GIPPSLAND PORTS

GEOTECHNICAL INVESTIGATION

LONG JETTY REHABILITATION

PORT WELSHPOOL

Report No: 113173

Date: 29 June 2011

GEOTECHNICAL INVESTIGATION

By

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1. INTRODUCTION

1.01 **Investigation Requested By:** The geotechnical investigation was commissioned by Mr Gary Lugton of Gippsland Ports, in a purchase order (No: 30645) dated 24th March, 2011.

1.02 **Purpose of Investigation:** It is proposed to rehabilitate the existing historic 'Long Jetty' at Port Welshpool. In order to derive the options for this potential rehabilitation it was required that a geotechnical investigation be undertaken. Herein it was required to drill four (6) boreholes along the length of the existing jetty, to determine the sub-seabed soil profile for piling conditions. A brief was provided requiring boreholes to extend to some 10.0m below seabed level.

1.03 **Geology:** The 1:250,000 Series Geological Survey of Victoria, Warragul Sheet indicates the subject site to be underlain by Quaternary deposits, including swamp and lagoon deposits, calcareous and siliceous sand sheets.

1.04 **Field Methods:** Each of the boreholes was drilled using a trailer mounted Gemco rotary drill rig, situated on various sections along the existing Long Jetty. Due to the removal of sections of the Jetty, the drill had to be moved to and from boreholes 5 and 6 by barge. As part of the investigation, the following field methods were incorporated:

i) **Rotary Wash Boring:** The boreholes were drilled using a 75 millimetre diameter tungsten tri-blade bit in conjunction with 90 millimetre diameter steel casing.

ii) **Standard Penetration Testing:** Standard penetration testing was conducted at regular intervals within each of the boreholes in accordance with the test procedure outlined in Australian Standard 1289, "Methods of Testing Soils For Engineering Purposes," Test Method 6.3.1, 1993.

iii) **Logging of Soil Profiles:** The soil profiles encountered in each of the boreholes were logged in accordance with Australian Standard AS 1726 - 1993, "Geotechnical Site Investigations."

1.05 **Laboratory Test Methods:** All soil samples were transferred to A.S. James' National Association of Testing Authorities registered Clayton South laboratory, where testing was undertaken by trained laboratory technicians. All laboratory testing was performed in strict accordance with the test methods outlined in Australian Standard AS 1289, "Method of Testing Soils for Engineering Purposes".

	AS Test Method
• Grain Size Distribution	1289 3.6.1

2. RESULTS

2.01 **Borehole Locations:** Six (6) boreholes were drilled between 11h May and 2nd June, 2011, at the approximate locations indicated on Figure 1.

The logs of the boreholes together with the results of standard penetration tests carried out in each of the boreholes are given on Figures 2 – 7.

Note: All borehole logs, test results and other depths given in this report are relative to the seabed level and this level relative to the existing jetty level is given on the logs.

2.02 **Sub-Surface Soil Profile:** As per the borehole investigation, the subsoil consists of grey silty sand throughout the depth investigated. The top 2.0m generally consists of loose sands and with increasing depth the SPT N-values are found to be increasing with the depth. The exception to this is approximately at 9.0m depth in borehole 6, a relatively low SPT N value of 7 was recorded whereas in the remaining boreholes high SPT N values were noted at this depth. The sand contained sea shells generally within the top 4 metres and each borehole intersected layers of 5mm quartz gravel beyond 3 metres. These layers of quartz gravel were typically 500mm in depth.

2.2 Laboratory Testing.

Good correlations exist between moisture content and strength in Silurian deposits.

2.2.1 **Test Program - Soil Samples:** Upon receipt in the laboratory the disturbed soil samples retrieved from the boreholes were tested for Grain Size Distribution and the results are given on Figures 8-9 . Results indicate the sands are generally fine grained with less percentage of silt

3. RECOMMENDATIONS

3.1.1 Considering the thickness of the loose sand layers at shallow depths the proposed structure needs to be constructed on piles. The use of driven piles (steel/concrete) would appear to be a suitable pile type for the proposed construction.

3.1.2 **Pile Load Capacity:** Piling contractors should make their own assessment of piling conditions and load carrying capacities of proprietary pile types, based on the information contained within this report. Yet, as a guide, it is estimated that a 350 millimetre square precast concrete driven pile approximately 10.0m metres into the medium dense to dense sand (i.e. 10m below existing seabed level) will safely support a load up to 500kN, whereas a 350mm diameter steel pile driven to the same layer will be able to carry a load up to 400kN. These calculations are based on the sand profile encountered in borehole 6 (assuming the worst case – loose / medium dense sand approx. from 9.0-10.0m). However, in the remaining boreholes a denser sand layer was encountered at this depth.

