



Kingborough Council

Taroona Landslide Risk Assessment & Mitigation Stages 2 & 3 Report for Stage 2B - Geological Drilling Factual Report & Installation of New Ground Control Points

February 2014

Table of contents

1.	Introduction	1
1.1	Purpose of this Report.....	1
1.2	Previous Studies undertaken by GHD.....	1
1.3	Scope and Limitations	2
2.	Drilling for Installation of the Inclinerometer IBH-2013 (MRT Borehole ID 36299)	3
2.1	Inclinerometer Installation (IBH-2013, MRT borehole I.D 36299)	3
3.	Drilling for Installation of the Vibrating Wire Piezometer (VWP-2013)	5
3.1	Vibrating Wire Piezometer (VWP-2013) Installation	5
4.	Installation of Permanent Ground Control Points by PDA Surveyors	9

Figure Index

Figure 1	85 mm inclinometer casing	4
Figure 2	Inclinerometer end cap	4
Figure 3	Installation of inclinometer through drill casing showing attached flat pack hose for grouting.....	4
Figure 4	Inclinerometer following removal of drill casing, prior to grouting of borehole (note conductor casing surface).....	4
Figure 5	HMA Geotechnical Systems Australia supplied vibrating wire piezometers (Model 1200).....	5
Figure 6	VWP1 attached to base of carrier PVC (62.55 mbgl).....	6
Figure 7	VQP2 attached to carrier PVC (top of length seven, 21 mbgs)	6
Figure 8	VWPs were installed through drilling rods to prevent borehole collapse.....	6
Figure 9	Carrier PVC pipe (11 x 6 m lengths)	6
Figure 10	Testing VWP cable impedance with multimeter.....	7
Figure 11	Grouting borehole.....	7
Figure 12	Surface routing of VWP cable prior to installation of control box.....	7
Figure 13	VWP cable management.....	7
Figure 14	Grout Mixer	8
Figure 15	Installation of control box support	8
Figure 16	Control Box, showing VWP wiring and earth cable.....	8
Figure 17	VWP control box (foreground), inclinometer gatic (background)	8

Appendices

Appendix A –Site Plan Showing Location of the Taroona Landslide & the New Instrumentation (VWP_2013, Inclinator IBH_2013) & Additional Ground Control Points

Appendix B – Geotechnical Logs

Appendix C - Core Photos

Appendix D – VWP Installation Guide

Appendix E –Installation of Permanent Survey Monuments by PDA Surveyors

1. Introduction

This report has been prepared to satisfy Stage 2, Part B of the Kingborough Council Tender Brief, 'Taroona Landslide Risk Assessment and Mitigation Plan – Stages 2 & 3, AB-1223.

The Taroona landslide is characterised by slow and intermittent movements, but due to the complexity of the underlying geology and the fact that the triggering factors are not well quantified, the landslide's regional extent and behaviour is not very well understood.

Two State schools (Taroona Primary and Taroona High School), the Channel Highway, suburban roads, various infrastructure assets such as water, sewer, telecommunications and Aurora Energy power lines, and several tens of houses are located on or within the landslide feature.

This Stage 2B report presents the factual information pertaining to the geological drilling and instrumentation installation. The study area is defined in the site plan (refer Appendix A) and the slope movements observed in the area are also referred to as the School Creek Landslide.

1.1 Purpose of this Report

The purpose of this report is to present details relating to:

- The drilling of two (2) boreholes (IBH-2013 and VBH-2013)
- Installation of a pair of Vibrating Wire Piezometers (VWP) within VBH-2013 and an inclinometer within IBH-2013
- The geological conditions encountered within borehole IBH-2013
- The details of the installation of 17 new Ground Control Points (GCP) - permanent survey marks installed by PDA Surveyors for the ongoing monitoring of the landslide movements.

These investigations have been undertaken to assist in determining the risks posed by the Taroona Landslide, replace previously installed inclinometer (I92-14) that failed due to excessive slope movements, and supplement the monitoring network by installing an additional 17 Ground Control Points (GCP) to provide additional information relating to the southern extent of the landslide.

1.2 Previous Studies undertaken by GHD

Stage 1 investigation (GHD report 32/15950/55683, 'Report for Technical Review for Taroona Landslide – Risk Assessment & Mitigation Stage 1' prepared for Kingborough Council, March 2012)

GHD completed a desktop review of previously published reports and data on the slope movements identified in the vicinity of the Taroona Primary and High Schools. These included reports by Coffey Geosciences and Mineral Resources Tasmania (MRT) which presented different models of landslide activity in the study area. The data reviewed included survey monitoring points and borehole data (including inclinometer readings) and InSAR (Synthetic Aperture Radar) analyses.

It is noted that numerous survey monitoring sites including inclinometers have been installed and partially monitored over many years to record slope movements. One inclinometer has failed due to excessive movements (I92-14) and the position of this inclinometer is near the entrance to the school grounds below the Channel Highway.

Stage 2A investigation (GHD report 32/16698, 'Report for Tarooma Landslide Risk Assessment & Mitigation, Stages 2 & 3 – Stage 2A' prepared for Kingborough Council, June 2013)

GHD presented the findings of additional investigation and analysis, including visual structural site surveys of selected properties, CCTV remote camera survey of underground drainage pipes and analysis of InSAR data to further understand the movements of the hillside in the Tarooma area.

It was recommended that improvements be made to the current survey network through the installation of an additional 17 permanent ground control points (GCP's) and the installation of an additional inclinometer (to replace failed inclinometer I92-14) and vibrating wire piezometers to monitor pore water pressure from groundwater fluctuations; the data from which would be useful in correlating observed movements from the inclinometers with rainfall records.

The current report provides details of the installation of the two boreholes; one for the vibrating wire piezometer and the other for the inclinometer. It also documents the installation of the GCP's (permanent survey mark installations) undertaken by PDA Surveyors.

1.3 Scope and Limitations

This report has been prepared by GHD for Kingborough Council and may only be used and relied on by Kingborough Council for the purpose agreed between GHD and the Kingborough Council as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Kingborough Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD as described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

2. Drilling for Installation of the Inclinator IBH-2013 (MRT Borehole ID 36299)

The borehole was commenced using an air-blade to install conductor casing to a depth of 1.3 meters below ground surface (mbgs) and then continued using a PQ size triple tube wireline system to recover 85 mm nominal diameter core.

Below a thin residual soil horizon the recovered core typically comprised of very stiff to hard, friable clays and intermittent zones of moderately weathered Dolerite cobbles and boulders. Fine to medium grained sands and fine grained gravels were found to be secondary or trace components throughout much of the recovered core.

Defects appeared to be regularly spaced, however tended to increase in frequency between the following depth intervals: 6.00 – 12.00 mbgs, 17.80 – 23.35 mbgs and 62.90 – 70.10 mbgs. It is noted that defects typically appeared to have similar dips and orientations (i.e. 40 – 60 degrees) and demonstrated polished/slickenside planar surfaces.

Polished/slickenside surfaces were noted from 9.00 mbgs and were most prominent between 20.65 – 23.35 mbgs and 57.40 – 70.10 mbgs. Stratigraphy was generally found to be consistent with the deposits identified by Latinovic et al. (2001).

The borehole log and core tray photographs can be found in Appendix Band Appendix C respectively.

2.1 Inclinator Installation (IBH-2013, MRT borehole I.D 36299)

Following completion of the drilling works, 85 mm QC inclinometer casing was installed through the drill rods to a depth of 70.10 mbgs.

During installation, the casing was supported at the surface by a clamp attached to the drill rig and filled with potable water to achieve negative buoyancy.

Each 3 m length of casing was joined with a snap lock coupling system. Casing grooves were aligned with the expected direction of landslip movement i.e. 60° (North East).

To prevent possible borehole collapse, the inclinometer was installed through the drill casing, which was then removed prior to grouting. Approximately 24 x 3 m lengths of casing were installed into the borehole.

Grout was pumped into the bore hole from the surface using a flat-pack tremie hose that was strapped to the inclinometer casing during installation. Approximately 1,100 L of grout was pressure pumped into the borehole at a mix ratio of 1:1:0.01 (cement:water:bentonite). Following grouting, the 1.8 m length of conductor casing was removed and the inclinometer casing was cut approximately 300 mm below grade and finished with a flush mounted trafficable cover, secured with 8 mm hex nuts.

Figure 1 85 mm inclinometer casing



Figure 2 Inclinometer end cap



Figure 3 Installation of inclinometer through drill casing showing attached flat pack hose for grouting

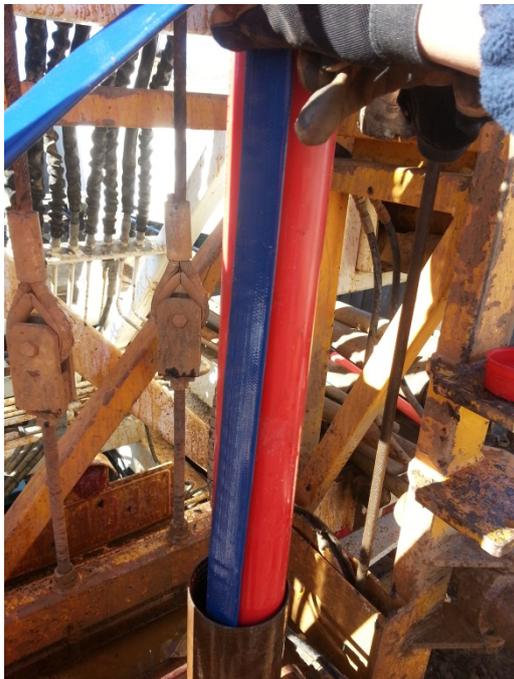
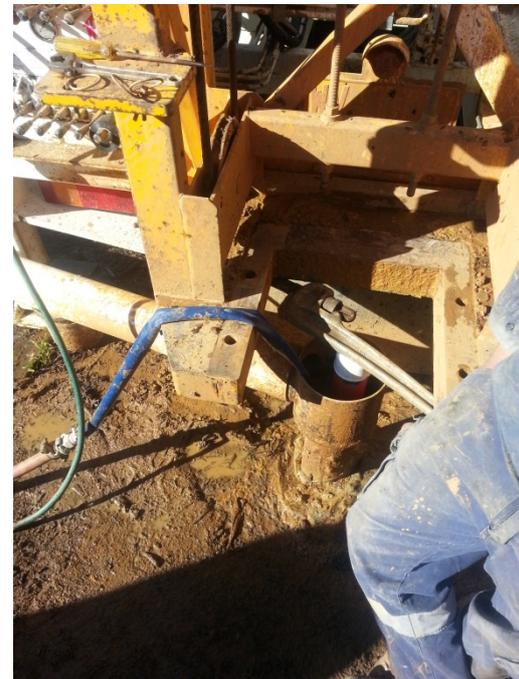


Figure 4 Inclinometer following removal of drill casing, prior to grouting of borehole (note conductor casing surface)



3. Drilling for Installation of the Vibrating Wire Piezometer (VWP-2013)

The borehole was commenced using a PQ size triple tube wireline system to a depth of 8 mbgs, after which an 80 mm diameter roller cone bit and casing advancer progressed the borehole to a depth of 63.15 mbgs. As VWP-2013 was drilled approximately 1 m to the west of IBH-2013, a geological log was not compiled.

