REPORT

TO
TOMPKINS MDA ARCHITECTS PTY LTD

ON
HYDROGEOLOGICAL ASSESSMENT

FOR
PROPOSED MANLY ANDREW 'BOY' CHARLTON SWIM CENTRE REDEVELOPMENT

AT
KENNETH ROAD, MANLY, NSW

5 November 2013
Ref: 26655ZH3rpt

JK Geotechnics
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

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Date: 5 November 2013
Report No: 26655ZH3rpt
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For and on behalf of
JK GEOTECHNICS
PO Box 976
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TABLE OF CONTENTS

1 INTRODUCTION

This report presents the results of a hydrogeological assessment for the proposed Manly Andrew 'Boy' Charlton (ABC) Swim Centre redevelopment at Kenneth Road, Manly, NSW. The hydrogeological assessment was commissioned by Mr Michael Davies of TompkinsMDA Architects Pty Ltd (TMDA) in an email, dated 1 November 2013.

JK Geotechnics have previously completed a supplementary geotechnical investigation at the site (Report reference: 26655ZH2rpt, dated 16 August 2013) for the proposed redevelopment and the relevant information from the previous geotechnical investigation has been used to supplement the results of this assessment. The previous borehole logs are attached to this report for ease of reference.

To assist with our assessment, we have been supplied the following information prepared by TMDA:

1. A sub-floor plan of the proposed redevelopment (Project/Drawing Number: 1310 00, dated 30 October 2013). The sub-floor plan has been laid over a survey plan of the site. The supplied sub-floor plan is presented in the attached Appendix A;
2. A table showing an analysis of ground and groundwater levels for the excavations that will be required as part of the proposed redevelopment. The supplied table is presented in the attached Appendix B; and
3. An estimated time of dewatering of between three to four months.

Based on our review of the supplied information, the proposed redevelopment will require excavation to depths between about 0.2m and 1.7m below existing ground levels. The excavation will extend a maximum depth of about 0.9m below the groundwater level in the vicinity of the proposed Leisure Pool Balance tank (LPBT) and Backwash tank (BT) and to a maximum depth of between about 0.2m and 0.7m below groundwater levels in the vicinity of the proposed Programme Pool Balance tank (PPBT) and 25m Pool Balance tank (PBT). Dewatering will therefore be required to enable construction to be carried out in 'dry' conditions.

The purpose of the assessment was to assess the likely groundwater pump-out volumes which will be required.

2 RESULTS OF THE ASSESSMENT

2.1 Site Description

The site description contained in our previous supplementary geotechnical investigation report as referenced above is still valid and should be referred to.

2.2 Subsurface Conditions

Based on the previous investigation results, the site is underlain by sandy fill overlying alluvial sands and silty sands with sandstone bedrock at variable depth.

Where excavation is proposed, the closest boreholes to those areas (ie. BH3, BH102, BH108 and BH103) encountered sandstone bedrock at depths between 2.2m (BH3) and 6.5m (BH103).

The graphical borehole summary/Section B-B from our previous report is presented as Figure 2. Also shown on the attached Figure 2 are the groundwater levels as encountered in the boreholes during the fieldwork, as well as the proposed bulk excavation levels (BEL) as indicated in the supplied TMDA table (ie. RL1.45m for the PPBT and PBT and RL1.5m for LPBT and BT).

2.3 Groundwater Analyses

2.3.1 Groundwater Levels

A summary of the groundwater observations and measurements made within the boreholes located closest to the areas of proposed excavation during the fieldwork in July 2013 and within the groundwater monitoring standpipe installed into BH4 in August and November 2013 is tabulated below.

Borehole	Depth/RL Below Ground Surface Level (m/mAHD)		
	Groundwater Seepage	Groundwater Depth on Completion	Groundwater Depth (After Some Time)
BH3	1.0/2.2	0.8/2.4	N/A
BH4*	0.6/2.7	0.8/2.5	1.62/1.68 on 19 August 2013 2.02/1.28 on 1 November 2013
BH102	1.2/2.0	1.4/1.8	N/A
BH103	1.6/1.5	1.6/1.5	N/A
BH108	1.2/2.0	1.1/2.1	N/A

The groundwater levels on completion of drilling ranged between 0.8m and 1.6m depth. The groundwater level measurements made in the standpipe installed into BH4 in August and

November 2013 show that the groundwater level (at least at that location) are lower than the groundwater level measurements made during the fieldwork in July 2013.

We note that apart from the two isolated groundwater measurements made in BH4 as tabulated above, no other long term groundwater monitoring has been completed.

2.3.2 Seepage Analyses

Seepage analyses using the commercially available computer program, SEEP/W, were carried out in order to estimate the pump-out volume rate required to lower the groundwater level to about 0.4m below bulk excavation level (ie. to about RL1.1m).

The seepage analyses were completed based on the following assumptions:

1. An open excavation 1.7m deep, with the sides of the excavation temporarily battered to 1 Vertical (V) on 1.5 Horizontal (H);
2. The depth to the underlying sandstone bedrock being at either RL1.0m or RL-3.4m, based on the subsurface conditions encountered in BH3 (located adjacent to the proposed LPBT and BT) and BH103 (located adjacent to the northern end of the proposed PPBT and PBT), respectively;
3. A coefficient of permeability, 'k', for the silty sand fill and underlying natural sands/silty sands of $5x10^{-5}$m/sec. This 'k' value is based on our experience and permeability testing of similar soils and with reference to the relationship between the coefficient of permeability and percent by weight passing No.200 sieve (approximately equivalent to 0.075mm) which is presented as Figure 8.5 in the DM7 Design Manual (1971), a copy of which is presented in Appendix C. We note that the percentage passing the 0.075mm sieve size for the natural sand sample tested from BH1 during our previous investigations was 4%, which corresponds with a 'k' value of about $1x10^{-5}$m/sec. The adopted 'k' value for this assessment is higher and is therefore considered conservative (ie. will result in a higher pump-out rate compared to a lower 'k' value);
4. With reference to the supplied sub-floor plan, the approximate surface area of the proposed PPBT, PBT, LPBT and BT structures is about $181m^2$. The footprint of these structures will range between about 3.5m to 9m wide over a length of about 42m, which takes into account the 90˚ bend at the northern end of the proposed PPBT and PBT structures. This is equivalent to an average width of about 4.3m (ie. $181m^2/42m$). We have assumed a working space of 1.5m on either side of the proposed structures wil be

required during construction and therefore the width of the open excavation section has been modelled as 7.3m (ie. 4.3m + 1.5m +1.5m); and

5. A groundwater level at RL2.4m, which corresponds with the shallowest groundwater level measured in the closest boreholes to the proposed structures, as tabulated above in Section 2.3.1.

The printouts of the hydrogeological models and analyses are presented in Figures 3, 4, 5 and 6. The pump-out rates indicated vary between 0.44m^3/hour and 0.60m^3/hour.

Based on the supplied information and our assumptions, a maximum groundwater pump-out volume of 1,728m^3 or 1.73ML (ie. 0.60m^{3}hour x 24 hrs/day x 120 days) is indicated.

