WGA
WALLBRIDGE GILBERT AZTEC

City of Onkaparinga
PO Box 1
NOARLUNGA CENTRE SA 5168

17th August 2020

Project No. WGA201245

Attention: Rob Bau

Dear Rob,

WITTON BLUFF BASE TRAIL – PORT NOARLUNGA BEACH
GEOTECHNICAL INVESTIGATION FOR PROPOSED BOARDWALK

1. INTRODUCTION

A geotechnical investigation has been undertaken by Wallbridge Gilbert Aztec (WGA) for an elevated boardwalk and bridge section of the Witton Bluff Base Trail (WBBT). This section of the boardwalk spans a sandy embayment between near vertical limestone shelves (refer to Figure 1).

The aim of the geotechnical assessment was to assess the subsurface conditions within the embayment in order to provide recommendations relating to footing design.

This report describes the geotechnical investigations undertaken for the WBBT and summarises the subsurface conditions encountered. Recommendations for the design of footings for the proposed boardwalk are presented in Section 7.

2. REGIONAL GEOLOGY

Regional Geology of the Port Noarlunga region comprises marine sediments from the Eocene 56-34 MA marine transgression, when the sea advanced toward the east depositing sequences of sand and limestone.

The Geological Survey of South Australia (1:100 000 scale) "*Yankalilla"* map sheet indicates that the geology of the area consists of limestone of the Blanche Point Formation. The Blanche Point Formation is overlain by the Quaternary sediments of the Ngaltinga (Keswick) Clay and Semaphore Sand member.

3. BACKGROUND

A report by Golder Associates (2001) assessed the stability of the coastal cliffs along 30 km of coastline including the Witton Bluff area. The study focussed on providing Council with a tool to prioritise the implementation of appropriate risk management strategy. One of the identified high-risk areas was the area near the proposed Witton Bluff Base Trail. The cliff crest was assessed to be recessing faster than the cliff toe.

URS (2004) extended on the Golders report, with a more detailed examination of the Witton Bluff area.

60 Wyatt Street
Adelaide SA 5000
T: 08 8223 7433
WGASA Pty Ltd
ABN 97 617 437 724

URS (2005) consolidated the previous reports and added a Geological hazard assessment and provided an options assessment for the proposed path alignment.

- Option 1 – along the top of the cliff presented environmental, access, parking and traffic challenges that were deemed to be unlikely the ideal solution.
- Option 2 – Across gullied slope of cliff was considered geotechnically infeasible.
- Option 3 – Along limestone base platform was considered as feasible and preferred option from a geotechnical and environmental perspective.
- Option 4 – Along reclaimed land on the ocean side of the limestone base platform was considered to be a feasible and preferred geotechnical solution, however, was assessed as restrictive due to environmental and cost perspectives.
- Option 5 – Some combination of options 1-4 were assessed to have equal geotechnical preference to that of option 3, with the inability to perform as well as option 3 with regard to environmental and cost considerations.

Option 3, with Option 4 in areas where the limestone platform is narrow or absent, was assessed as the preferred option, with preference of a boardwalk chosen over a pavement type path.

Consideration for the northern and southern connection were assessed with a sloping boardwalk ramp favoured in the north and a path running up behind the limestone point, then down the southern face to connect with the promenade favoured in the south.

4. OUTLINE OF GEOTECHNICAL INVESTIGATION

The field work was carried out on the 23rd July 2020 and comprised drilling three boreholes (referred to as BH1, BH2 and BH3) to depths of 0.9 m to 1.6 m within the embayment (refer to Figure 1).

Figure 1: Borehole Drilling, Note Limestone Shelf in The Background

The boreholes were drilled with a portable drilling equipment, using continuous push tube sampling methods. Push tube refusal was met in each borehole on weathered limestone.

The locations of the boreholes are shown approximately on the attached Figure 1.