3.1.3 **Pile Settlements:** Pile settlements for a 350 millimetre diameter steel or square concrete pile are estimated to be less than 10 millimetres, with differential settlements between adjacent piles being slightly less than half of the total estimated pile settlement.

3.1.4 **Lateral Pile Loads:** The ultimate lateral resistance H_u of free-head piles in cohesionless soils is conservatively given by the lesser of Equations 1 and 2.

$$H_u = \frac{\gamma d L^3 \tan^2(¼\pi + ½\phi)}{2(e + L)} \quad \text{……Equation (1)}$$

And the value of H_u which is the solution to the following equation:

$$H_u \{ e + 0.54 \sqrt{\frac{H_u}{[\, d\gamma \tan^2(45 + ½\phi)\,]}} \} = M_y \quad \text{……Equation (2)}$$

Where

e = Eccentricity of applied load above the medium dense to dense sand

M_y = Yield moment of pile section

d = Pile diameter

L = Embedded length of pile

ϕ = Angle of internal friction of the sand

γ = Bulk unit weight of Sand

Note: Lateral Pile capacity above 2.0m should be neglected

The following soil parameters should be adopted for a layered analysis:

0.0 – 2.0 metres (loose sand) - $Ø_u = 25^0$ (Neglect)
2.0-9.0 metres (dense sand) - $Ø_u = 38^0$
9.0-10.0 metres (medium dense to dense sand) - $Ø_u = 34^0$

Lateral deflections of the pile footings can be calculated using the following estimated parameters, which are based on correlations and experience:

0.0 – 2.0 metres (loose sand) - Elastic Modulus = 10 MPa
2.0-9.0 metres (dense sand) - Elastic Modulus = 70 MPa
9.0-10.0 metres (medium dense to dense sand) - Elastic Modulus = 50 MPa

3.1.5 **Pile Testing:** The use of a Pile Driver Analyser (PDA) or equivalent on a number of piles driven at the commencement of the piling contract will need to be used to establish driving and set criteria for subsequent piles. The testing of the piles shall be in accordance with Section 8 of Australian Standard 2159 – 1995, "Piling Design and Installation."

3.1.6 **Pile Driving Conditions:** The presence of quartz gravels within the proposed pile driving depths is anticipated to lead to difficult pile driving conditions steel tube or concrete piles.

3.1.7 **Earthquake Loading:** In accordance with Australian Standard 1170.4-2007, Part 4, "Earthquake Actions in Australia", site sub- soil class of – C_e –Shallow soil site and Hazard Factor (Z) of 0.08 should be adopted for the design of the proposed structure at the subject site.

3.1.8 **General:** Conditions may change with the seasons. In particular, the soils underlying the subject site at shallow depths may become saturated and unworkable following prolonged periods of rainfall, particularly during the winter and spring months.

The above recommendations are based on the bore and test results, together with experience of similar conditions and are expected to be typical of the area or areas being considered. Nevertheless, all excavations should be examined carefully and any unusual feature reported to us in order to determine whether any changes might be advisable.

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A.S. JAMES PTY LTD Geotechnical Engineers	JOB: Long Jetty Rehabilitation PORT WELSHPOOL, VIC	JOB No. 113173 DATE: June, 2011

PLAN OF APPROXIMATE BOREHOLE LOCATIONS (N.T.S.)	Tested: Drawn: A. Johnson	Figure 1

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Location: Long Jetty **Borehole:** 1
PORT WELSHPOOL
Job No. 113173 **Date:** 30/05/11
Ground Water: Tidal

Soil Type	Description		Depth	Tests	Results
SAND	Grey, moist to wet	SM/SP	**0.00**		Deck Level Just above Ground level
	Silty, with seashells				
	Loose				
				+	N = - / - / 1
					N = 1
			2.00		(No sample recovery)
				+	N = 18 / 12 / 17
SAND	Grey, moist to wet	SM/SP			N = 29
	Silty, with sea shells and 5mm quartz gravel				
	Medium dense to dense				
				+	N = 26 / 14 for 60mm bouncing
				+	N = 26 bouncing
				+	N = 20 / 12 / 8 for 50mm
					(No sample recovery)
				+	N = 8 / 12 / 14
					N = 26
END OF BOREHOLE			**10.00**		