3 COMMENTS AND RECOMMENDATIONS

Based on the above analyses, a total maximum pump-out rate of approximately 0.60m^3/hour will be required in order to drop and maintain the groundwater level at approximately 0.4m below bulk excavation level (ie. about RL1.1m). A total pump-out volume of 1.73ML will be required over the four month dewatering period.

There is expected to be a slight drawdown of groundwater levels within about 30m of the proposed dewatering. We do not expect this to be an issue with respect to potential ground settlements due to dewatering, as there are no existing structures within 30m of the areas requiring dewatering.

We recommend that the actual pump-out volumes be monitored, in order to confirm the above.

4 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

Occasionally, the subsurface conditions between the completed boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

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BOREHOLE LOG

Borehole No. 1
1/3

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 1&2-7-13
Method: SPIRAL AUGER JK300
Logged/Checked by: D.S./A.J.H.
R.L. Surface: ≈ 2.4m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
ON COMPLET-ION ▼					N = 8 2,3,5	0			FILL: Silty sand, fine to medium grained, brown, trace of shell fragments and root fibres.	D			GRASS COVER
▶						1			FILL: Silty sand, fine to medium grained, brown, trace of shell fragments.	W			APPEARS POORLY TO MODERATELY COMPACTED
					N = 6 3,3,3	2		SP	SAND: fine to medium grained, light grey, trace of silt fines and shell fragments.	W	L		ALLUVIAL
					N = 4 2,2,2	3					VL		
					N = 2 1,1,1	5							
					N = 8 4,4,4	6			as above, but with clay fines.		L		
						7							

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BOREHOLE LOG

Borehole No. 1 2/3

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 1&2-7-13
Method: SPIRAL AUGER JK300
Logged/Checked by: D.S./A.J.H.
R.L. Surface: ≈ 2.4m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						8		SP	SAND: fine to medium grained, light grey, with clay fines.	W			THE SOIL DESCRIPTION BELOW 7.5m DEPTH WAS BASED ON THE DRILL SPOIL RETURN. PURPOSE OF DEEPER DRILLING WAS TO PROVE BEDROCK ONLY
						9							
						10							
						11							
						12							
						13							
						14		-	SANDSTONE BEDROCK: fine to coarse grained, light brown.	SW	M		MODERATE 'TC' BIT RESISTANCE

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BOREHOLE LOG

Borehole No. 1 3/3

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 1&2-7-13
Method: SPIRAL AUGER JK300
Logged/Checked by: D.S./A.J.H.
R.L. Surface: ≈ 2.4m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
									SANDSTONE BEDROCK: fine to coarse grained, light brown.	SW	M		
						15			END OF BOREHOLE AT 14.5m				DRILLING TERMINATED AT 14.5m DEPTH, DUE TO AUGER BREAKING WHILST PROVING BEDROCK. BEDROCK DESCRIPTION, WEATHERING AND STRENGTH BASED ON BH2 CONDITIONS
						16							
						17							
						18							
						19							
						20							

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BOREHOLE LOG

Borehole No. 2
1/2

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 1&2-7-13
Method: SPIRAL AUGER JK300
Logged/Checked by: D.S./A.J.H.
R.L. Surface: ≈ 2.8m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa)	Remarks
ON COMPLET-ION ▼					N = 2 2,1,1	0			FILL: Silty sand, fine to medium grained, brown, trace of clay fines and root fibres.	M			GRASS COVER
									FILL: Silty sand, fine to medium grained, brown, trace of clay fines.				APPEARS POORLY COMPACTED
▶						1				W			
					N = 8 2,4,4	2		SM	SILTY SAND: fine to medium grained, grey brown.	W	L		ALLUVIAL
									as above, but light grey.		VL		
					N = 2 1,1,1	3							
						4							
					N = 0 0,0,0	5							
						6		SC	CLAYEY SAND: fine to coarse grained, light grey and brown, trace of shell fragments.				
					N = 2 2,1,1	7							

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BOREHOLE LOG

Borehole No. 2 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 2.8m

Date: 1&2-7-13 **Datum:** ASSUMED

Logged/Checked by: D.S./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
					Nc= 2, 2, 3	8		SC	CLAYEY SAND: fine to medium grained, light grey.	W	VL		
					Nc= 0, 0, 0	9		CH	SILTY CLAY: high plasticity, dark grey.	MC>PL	VS	20, 20, 20	HP TESTING CARRIED OUT ON REMOULDED AUGER SAMPLE
						10		SC	CLAYEY SAND: fine to medium grained, light grey.	W	(MD)		- 10mm
						11							
						12		-	SANDSTONE: fine to coarse grained, light brown.	SW	M-H		MODERATE TO HIGH 'TC' BIT RESISTANCE
						13							
						14			END OF BOREHOLE AT 13.5m				

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BOREHOLE LOG

Borehole No. 3
1/1

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 1-7-13
Method: SPIRAL AUGER JK300
Logged/Checked by: D.S./A.J.H.
R.L. Surface: ≈ 3.2m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
ON COMPLET-ION ▼					N = 3 1,1,2	0			FILL: Silty sand, fine to medium grained, brown, with fine to medium grained sandstone gravel, trace of root fibres.	D			GRASS COVER APPEARS POORLY COMPACTED
					N = 10 1,1,9	1			FILL: Silty sand, fine to coarse grained, brown and orange brown, with clay fines, trace of sandstone gravel.	W			
						2		SP	SAND: fine to coarse grained, light grey.	W	L		ALLUVIAL
								-	SANDSTONE: fine to coarse grained, light grey.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
						3				SW	L-M		LOW TO MODERATE RESISTANCE
										SW-FR	H		HIGH RESISTANCE
						4			END OF BOREHOLE AT 3.9m				'TC' BIT REFUSAL
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. 4 1/2

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 1-7-13
Method: SPIRAL AUGER JK300
Logged/Checked by: D.S./A.J.H.
R.L. Surface: ≈ 3.3m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			BITUMINOUS SEAL: 30mm.t	D			
					N > 28 11,17, 11/100mm				FILL: Silty sandy gravel, fine to coarse grained igneous, dark grey, fine to coarse grained sand.				APPEARS WELL COMPACTED
▶ ▼ ON COMPLETION & AFTER 3.5 HRS					REFUSAL	1		SM	FILL: Clayey sand, fine to coarse grained, brown, with fine to medium grained sandstone gravel, trace of fine to medium grained igneous gravel and slag.	M			
					N = 13 4,5,8	2			SILTY SAND: fine to medium grained, light grey and grey.	W	MD		ALLUVIAL
					N = 1 1,1,0	3			SILTY SAND: fine to medium grained, brown.		VL		
					N > 8 3,3,5/ 100mm	4		SC	CLAYEY SAND: fine to medium grained, light grey and brown.		L		
					REFUSAL	5		-	SANDSTONE: fine to medium grained, light grey, brown and red brown.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
										DW	L		LOW TO MODERATE RESISTANCE
						6			SANDSTONE: fine to medium grained, light grey and red brown.		M		MODERATE RESISTANCE
						7							

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BOREHOLE LOG

Borehole No. 4 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 1-7-13

Method: SPIRAL AUGER
JK300

Logged/Checked by: D.S./A.J.H.