A Dynamic Cone Penetrometer (DCP) test was performed adjacent to each borehole to assess the in-situ strength of the soil profile. The results of the DCP tests are shown on the respective logs.

The subsurface profile encountered in the boreholes is described on the attached engineering logs. Also attached are two explanation sheets that outline the terms and symbols used in their preparation.

A site walkover by a geologist from WGA was performed on 23rd of June 2020 and included a visual and rock pick assessment of the limestone along the proposed boardwalk.

5. SITE CONDITIONS

The WBBT project involves the construction of a new shared use pathway located around Witton Bluff, between the foreshore at Christies Beach and Port Noarlunga. A new boardwalk pathway is proposed around the base of the cliffs and along the limestone shelf to the Port Noarlunga foreshore.

An excerpt from the architectural landscape concept of the proposed boardwalk (08146SK02B Swanbury Penglase Architects) is reproduced as Figure 3.1.

Figure 2: Site and Proposed Boardwalk Layout

The boardwalk will be predominantly located along an erosional limestone shelf, up to 4 m in height, that lies in front of the coastal cliffs. The Quaternary aged sediments overlying the limestone have been eroded in the past.

Wave and tidal erosion have created the ‘stepped’ geomorphology of the unit, with the formation of a sandy embayment between 2 distinct limestone shelves. An elevated structure is proposed for the boardwalk over the sandy embayment, between the limestone shelves.

The embayment contains rip-rap rock protection (refer to Figure 2) to prevent further erosion of the limestone at the toe of the cliff. Historical information indicates that the rip-rap was placed in 2013 at the location of previous cliff instability and a cave.

Figure 3: Rip-rap Protection Abutting the Limestone Shelf

Rock pick assessment by a geologist from WGA of the limestone platform estimated that a Mohs hardness scale value of 3 - 4 (equivalent to Vickers Hardness value of 157 - 315 kg/mm^2) was representative of the surface of the limestone. It was also noted that the exposed limestone is relatively homogenous.

The limestone shelf is undercut at the base in places due to erosion.

6. RESULTS OF GEOTECHNICAL INVESTIGATION

The natural subsurface profile encountered in the boreholes was broadly consistent with the regional geology and generally comprised recent Semaphore Sand overlying limestone (Blanche Point Formation).

The Semaphore Sand was described as fine to medium grained, orange and pale yellow-brown sand. Based on the results of the DCP testing and observed drilling resistance, the sand was assessed to be in a loose to dense condition.

The limestone recovered was fractured and of medium to high strength, fine to medium grained, pale brown to green-grey and encountered below depths of about 0.6 m and 1.1 m. High plasticity pale brown to pale green-grey clay of stiff to very stiff consistency was encountered interbedded in the limestone.

A layer of fine to medium grained, orange, black, pale brown and white sandy gravel, rounded with shell fragments, was encountered in BH1 between the sand and limestone.

Groundwater (seawater) was encountered in each of the boreholes at around 0.3 m depth. Tidal variations in groundwater level occur and the embayment is submerged at high tide.

7. GEOTECHNICAL ASSESSMENT

7.1 General

Across the sandy embayment, it is recommended that the elevated boardwalk structure be supported by footings founded on weathered limestone beneath the beach sand. At each end of the sandy embayment footings may be founded directly on the surface of the limestone shelf.

Large spread footings founded on the limestone are not expected to be practical in the embayment due to the presence of shallow groundwater and sandy soils, which would require relatively flat batters to be adopted for footing excavations.

Conventional (uncased) bored piles are expected to be problematic due to collapse of the pile shaft. Bored piles would need to be supported by temporary casing and the use of specialist tungsten tipped core barrels would need to be used to penetrate the limestone. Conventional earth augers are expected to met refusal on the limestone.

Small-diameter piles driven to practical refusal in the limestone are recommended. Suitable driven pile types would include steel tube or steel H-section. Timber or precast concrete are unlikely to be suitable as they are more likely to be susceptible to damage during driving.