3.1 Vibrating Wire Piezometer (VWP-2013) Installation

Following completion of the drilling works, the VWPs were installed in accordance with the GHD Standard Operating Procedure for the Installation and Operation of Vibrating Wire Piezometers. (Refer to Appendix D for the installation guide). The VWPs were supplied by HMA Geotechnical Systems Australia.

Carrier PVC casing was used to stabilise the VWPs and cable during installation in addition to providing a conduit for grouting. A total of 66 m (11 x 6 m lengths) of 25 mm diameter PVC was required. VWP1 (SN: 18496) was attached approximately 600 mm from the bottom of the initial length of PVC pipe (approximately 62.55 mbgs). VWP2 (SN: 18537) was attached on the join between length 7 and 8 (approximately 21 mbgs). Duct tape was used to secure VWPs and cable to the PVC pipe and the bottom 600 mm of pipe was drilled to facilitate the egress of grout into the borehole.

A multi-meter was used to test the baseline cable impedance prior to the installation of the VWPs. The impedance was then tested throughout the installation process to ensure that the cables had not been damaged.

The VWPs were installed through the drill casing, which was removed prior to grouting. Grout was pressure pumped into the borehole through the top of the PVC pipe at a mix ratio of 1:1:0.01 (cement:water:bentonite). Approximately 571 L of grout was consumed. The VWP control box housing was then concreted in the garden bed (approximately 1 m from the grouted borehole). VWP cables were routed through a small trench (refer to Error! Reference source not found.) into the control box housing along with the earth cable.

Figure 5 HMA Geotechnical Systems Australia supplied vibrating wire piezometers (Model 1200)



Figure 6 VWP1 attached to base of carrier PVC (62.55 mbgl)

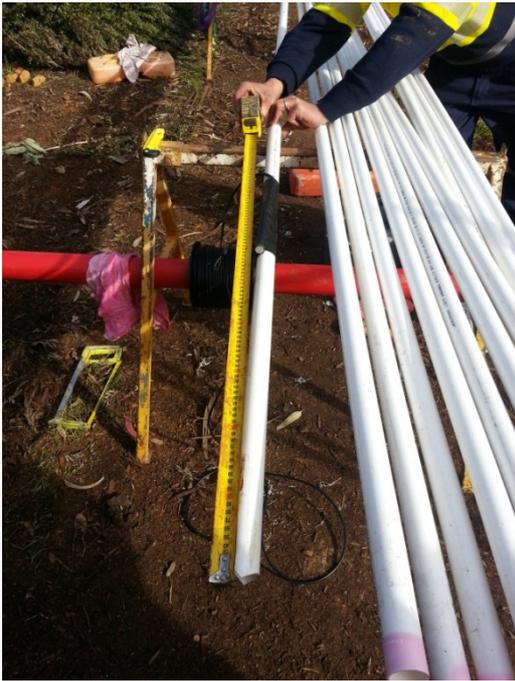


Figure 7 VQP2 attached to carrier PVC (top of length seven, 21 mbgs)



Figure 8 VWPs were installed through drilling rods to prevent borehole collapse



Figure 9 Carrier PVC pipe (11 x 6 m lengths)



Figure 10 Testing VWP cable impedance with multimeter



Figure 11 Grouting borehole



Figure 12 Surface routing of VWP cable prior to installation of control box



Figure 13 VWP cable management



Figure 14 Grout Mixer



Figure 15 Installation of control box support



Figure 16 Control Box, showing VWP wiring and earth cable



Figure 17 VWP control box (foreground), inclinometer gatic (background)



4. Installation of Permanent Ground Control Points by PDA Surveyors

As part of the Stage 2B works for the Taroona landslide monitoring project, additional Ground Control Points (GCP) were requested to be placed in various locations surrounding and within the known landslide area.

GHD engaged PDA Surveyors to install 17 additional permanent survey monuments to allow the long term monitoring of landslide activity within the Taroona area. This work was undertaken in November and December 2013.

The site plan and tables presented in Appendix E shows the location and names of each of these monitoring points.

The GCP's were located approximately as per the marked-up plan supplied by MRT's Colin Mazengarb, however the final locations were adjusted in consultation with GHD's Kate McIntosh & MRT's Colin Mazengarb to optimise measurement parameters of the network, in particular for inter-visibility and unobstructed view of the sky to optimise GNSS observations.

All GCP's installed are 2 m in lengths and of 20 mm diameter. 316 Grade Stainless Steel rod driven flush to the surface (or rejection for PDA107) and centre punched. A 1 m deep high strength concrete collar surrounds each GCP, for additional stability.

All marks were observed by multiple GNSS observations legs utilising 4 Trimble R8-Model 2 GNSS receivers to at least three other GCP's as well as a new GNSS base station observing point located on bed rock at the Mt Nelson Signal Station. Geoscience Australia's GNSS post processing facility. "AusPOS" was used to determine MGA94 & AHD83 coordinates for this point.

A precise theodolite traverse was then undertaken utilising a Trimble S8 robotic theodolite to further strengthen the GCP network. All data was then processed in CompNET least squares processing software to rigorously adjust all observations for optimum network strength and thus increase confidence in derived coordinates.

A precise digital level run was then undertaken using a Trimble DiNi level to ensure all levels were to the same accuracy as stage 1 results, which were $\pm 1\text{mm}$ on 1km two way levelling run.

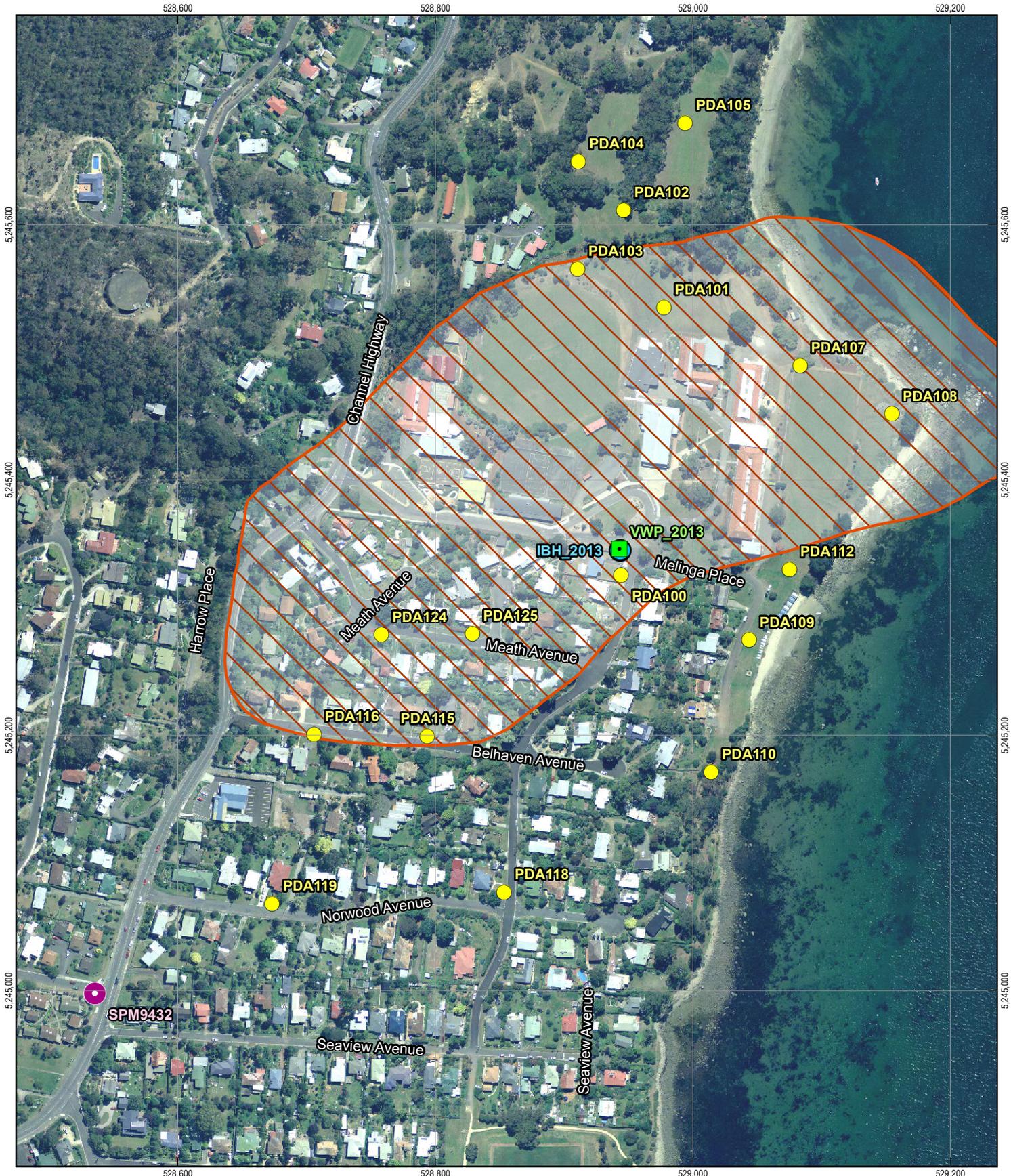
All GCP's were coordinated to an accuracy of $\pm 4\text{mm}$ horizontally and $\pm 1\text{mm}$ vertically with SPM9432 being adopted as having the same coordinates as the original Stage 1 survey to allow direct comparison of all coordinates when next surveyed.

Published coordinates per SurCOM (Survey Mark)

Register controlled by DPIPWE of SPM9432 E 528,535.544, N 5,244,997.760 RL 44.41.

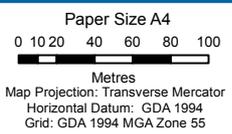
Appendices

Appendix A – Site Plan Showing Location of the
Taroona Landslide & the New
Instrumentation (VWP_2013,
Inclinometer IBH_2013) & Additional
Ground Control Points



LEGEND

- Ground Control Marks
- State Permanent Mark
- ⊗ Inclinator IBH-2013
- Vibrating Wire Piezometer VWP-2013
- School Creek Landslide



Kingborough Council
 Taroon Landslide Risk Assessment Stages 2 & 3
**Site Plan - instrumentation and
 additional survey monitoring points**

Job Number 32-16698
 Revision 0
 Date 26 Feb 2014

Appendix A

Appendix B – Geotechnical Logs

BOREHOLE LOG SHEET WITH INCLINOMETER

HOLE No. IBH-2013

SHEET 1 OF 13

Client : Kingborough Council
 Project : Taroona Landslide Risk Assessment
 Location : 101 Flinders Esplanade, Taroona, Tasmania
 Position : 528943.6 E 5245344.9 N MGA94 / 55 Surface RL: 25.7m AHD Angle from Horiz. : 90°000°
 Rig Type : HP Scout MkIV Mounting: Truck Contractor : KMR Driller : D. Richardson
 Date Started : 29/7/13 Date Completed : 5/8/13 Logged by : JSP
 Processed : P.J.L.
 Checked : *P.J.L.*
 Date : 26.2.2014

GEO BOREHOLE 3216698.GPJ GHD GEO TEMPLATE.GDT 28/2/14

DRILLING					MATERIAL					INCLINOMETER			
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description	Moisture Condition	Consistency / Density Index	Comments / Observations	INCLINOMETER Log	Components
1	Solid Flight Auger	PW casing	GNE		0.50 (25.23)		ML	Sandy SILT Brown to black, moist, loose; sand is fine to medium grained; organics (TOPSOIL)	M	L			
					1.30		CL-CI	CLAY Tan, low to medium plasticity, slightly moist to moist, very stiff to hard; trace sand, fine to medium grained. (COLLUVIUM)	M	VSt			
								Start of coring at 1.3 metres. For Cored interval, see Core Log Sheet.					
2													
3													
4													
5													
6													

See standard sheets for details of abbreviations & basis of descriptions



GHD GEOTECHNICS
 GPO Box 668, Brisbane Qld 4001
 T: 61 7 3316 3000 F: 61 7 3316 3333 E: bnemail@ghd.com.au
 CLIENTS | PEOPLE | PERFORMANCE

Job No.