R.L. Surface: ≈ 3.3m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
									SANDSTONE: fine to medium grained, light grey and red brown.	DW	M		
						8			END OF BOREHOLE AT 7.5m				CLASS 18 uPVC STANDPIPE INSTALLED TO 5m DEPTH SLOTTED BETWEEN 1m AND 5m, UNSLOTTED BETWEEN 0m AND 1m DEPTH, BACKFILLED WITH 2mm SAND FROM 1m TO 5m DEPTH, BENTONITE SEAL FROM 0.5m TO 1m DEPTH, GATIC COVER CONCRETED AT SURFACE
						9							
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. 101 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.1m

Date: 30-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			ASPHALTIC CONCRETE: 30mm.t FILL: Sandy gravel, fine to medium grained igneous, dark grey, fine to medium grained sand. FILL: Silty sand, fine to medium grained, dark brown, with clay.	M			
ON COMPLET-ION ▼						1		SM	SILTY SAND: fine to medium grained, grey and light grey.	M	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
▶						2				W			
						3							STRONG HYDROCARBON ODOUR BETWEEN APPROXIMATELY 3.0m AND 4.7m DEPTH
						4							
						5		-	SANDSTONE: fine to medium grained, light grey, brown and red brown, with L strength bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
						6			SANDSTONE: fine to medium grained, light grey and red brown.	DW	L		LOW RESISTANCE
						7							

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BOREHOLE LOG

Borehole No. 101 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.1m

Date: 30-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
									SANDSTONE: fine to medium grained, light grey and red brown.	DW	L-M		
									END OF BOREHOLE AT 7.5m				
						8							
						9							
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. 102
1/1

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30-7-13

Method: SPIRAL AUGER
JK305

Logged/Checked by: O.F./A.J.H.

R.L. Surface: ≈ 3.2m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
▶ ON COMPLET-ION ▼						0			FILL: Silty sand, fine to medium grained, dark brown, trace of fine to medium grained sandstone gravel, roots and root fibres.	M			GRASS COVER
						1				W			HYDROCARBON ODOUR BETWEEN APPROXIMATELY 1.2m AND 1.7m DEPTH
								SP	SAND: fine to medium grained, grey.	W	-		ALLUVIAL
						2							PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						3		-	SANDSTONE: fine to medium grained, light grey and red brown.	DW	L-M		LOW TO MODERATE 'TC' BIT RESISTANCE
											H		HIGH RESISTANCE 'TC' BIT REFUSAL
									END OF BOREHOLE AT 3.6m				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. 103
1/2

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30-7-13
Method: SPIRAL AUGER JK305
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 3.1m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Silty sand, fine to medium grained, dark brown, with fine to medium grained sandstone and igneous gravel, roots and root fibres.	M			
▼ ON COMPLET-ION						1		SP	SAND: fine to medium grained, grey and light grey, trace of quartz gravel.	W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						2							
						3							
						4							
						5							
						6							
						7		-	SANDSTONE: fine to coarse grained, light grey.	SW	L		LOW 'TC' BIT RESISTANCE

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BOREHOLE LOG

Borehole No. 103 2/2

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30-7-13
Method: SPIRAL AUGER JK305
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 3.1m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						8			SANDSTONE: fine to coarse grained, light grey.	SW	L		
											L-M		LOW TO MODERATE RESISTANCE
						9			END OF BOREHOLE AT 9.0m				
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. 104
1/2

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30&31-7-13
Method: SPIRAL AUGER JK305
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 2.9m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa)	Remarks
						0			FILL: Silty sand, fine to medium grained, brown, trace of clay fines, roots and root fibres.	M			GRASS COVER
									FILL: Silty sand, fine to medium grained, brown, trace of clay fines.				
ON COMPLET-ION ▼						1		SM	SILTY SAND: fine to medium grained, grey brown.	M	-		ALLUVIAL
▶						2				W			PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						3							
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. 104 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 2.9m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
								SM	SILTY SAND: fine to medium grained, grey.	W	-		
						8							
						9							
						10		-	SANDSTONE: fine to coarse grained, light grey and orange brown.	DW	VL-L		LOW 'TC' BIT RESISTANCE
											L-M		
						11					M-H		MODERATE TO HIGH RESISTANCE
									END OF BOREHOLE AT 11.0m				
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. 105 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30&31-7-13

Method: SPIRAL AUGER JK305

Logged/Checked by: O.F./

R.L. Surface: ≈ 2.7m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Silty sand, fine to medium grained, brown and dark brown, trace of clay fines and glass fragments.	M			
▼ ON COMPLET-ION						1		SM	SILTY SAND: fine to medium grained, grey brown.	M / W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						2							
						3			as above, but light grey.				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. 105 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30&31-7-13

Method: SPIRAL AUGER JK305

Logged/Checked by: O.F./

R.L. Surface: ≈ 2.7m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	■					8		SM	SILTY SAND: fine to medium grained, light grey.	W	-		
						9							
						10		-	SANDSTONE: fine to medium grained, light grey.	DW	VL-L		LOW 'TC' BIT RESISTANCE
						11				SW	M-H		MODERATE RESISTANCE
						12			END OF BOREHOLE AT 11.5m				
						13							
						14							

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BOREHOLE LOG

Borehole No. 106
1/1

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30&31-7-13
Method: SPIRAL AUGER JK305
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 2.4m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa)	Remarks
ON COMPLETION ▼						0			FILL: Silty sand, fine to medium grained, brown, trace of shell fragments and root fibres.	M			
									FILL: Silty sand, fine to medium grained, brown, trace of shell fragments.				
▶						1				W			
								SP	SAND: fine to medium grained, light grey, trace of shell fragments.	W	-		ALLUVIAL
						2							
						3			END OF BOREHOLE AT 3.0m				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. 107
1/1

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30&31-7-13
Method: SPIRAL AUGER JK305
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 3.4m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Silty sand, fine to medium grained, dark brown, trace of fine to medium grained igneous gravel and root fibres.	M			GRASS COVER
						1			as above, but with fine to medium grained igneous gravel.				
ON COMPLET-ION ▼								SM	SILTY SAND: fine to medium grained, light grey and brown.	M	-		ALLUVIAL
▶						2				W			
						3			END OF BOREHOLE AT 3.0m				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. 108
1/2

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 31-7-13
Method: SPIRAL AUGER JK350
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 3.2m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
ON COMPLET-ION ▼						0			FILL: Silty sand, fine to medium grained, dark brown, trace of fine to medium grained sandstone gravel, roots and root fibres.	M			
▶						1				W			
						2		SP	SAND: fine to medium grained, grey.	W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						3							
						4		-	SANDSTONE: fine to coarse grained, light grey.	SW-FR	M-H		MODERATE 'TC' BIT RESISTANCE
						5			REFER TO CORED BOREHOLE LOG				
						6							
						7							

