	C/- OPUS International Consultants	**Date Reported:**	18-Nov-2013
	PO Box 5848	**Quote No:**	
	AUCKLAND 1141	**Order No:**	1-C095.25
		Client Reference:	Manuka Reservoirs 1-C0935
		Submitted By:	Tom Van Deelen

Sample Type: Soil

Sample Name:		HA13/01-1.0m 04-Nov-2013	HA13/01-3.0m 04-Nov-2013	HA13/02-0.5m 04-Nov-2013	HA13/02-2.0m 04-Nov-2013	HA13/03-1.0m 04-Nov-2013
Lab Number:		1200626.1	1200626.2	1200626.3	1200626.4	1200626.5
Individual Tests						
Dry Matter	g/100g as rcvd	64	61	75	64	64
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	< 2	< 2	< 2	< 2	< 2
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	0.15	< 0.10	< 0.10	< 0.10
Total Recoverable Chromium	mg/kg dry wt	24	24	22	24	26
Total Recoverable Copper	mg/kg dry wt	12	42	7	25	34
Total Recoverable Lead	mg/kg dry wt	6.7	8.9	7.2	6.1	10.1
Total Recoverable Nickel	mg/kg dry wt	4	27	3	8	9
Total Recoverable Zinc	mg/kg dry wt	25	97	18	39	47
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Acenaphthylene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Anthracene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Benzo[a]anthracene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Benzo[k]fluoranthene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Chrysene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Fluoranthene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Fluorene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Naphthalene	mg/kg dry wt	< 0.17	< 0.18	< 0.15	< 0.18	< 0.17
Phenanthrene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04
Pyrene	mg/kg dry wt	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04

Sample Name:		HA13/03-3.0m 04-Nov-2013				
Lab Number:		1200626.6				
Individual Tests						
Dry Matter	g/100g as rcvd	65	-	-	-	-
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	< 2	-	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.11	-	-	-	-
Total Recoverable Chromium	mg/kg dry wt	30	-	-	-	-
Total Recoverable Copper	mg/kg dry wt	40	-	-	-	-

Sample Type: Soil						
Sample Name:		HA13/03-3.0m 04-Nov-2013				
Lab Number:		1200626.6				
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Lead	mg/kg dry wt	6.7	-	-	-	-
Total Recoverable Nickel	mg/kg dry wt	23	-	-	-	-
Total Recoverable Zinc	mg/kg dry wt	81	-	-	-	-
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.04	-	-	-	-
Acenaphthylene	mg/kg dry wt	< 0.04	-	-	-	-
Anthracene	mg/kg dry wt	< 0.04	-	-	-	-
Benzo[a]anthracene	mg/kg dry wt	< 0.04	-	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.04	-	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.04	-	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.04	-	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	< 0.04	-	-	-	-
Chrysene	mg/kg dry wt	< 0.04	-	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.04	-	-	-	-
Fluoranthene	mg/kg dry wt	< 0.04	-	-	-	-
Fluorene	mg/kg dry wt	< 0.04	-	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.04	-	-	-	-
Naphthalene	mg/kg dry wt	< 0.17	-	-	-	-
Phenanthrene	mg/kg dry wt	< 0.04	-	-	-	-
Pyrene	mg/kg dry wt	< 0.04	-	-	-	-

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-6
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	-	1-6
Polycyclic Aromatic Hydrocarbons Screening in Soil	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis (modified US EPA 8270). Tested on as received sample. [KBIs:5786,2805,2695]	-	1-6
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-6
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-6

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental Division

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