3216698

CORE LOG SHEET WITH INCLINOMETER

HOLE No. IBH-2013

SHEET 4 OF 13

Client :	Kingborough Council			Processed :	PJL
Project :	Taroona Landslide Risk Assessment			Checked :	<i>Alle</i>
Location :	101 Flinders Esplanade, Taroona, Tasmania			Date :	26.2.14
Position :	528943.6 E	5245344.9 N	MGA94 / 55	Surface RL: 25.7m	AHD
Angle from Horiz. :	90°/000°		Contractor :	KMR	
Rig Type :	HP Scout MkIV	Mounting:	Truck	Driller :	D. Richardson
Casing Dia. :	PQ3	Barrel (m) :	1.60	Bit :	Face Discharge
Date Started :	29/7/13	Date Completed :	5/8/13	Logged by :	JSP
				Date Logged :	29/7/2013

GEO CORE ONLY 3216698.GPJ GHD GEO TEMPLATE.GDT 28/2/14

DRILLING				MATERIAL				NATURAL FRACTURES				INCLINOMETER Log	COMPONENTS
Progress	Scale (m)	Drilling & Casing	Water	Description	Estimated Strength	Spacing	Additional Data	Weathering	Visual	Visual			
		Drill Depth (m)	(Core Loss / Run %)	ROCK TYPE, colour, grain size, structure (texture, mineral composition, hardness, alteration, cementation, etc. as applicable) and SOIL TYPE, moisture, colour, consistency, structure, minor components (origin)	Is ₍₅₀₎ MPa	(mm)	(joints, partings, seams, zones and veins) Fracture type, orientation, infilling or coating, shape, roughness, other.	EL 0.03 VL 0.1 L 0.3 M 1 H 3 VH 10 EH	20 40 100 300 1000				
				stained. Sandy CLAY Dark orange to brown, low plasticity, very hard; Sand is medium grained.									
	13		(0)	12.70-13.10m; highly fractured zone			12.70-13.40m; FZ						
		13.40		13.10-13.40m; extremely fractured zone			13.40m; DB						
	14		(0)										
		14.80		14.80m; some pale yellow streaks/mottling.			14.80m; DB						
	15		(0)				15.15m; JT, 80d, UN-PLN, SO, OP						
			(0)				15.50m; JT, 40d, PLN, SO, OP						
	16		(0)				16.05m; JT, 30d, PLN, SO, OP						
	17	16.90		DOLERITE BOULDER Tan to yellow-grey, fine to medium grained, some iron staining, waxy/polished appearance.	HW-MW		16.75m; DB 16.85m; JT, 30d, PLN, RF-SO, OP 16.90m; DB						
	18	17.80		17.70m; highly fractured zone. Silty CLAY Red-brown, medium plasticity, hard;			17.70-17.80m; FZ (HB) 17.80m; DB						

See standard sheets for details of abbreviations & basis of descriptions

GHD GEOTECHNICS
 GPO Box 668, Brisbane Qld 4001
 T: 61 7 3316 3000 F: 61 7 3316 3333 E: bncmail@ghd.com.au
 CLIENTS | PEOPLE | PERFORMANCE

Job No. **3216698**

CORE LOG SHEET WITH INCLINOMETER

GEO. CORE ONLY. 3216698.GPJ GHD GEO TEMPLATE.GDT 26/2/14

Client : Kingborough Council	HOLE No. IBH-2013			SHEET 6 OF 13	
Project : Taroona Landslide Risk Assessment					
Location : 101 Flinders Esplanade, Taroona, Tasmania	Position : 528943.6 E 5245344.9 N MGA94 / 55	Surface RL: 25.7m	AHD	Angle from Horiz. : 90°/000°	Processed : P.J.L
Rig Type : HP Scout MkII	Mounting: Truck	Contractor : KMR	Driller : D. Richardson	Checked : <i>PML</i>	
Casing Dia. : PQ3	Barrel (m) : 1.60	Bit : Face Discharge	Bit Condition : NEW	Date : 26.2.14	
Date Started : 29/7/13	Date Completed : 5/8/13	Logged by : JSP	Date Logged : 29/7/2013		

DRILLING			MATERIAL				NATURAL FRACTURES			INCLINOMETER Log	COMPONENTS
Progress	Drilling & Casing Water	Drill Depth (m) (Core Loss / Run %)	SAMPLES & TESTS	Depth / (RL) metres	Graphic Log	Description ROCK TYPE, colour, grain size, structure (texture, mineral composition, hardness, alteration, cementation, etc. as applicable) and SOIL TYPE, moisture, colour, consistency, structure, minor components (origin)	Estimated Strength Is(50) MPa	Spacing (mm)	Additional Data (joints, partings, seams, zones and veins) Fracture type, orientation, infilling or coating, shape, roughness, other.		
SCALE (m)										Weathering	Visual
		24.10					EL 0.03 VL 0.1 L 0.3 M 1 H 3 VH 3 EH 10	20 40 100 300 1000			
		(0)								24.10m; DB	
		25.60								25.45m; JT, 20d, UN-PLN, SLK, OP 25.60m; DB	
		(0)								26.30m; JT, 60d, UN-PLN, SLK, OP	
	PQ3	27.10		26.45 (-0.72)		Sandy CLAY with gravel Orangey-brown mottled grey, low plasticity, hard; sand is medium to coarse grained, poorly graded; gravels are fine to medium grained, poorly graded, sub-angular; trace cobbles.				27.10m; DB	
		(0)								27.55m; JT, 60d, PLN, SLK, OP 27.75m; JT, 50d, UN-PLN, SLK, OP 27.90m; JT, 40d, PLN, SLK, OP 28.05m; JT, 40d, UN, RF, OP 28.10-28.50m; FZ	
		28.60		28.60 (28.60) (-2.92)		28.00-28.15m; DOLERITE COBBLE, grey-white, fine to medium grained, highly weathered, low strength.	HW				
		(0)								28.60m; DB 28.69m; JT, 50d, UN, RF-VR, OP 28.80m; JT, 50d, PLN, SO-SLK, OP	
		28.95		28.95 (-3.22)		CORE LOSS (50mm) Sandy CLAY with some gravel Orangey-brown, low plasticity, hard; sand is medium to coarse grained, poorly graded; gravels are fine to medium grained, poorly graded, sub-angular; Clayey SAND with gravel Light grey to green-grey with some light brown mottling, fine to coarse grained, poorly graded, very dense, weakly cemented; Clay is low plasticity; gravels are pale yellow-grey, fine to medium grained, sub-angular.				29.09m; JT, 60d, UN-PLN, RF, OP	
		(3)									
		30									

CORE LOG SHEET WITH INCLINOMETER

HOLE No. IBH-2013

SHEET 8 OF 13

Client : Kingborough Council				Processed : P.J.L
Project : Tarooma Landslide Risk Assessment				Checked : <i>RMc</i>
Location : 101 Flinders Esplanade, Tarooma, Tasmania	Surface RL: 25.7m	AHD	Angle from Horiz. : 90°/000°	Date : 26.2.14
Position : 528943.6 E 5245344.9 N MGA94 / 55	Rig Type : HP Scout MkII	Mounting: Truck	Contractor : KMR	Driller : D. Richardson
Casing Dia. : PQ3	Barrel (m) : 1.60	Bit : Face Discharge	Bit Condition : NEW	Date : 26.2.14
Date Started : 29/7/13	Date Completed : 5/8/13	Logged by : JSP	Date Logged : 29/7/2013	

GEO. CORE ONLY 3216698.GPJ GHD GEO TEMPLATE.GDT 26/2/14

DRILLING				MATERIAL				NATURAL FRACTURES				INCLINOMETER Log	COMPONENTS
Progress	SCALE (m)	Drilling & Casing	Water	Description	Estimated Strength	Spacing (mm)	Additional Data	Weathering	Visual	INCLINOMETER Log	COMPONENTS		
		Drill Depth (m)	(Core Loss / Run %)	ROCK TYPE, colour, grain size, structure (texture, mineral composition, hardness, alteration, cementation, etc. as applicable) and SOIL TYPE, moisture, colour, consistency, structure, minor components (origin)	Is(50) MPa		(joints, partings, seams, zones and veins) Fracture type, orientation, infilling or coating, shape, roughness, other.	EL 0.03 VL 0.1 L 0.3 M 1 H 3 VH 10 EH	20 40 100 300 1000				
		36.40		COBBLE 36.00m; COARSE GRAVEL / COBBLE			36.40m; DB						
				Sandy CLAY / Clayey SAND with some gravel light grey-brown to yellow-brown with some red streaks; Sand is fine to coarse grained, very dense; clay is low to medium plasticity; gravels are fine grained, sub-angular.									
		38.00	(0)				38.00m; DB						
		39.40	(0)				39.40m; DB						
		40.90	(0)	40.60m; becomes dark grey-brown to brown			40.90m; DB						
							41.20m; JT, 50d, CL						

CORE LOG SHEET WITH INCLINOMETER

GEO. CORE ONLY 3216698.GPJ GHD GEO. TEMPLATE.GDT 26/2/14

Client : Kingborough Council		HOLE No. IBH-2013	
Project : Taroona Landslide Risk Assessment		SHEET 9 OF 13	
Location : 101 Flinders Esplanade, Taroona, Tasmania			
Position : 528943.6 E 5245344.9 N MGA94 / 55	Surface RL: 25.7m	AHD	Angle from Horiz. : 90°/000°
Rig Type : HP Scout MkIV	Mounting: Truck	Contractor : KMR	Driller : D. Richardson
Casing Dia. : PQ3	Barrel (m) : 1.60	Bit : Face Discharge	Bit Condition : NEW
Date Started : 29/7/13	Date Completed : 5/8/13	Logged by : JSP	Date Logged : 29/7/2013
		Processed : P.JL	Checked : <i>R.Mc</i>
			Date : 26.2.14