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CORED BOREHOLE LOG

Borehole No. 108 2/2

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Core Size:** NMLC **R.L. Surface:** ≈ 3.2m
Date: 31-7-13 **Inclination:** VERTICAL **Datum:** ASSUMED
Drill Type: JK350 **Bearing:** - **Logged/Checked by:** O.F./A.J.H.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT DETAILS DEFECT SPACING (mm) 500 300 100 50 30 10	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		4		START CORING AT 4.39m					
NO RET-URN		5		CORE LOSS 0.09m SANDSTONE: fine to coarse grained, light grey, bedded at 0-5°.	SW - FR	M-H M			- Be, 0-10°, Un, S - XWS, 0°, 15mm.t
		6		as above, but with dark grey laminae bedded at 0-5°, spacing 0-20mm.		M			- Be, 0°, P, S
		7		END OF BOREHOLE AT 7.05m					
		8							
		9							
		10							

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BOREHOLE LOG

Borehole No. 109
1/3

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 31-7-13
Method: SPIRAL AUGER JK350
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 2.9m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Silty sand, fine to medium grained, brown and dark brown, with clay and fine to medium grained sandstone gravel, trace of roots and root fibres.	M			GRASS COVER
ON COMPLET-ION ▼						1				W			
								SM	SILTY SAND: fine to medium grained, grey brown.	W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						2							
						3							
						4							
						5							
						6							
								SP	SAND: fine to medium grained, grey and light grey.				
						7							

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BOREHOLE LOG

Borehole No. 109
2/3

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 31-7-13
Method: SPIRAL AUGER JK350
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 2.9m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
								SP	SAND: fine to medium grained, grey and light grey.	W	-		
						8		-	SANDSONE: fine to coarse grained, light grey.	DW	VL-L		LOW 'TC' BIT RESISTANCE
						9			REFER TO CORED BOREHOLE LOG				
						10							
						11							
						12							
						13							
						14							

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CORED BOREHOLE LOG

Borehole No. 109 3/3

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Core Size:** NMLC **R.L. Surface:** ≈ 2.9m
Date: 31-7-13 **Inclination:** VERTICAL **Datum:** ASSUMED
Drill Type: JK350 **Bearing:** - **Logged/Checked by:** O.F./A.J.H.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT DETAILS DEFECT SPACING (mm) 600 200 100 60 30 10	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		8		START CORING AT 8.97m					
FULL RETURN		9		SANDSTONE: fine to coarse grained, light grey, bedded at 0-5°.	DW	VL-L			- CS, 0°, 70mm.t - CS, 0°, 40mm.t - J, 45°, P, R - XWS, 10°, 5mm.t - XWS, 0-5°, 50mm.t
					XW	EL			
		10		as above, but dark brown and light grey, bedded at 5-15°.	DW	M-H			
		11							- XWS, 10°, 3mm.t - HEALED J, 80-90°, Un, IS
		12							- XWS, 5°, 3mm.t
				END OF BOREHOLE AT 12.14m					
		13							
		14							

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BOREHOLE LOG

Borehole No. 110 1/3

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≈ 3.0m
Date: 30-7-13 **Datum:** ASSUMED
Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0		-	ASPHALTIC CONCRETE: 50mm.t FILL: Sandy gravel, fine to medium grained igneous, dark grey.	M			
ON COMPLET-ION ▼						1			FILL: Silty sand, fine to medium grained, dark brown, with clay fines.				
▶						2		SM	SILTY SAND: fine to medium grained, grey and dark grey.	M W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						3							
						4							
						5							
						6		-	SANDSTONE: fine to medium grained, light grey brown and red brown.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
						7							

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BOREHOLE LOG

Borehole No. 110
2/3

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30-7-13
Method: SPIRAL AUGER JK350
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 3.0m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
									SANDSTONE: fine to medium grained, light grey and red brown.	DW	L-M		LOW TO MODERATE RESISTANCE
						8			REFER TO CORED BOREHOLE LOG				
						9							
						10							
						11							
						12							
						13							
						14							

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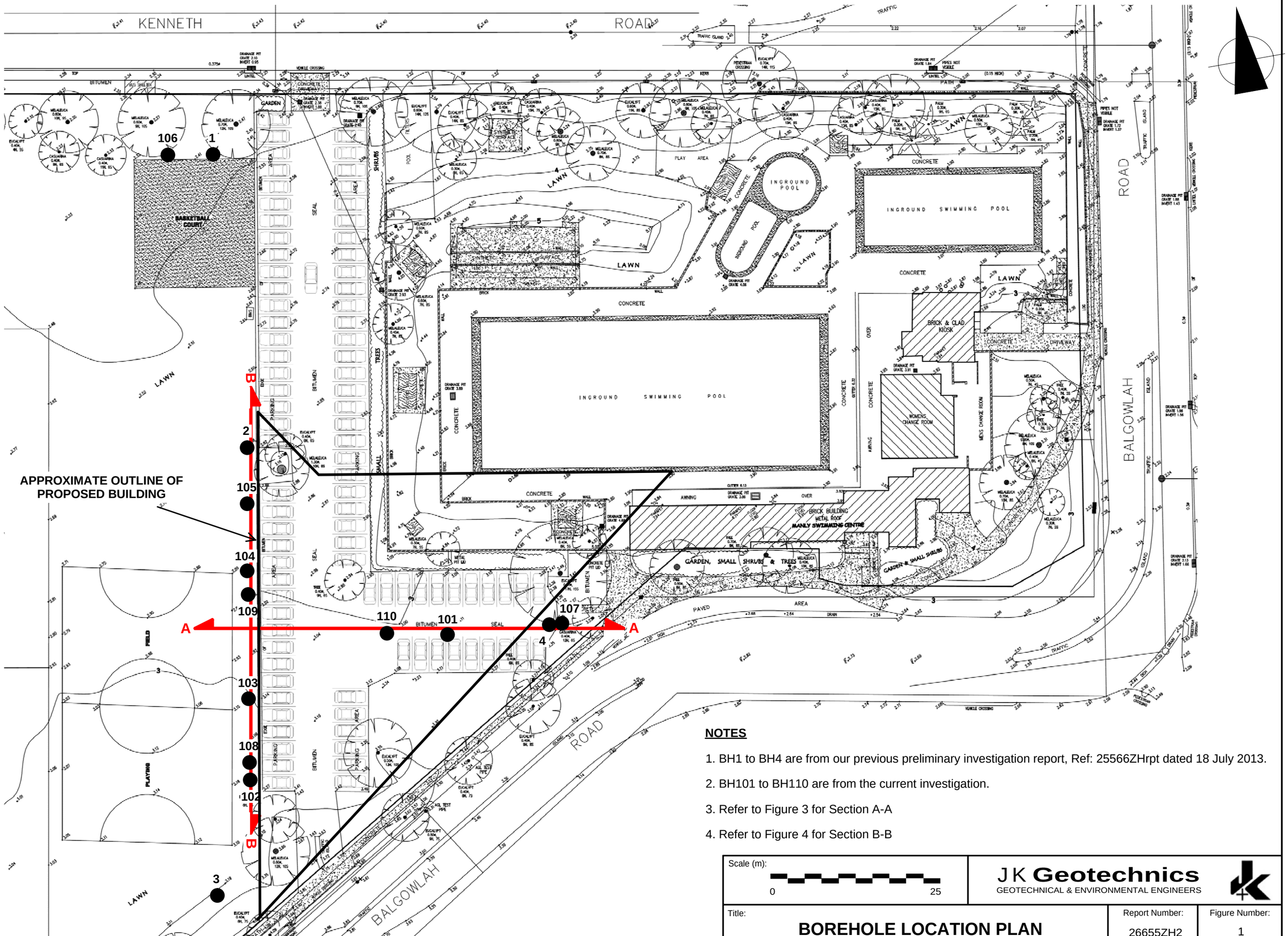
CORED BOREHOLE LOG