The design of the piles would need to consider:

- the durability of steel and concrete in a marine environment;
- variability in the weathered limestone. The depth, strength and thickness of the limestone has the potential to be highly variable and weaker zones of soil strength material (sand and clay) may be present;
- where piles met refusal at shallow depth with minimal pile penetration into the limestone, the lateral and uplift capacity of the piles may be inadequate. Lateral loading on the piles could be reduced by cross-bracing. Alternatively, the pile locations could be pre-drilled with a pneumatic hammer to reduce pile driving resistance and allow the piles to be founded deeper.

Recommendations for design and construction of driven piles and shallow footings founded on the limestone shelf are provided in the following sections.

7.2 Site Classification

Based on a visual-tactile assessment, the soil profile is assessed to be essentially non-reactive with respect to shrink-swell movements caused by changes in soil moisture content.

Based on the design soil suction change profile for Adelaide presented in AS 2870-2011 “Residential slabs and footings”, a characteristic surface movement (y_s) of less than 5 mm is predicted for the site at the current ground surface level.

In accordance with a classification system presented in AS 2870, a site classification of Class A (Sand site) is considered appropriate for the soil profile encountered based on reactive soil movements below the current site levels.

7.3 Site Factor

Using the Classification System presented in AS 1170.4-2007 "*Structural design actions Part 4: Earthquake actions in Australia*", it is assessed that the site sub-soil class would be Class Be (Rock Site).

7.4 Durability

Based on the tidal/splash zone marine environment, an exposure classification of “*severe”* is considered appropriate for buried steel and concrete in accordance with the guidelines of Tables 6.4.2(A) and 6.5.2(A) in AS 2159-2009 “*Piling – Design and Installation”*.

7.5 Pile Design

Design Parameters

It is recommended that piles be driven to practical refusal in the weathered limestone, with a minimum embedment of 2 pile diameters or 0.6 m into the limestone.

The piles would be essentially end-bearing with shaft resistance above the weathered limestone neglected due to the effects of disturbance or future erosion.

A driven pile founded in limestone may be proportioned on the basis of the following geotechnical parameters:

Ultimate End Bearing Pressure : 5000 kPa(1) ;

Ultimate Shaft Adhesion:

- soil : neglect

- limestone : 100 kPa(1,2);

Notes:

1. Assumes piles are founded in limestone of at least medium rock strength. To be verified by a recognised pile driving formula during construction.

2. Assumes driven piles form a tight fit in any pre-bored holes the rock is not overly disturbed during drilling. Cone pull-out failure may govern at shallow pile embedment depths.

In accordance with the guidelines of AS 2159-2009 *"Piling - Design and Installation"* a geotechnical strength reduction factor, ϕ_g, must be applied to the ultimate geotechnical parameters presented above to determine the design geotechnical strength, $R_{d,g}$, which must then be equal to or exceed the design action effect, E_d.

Based on clause 8.2.4(C) a basic geotechnical strength reduction factor, ϕ_{gb} of 0.4 is recommended. A higher geotechnical reduction factor may be used if pile load testing to verify pile serviceability is conducted during construction. Further advice should be sought on this issue if required.

To estimate the lateral pile capacity, it may be conservatively assumed that the limestone can be modelled as a granular soil with a coefficient of passive earth pressure (K_p) of 4.6.

Using Broms' theory, the ultimate lateral resistance of a pile would be calculated as $3K_p\sigma'_{vo}$, where σ'_{vo} is the effective over-burden pressure in kPa. It is recommended the lateral resistance provided by the soil above the limestone be neglected.

Further advice on pile design issues may be provided once the design loadings are known.

Constructability Issues

The loose and wet sands above the limestone will collapse in unsupported pile shafts and the use of conventional bored piles is expected to be unsuitable

Difficulties driving piles through the limestone of varying thickness and strength may be encountered and the use of thick-walled steel pile sections is recommended to achieve the required embedment depths for lateral/uplift resistance, and to enhance the long-term durability. Care must be taken to prevent damage to the pile section during driving.