DRILLING				MATERIAL				NATURAL FRACTURES			
Progress		Drill Depth (m)	(Core Loss / Run %)	Description	Estimated Strength $I_{s(50)}$ MPa	Spacing (mm)	Additional Data	INCLINOMETER Log	COMPONENTS		
SCALE (m)	Drilling & Casing									SAMPLES & TESTS	Depth / (RL) metres
		42.40		42.30m; becomes light yellow-brown mottled orangey-brown			42.40m; DB				
		43.90	(0)				43.90m; DB				
	PQ3	45.40	(0)	45.20 (-19.47) Clayey SAND Light yellow-brown mottled red-brown, fine to medium grained, very dense; clay is low plasticity; trace gravels, fine to medium grained, sub-rounded to sub-angular.			45.40m; DB				
		46.90	(0)				46.05m; JT, 40d, UN, RF-SO, OP				
		47.30 (-21.57)	(0)	47.30 (-21.57) Sandy CLAY / Clayey SAND Light brown with pale yellow-brown mottling; clay is low to medium plasticity, very hard; Sand is fine to medium grained, very dense; trace coarse sand; trace fine gravels, sub-angular to angular.			46.90m; DB				

See standard sheets for details of abbreviations & basis of descriptions



GHD GEOTECHNICS
 GPO Box 668, Brisbane Qld 4001
 T: 61 7 3316 3000 F: 61 7 3316 3333 E: bnemail@ghd.com.au
 CLIENTS | PEOPLE | PERFORMANCE

Job No.
3216698

CORE LOG SHEET WITH INCLINOMETER

HOLE No. IBH-2013

SHEET 10 OF 13

Client :	Kingborough Council			Processed :	PJL
Project :	Taroona Landslide Risk Assessment			Checked :	<i>AME</i>
Location :	101 Flinders Esplanade, Taroona, Tasmania			Date :	26.2.14
Position :	528943.6 E	5245344.9 N	MGA94 / 55	Surface RL: 25.7m	AHD
Rig Type :	HP Scout MkIV	Mounting: Truck	Contractor : KMR	Driller : D. Richardson	
Casing Dia. :	PQ3	Barrel (m) : 1.60	Bit : Face Discharge	Bit Condition : NEW	
Date Started :	29/7/13	Date Completed : 5/8/13	Logged by : JSP	Date Logged : 29/7/2013	

GEO. CORE ONLY 3216698.GPJ GHD.GEO.TEMPLATE.GDT 26/2/14

DRILLING				MATERIAL				NATURAL FRACTURES				INCLINOMETER Log	COMPONENTS
Progress	Scale (m)	Drilling & Casing	Water	Description	Weathering	Estimated Strength $I_{s(60)}$ MPa	Spacing (mm)	Additional Data	Visual				
		Drill Depth (m)	(Core Loss / Run %)	ROCK TYPE, colour, grain size, structure (texture, mineral composition, hardness, alteration, cementation, etc. as applicable) and SOIL TYPE, moisture, colour, consistency, structure, minor components (origin)	EL 0.03 VL 0.1 L 0.3 M 1 H 3 VH 10 EH	20 40 100 300 1000	(joints, partings, seams, zones and veins) Fracture type, orientation, infilling or coating, shape, roughness, other.						
		48.40						48.30m; JT, 15d, PLN, SO, OP 48.40m; DB					
			(0)					49.00m; DB					
		49.90						49.50m; JT, 40d, ST, SO, OP					
			(0)					50.10m; JT, 20d, UN, RF, OP					
	PQ3	51.40		DOLERITE BOULDER Grey, iron stained, fine to medium grained, slightly weathered, high strength. Sandy CLAY Red-brown with some pale brown-grey mottling, low plasticity, very hard; sand is fine to medium grained; trace gravels, fine grained, sub-angular.	SW			51.30m; HB(?) 51.40m; DB					
			(0)					52.15m; JT, 70d, PLN, SLK, OP					
		52.90						52.90m; DB 52.90-52.95m; FZ					
			(0)										
				51.95m; band of coarse grained sand, light yellow brown, with gravels, fine grained, angular.									
				Clayey SAND with gravel Light yellow-grey brown with red-brown mottling, medium to coarse grained, poorly graded, very dense, weakly cemented; clay is low plasticity; gravels are fine to coarse grained, poorly graded, sub-angular.									

See standard sheets for details of abbreviations & basis of descriptions



GHD GEOTECHNICS
 GPO Box 668, Brisbane Qld 4001
 T: 61 7 3316 3000 F: 61 7 3316 3333 E: bnemail@ghd.com.au
 CLIENTS | PEOPLE | PERFORMANCE

Job No.
3216698

CORE LOG SHEET WITH INCLINOMETER

HOLE No. IBH-2013

SHEET 11 OF 13

Client :	Kingborough Council			Processed :	PJL
Project :	Taroona Landslide Risk Assessment			Checked :	<i>KML</i>
Location :	101 Flinders Esplanade, Taroona, Tasmania			Date :	26.2.14
Position :	528943.6 E	5245344.9 N	MGA94 / 55	Surface RL: 25.7m	AHD
Rig Type :	HP Scout MkII	Mounting: Truck	Contractor :	KMR	Drifter : D. Richardson
Casing Dia. :	PQ3	Barrel (m) : 1.60	Bit : Face Discharge	Bit Condition :	NEW
Date Started :	29/7/13	Date Completed : 5/8/13	Logged by :	JSP	Date Logged : 29/7/2013

GEO_CORE_ONLY_3216698.GPJ_GHD_GEO_TEMPLATE.GDT_26/2/14

DRILLING				MATERIAL				NATURAL FRACTURES				INCLINOMETER Log	COMPONENTS
Progress	Scale (m)	Drilling & Casing	Water	Description	Weathering	Estimated Strength Is(50) MPa	Spacing (mm)	Additional Data	Visual				
				ROCK TYPE, colour, grain size, structure (texture, mineral composition, hardness, alteration, cementation, etc. as applicable) and SOIL TYPE, moisture, colour, consistency, structure, minor components (origin)	EL 0.03 VL 0.1 L 0.3 M 1 H 3 VH 10 EH		20 40 100 300 1000	(joints, partings, seams, zones and veins) Fracture type, orientation, infilling or coating, shape, roughness, other.					
	54.40			54.40m; Clay seam, high plasticity, moist, 50mm thick. 54.60-55.55m; becomes highly fractured.				54.10m; JT, 60d, UN, SLK, OP 54.40m; SM, SUBHZ, CLAY, 50mm, OP. 54.65-55.55m; FZ					
	55.90			DOLERITE BOULDER Light yellow-grey, some iron staining, fine to medium grained, slightly weathered, high to very high strength; some microfracturing, randomly orientated, healed.	SW			55.90m; JT, 70d, PLN, SLK, OP 56.20m; JT, 20d, CL 56.30m; HB 56.90m; HB					
	57.40			Sandy CLAY with gravel Red to dark brown, low plasticity, hard to very hard; sand is medium to coarse grained; gravels are fine to coarse grained, poorly graded, sub-angular; trace cobbles, sub-angular.				57.40m; JT, 10d, PLN, SO, OP 57.45m; JT, 40d, PLN, SO, OP					
	58.90			Sandy CLAY Red-brown with some dark grey mottling, low plasticity, hard to very hard; sand is medium to coarse grained; trace gravels, fine grained, sub-angular.				58.10m; JT, 20d, PLN, SLK, OP 58.90m; JT, 30d, PLN, SLK, OP					

CORE LOG SHEET WITH INCLINOMETER

GEO_CORE_ONLY 3216698.GPJ GHD GEO_TEMPLATE.GDT 26/2/14

Client : Kingborough Council		HOLE No. IBH-2013	
Project : Taroona Landslide Risk Assessment		SHEET 12 OF 13	
Location : 101 Flinders Esplanade, Taroona, Tasmania		Surface RL: 25.7m AHD	Angle from Horiz. : 90°/000°
Position : 528943.6 E 5245344.9 N MGA94 / 55		Contractor : KMR	Processed : PJL
Rig Type : HP Scout MkIV	Mounting: Truck	Driller : D. Richardson	Checked : <i>AdMc</i>
Casing Dia. : PQ3	Barrel (m) : 1.60	Bit : Face Discharge	Date : 26.2.14
Date Started : 29/7/13	Date Completed : 5/8/13	Logged by : JSP	Date Logged : 29/7/2013

DRILLING			MATERIAL				NATURAL FRACTURES			INCLINOMETER Log	COMPONENTS					
Progress	Scale (m)	Drilling & Casing	Description	Estimated Strength	Spacing	Additional Data	Weathering	Visual								
Water	Drill Depth (m)	(Core Loss / Run %)	ROCK TYPE, colour, grain size, structure (texture, mineral composition, hardness, alteration, cementation, etc. as applicable) and SOIL TYPE, moisture, colour, consistency, structure, minor components (origin)	Is(50) MPa	(mm)	(joints, partings, seams, zones and veins) Fracture type, orientation, infilling or coating, shape, roughness, other.										
SAMPLES & TESTS	Depth / (RL) metres	Graphic Log		EL 0.03	VL 0.1	L 0.3	M 1	H 3	VH 10	EH	20	40	100	300	1000	
	60.10 (-34.37)		DOLERITE BOULDER Light grey, iron stained, medium grained, moderately weathered, medium to high strength.	MW												SLK, OP
	60.35 (-34.62)		Sandy CLAY Red-brown with some dark grey mottling, low plasticity, hard to very hard; sand is medium to coarse grained; trace gravels, fine grained, sub-angular.													60.15m; JT, 40d, PLN, SLK, OP 60.25m; JT, 50d, UN-PLN, SLK, OP
	61.00 (-35.27)		Silty CLAY Red-brown, medium plasticity, very hard; some sand, fine to coarse grained; trace gravels, light yellow, fine to medium grained, sub-angular.													61.60m; JT, 40d, ST, SC, OP 61.80m; JT, 40d, ST, SO, OP
	61.40	(0)														
	61.90	(0)														
	62.30	(0)														62.30m; JT, 50d, UN, SO-SLK, OP
	63.40	(0)	63.40m; Some intermittent green banding.													63.10m; JT, 50d, UN, SO-SLK, OP 63.40m; JT, 40d, PLN, SO-SLK, OP
	64.60 (-38.87)		CORE LOSS (300mm)													64.30m; JT, 20d, UN, SO, OP 64.50m; JT, 30d, PLN, SLK, OP
	64.90 (-39.17)		Sandy CLAY Orange-red to brown, low to medium plasticity, hard to very hard; sand is fine to coarse grained.													65.00-65.40m; JT, 80d, PLN, SO, OP 65.40-65.75m; JT, 10d, UN, SO-SLK, OP
	66	(0)														

See standard sheets for details of abbreviations & basis of descriptions



GHD GEOTECHNICS
 GPO Box 668, Brisbane Qld 4001
 T: 61 7 3316 3000 F: 61 7 3316 3333 E: bnemail@ghd.com.au
 CLIENTS | PEOPLE | PERFORMANCE