Borehole No. 110
3/3

Client: MANLY COUNCIL
Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE
Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 | **Core Size:** NMLC | **R.L. Surface:** ≈ 3.0m
Date: 31-7-13 | **Inclination:** VERTICAL | **Datum:** ASSUMED
Drill Type: JK350 | **Bearing:** - | **Logged/Checked by:** O.F./A.J.H.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT DETAILS: DEFECT SPACING (mm) 500 300 100 60 30 10	DEFECT DETAILS: DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		7		START CORING AT 7.56m						
				SANDSTONE: fine to medium grained, light grey and brown, with dark grey laminae at 0°-5°.	DW	M			- Be, 5°, P, S - CS, 0°, 220mm.t	
		8		CORE LOSS 0.15m						
				SANDSTONE: fine to medium grained, light grey, trace of quartz gravel, bedded at 0-5°.	SW	M				
				CORE LOSS 0.43m						
FULL RET-URN		9		SANDSTONE: fine to medium grained, light grey, massive.	XW SW-FR	EL M			- XWS, 5°, 5mm.t	
		10								
		11		END OF BOREHOLE AT 10.82m						
		12								
		13								



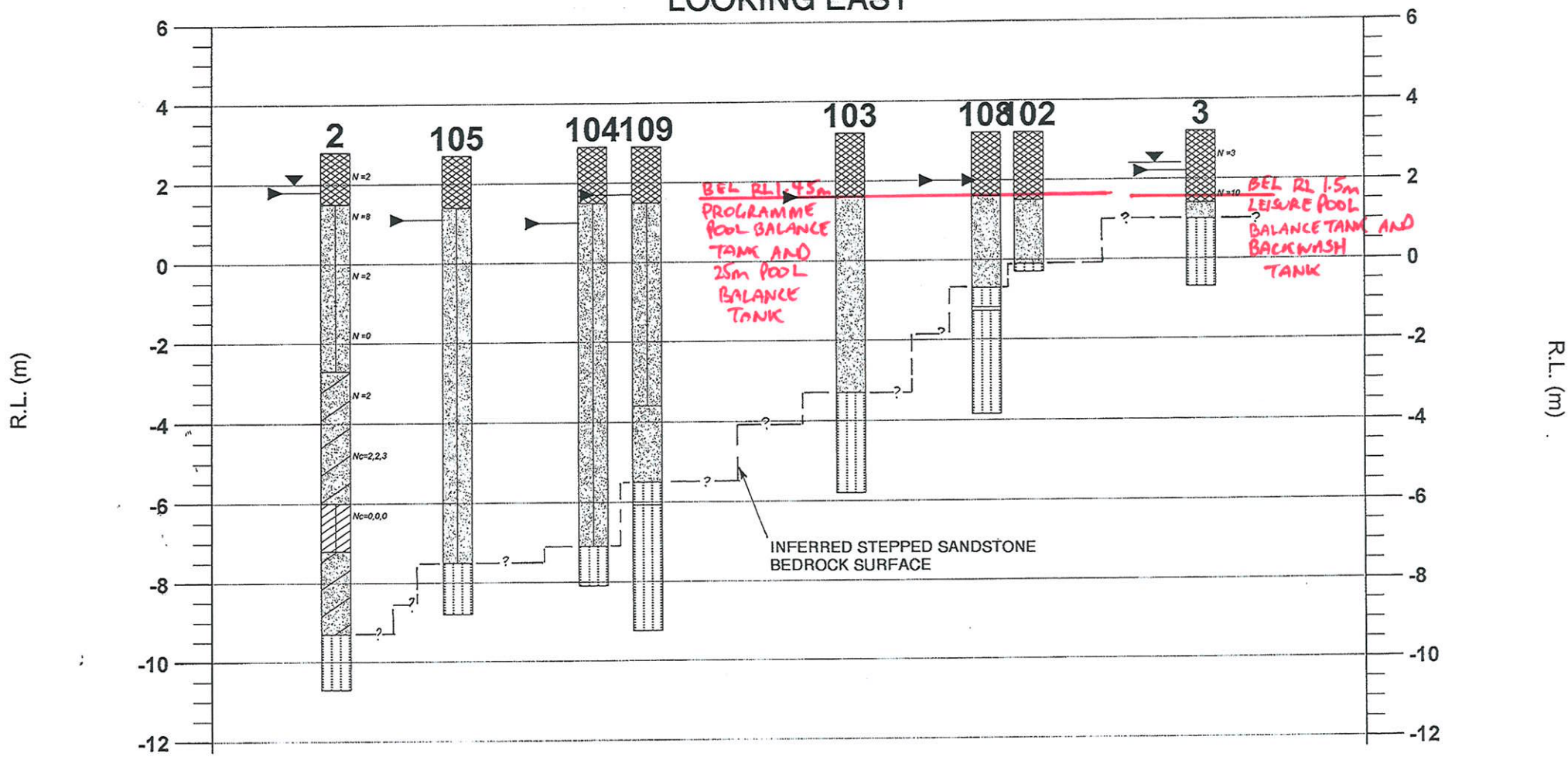
NOTES

1. BH1 to BH4 are from our previous preliminary investigation report, Ref: 25566ZHrpt dated 18 July 2013.
2. BH101 to BH110 are from the current investigation.
3. Refer to Figure 3 for Section A-A
4. Refer to Figure 4 for Section B-B

Scale (m): 0 — 25	JK Geotechnics GEOTECHNICAL & ENVIRONMENTAL ENGINEERS		
Title: **BOREHOLE LOCATION PLAN**		Report Number: 26655ZH2	Figure Number: 1

GRAPHICAL BOREHOLE SUMMARY

SECTION B–B
LOOKING EAST



Fill
Silty Clay
Silty Sand
Sandstone/ Greywacke
Clayey Sand
Sand
Core Loss/ Empty
Observed water level
Groundwater seepage level

N SPT "N" VALUE

Nc SOLID CONE BLOW COUNTS PER 150mm

NOTE: REFER TO BOREHOLE LOGS

Scale: 1 : 100 (vert) ; APPROX. 1:300 (horiz)