+ Standard Penetration Test - N blows/150mm. incr.
I Undisturbed Sample - Diameter Stated
s Vane Shear Strength
p Pocket Penetrometer Resistance

c Apparent Cohesion
Ø Friction Angle
P Wet Density
w Moisture Content

L.L. Liquid Limit
P.L. Plastic Limit
P.I. Plasticity Index
L.S. Linear Shrinkage

Figure 2

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Location: Long Jetty **Borehole:** 2
PORT WELSHPOOL
Job No. 113173 **Date:** 30/05/11
Ground Water: Tidal

Soil Type	Description		Depth			
SAND	Grey, moist to wet	SM/SP	**0.00**			**Note:**
	Silty, with seashells					Jetty 3.0m above Seabed
	Loose tending dense					
					+	N = 4 / 2 for 300mm
			2.00			
					+	N = 9 / 21 / 10 for 60mm
SAND	Grey, moist to wet	SM/SP				
	Silty, with sea shells and 5mm quartz gravel					
	Dense				+	N = 8 / 15 / 20
						N = 35
					+	N = 9 / 13 / 27
						N = 40
					+	N = 19 / 30 for 140mm bouncing
					+	N = 10 / 17 / 27
						N = 44
	END OF BOREHOLE		**10.00**			

+ Standard Penetration Test - N blows/150mm. incr.	c Apparent Cohesion	L.L. Liquid Limit	**Figure 3**
I Undisturbed Sample - Diameter Stated	Ø Friction Angle	P.L. Plastic Limit	
s Vane Shear Strength	P Wet Density	P.I. Plasticity Index	
p Pocket Penetrometer Resistance	w Moisture Content	L.S. Linear Shrinkage	

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Location: Long Jetty **Borehole:** 3
PORT WELSHPOOL
Job No. 113173 **Date:** 30/05/11
Ground Water: Tidal

Soil Type	Description		Depth	Tests	Results
SAND	Grey, moist to wet	SM/SP	**0.00**		**Note:**
	Silty, with seashells				Jetty 3.0m above Seabed
	Loose				
			2.00		
				+	N = 10 / 13 / 12
					N = 25
SAND	Light grey brown, moist to wet	SM/SP			(No sample recovery)
	Silty, with sea shells and 5mm quartz gravel				
	Medium dense to dense				
				+	N = 9 / 17 / 18
					N = 35
				+	N = 40 for 80mm bouncing
				+	N = 20 / 14 / 11
					N = 25
					(No sample recovery)
				+	N = 7 / 30 bouncing
	END OF BOREHOLE		**10.00**		

+ Standard Penetration Test - N blows/150mm. incr.
I Undisturbed Sample - Diameter Stated
s Vane Shear Strength
p Pocket Penetrometer Resistance

c Apparent Cohesion
Ø Friction Angle
P Wet Density
w Moisture Content

L.L. Liquid Limit
P.L. Plastic Limit
P.I. Plasticity Index
L.S. Linear Shrinkage

Figure 4

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Location: Long Jetty **Borehole:** 4
PORT WELSHPOOL
Job No. 113173 **Date:** 30/05/11
Ground Water: Tidal

Soil Type	Description		Depth	Tests	Results
SAND	Grey, moist to wet	SM/SP	**0.00**		**Note:**
	Silty with sea shells				Jetty 4.8m above Seabed
	Loose				
			2.00		
SAND	Grey, moist to wet	SM/SP			
	Silty, with sea shells and 5mm quartz gravel				
	Medium dense to dense			+	N = 10 / 13 / 17
					N = 30
				+	N = 6 / 6 / 13
					N = 19
				+	N = 13 / 13 / 16
					N = 29
				+	N = 14 / 23 / 20 For 100mm bouncing
				+	N = 6 / 10 / 22
					N = 32
	END OF BOREHOLE		**10.00**		

+ Standard Penetration Test - N blows/150mm. incr.
I Undisturbed Sample - Diameter Stated
s Vane Shear Strength
p Pocket Penetrometer Resistance

c Apparent Cohesion
Ø Friction Angle
P Wet Density
w Moisture Content

L.L. Liquid Limit
P.L. Plastic Limit
P.I. Plasticity Index
L.S. Linear Shrinkage

Figure 5

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Location: Long Jetty **Borehole:** 5
PORT WELSHPOOL
Job No. 113173 **Date:** 30/05/11
Ground Water: Tidal