Job No.
3216698

CORE LOG SHEET WITH INCLINOMETER

Client :	Kingborough Council		HOLE No. IBH-2013	
Project :	Taroona Landslide Risk Assessment		SHEET 13 OF 13	
Location :	101 Flinders Esplanade, Taroona, Tasmania		Surface RL: 25.7m	AHD
Position :	528943.6 E	5245344.9 N	MGA94 / 55	Angle from Horiz. : 90°/000°
Rig Type :	HP Scout MkIV	Mounting: Truck	Contractor : KMR	Driller : D. Richardson
Casing Dia. :	PQ3	Barrel (m) : 1.60	Bit : Face Discharge	Bit Condition : NEW
Date Started :	29/7/13	Date Completed : 5/8/13	Logged by : JSP	Date Logged : 29/7/2013
				Processed : P.JL
				Checked : <i>APM</i>
				Date : 26.2.14

DRILLING				MATERIAL				NATURAL FRACTURES				INCLINOMETER Log	COMPONENTS
Progress	Scale (m)	Drilling & Casing	Water	Description	Weathering	Estimated Strength Is(50) MPa	Spacing (mm)	Additional Data	Visual				
Drill Depth (m)	(Core Loss / Run %)	SAMPLES & TESTS		Depth / (RL) metres	Graphic Log	EL 0.03 VL 0.1 L 0.3 M 1 H 3 VH 10 EH	20 40 100 300 1000	(joints, partings, seams, zones and veins) Fracture type, orientation, infilling or coating, shape, roughness, other.	Visual				
66.10	(0)			66.90 -41.17)				66.10m; DB					
67.10	(0)			68.40 -42.87)	DOLERITE BOULDERS and COBBLES in Sandy CLAY matrix; Boulders and cobbles are light grey, fine to medium grained, moderately to slightly weathered, high strength; Sandy CLAY matrix is light red-brown with some light grey streaks/mottling, low plasticity, hard to very hard; sand is fine to coarse grained; some gravels, fine grained, sub-angular. 69.90-67.10m; COBBLE 67.40-67.50m; COBBLE 67.75-68.40m; BOULDER	MW-SW MW-SW SW	67.10m; JT, 40d, PLN, SLK, OP 67.60m; JT, 40d, PLN, SLK, OP 67.75m; JT, 50d, PLN, SLK, OP						
68.60	(0)				Sandy CLAY with gravel Red-brown with some light yellow-brown mottling, low plasticity, very hard; Sand is medium to coarse grained; Gravels are fine to medium grained, trace coarse grained, poorly graded, sub-angular to sub-rounded.			68.40m; JT, 40d, PLN, SLK, OP 68.80m; DB 68.80m; JT, 15d, PLN, SLK, OP 69.10m; JT, 20d, PLN, SLK, OP 69.30-69.80m; JT, 80d, UN, SLK, OP					
70.10	(0)			70.10 -44.37)	END OF BOREHOLE @ 70.10m (TARGET DEPTH OBTAINED)			70.00m; JT, 50d, PLN, SLK, OP					

See standard sheets for details of abbreviations & basis of descriptions

GHD GEOTECHNICS
 GPO Box 668, Brisbane Qld 4001
 T: 61 7 3316 3000 F: 61 7 3316 3333 E: bnemail@ghd.com.au
 CLIENTS | PEOPLE | PERFORMANCE

Job No. **3216698**

GEO CORE ONLY 3216698.GPJ GHD GEO TEMPLATE GDT 26/2/14

Appendix C - Core Photos

PQ core was collected in plastic core trays capable of storing up to 3 m of core. A total of 25 core trays were required to store the core during the drilling of IBH-2013. Note several trays 01, 02, and 03 have been boxed right to left against convention. The remainder have been boxed conventionally.

Tray 01(1.30 to 3.00 mbgs)



Tray 02 (3.00 to 6.00 mbgs)



Tray 03 (6.00 to 9.00 mbgs)



Tray 04 (9.00 to 12.00 mbgs)



Tray 05 (12.00 to 15.00 mbgs)



Tray 06 (15.00 to 17.80 mbgs)



Tray 07 (17.80 to 20.65 mbgs)



Tray 08 (20.65 to 23.35 mbgs)



Tray 09 (23.35 to 26.15 mbgs)



Tray 10 (26.15 to 28.99 mbgs)



Tray 11 (28.99 to 31.90 mbgs)



Tray 12 (31.90 to 34.80 mbgs)



Tray 13 (34.80 to 37.62 mbgs)



Tray 14 (37.62 to 40.50 mbgs)



Tray 15 (40.50 to 43.40 mbgs)



Tray 16 (43.40 to 46.30 mbgs)



Tray 17 (46.30 to 49.10 mbgs)



Tray 18 (49.10 to 51.85 mbgs)



Tray 19 (51.85 to 54.65)



Tray 20 (54.65 to 57.40)



Tray 21 (57.40 to 60.20)



Tray 22 (60.20 to 62.90)



Tray 23 (62.90 to 65.75)



Tray 24 (65.75 to 68.40)



Tray 25 (68.40 to 70.10 mbgs)



Appendix D – VWP Installation Guide

Standard Operating
Procedure (SOP) for the
Installation and Operation
of Vibrating Wire
Piezometers

February 2013



This Vibrating Wire Piezometer Installation Procedure ("Report"):

- 1. has been prepared by GHD Pty Ltd ("GHD") for use on site;*
- 2. may only be used and relied on by GHD personnel;*
- 3. must not be copied to, used by, or relied on by any person without the prior written consent of GHD;*
- 4. may only be used for the purpose of installing Vibrating Wire Piezometers (and must not be used for any other purpose).*

GHD and its servants, employees and officers otherwise expressly disclaim responsibility to any person arising from or in connection with this Report.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the Report are excluded unless they are expressly stated to apply in this Report.

GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

Subject to the paragraphs in this section of the Report, the opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation. GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with those opinions, conclusions and any recommendations.



Contents

1.	Introduction	1
2.	Principles of Operation	2
2.1	applying this equation and the coefficients.VWP Readers	2
2.2	Data Logger Monitoring Procedure	2
3.	Safety	4
3.1	JSEA	4
3.2	Safety Issues	4
4.	Vibrating Wire Piezometer (VWP) Installation	6
4.1	Pre-Installation Testing	6
4.2	Preparation for installation	6
4.3	Installation Equipment/Materials	7
4.4	Installation Procedure	8
4.5	Additional Points	13
4.6	Wiring	14
5.	Acknowledgement	16
6.	References	17

Table Index

Table 1	Glossary of Terms	5
Table 2	Conversions	5
Table 3	Recommended cement-bentonite-water mixes (NUDLC, 2012)	11
Table 4	VWP Installation Tally Sheet	16

Figure Index

Figure 1	Grout Mixing	12
----------	--------------	----

Appendices

- A Calibration Sheets



- B Example VWP JSEA
- C Equipment Requirements
- D Example VWP Installation Diagram
- E Casing Tally Sheet



Table 1 Glossary of Terms

Acronym	Description
JSEA	Job Safety (and Environment) Analysis
kPa	Kilopascals
m	Metres
PVC	Polyvinyl Chloride
WVP	Vibrating Wire Piezometer
WVP Reader	An instrument that is attached to the cabling to collect a WVP reading.

Table 2 Conversions

Unit	Conversion
100 PSI	689 kPa or 68.9 m head
100 kPa	10 m head
100 kPa	14.5 PSI



1. Introduction

This manual is intended to serve as a detailed guide for both the installation and operation of direct 'grouted-in' Vibrating Wire Piezometers (VWP). This document incorporates installation, testing, and safety requirements.

There are several manufactures of VWPs and as such, the specific manufacturer's manual should be reviewed and understood prior to the installation and use of a VWP.

VWPs can be installed within a borehole using a number of methods:

- ▶ Attached to polypipe;
- ▶ Attached to PVC casing;
- ▶ Suspended on wires.

This procedure documents the PVC casing installation method whereby the VWP is strapped to a 'carrier' casing. The general principles however, do apply to the other installation methods.

A general check list for installation requirements including safety documentation and installation photographs are provided within this procedure.



2. Principles of Operation

2.1 Operating Principles

The vibrating wire piezometer (VWP) converts water pressure to a frequency signal through a diaphragm device and a pre-tensioned steel wire. The piezometer is designed so that a change in pressure on the diaphragm causes a change in the tension of the connecting wire. As a change in pressure occurs, the wire will vibrate at its natural frequency. The frequency of vibration is controlled by the tension of the wire: the frequency squared is directly proportion to the pressure on the diaphragm, and extremely linear.

As this vibration of the wire occurs in proximity to a built-in magnetic coil, the frequency is detected by the coil and then transmitted through the sensor cable to a readout device at the surface which measures the frequency and temperature and displays the value.

Each individual VWP is calibrated by the manufacturer and supplied with a calibration certificate. These certificates include graphs and equations used in deriving the calibration factors and pressure/temperature coefficients, which can be used to convert collected data readings into pressures. (see Appendix A for examples).

2.2 VWP Readers

A reading is made by connecting a VWP 'reader' to the cabling. These readers are usually hand-held and can be rented or purchased from the VWP manufacturer or hired from GHD's equipment pool. The following features are standard with the Geotechnical Systems Australia (GSA) type VWPs:

- ▶ four colour-coded alligator clips;
- ▶ displays a frequency (squared), period (milliseconds) and temperature;
- ▶ may display a 'ghost' reading or 'reading invalid', particularly if not connected to cabling correctly or if colour-coded wires are crossed. This error is normal and usually disappears within seconds if the problem is resolved;
- ▶ operates on 2 x 9V batteries;
- ▶ automatically shuts down after approximately 90 seconds;
- ▶ LCD display can blacken if exposed too long in sunlight.

2.3 Data Logger Monitoring Procedure

- 1) Unlock the metal terminal enclosure;
- 2) The VWP terminals are usually installed horizontally with 4 terminals per piezometer. The rows are labelled V1, V2 & V3 etc.
- 3) Plug the leads into the portable unit following the colour coding for the jacks;



- 4) Connect the alligator clip ends to the piezometer terminals. Red and Black usually relate to positive and negative piezometer terminals, whilst white and green are temperature terminals;
- 5) Turn on the portable unit by press and hold on button;
- 6) Allow the unit to take approximately 3 readings (about 5 seconds) and record the 4 digit hertz² reading for the piezometer read e.g. V01, also record temperature reading if available. No need to record μ S reading;
- 7) Check reading against expected reading
- 8) The temperature terminals do not need to be connected to retrieve a reading from the piezometer;
- 9) Remove leads from terminals and shut and lock the enclosure door.



3. Safety

3.1 JSEA

Review the JSEA template for VWP installations (Appendix B) before commencing work and **amend** as required.