Pre-drilling of the pile locations into the rock could be considered.

Contractors should allow for varying pile founding depths and the need to cut-off piles which meet premature refusal.

Pile driving equipment would need to consider the dynamic beach environment at the site and the need to construct a temporary piling platform to provide access for construction equipment.

7.6 Surface Footings

For the section of the boardwalk over the limestone shelf, it is expected that the boardwalk could be supported by shallow pad footings founded directly on the limestone.

It is expected that the footings would be excavated using a jack-hammer, rock-breaker and hand tools. Footings founded in limestone of at least low strength may be proportioned based on a maximum allowable bearing pressure of 150 kPa under vertical loading.

Footings must be located at least 2 m from the vertical face of the limestone shelf.

The uplift and lateral resistance of the footing could be enhanced by the use of a rock anchor(s) extending below the base of the footing into the limestone. The rock anchor would comprise a galvanised reinforcing bar grouted into a pre-drilled borehole. An allowable bond strength of 250 kPa is recommended for limestone of at least medium strength and a suitably roughened borehole.

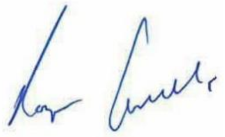
The footing design parameters for the limestone would need to be confirmed by a geotechnical engineer during footing construction.

8. LIMITATIONS

The recommendations contained within this report have been based on the subsurface conditions encountered in a limited number of boreholes and the judgement and opinion of WGA. To the best of our knowledge, the subsurface conditions described in this report provide a reasonable interpretation of the typical subsurface conditions likely to be encountered on site.

It must be accepted that variations in subsurface conditions are likely to occur over the site and such variations may impact on the design recommendations provided. Under no circumstances can it be assumed that this report represents the actual subsurface conditions at all locations over the site.

Yours faithfully



Roger Grounds
for
WALLBRIDGE GILBERT AZTEC

Attachments:
Appendix A - Figure 1: Borehole location plan
Appendix B - Engineering logs of boreholes BH1 to BH3
Appendix C - Laboratory Test Results

RG:sem

APPENDIX A
FIGURES

Image: Land Services Group,
Government of South Australia

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Drawn by	HRJ	WGA WALLBRIDGE GILBERT AZTEC	Client:	CITY OF ONKAPARINGA	
Approved	RWG		Project:	WITTON BLUFF BASE TRAIL	
Date	4-8-20		Title:	BOREHOLE LOCATION PLAN	
Dimensions	-				
Original	-		Project No.: WGA201245	Ref.	FIGURE 1

APPENDIX B
RESULTS OF FIELD INVESTIGATION

WGA
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60 Wyatt Street, Adelaide
South Australia 5000
Telephone 08 8223 7433
Email adelaide@wga.com.au

Date Drilled:	23/07/2020		
Date Logged:	23/07/2020	**Borehole No.**	
Logged by:	**JL**	**BH1**	
Drilling Method:	Push Tube		
Drill Rig/Mount:	Portable	Page 1 of 1	

Legend:

Moisture Condition	**Density Index - Granular**	**Consistency - Cohesive**	
D - Dry	VL/L - Very Loose/Loose	VS - Very Soft	Vst-Very Stiff
M - Moist	MD- Medium Dense	S - Soft	H - Hard
W - Wet	D/VD- Dense/Very Dense	F - Firm	Fb - Friable
Wp - Plastic Limit		St - Stiff	
USCS: Unified Soil Classification System		↓GW = Groundwater	