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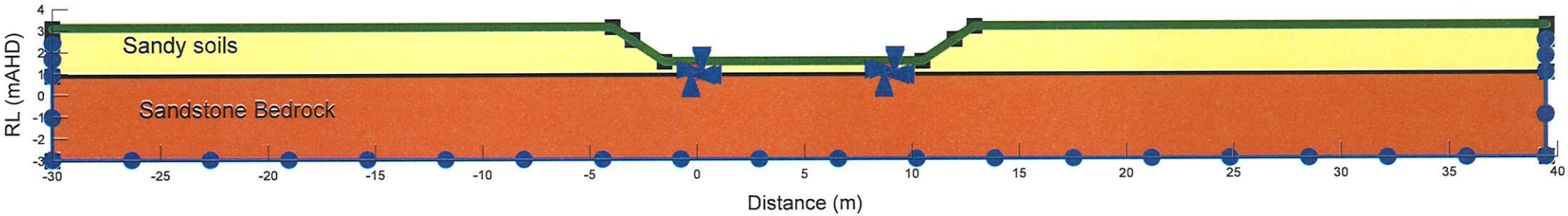
Job No.: 26655ZH2

Figure No.: 2



HYDROGEOLOGICAL MODEL (SHALLOW BEDROCK)

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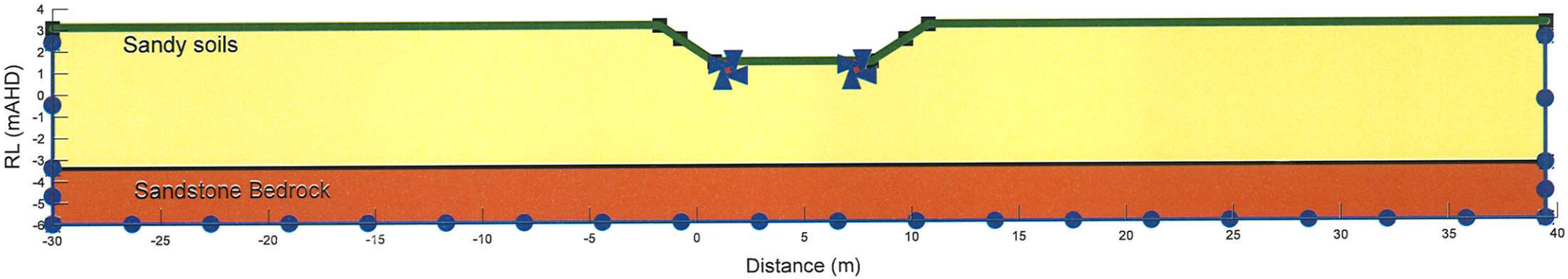
Report No. 26655ZH3 Figure No. 3



HYDROGEOLOGICAL MODEL (DEEP BEDROCK)

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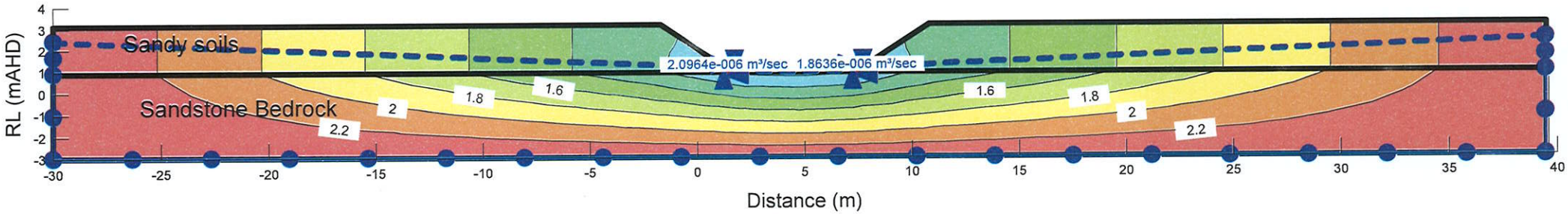
Report No. 26655ZH3 Figure No. 4



SEEPAGE ANALYSIS (SHALLOW BEDROCK)

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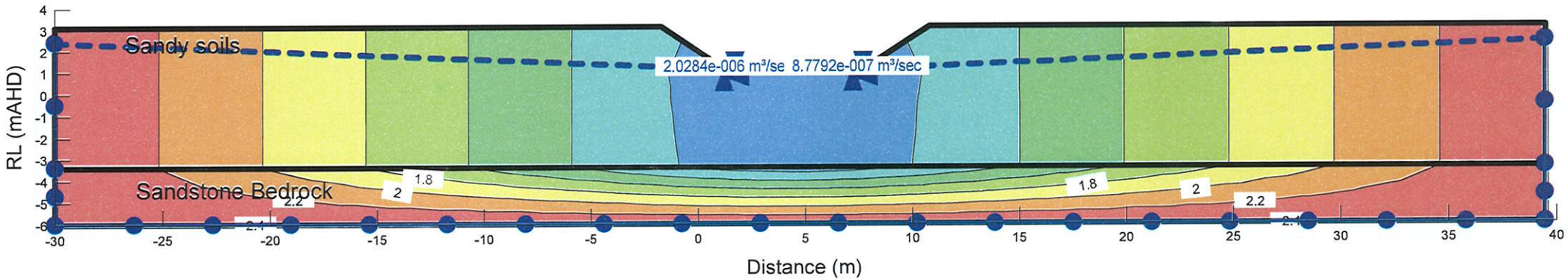
Report No. 26655ZH3 Figure No. 5



SEEPAGE ANALYSIS (DEEP BEDROCK)

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Report No. 26655ZH3 Figure No. 6

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the SAA Site Investigation Code. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the grading of other particles present (e.g. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'Shale' is used to describe thinly bedded to laminated siltstone.

SAMPLING

Sampling is carried out during drilling or from other excavations to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock fragments. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term 'mud' encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

- In the case where full penetration is obtained with successive blow counts for each 150mm of, say, 4, 6 and 7 blows, as

  N = 13
  4, 6, 7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as

  N>30
  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

A modification to the SPT test is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as "N_c" on the borehole logs, together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

  The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than “straight line” variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

Where groundwater levels are measured in boreholes, there are several potential problems:

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole or ‘reverted’ chemically if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after stabilising at intervals ranging from several days to perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg bricks, steel etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 *'Methods of Testing Soil for Engineering Purposes'*. Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg to a twenty storey building). If this happens, the company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

If these occur, the company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed that at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document *'Guidelines for the Provision of Geotechnical Information in Tender Documents'*, published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. License to use the documents may be revoked without notice if the Client is in breach of any objection to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

The company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to

ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or

iii) full time engineering presence on site.

GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL


FILL


TOPSOIL


CLAY (CL, CH)


SILT (ML, MH)


SAND (SP, SW)


GRAVEL (GP, GW)


SANDY CLAY (CL, CH)


SILTY CLAY (CL, CH)


CLAYEY SAND (SC)


SILTY SAND (SM)


GRAVELLY CLAY (CL, CH)


CLAYEY GRAVEL (GC)


SANDY SILT (ML)


PEAT AND ORGANIC SOILS

ROCK


CONGLOMERATE


SANDSTONE


SHALE


SILTSTONE, MUDSTONE, CLAYSTONE


LIMESTONE


PHYLLITE, SCHIST


TUFF


GRANITE, GABBRO


DOLERITE, DIORITE


BASALT, ANDESITE


QUARTZITE

DEFECTS AND INCLUSIONS


CLAY SEAM


SHEARED OR CRUSHED SEAM


BRECCIATED OR SHATTERED SEAM/ZONE


IRONSTONE GRAVEL


ORGANIC MATERIAL

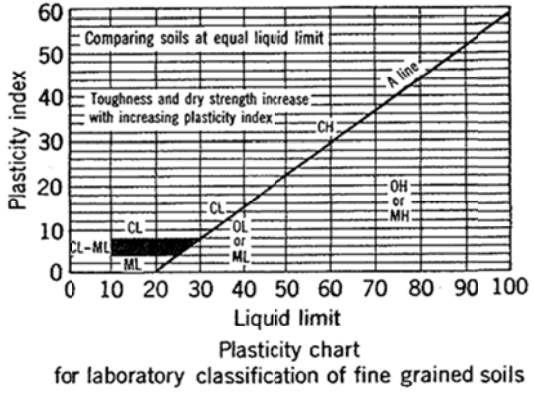
OTHER MATERIALS


CONCRETE


BITUMINOUS CONCRETE, COAL


COLLUVIUM

Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)				Group Symbols [a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils More than half of material is *larger* than 75 μm sieve size[b] (The 75 μm sieve size is about the smallest particle visible to naked eye)	Gravels More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP* More than 12% *GM, GC, SM, SC* 5% to 12% *Borderline* cases requiring use of dual symbols $C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for *GW* Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols Atterberg limits above "A" line, with *PI* greater than 7 $C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for *SW* Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols Atterberg limits below "A" line with *PI* greater than 7
		Gravels with fines (appreciable amount of fines)	Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		
			Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		
	Sands More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines		
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		
Fine-grained soils More than half of material is *smaller* than 75 μm sieve size (The 75 μm sieve size is about the smallest particle visible to naked eye)	Identification Procedures on Fraction Smaller than 380 μm Sieve Size						
		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)			
	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

Note: 1 Soils possessing characteristics of two groups are designated by combinations of group symbols (eg. GW-GC, well graded gravel-sand mixture with clay fines).
2 Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record	▼	Standing water level. Time delay following completion of drilling may be shown.
	C	Extent of borehole collapse shortly after drilling.
	▶	Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos screening.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY – Runs freely through fingers.
	M	MOIST – Does not run freely but no free water visible on soil surface.
	W	WET – Free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT – Unconfined compressive strength less than 25kPa
	S	SOFT – Unconfined compressive strength 25-50kPa
	F	FIRM – Unconfined compressive strength 50-100kPa
	St	STIFF – Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF – Unconfined compressive strength 200-400kPa
	H	HARD – Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** / **SPT 'N' Value Range (Blows/300mm)**
	VL	Very Loose <15 0-4
	L	Loose 15-35 4-10
	MD	Medium Dense 35-65 10-30
	D	Dense 65-85 30-50
	VD	Very Dense >85 >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

LOG SYMBOLS continued

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

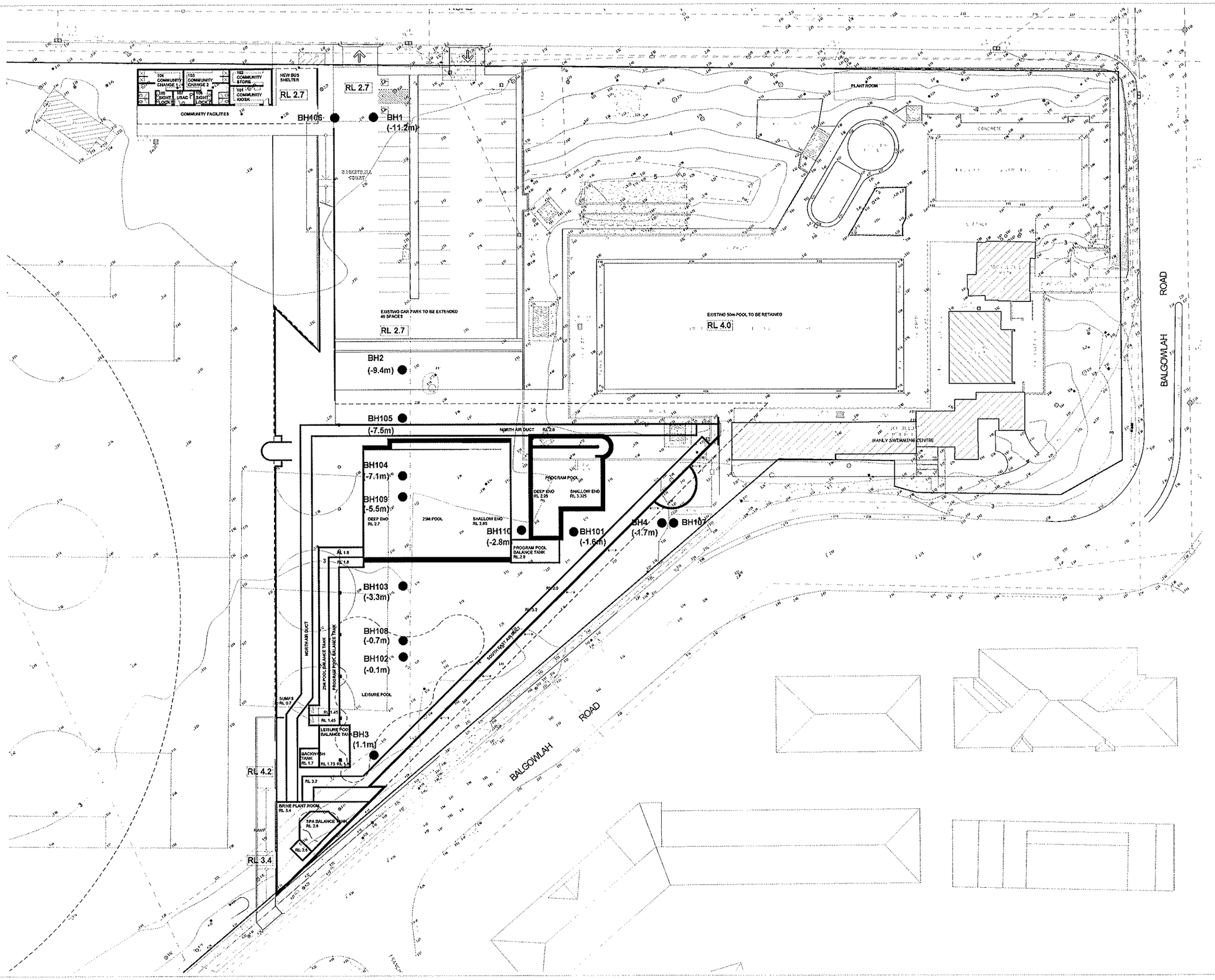
Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL		Easily remoulded by hand to a material with soil properties.
----------	----------	0.03	
Very Low:	VL		May be crumbled in the hand. Sandstone is "sugary" and friable.
----------	----------	0.1	
Low:	L		A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
----------	----------	0.3	
Medium Strength:	M		A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
----------	----------	1	
High:	H		A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
----------	----------	3	
Very High:	VH		A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
----------	----------	10	
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	

APPENDIX A



ISSUE	AMENDMENT	DATE	BY

GENERAL NOTES

1 INTERNAL WALL NUMBERS 2 3 4

Verify all dimensions shown at the site. Work only to figured dimensions. Do not scale the drawings. Report any discrepancies to the Architect for decision and clarification.