3.2 Safety Issues

1. Ensure that drillers are familiar and experienced with VWP installations.
 - If not, this procedure and associated JSEA should be reviewed by the drilling contractor.
 - Note that the installation procedure is akin to tremmie grouting. Most drilling contractors have standard operating procedures (SOPs) for casing installation and grouting.
2. Wear Personal Protective Equipment (PPE) at all times, as indicated in JSEA
3. Partake in the driller's safety induction for the drill rig site, and listen to any instructions given
4. Drillers have a good method of running and holding the casing – they will need to lift the head and clamp to hold the un-belled casing. Casing clamps and the casing entry are potential pinch points. Ensure that all site personnel have a useful and unique role, to avoid getting into each other's' way and to make the most of all available persons.
5. Running the VWP cables – ensure that the driller lowers the casing very slowly on the wireline to avoid tangles in the cable as they are run in and strapped to the casing.
6. Use a good solid piece of thin pipe (or star picket) as an axle for the cable reels. This can be set up on coring trestles. One person is required to manage these by slowly feeding out the required reels to avoid them being 'pulled' downhole by the lowered VWP, which may cause hyperextension and damage of the cables.
7. Some installations may comprise multiple VWPs required in the same borehole. Cable and general site management is key as cabling may pose a trip or entanglement risk.
8. Mixing of cement and bentonite
 - Impellers and pinch points
 - Manual handling;
 - Dust, dermatitis
9. Pumping grout through the carrier pipe
 - this involves high pressures, risks of bursts/leaks, and getting sprayed with grout;
 - tie tremmie lines back to rig in case of failure, preferably using snatch-straps.



10. If, at any time, the operation is not proceeding as expected, **STOP** and **THINK** and, if concerned, telephone to **SEEK ADVICE**.



4. Vibrating Wire Piezometer (VWP) Installation

4.1 Pre-Installation Testing

This should be undertaken at the yard / storage area prior to mobilising the VWP and associated cabling to the drill site.

Although these piezometers are calibrated immediately before leaving the supplier, two simple checks should be carried out to confirm that the sensor has not been damaged in transport.

1. Familiarise yourself within the VWP 'reader' operation. The readout connecting wires are commonly colour-coded. Carry spare batteries.

Geosystems VWPs have colour coded connections (e.g. red, black, white, yellow). Slope Indicator company typically have orange, white with orange stripe (frequency), blue, blue with orange stripe (temperature) colour coding.

2. Check that the vibrating wire sensor works by collecting a frequency and temperature reading in the open air prior to installation (check the zero reading against that specified for the particular sensor in its accompanying calibration sheet, Appendix A).

The measured zero should be near the factory zero reading (note that it will not be the same as it will vary according to the ambient temperature and barometric pressure).

3. Immerse the sensor in a column of water and measure the readout to check the output (frequency) at two immersion depths. This check confirms that the sensor is working before installation and can be carried out in a length of blank PVC casing, capped at its base and filled with water, or in a 200 L drum.

The accuracy of the reading can be also checked by applying the indicated frequency squared and temperature to the equation (and coefficients) supplied with the calibration sheets for the particular sensor.

4. Copy / scan the piezometer calibration sheets and save these to the job folder.

4.2 Preparation for installation

1. Review geology, geophysics and select intervals for installation.
2. Prepare installation diagram and list of installation materials for the proposed installation (Appendix C and Appendix D);
3. Check that the length of sensor cable is correct for the particular installation by comparing to the geological and geophysical logs;
4. Check that the VWP is correctly rated for the proposed depth setting (10 kPa = 1 m hydrostatic pressure);
5. Check battery drill is charged / availability of saw and availability of circular drill bit with at least 30 mm diameter;



6. Check operation of VWP 'reader' and spare batteries;
7. Ensure the availability of a sufficient quantity of Class 18, 25 mm diameter pipe (HDPE or PVC). Inspect and confirm by measurement all pipe lengths to ensure they are all the standard length. The pipe-string should approximately 5 m longer than the length of the hole to which you later attach the sensors;
8. In the case of belled-pipe, confirm the availability of sufficient quantity of self-tapping screws and glue;
9. Measure and confirm the length of the PVC pipe. Socketed PVC pipe is commonly 6.035 mm (with 0.035 mm make-up);
10. Number EACH piece of PVC with a marker (1, 2, 3, 4, etc.) and follow this numbering system throughout the installation.
 - Prior to installation, determine which PVC length will correspond to the depths at which the sensors will be placed, and mark the planned location of the sensors along with the sensor ID (e.g. V01, V02 or V03). This will avoid counting errors and confusion during the installation;
 - A casing tally sheet (refer Appendix E) can be used so that depths in the hole can be readily and rapidly determined.
 - Often the PVC casing is stamped by the manufacturer. It is a good idea to number the casing to align with the manufacturers stamping. This is done to keep the VWPs aligned during installation.
 - Request drillers to 'strap' casing (i.e. keep a running total);
11. Assess the permeability of the formation being monitored. Relatively impermeable formations may require higher bentonite mixes.
12. Calculate the volume of the drill hole per metre of its length, to determine the volume of grout required. Based on the nature of the rock mass, 5% to 10% of grout volume should be added for losses to formation (highly fractured or karstic ground can require more than 100% more than the casing volume). Also determine the maximum depth of the first grout run depending on the depth of the hole and the casing to be retrieved as stated by any state regulatory requirements (e.g. NSW regulations call for a maximum of 200 m that can be grouted in each run). If more than one grout run is required, assess how grouting will be completed.
13. Assess the hole stability. This will dictate whether the installation will occur in an open hole or via the drill rods.

4.3 Installation Equipment/Materials

A full list of materials, equipment and consumables is provided in Appendix C.



4.4 Installation Procedure

4.4.1 Method

VWPs can be installed in open boreholes provided sufficient hole stability exists, or through the drilling rods in unstable boreholes. This procedure is specific to the open hole installation method, however only minor adaption is required for installation through the drilling rods.

Open Hole Installation

In the open hole method, the PVC carrier pipe is commonly suspended in the borehole, off the bottom.

The pipe (and sensor) string are lowered into the hole one length of pipe at a time, using the drilling rig and pipe clamps to progressively lower the pipe (and sensor) string. A pipe clamp is used on the rig table, and a second to hoist and hold each new length by the rig winch.

Installation through Drill Rods

If installing through the drill rods, the VWP and carrier casing is installed one length at a time as per the Open-Hole method, **BUT** the difference being that the pipe is rested on the bottom of the hole, and upon completion insertion of the pipe, the drill rods are lifted 'above' the pipe (i.e. no way to suspend pipe whilst removing drill rods). Excess cable is cut at the surface and attached to the carrier pipe to enable removal of the drill pipe.

4.4.2 Procedure

1. Ensure the driller has circulated, cleaned the hole of drill cuttings, and conditioned the hole in readiness for the installation.
2. Measure the water level in the borehole before running pipe and sensors.
3. Label the cable reels to ensure cables and VWP sensors match the desired depths and ratings. Record and double check VWP serial numbers (stamped on VWP casing);
4. If the hole is unstable, or considered likely to become unstable, the pipe and sensors should be lowered into the hole through the drill string which has previously been lowered into the hole. The drill string should be open at the base, without core barrel or drill bit.
5. Ensure the hole is open over the depth to which PVC casing is to be installed. This can be checked with the drill string (if this is being used in an unstable hole) or by using a depthing line, or geophysics (if hole has been overdrilled). Review of geophysical calliper logs may assist in confirming hole diameters, squeeze zones etc.
6. The bottom end (sump) of the first length of PVC pipe should be slotted or drilled to enable grout to exit the conduit. Grout exit holes should be carefully cut into the pipe on the bottom 1.5 m to 6 m of its length. Hole should be drilled to 15 mm to



20 mm in diameter using a 15 mm to 20 mm holesaw bit or 'bird beak' slots cut with a saw. Holes should be placed randomly along the 1.5 m length at 10 cm spacing.

7. Some drillers prefer to cap the piping to prevent clay plugging the end, however if insufficient slots are cut, the pipe may take time to fill with mud and be buoyant. Other drillers cut a slight taper on the bottom so that the PVC can pass across ledges that may be present in a borehole. Invert and fill the sensor cap: Immediately prior to the sensor entering the hole (i.e. during the lowering of the pipe/cable string), pull off the small cap with porous filter, located at the end of the sensor. covering the diaphragm . Fill the space above the diaphragm with clean water. Push the sintered disc back in place, repeating if necessary until water is squeezed through the porous end. The filling of this space should prevent an airlock, which may cause errors in pressure readings. Typically the bottom sensor will be attached to the second bottom length of PVC (above the length with grout exit slots) using strong adhesive tape at the depth according to the installation diagram. The sensor should be fastened to the pipe facing upwards (i.e. inverted), with about a 150 mm loop of cable taped carefully to the pipe to avoid straining the joint from cable to sensor. Ensure you don't cover the sensor top. Measure and note the precise length at which the sensor is connected to the pipe.

8. While the VWP is at the surface, prior to the sensor entering the bore, measure the sensor reading and temperature, and record it. This will form the zero reading in subsequent calculations.

Some VWP cable manufactures have metre intervals recorded on the cabling. Record the metreage nearest the VWP sensor (and on the cable again when the PVC carrier pipe has been landed) to **a)** confirm depths in hole; and **b)** facilitate matching VWP sensors at the surface.

9. Tape the cable to the pipe at approximately 2 m intervals along its length. Progressively tape the cable to each length of pipe as it is being lowered into the hole. Glue each joint carefully, using cleaning fluid and solvent cement.

Drillers need to take care when clamping casing that cables are not pinched or severed. Drillers (and offsidiers) need to apply care when cutting duct tape etc near the cables to avoid damaging the cabling.

It is a good idea to keep the VWPs and cabling aligned in the borehole. If the casing becomes stuck or encounters a 'squeezed' zone, it can be rotated to facilitate installation. This can be achieved by getting the drillers to align the casing manufacturers' stamping marks when solvent joining adjacent lengths.

Some drillers prefer to run the cabling directly from the spools to the conduit / casing. For the rig to move from the bore, the cables would have to be cut (as they extend above the rotary table). Other drillers prefer to loop the cable underneath the rotary table before attaching to the PVC. Whilst this avoids the need to cut the cables before rig shift, it may create extra handling and risk of cable damage (as it rubs on the underside of the rotary table).

10. To provide additional tensile support for deep VWP installations, it is recommended that the PVC carrier casing is screwed. A good rule of thumb: 1 screw for first



10 lengths, 2 screws for next 10 lengths, 3 screws for subsequent lengths. Beware of VWP cabling when drilling and screwing these.

11. Test operation of VWPs every 10 to 15 lengths, and after any squeeze zones have been encountered. If VWPs are no longer working, remove from borehole and recondition borehole (or consider installation through drilling rods).
12. Connect the second sensor at the previously marked sensor location in the same fashion as the bottom sensor connection described in Steps 6-11.
13. When the casing (and VWPs) have been landed, it is preferable to clamp the casing to hold it into position. The clamp should be located below the rotary table to enable a rig shift whilst grout is curing.
14. If cementing in two batches, attach a Poly tremmie pipe at the predetermined depth (and record in tally book). Note that tremmie pipes may tend to twist the conduit. It is often easier to tape the cabling to the PVC whilst in the clamps, and then tape the Poly pipe separately once the clamp has been removed (and casing held by winch clamp).
15. If the installation has been completed through a drill pipe, tape excess sensor cables to the last length of the PVC prior removing the drill string from the drillhole. When pulling the rods, ensure that the driller does not rotate the string. Alternatively, tuck the excess cabling into the top pipe and tape the top to secure them safely within.
16. If using the tally book (refer Appendix E), the pipe totals will be to a particular datum (usually ground surface). You may need to add an additional length (some stick-up) to enable clamping (to the rig table / or at ground level). **As the grout may take >2 days to cure, it is recommended that the casing be clamped at ground level to enable rig shift whilst the grout is curing.**
17. Once the PVC pipe string and sensors have been installed to the final depth, and prior to the addition of grout, measure each sensor reading and record it. Check that the pressure reading at the sensor is the same as the estimated head of water above the sensor using the equation provided by the manufacturer. This is the last check that the sensor is working correctly before grout is added and the sensor is fixed in place permanently.
18. Circulate water (or mud) through the conduit to ensure circulation can be achieved. This can also act to remove heavy solids that may have settled during the installation, reducing cementing pressures.