Project Number: **WGA201245**
Location: **WITTON BLUFF BASE TRAIL**

		Composition of soil	Condition of soil			Structure and additional observations	
Depth below surface (m)	USCS Symbol	Soil Description (type, plasticity, grading, colour, secondary and minor components)	Moisture Condition	Consistency or Density Index	Hand Penetrometer Reading (kPa)	(e.g. soil origin, defects, cementing, likely I_{pt} (%))	**DCP blows/100mm**
	SP	SAND, fine to medium grained sand, pale brown, orange, pale yellow-brown	W	L		beach sand	1
				D			5
							6
							7
0.5							6
0.65		grades fine to coarse grained, with fine grained gravel					6
	GP	sandy GRAVEL, fine to medium grained (rounded), including shell pieces, orange, black, pale brown, white, fine to coarse grained sand	W	D			6
							>20
1.0	CH	CLAY, high plasticity, pale brown, with interbedded layers of LIMESTONE, pale brown, medium to high strength, fractured	>Wp	F/St	75		
		borehole terminated 1.1m (refusal)					
1.5							
2.0							
2.5							
3.0							

Depth to Groundwater: 0.3m

Trees at Site: **No**

WGA
WALLBRIDGE GILBERT AZTEC
60 Wyatt Street, Adelaide
South Australia 5000
Telephone 08 8223 7433
Email adelaide@wga.com.au

Date Drilled:	23/07/2020	**Borehole No.**
Date Logged:	23/07/2020	**BH2**
Logged by:	**JL**	
Drilling Method:	Push Tube	
Drill Rig/Mount:	Portable	Page 1 of 1

Legend:

Moisture Condition	Density Index - Granular	Consistency - Cohesive	
D - Dry	VL/L - Very Loose/Loose	VS - Very Soft	Vst-Very Stiff
M - Moist	MD- Medium Dense	S - Soft	H - Hard
W - Wet	D/VD- Dense/Very Dense	F - Firm	Fb - Friable
Wp - Plastic Limit		St - Stiff	
USCS: Unified Soil Classification System		↓GW = Groundwater	

Project Number: **WGA201245**
Location: **WITTON BLUFF BASE TRAIL**

Depth below surface (m)	USCS Symbol	Composition of soil: Soil Description (type, plasticity, grading, colour, secondary and minor components)	Condition of soil: Moisture Condition	Consistency or Density Index	Hand Penetrometer Reading (kPa)	Structure and additional observations (e.g. soil origin, defects, cementing, likely I_{pt} (%)) **DCP blows/100mm**
	SP	SAND, fine to medium grained, pale brown, orange, pale yellow-	W	L		1
		brown		D		5
						5
0.45						8
0.5		LIMESTONE, fine grained, pale brown, pale green-grey, medium to				>20
		high strength, fractured				
	CH	mainly CLAY, high plasticity, pale brown, pale green-grey, trace sand	>Wp	Vst	220	
		some fractured limestone bands (as above), and sandier pockets				
1.0						
					430	
					180	
1.5					260	
					240	
		borehole terminated at 1.6m (refusal)				
2.0						
2.5						
3.0						

Depth to Groundwater: 0.3m **Trees at Site: No**

WGA
WALLBRIDGE GILBERT AZTEC

60 Wyatt Street, Adelaide
South Australia 5000
Telephone 08 8223 7433
Email adelaide@wga.com.au

Date Drilled:	23/07/2020	**Borehole No.**
Date Logged:	23/07/2020	**BH3**
Logged by:	**JL**	
Drilling Method:	Push Tube	
Drill Rig/Mount:	Portable	Page 1 of 1

Legend:

Moisture Condition	**Density Index - Granular**	**Consistency - Cohesive**	
D - Dry	VL/L - Very Loose/Loose	VS - Very Soft	Vst-Very Stiff
M - Moist	MD- Medium Dense	S - Soft	H - Hard
W - Wet	D/VD- Dense/Very Dense	F - Firm	Fb - Friable
Wp - Plastic Limit		St - Stiff	
USCS: Unified Soil Classification System		↓GW = Groundwater	