Soil Type	Description		Depth	Tests	Results
SAND	Grey, moist to wet	SM/SP	**0.00**		**Note:**
	Silty with sea shells				Jetty 7.8m above Seabed
	Loose				
			2.00		
				+	N = 5 / 5 / 6
					N = 11
				+	N = 13 / 24 bouncing
SAND	Grey, moist to wet	SM/SP			
	Silty, with sea shells and 5mm quartz gravel				
	Medium dense to dense				
				+	N = 10 / 13 / 26
					N = 39
				+	N = 12 / 12 / 24
					N = 36
				+	N = 8 / 8 / 15
					N = 23
	END OF BOREHOLE		**10.00**		

+ Standard Penetration Test - N blows/150mm. incr.	c Apparent Cohesion	L.L. Liquid Limit	**Figure 6**
I Undisturbed Sample - Diameter Stated	Ø Friction Angle	P.L. Plastic Limit	
s Vane Shear Strength	P Wet Density	P.I. Plasticity Index	
p Pocket Penetrometer Resistance	w Moisture Content	L.S. Linear Shrinkage	

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Geotechnical Engineers

Location: Long Jetty **Borehole:** 6
PORT WELSHPOOL
Job No. 113173 **Date:** 30/05/11
Ground Water: Tidal

Soil Type	Description		Depth	Tests	Results
SAND	Grey, moist to wet	SM/SP	**0.00**		**Note:**
	Silty with sea shells				Jetty 10.0m above Seabed
	Loose				
				+	N = 6 / 10 / 13
					N = 23
SAND	Grey, moist to wet	SM/SP			
	Silty, with sea shells and 5mm quartz gravel				
	Medium dense to dense				
				+	N = 10 / 21 / 9 for 70mm
				+	N = 9 / 11 / 16
					N = 27
				+	N = 13 / 15 / 20
					N = 35
			9.00	+	N = 4 / 3 / 4
SAND	Grey, moist to wet	SM/SP			N = 7
	Silty, with 5mm quartz gravel				
	Loose to medium dense				
	END OF BOREHOLE		**10.00**		

+ Standard Penetration Test - N blows/150mm. incr.
I Undisturbed Sample - Diameter Stated
s Vane Shear Strength
p Pocket Penetrometer Resistance

c Apparent Cohesion
Ø Friction Angle
P Wet Density
w Moisture Content

L.L. Liquid Limit
P.L. Plastic Limit
P.I. Plasticity Index
L.S. Linear Shrinkage

Figure 7

A.S. JAMES PTY.LTD **Geotechnical Engineers** **Clayton Laboratory** **16 Libbett Av Clayton South**	**JOB:** Long Jetty Port Welshpool	**JOB No.**	113173
		REPORT No:	L001
		DATE:	28-Jun-11

FOR Gipsland Ports
97 Main St
BAIRNSDALE 3875

Test	Lab Sample No.	Location	Depth (m)	Sample Description	Condition	Preparation
1	45684	Bore Hole 2	10.5	SAND, Granitic, Grey Brown		
2	45685	Bore Hole 4	9.5	SAND, Trace Silt, Grey		
3	45686	Bore Hole 5	7.5	SAND, Trace Silt, Grey		
4	45687	Bore Hole 6	3.0	SAND, Trace Silt, Grey		

Grading of Samples

Aperture Size mm		75.0	53.0	37.5	26.5	19.0	13.2	9.5	6.7	4.75	2.36	1.18	0.600	0.425	0.300	0.150	0.075
% passing Sample	No. 45684	100	100	100	100	100	100	100	100	100	98	84	73	66	62	11	3
% passing Sample	No. 45685	100	100	100	100	100	100	100	100	100	100	100	100	100	100	92	8
% passing Sample	No. 45686	100	100	100	100	100	100	100	100	100	100	100	100	100	100	89	8
% passing Sample	No. 45687	100	100	100	100	100	99	98	96	95	92	91	89	88	88	60	11

Plastic Index of Samples

Test	Lab Sample No	Liquid Limit	Plastic Limit	Linear Shrinkage	Shrinkage Behaviour	Plasticity Index
1						
2						
3						
4						