This drawing should be read in conjunction with the relevant Contracts, Specifications and Drawings.

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CLIENT
MANLY COUNCIL

PROJECT
MANLY ANDREW "BOY" CHARLTON SWIM CENTRE REDEVELOPMENT

DRAWING TITLE
SURVEY PLAN

PROJECT/DRAWING NUMBER
1310 00

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Issue
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

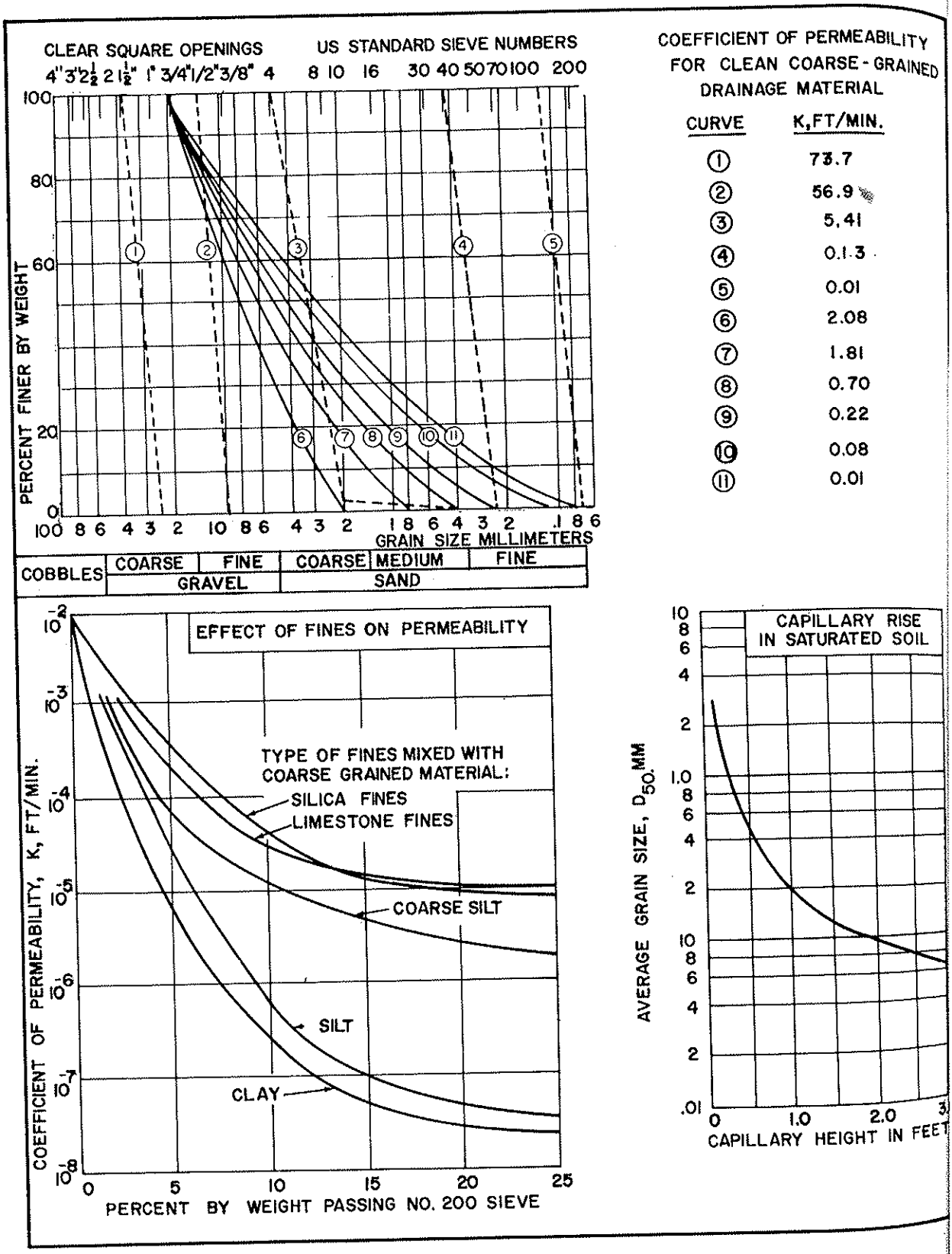
APPENDIX B

MANLY ANDREW "BOY" CHARLTON SWIM CENTRE REDEVELOPMENT
KENNETH AND BALGOWLAH ROADS BALGOWLAH NSW

ANALYSIS OF PROPOSED EXCAVATION

Built element	RL Built Surface of Element	RL underside of Element	RL Adjacent ground surface	Depth of Excavation required (metres)	Closest Bore Hole Reference Number	RL ground water at reference borehole	Excavation below Ground Water Level (metres)
Lower Ground Floor Concourse	4.2	4.0	3.11	n/a	101	1.8	n/a
North Air Duct 125m2	4.2	2.0	2.7	0.7	105	1.1	n/a
South East Air Duct 112m2	4.2	2.0	3.11	1.11	101	1.8	n/a
Programme Pool minimum depth	4.2	3.125	3.11	n/a	101	1.8	n/a
Programme Pool maximum depth	4.2	2.750	3.0	0.25	110	1.8	n/a
25m pool Minimum depth	4.2	2.750	2.94	0.19	110	1.8	n/a
25m pool Maximum depth	4.2	2.5	2.88	0.38	104	1.3	n/a
Upper Ground Floor Concourse	5.4	5.2	3.11	n/a	102	2.0	n/a
South East Air Duct 172m2	5.4	3.2	3.35	0.15	3	2.4	n/a
Leisure Pool Minimum	5.4	5.2	3.11	n/a	102	2.0	n/a
Leisure Pool Maximum	5.4	4.2	3.11	n/a	102	2.0	n/a
Programme Pool Balance Tank 65m2	4.2	1.45	3.14	1.69	103	1.5	0.19
25m Pool Balance Tank 67m2	4.2	1.45	3.14	1.69	103	1.5	0.19
Leisure Pool Balance Tank 41m2	5.4	1.5	3.11	1.61	3	2.4	0.9
Pool Plant Room 110m2	4.2	4.0	3.11	n/a	3	2.4	n/a
Brine Plant Room 130m2	3.4	3.2	3.92	0.72	3	2.4	n/a
Backwash Tank 12m2	4.2	1.5	3.11	1.61	3	2.4	0.9

APPENDIX C



COEFFICIENT OF PERMEABILITY FOR CLEAN COARSE-GRAINED DRAINAGE MATERIAL

CURVE	K, FT/MIN.
①	73.7
②	56.9
③	5.41
④	0.13
⑤	0.01
⑥	2.08
⑦	1.81
⑧	0.70
⑨	0.22
⑩	0.08
⑪	0.01

FIGURE 8-5
Permeability and Capillarity of Drainage Materials