Project Number: **WGA201245**

Location: **WITTON BLUFF BASE TRAIL**

		Composition of soil	Condition of soil			Structure and additional observations
Depth below surface (m)	USCS Symbol	Soil Description (type, plasticity, grading, colour, secondary and minor components)	Moisture Condition	Consistency or Density Index	Hand Penetrometer Reading (kPa)	(e.g. soil origin, defects, cementing, likely I_{pt} (%)) **DCP blows/100mm**
	SP	SAND, fine to medium grained, orange, pale yellow-brown, pale	W	MD		1
		brown				3
						3
						3
0.5						6
				D		6
						6
0.75		LIMESTONE, fine to medium grained, grey, fractured, medium to	M-W			6
		high strength with low strength pockets (weakly cemented silty sand)				
1.0		borehole terminated 0.9m (refusal)				
1.5						
2.0						
2.5						
3.0						

Depth to Groundwater: 0.3m **Trees at Site:** **No**

WGA

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DESCRIPTION AND CLASSIFICATION OF SOILS[(1)] FOR ENGINEERING PURPOSES
EXPLANATION SHEET TO ACCOMPANY ENGINEERING LOGS (SHEET 1)

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in general accordance with the Unified Soil Classification (UCS) as shown in Table 1 on Sheet 2 using visual-tactile methods.

PARTICLE SIZES

NAME	FRACTION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6.7 mm to 20 mm
	fine	2.36 mm to 6.7 mm
Sand	coarse	600 µm to 2.36 mm
	medium	210 µm to 600 µm
	fine	75 µm to 210 µm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil feels cool and darkened in colour. Cohesive soils can be mounded. Granular soils tend to cohere.

Wet Similar to moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH Su (kPa)	FIELD ASSESSMENT
Very Soft	≤12	A finger can be pushed well into the soil with little effort.
Soft	12 to 25	A finger can be pushed into the soil to about 25 mm depth.
Firm	25 to 50	The soil can be indented about 5 mm with the thumb.
Stiff	50 to 100	The surface of the soil can be indented with the thumb.
Very Stiff	100 to200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	Not able to be measured	Crumbles or powders when scraped by thumbnail.

The undrained shear strength is assessed in the field using a pocket or hand penetrometer (PP). The undrained shear strength is approximately one half of the hand penetrometer reading.

DENSITY INDEX OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 to 35
Medium Dense	35 to 65
Dense	65 to 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	FIELD ASSESSMENT	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye.	Coarse grained soils: ≤5% Fine grained soils: ≤15%
With some	Presence easily detected by feel or eye.	Coarse grained soils: >5 to≤12% Fine grained soils: >15 to ≤30%

SOIL STRUCTURE

INCLUSIONS		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly Cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately Cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

SOIL ORIGIN

MATERIALS WEATHERED IN-SITU

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian	Deposited by wind.
Alluvial	Deposited by streams and rivers.
Colluvial	Deposited on slopes (transported downslope by gravity)
Fill	Placed by man. Fill may be markedly more variable between tested locations than naturally occurring soils.
Marine	Deposited in ocean basins, bays, beaches and estuaries.

Note: (1) materials found in the ground are generally described as a soil if the material can be remoulded or disintegrated by hand in the field condition or in water. Other materials are described using rock description terms.

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Table 1: SOIL CLASSIFICATION AND FIELD IDENTIFICATION AND DESCRIPTION (SHEET 2)