The driller should apply caution in applying pump pressures, e.g. use bean pump, to minimise damage to the conduit casing.
19. Select an appropriate cement, bentonite and water mix as shown in Table 3. An 8% to 10% bentonite mix is recommended for low porosity rock formations, whereas a 6% to 7% mix is suitable for sand aquifers with high pore pressures.

Mixing water is to be of good quality, with a pH of 6.5 to 7.5 where possible. Cement used is to be general purpose construction cement with no additives.



Table 3 Recommended cement-bentonite-water mixes (NUDLC, 2012)

Cement 20 kg bags	% Bentonite in mix (i)	Mass of bentonite (kg)	Volume of water (litres) (ii)	SG (kg/L)	Yield per bag of cement (litres)	Firmness
2	5	2	55	1.42	68.47	Firm
2	6	2.4	60	1.39	73.63	
2	7	2.8	65	1.36	78.79	
2	8	3.2	70	1.33	83.95	
2	9	3.6	75	1.3	89.11	
2	10	4	90	1.27	94.27	Malleable to plastic

Notes:

1. A 10% or greater bentonite mix is not recommended for normal cementing operations.
2. Bentonite mixes can be affected by the quality of water used.
3. Confirm cement bag size. Some cement comes in 40 kg bags.

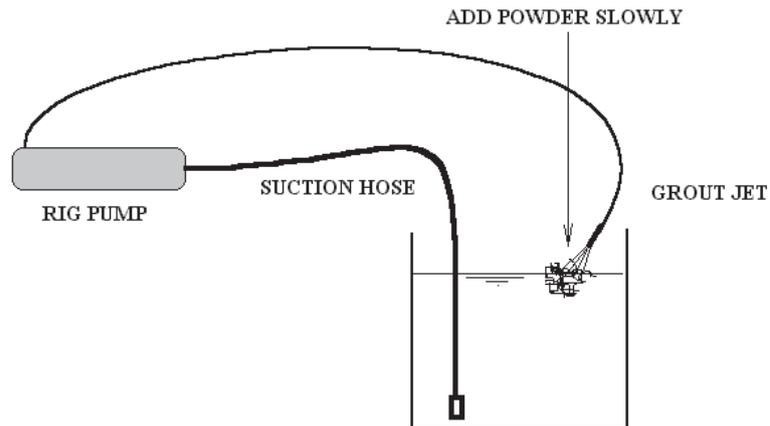
20. **Mix cement with water first.** This is contrary to what most water bore drillers are familiar with. If the bentonite is mixed first, the resultant mix will be too viscous to pump.

Then mix in the bentonite. When water and cement are mixed first, the water-cement ratio stays fixed and the strength/modulus of the set grout is more predictable. If bentonite slurry is mixed first, the water-cement ratio cannot be controlled because the addition of cement must stop when the slurry thickens to a consistency that is still pumpable.

Drillers may have specific grouting plants, or they may rely upon simple tanks and 'flex drive' pumps, with a set up similar to that shown in Figure 1.



Figure 1 Grout Mixing



A measured quantity of clean water goes into the mixing tub/barrel first and the pumping and circulation starts. Then the cement is gradually added to the water and mixed thoroughly. At this stage the mix is like grey water. Next, bentonite powder is slowly added into the jetting area of the barrel, slowly enough so clumps of bentonite do not form. This should be constantly checked by scraping the bottom with a shovel. When clumps form, slow down and do not add any more powder until they are dispersed. Keep adding bentonite until the watery mix transitions to an oily/slimy consistency. Observe the consistency while mixing and let the grout thicken for another five to ten minutes. Generally, the mix thickens some more with added mixing time. Add more bentonite as required. When it is smooth and like thick cream or pancake batter, it is as heavy as is it feasible to pump.

If the grout is too thin, the solids and the water will separate. If the grout is too thick, it will be difficult to pump. There is no particular amount of bentonite that you must add. The thickness of the grout varies with water, temperature, and agitation, so the amount of bentonite required will vary.

If no calculator is available, an old driller's trick to determine hole volume (generally slightly over estimates volume):

$$\text{hole volume (Litres per metre)} = \frac{(\text{hole size in inches})^2}{2}$$

19. Collect samples of each grout batch to monitor cure times and performance.
20. Pump the grout through the PVC pipe carrier (to which the sensors and cables are attached) in a single operation, thereby filling the hole from the base. Therefore, ensure that the pumps are fuelled up, and you have the full amount of grout mixed up. Example grout calculations are shown in Appendix G.
21. The grout should be pumped in one go, due the low pressure pumps drillers typically have (usually just a flexdrive) as once you stop pumping, you won't be



able to get any more grout in so make sure pumps are all fuelled up, and you have the full batch of grout mixed up and pump in hole.

22. Allow 1 to 2 days for curing/shrinking of the grout. If the level of the grout drops below the ground surface but the borehole stays open, check top of the grout, mix and add more grout from the surface until the borehole is again filled all the way to the top. This might be difficult to achieve in areas with significant fracturing (natural or induced by blasting). Subsequent grout batches can be neater i.e. less or zero % bentonite.
23. Provided that the casing is clamped at ground level, the rig can be shifted. You may need to cut the cables (allow 10 m additional length) and feed through the rig table. Record the end metreage of each cable (if marked on the cable itself).
Don't release clamps until grout has cured (based on sample inspection)
24. Once a cable is cut/shortened, clearly re-label each transducer cable for later reference.
25. Complete the head works, including installation of loggers and/or terminal boxes as required
26. The installation diagram should then be adjusted based on the actual measurements collected during the installation and presented as final completion diagram.

4.5 Additional Points

- ▶ Take photos (using camera or smart phone) throughout the process and of the finished product
- ▶ Keep a log of time taken during each step to help in estimating installation duration and planning for grout preparation etc.
- ▶ Keep the cable reasonably tight and straight as you run it in
- ▶ Ensure VWPs are inverted and tips are filled with water
- ▶ Request an experienced driller when running VWPs if possible, and check with the drilling supervisor
- ▶ Allow at least 5 m to 10 m of extra cable at the surface, and any leftover can be cut off to keep site tidy.
- ▶ Allow for extra time and material/equipment requirements if the cables are to be spliced or joined to piezometers on site. For example: soldering iron, generator, heat gun, heat shrink at suitable sizes, heat shrink tape.
- ▶ A skilled contractor can install 300 m (i.e. 50 lengths within about 4 hrs).
- ▶ Don't be in a hurry to inject grout – keep grout pumping pressures to a minimum (particularly for deeper installations).
- ▶ In terms of grout batches, consider the weight of the batch and rating of the VWP. VWP sensors are commonly rated above their operating pressures. For example;
S.G. grout = 1.33



Overlying weight at 300 m depth = 300 m x 10 kPa x 1.33 = 4,000 kPa

A GSA M1200 5,000 kPa sensor has a maximum rating of 7,500 kPa (from calibration sheet). Therefore the weight of grout will not over pressurise the sensor.

- ▶ Don't overfill with grout. Top grout to approximately 0.5 m of the surface to enable installation of the headworks / logging box.
- ▶ **Under no circumstances cut cables before they have been adequately and clearly labelled.**
- ▶ An experienced crew should be able to run around 300 m in 4 hrs.

4.6 What happens if it doesn't land

Prior to the installation of the VWPs, an assessment of hole condition should be made. If the hole is unstable, installation inside drill rods should be made (with the conduit casing resting on bottom). This is a time consuming process and often avoided.

In some cases however, despite all best efforts, you may encounter difficulties in landing the VWPs and conduit to the desired depth. Some things to consider under these circumstances:

- ▶ Review your geology and monitoring targets. The depths of the VWPs may still be adequate. Check with your supervisor.
- ▶ **Avoid using the head to 'push' the conduit into position. This poses to greater risk of damaging the conduit (snapping it) and preventing adequate cementing.**
- ▶ **Avoid repeated raising and lowering of the conduit string. Whilst a 'few' goes are acceptable, consider the risk of abrasion of the cabling on the walls of the borehole.**
- ▶ Attach the cementing head and gently circulate water/mud through the conduit. Flushing of casing to depth (an additional few meters) has been successfully achieved on a number of occasions.

If you are several meters of depth (and VWPs) are well outside of the desired target intervals, you may have to consider pulling the conduit and re-conditioning the borehole. This will require procurement of additional replacement conduit or joiners if the old conduit is reused.

4.7 Wiring

4.7.1 Tools

- ▶ Wire strippers (about \$30 from hardware)
- ▶ Small screw driver set (Phillips head and normal)
- ▶ Duct tape.
- ▶ Cable ties



- ▶ Stanley knife
- ▶ Permanent marker

4.7.2 Procedure

The wiring is generally not a difficult procedure, but care should be taken to ensure it is done correctly.

- ▶ Ensure each cable is adequately marked / identified (record metreages).
- ▶ If you are inexperienced with electrical wiring, cut a small length of cabling to practice upon.
- ▶ Cables can be spliced if you make a mistake, but this is best avoided.
- ▶ Feed cabling up through standpipe.
- ▶ Feed earth-stake cabling down through standpipe.
- ▶ Earth-stake to be pegged into ground and connected to wiring.
- ▶ Measure off sufficient cable and cut excess. A good guide is to coil the cable around the inside of the box (refer Appendix F).
- ▶ Strip back the outer black rubber of the cabling. You will need to strip off approximately 50 mm to 70 mm length. This should reveal 4 x plastic coated wires, and a fifth uncoated wire.
- ▶ Readjust your wire stripper, and strip off approximately 15 mm of wire from each of the 4 coloured wires.
- ▶ For each of the 4 coloured wires, bend the stripped ends back over themselves and twist to create and approximate 5 mm long terminal end.
- ▶ Unscrew the terminal box ends, and insert wires (refer Appendix F).
- ▶ The uncoated fifth wire should be attached to the earth terminal.
- ▶ Confirm operation.
- ▶ Use cable ties to keep wiring together and tidy, and away from the hinges to enable safe closing of the electrical cabinet door.
- ▶ Collect the initial readings from the readout box, comparing data to that obtained during the installation.



5. Acknowledgement

Some clients may require some form of acknowledgement that this procedure has been read, reviewed and understood. Parties involved in the installation should either:

- a) Complete and sign a JSEA (example JSEA attached as Appendix B)
- b) Sign the form below.

I have read the GHD Standard Operating Procedure (SOP) for the Installation and Operation of Vibrating Wire Piezometers and agree to work to this and other referenced procedures and JSEAs.