NATA

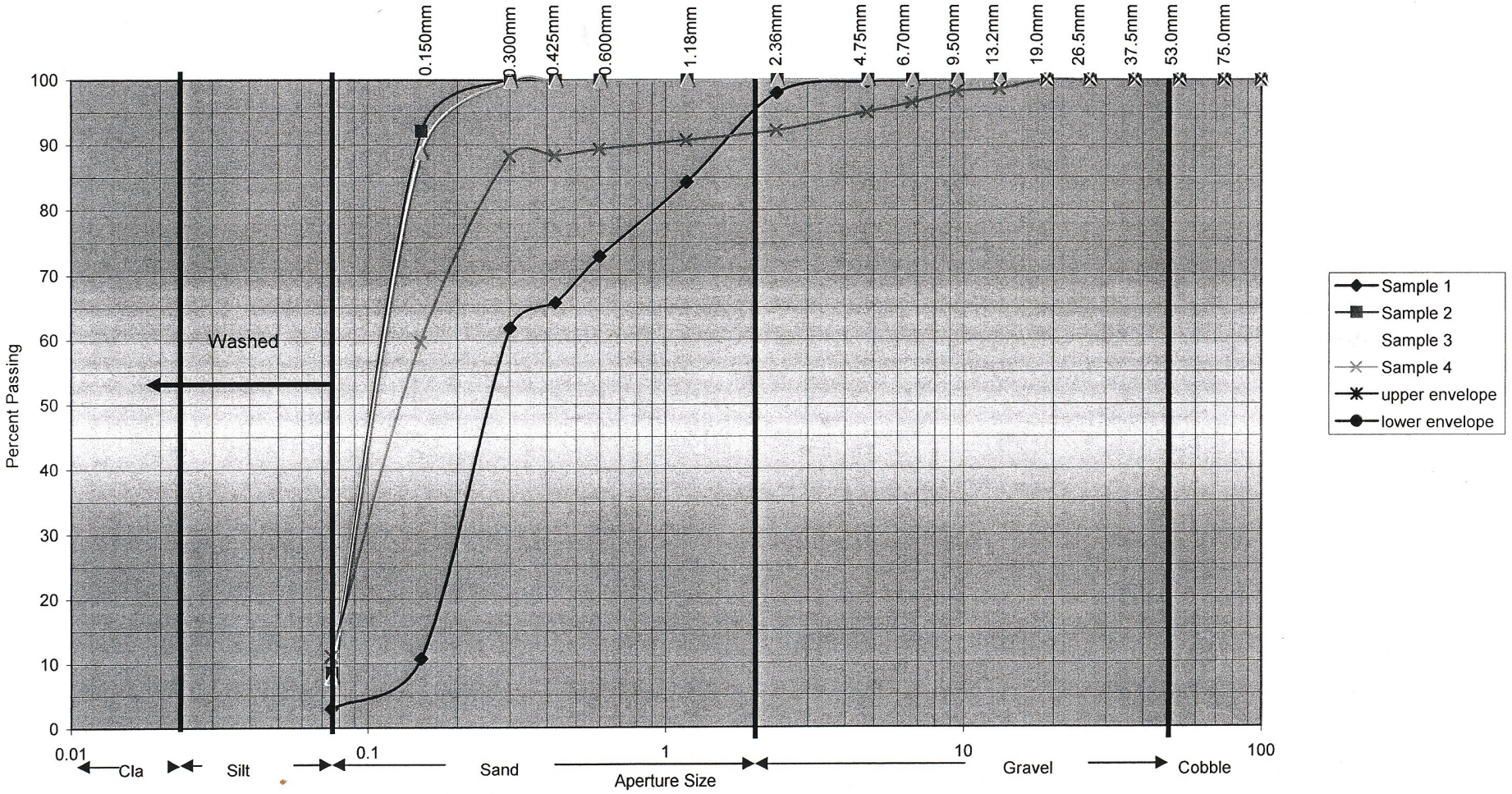
This document is issued in accordance
with NATA's accreditation requirements
Accredited for compliance with ISO/IEC 17025
Accreditation No. 934

Approved Signatory
B.Mcfarlane 28-Jun-11

Notes: Testing Carried Out On Samples As Supplied.

REPORT OF TEST RESULTS ON SOILS - SIEVE ANALYSIS & PLASTIC LIMITS AS PER AS1289 .1.1, 2.1.1,3.6.1, A.S.JAMES FORM No: LR007A (Fig 1) / REV 10 / 10/5/06	Tested By :	B.McFarlane	Figure 8
	Reported By :	B.McFarlane	1 of 2

A.S. JAMES PTY.LTD **Geotechnical Engineers** **Clayton Laboratory** **16 Libbett Av Clayton South**	**JOB:** Long Jetty Port Welshpool	**JOB No.** 113173 **REPORT No:** L001 **DATE:** 28-Jun-11



REPORT OF TEST RESULTS ON SOILS - SIEVE ANALYSIS & PLASTIC LIMITS AS PER AS1289 .1.1, 2.1.1,3.6.1, A.S.JAMES FORM No: LR007A (Fig 2) / REV 6 / 10/5/06	Tested By :	B.McFarlane	Figure 9
	Reported By :	B.McFarlane	2 of 2