<table>
<tr><th colspan="6">FIELD IDENTIFICATION PROCEDURES
(excluding particles larger than 60 mm and basing fractions on estimated mass)</th><th>USC</th><th>PRIMARY NAME</th></tr>
<tr><td rowspan="8">COARSE GRAINED SOILS
More than 65% of material less than 63 mm is larger than 0.075 mm</td><td rowspan="4">GRAVELS
More than half of coarse fraction is larger than 2.0 mm</td><td rowspan="2">CLEAN GRAVELS (Little or no fines)</td><td colspan="3">Wide range in grain size and substantial amounts of all intermediate particle sizes.</td><td>GW</td><td>GRAVEL</td></tr>
<tr><td colspan="3">Predominantly one size or a range of sizes with more intermediate sizes missing.</td><td>GP</td><td>GRAVEL</td></tr>
<tr><td rowspan="2">GRAVELS WITH FINES (Appreciable amount of fines</td><td colspan="3">Non-plastic fines (for identification procedures see ML below)</td><td>GM</td><td>SILTY GRAVEL</td></tr>
<tr><td colspan="3">Plastic fines (for identification procedures see CL below)</td><td>GC</td><td>CLAYEY GRAVEL</td></tr>
<tr><td rowspan="4">SANDS
More than half of coarse fraction is smaller than 2.0 mm</td><td rowspan="2">CLEAN SANDS (Little or no fines)</td><td colspan="3">Well graded. Wide range in grain sizes and substantial amounts of all intermediate sizes.</td><td>SW</td><td>SAND</td></tr>
<tr><td colspan="3">Poorly graded. Predominantly one size or a range of sizes with some intermediate sizes missing</td><td>SP</td><td>SAND</td></tr>
<tr><td rowspan="2">SANDS WITH FINES (Appreciable amount of fines)</td><td colspan="3">Non-plastic fines (for identification procedures see ML Below)</td><td>SM</td><td>SILTY SAND</td></tr>
<tr><td colspan="3">Plastic fines (for identification procedures see CL below)</td><td>SC</td><td>CLAYEY SAND</td></tr>
<tr><td></td><td colspan="5">IDENTIFICATION PROCEDURES ON PARTICLES <0.2 mm</td><td></td><td></td></tr>
<tr><td rowspan="7">FINE GRAINED SOILS
More than 35% of material less than 63 mm is smaller than 0.075 mm</td><td></td><td></td><td>DRY STRENGTH</td><td>DILATANCY</td><td>TOUGHNESS</td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="3">SILTS & CLAYS
Liquid limit less than or equal to 50</td><td>None to low</td><td>Quick to slow</td><td>None</td><td>ML</td><td>SILT</td></tr>
<tr><td>Medium to high</td><td>None</td><td>Medium</td><td>CL</td><td>CLAY</td></tr>
<tr><td>Low to medium</td><td>Slow to very slow</td><td>Low</td><td>OL</td><td>ORGANIC SILT</td></tr>
<tr><td colspan="2" rowspan="3">SILTS & CLAYS
Liquid limit greater than 50</td><td>Low to medium</td><td>Slow to very slow</td><td>Low to medium</td><td>MH</td><td>SILT</td></tr>
<tr><td>High</td><td>None</td><td>High</td><td>CH</td><td>CLAY</td></tr>
<tr><td>Medium to high</td><td>None</td><td>Low to medium</td><td>OH</td><td>ORGANIC CLAY</td></tr>
<tr><td colspan="3">HIGHLY ORGANIC SOILS</td><td colspan="3">Identified by colour, odour, spongy feel and frequently by fibrous texture.</td><td>Pt</td><td>PEAT</td></tr>
<tr><td colspan="8">* Low plasticity – Liquid Limit W_L Less than 35 %   * Medium plasticity - W_L between 35% and 50%</td></tr>
</table>

APPENDIX C
LABORATORY TEST RESULTS

WGA

WALLBRIDGE GILBERT AZTEC

GUIDE TO INTERPRETING YOUR **WGA GEOTECHNICAL REPORT**

This geotechnical report has been prepared by an experienced WGA Engineer. These notes have been prepared by WGA to assist the Client interpret and understand the report limitations.

SCOPE OF SERVICES

This report has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and WGA. In some circumstances, the scope of the services may have been altered by a range of factors such as time, budget and access restrictions.

GEOTECHNICAL INVESTIGATIONS

Geotechnical engineering is based extensively on professional judgment and opinion. It is far less precise than other engineering disciplines.

Geotechnical engineering reports are prepared to meet the specific needs of individual clients. This report was prepared expressly for the Client for the purposes indicated in the agreed scope of services. Use by any other persons for any purpose, or by the Client for a different purpose, may result in problems.

For example, a report prepared for a consulting civil engineer may not be adequate for a construction contractor or even another consulting engineer.

This report must not be used for any project other than that originally specified at the time the report was prepared, without seeking additional geotechnical advice.

PROJECT-SPECIFIC FACTORS

This report is based on a subsurface investigation designed to meet the requirements of a specific project. The subsurface investigation was formulated based on factors which include the nature of the development, its size and configuration, the location of any existing development on the site, and the location of access roads and parking areas. Unless further geotechnical advice is obtained in writing, this report may not provide appropriate recommendations if:

- the nature of the proposed development is changed; or
- the size, configuration, location or orientation of the proposed development is modified.

The report findings cannot be applied to any other sites, including adjacent sites.

SUBSURFACE CONDITIONS

Subsurface conditions are created by natural processes and the activity of man and may, therefore, be modified by changing natural forces or man-made influences. For example, water levels can vary with time and fill may be placed on a site. The report is based on conditions which existed at the time of subsurface exploration.

Construction operations at, or adjacent to, the site and natural events such as floods or groundwater fluctuations may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. WGA should be kept informed of any such events and should be consulted to determine if additional investigations are necessary

THIRD PARTY INTERPRETATION OF FINDINGS

WGA should be retained to assist other design professionals in the interpretation of relevant geotechnical findings, and to review the adequacy of plans and specifications relative to geotechnical issues. Costly problems can occur when other design professionals develop plans based on misinterpretations of a geotechnical report.

ENGINEERING LOGS SHOULD NOT BE SEPARATED FROM THE REPORT

The report presents the findings of the geotechnical investigation and must not be copied or altered in any way.

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Engineering logs and cross-sections are developed by geotechnical engineers based upon their interpretation of field logs and laboratory testing of samples. These logs and figures should not be redrawn for inclusion in other documents or separated from the report in any way.

To reduce the likelihood of misinterpretation, contractors should be given access to the complete geotechnical report prepared or authorised for use. The following publication should be referenced for further information.
Guidelines for the Provision of Geotechnical Information in construction Contracts (Engineers Australia, National Headquarters, Canberra 1987).

RELIANCE ON SUPPLIED DATA

In preparing the report, WGA may have relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations. Unless otherwise stated in the report, WGA has not verified the accuracy or completeness of such data. WGA will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misinterpreted or otherwise not fully disclosed to WGA.

LIMITATIONS OF SITE INVESTIGATIONS

In making an assessment of a site from a limited number of boreholes or test pits it is inevitable that variations will occur between test locations. Subsurface exploration identifies specific subsurface conditions only at those points from which samples have been taken. The likelihood that subsurface variations will not be detected can be reduced by increasing the frequency of test locations, although this has cost implications. The investigation program undertaken is a professional estimate of a reasonable scope of investigation required to provide a general profile of the subsurface conditions. The data derived from the site investigation program and subsequent laboratory testing are extrapolated across the site to form an inferred geotechnical model and an engineering opinion is formed about overall subsurface conditions and their likely behaviour with regard to the proposed development.

Despite subsurface exploration, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface conditions and anomalies.

The engineering logs are the subjective interpretation of the subsurface conditions encountered at a particular location, made by experienced personnel. The interpretation may be limited by the method of investigation, and cannot always be definitive. For example, inspection of an excavation or test pit allows a greater area of the subsurface profile to be inspected than borehole investigations, however, such methods are limited by depth and site disturbance restrictions.

The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained from the subsurface exploration. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, the services of WGA should be retained through design and construction stages, to identify variances, conduct additional tests if required and recommend solutions to any problems encountered on site.