Date	Print Name	Signature

Please report any suggested improvements, amendments to this procedure to your direct supervisor / GHD project manager.



6. References

- ▶ National Uniform Drillers Licensing Committee, 2012: '*Minimum Construction Requirements for Water Bores in Australia*' 3rd Edition. Often referred to as the ARMCANZ guidelines.
- ▶ Mikkelsen, P.E., and Green, G.E., '*Piezometers in fully grouted boreholes*'. Symposium on Field Measurements in Geomechanics, FMGM 2003, Oslo, Norway, September.



Appendix A
Calibration Sheets



VIBRATING WIRE PIEZOMETER CALIBRATION

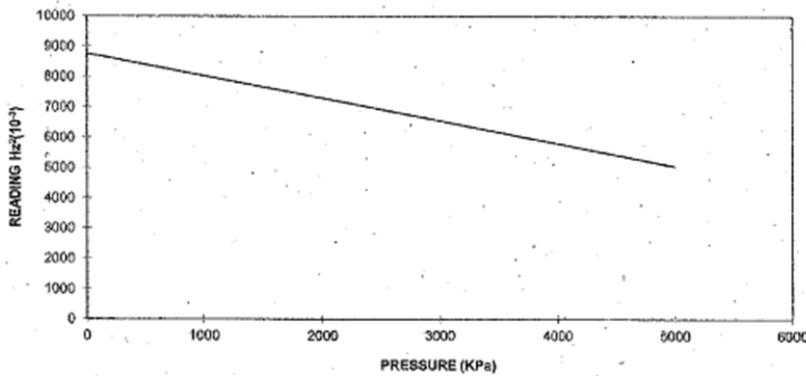
CLIENT : GHD SERVICES PTY LTD

JOB No 10553

SERIAL No. : 15052 340

RATING : 5000 KPa

PIEZOMETER CALIBRATION GRAPH



FACTORY ZERO READING : 8776 Hz²(10⁻³) ----- (F_F)

PRESSURE COEFFICIENT : 1.34840 KPa/Hz²(10⁻³) ----- (C_P)

AMBIENT TEMPERATURE : 20 °C ----- (T₀)

THERMAL COEFFICIENT : 0.06850 KPa/°C ----- (C_T)

SEE INSTRUCTION MANUAL FOR STANDARD THERMISTOR/TEMPERATURE DATA

MAXIMUM PRESSURE : 7500 KPa

BAROMETRIC PRESSURE : 1018 mBar

OPERATING TEMPERATURE RANGE : -30°C to +65°C

ZERO READING: (F₀) TO BE ESTABLISHED DURING INSTALLATION

$$\text{PORE PRESSURE} = (F_0 - F_1)C_P + (T_1 - T_0)C_T$$



VW Pressure Sensor Calibration Record

Customer : DGSI - Australia

Part Number : 92611075

Cust No.: 200425

Cable Length : 355 m

Date : October 25, 2011

Ser_Number 116314

Calibrated by : KB

Applied Pressure	Recorded Frequency	Calculated Pressure	Error % FS (non-conformity)
KPa_i =	Hz_i =	KPa_{-i} =	Err_i =
0.000	1963.7	-1.211	-0.02
1000.035	1892	1003.604	0.07
2000.071	1818.4	1997.196	-0.06
3000.106	1741.1	2999.452	-0.01
4000.141	1660.3	4001.875	0.03
5000.176	1575.9	4999.611	-0.01

To convert frequency reading to pressure in KPa:

$$P = (A \times F^2) + (B \times F) + C$$

$$A = -3.53937 \times 10^{-3}$$

Where : P = Pressure in KPa
F = Frequency reading in hertz

$$B = -3.67397 \times 10^{-1}$$

$$C = 1.43685 \times 10^4$$

Temp Coefficients

KPa/Deg C

KPa

Deg C

m = 0.00635

b = -0.152

TempOffset = -0.1

Calibration temperature DegC

Chamber = 20.7

Thermistor = 20.6



SLOPE INDICATOR

VW Piezometer Calibration Certificate

Serial #: 11-6231
 Range : 2000 kPa
 Cable Length: 85 m
 Date of Calibration: 10/21/2011

Part #: 52611040
 Cable Part #: 50613524
 Calibrated by: KB
 Note:

ABC Calibration Factors

	A	B	C
kPa	-5.296398E-4	-1.327587E-1	4.836819E+3
psi	-7.681776E-5	-1.925502E-2	7.015213E+2

Pressure in kPa/psi = (A x Hz²) + (B x Hz) + C, where Hz is frequency in Hertz.

TI Calibration Factors

	C0	C1	C2	C3	C4	C5
kPa	4.806714E+3	-1.177638E-1	1.194326E+0	-5.321669E-4	-1.951341E-4	-7.891929E-3
psi	6.971304E+2	-1.707959E-2	1.732162E-1	-7.718157E-5	-2.830081E-5	-1.144587E-3

Pressure in kPa/psi = C0 + (C1 x Hz) + (C2 x T) + (C3 x Hz²) + (C4 x Hz x T) + (C5 x T²)

Where Hz is the frequency reading in Hertz and T is the Thermistor reading in degrees C.
 TI factors are calculated from temperatures at 5.0, 15.0 and 25.0 degrees C.
 Applied pressure and temperature are NIST traceable.

Summary of Test Results at 15°C

Thermistor reading is 14.5 °C.

Applied Pressure is referenced to 1 atm. Calculated Pressure uses ABC Calibration factors.

Applied (kPa)	Equivalent (psi)	Frequency (Hz)	Calculated		Error (%FS)
			(kPa)	(psi)	
0.0	0.00	2899.4	-0.5	-0.08	0.03
200.0	29.01	2836.1	200.2	29.03	-0.01
400.0	58.02	2771.5	400.6	58.10	-0.03
600.0	87.02	2705.7	600.2	87.05	-0.01
800.0	116.03	2638.4	799.6	115.98	0.02
1000.0	145.04	2569.1	1000.0	145.03	0.00
1200.0	174.05	2498.1	1200.0	174.04	0.00
1400.0	203.05	2425.1	1400.0	203.05	0.00
1600.0	232.06	2350.0	1599.9	232.05	0.00
1800.0	261.07	2272.4	1800.2	261.09	-0.01
2000.0	290.08	2192.4	2000.0	290.07	0.00



Appendix B
Example VWP JSEA

(amend as per site specific requirements)



HSE009 Job Safety and Environmental Analysis (JSEA)

Reference Documentation		11.01.02 HSE Job Management Procedure								
Purpose of Form		The JSEA process identifies the safe and environmentally responsible method of work for individual site activities through the implementation of a HSE risk management approach prior to the commencement of site work considering normal, abnormal and emergency working conditions.								
Responsibility for Completion		Job Manager (or delegate) to complete in consultation with the job team (includes identification and delivery of training).								
Frequency of Completion and Review		JSEA to be developed prior to commencement of site work and reviewed at no more than 6 monthly intervals or where there are significant changes to the job scope, equipment, environment, personnel or statutory framework								
Note: C = Consequence, L = Likelihood, RR = Risk Rating NB: Consequence should be assessed first so that the likelihood rating is the likelihood of the selected consequence occurring										
Activity:		Job Name:		Job No:						
Work Description:	VWP installation			Job Location:	Date:					
For assistance in the consideration of Hazards see Potential HSE Hazards Table below										
Sequential Task Step	Hazards and Risks (Hazard = What could harm you or the environment Risk = What might go wrong and How might it happen)	Initial Risk Rating			Control Measures (Hazards should be eliminated wherever possible or minimised where elimination is not reasonably practicable. Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, Personal and Environmental Protective Equipment).	Reference Guide (e.g. Hazard Guides)	Residual Risk Rating			Person (s) Responsible (for implementing control measures)
		C	L	RR			C	L	RR	
Activity: General (see also other GHD method statements)										



General	Unfamiliar with site hazards	E	3	<p style="text-align: center;">Extreme</p>	<p>Contact Client and /or the relevant landowner and obtain approval to enter the site and information on access conditions, site conditions, site hazards, other site activities, weather conditions. Arrange appropriate vehicle, 4WD, if leaving well established maintained tracks.</p> <p>Check communication options available, coverage etc.</p> <p>Trip planning, daily working schedules, inclusive of travel time, shall not exceed 12 hours / day maximum, without the prior approval of the Project Leader Manager and in conjunction with appropriate rest breaks through the day. Site Visit Leader will brief all staff going to site on SWMS.</p> <p>At least one hardcopy of all the related documents on the day of site visit must be kept in each vehicle and with each walking party.</p> <p>See attached briefing note format and site plan.</p> <p>Ensure at least one person in each visit, or in each walking group if on foot, has a current First Aid Certificate.</p>	E	1	<p style="text-align: center;">Moderate</p>	
---------	------------------------------	---	---	---	---	---	---	--	--



Outdoor exposure	Sun exposure Heat exposure/stress Interaction with wildlife (snake bite, insect bite etc.) Fatigue	D	3	Significant	Wear a broad brim hat and sunscreen (SPF 30+). Reapply sunscreen every 2 hours. Carry electrolyte drink (powder) to replace salts, as required. Wear sun glasses (safety is preferable), long sleeved shirt and long trousers, enclosed sturdy/walking shoes (no sandals or cloth sneakers) First aid kit – be aware of nearest first aid/hospital facility. Rest as required. Consider shelter opportunities (rain, sun). Access to drinking water and food – remain hydrated / drink frequently. Communication equipment (e.g. mobile phone)	SWM002 (Outdoor Exposure)	D	2	Moderate
Fatigue	Loss of concentration Reduced performance Poor communication Errors in judgement	C	3	Moderate	Plan site visit to times of day when individuals are less likely to be affected by fatigue – at full light, i.e. not early morning (dawn) and not at dusk or night, and to reduce the potential for interactions with wildlife The drivers and passengers should get a good night's sleep before journey to reduce potential for fatigue. Arrange suitable accommodation as required Provide nutritional meals throughout the day Take sufficient water/drinks to ensure that the drivers and passengers remain fully hydrated Take drinks and food for breaks. Take rest breaks at least at 2 hourly intervals, with a minimum of 15 minutes to get out of vehicle, stretch, toilet stop, refreshments as required Alert colleagues if experiencing fatigue	HSEG07 - (Fatigue Management)	B	2	Negligible



Walking about sites (Trip hazards and falls)	Personal injury	B	3	Low	Wear appropriate footwear for the conditions. Stay alert – look where you are walking. Stop walking if making observations. Plan access into an area before proceeding.	HSG27 (Slips and Trips)	A	2	Negligible
Taking photographs	Reduced situational awareness Forget surroundings Cross roads without checking for vehicles	B	3	Low	Wear high visibility vests when on the site and adjacent to roads Be aware of own surroundings and what colleagues are engaged in / doing Appoint a colleague as lookout / spotter and support		A	2	Negligible
General	Unfit for work Medical incident	C	3	Moderate	No alcohol and drugs allowed to be consumed whilst travelling or while at work. Take required rest breaks, and drink and take food as required. Only drink water that is free from contamination / trusted sources. One of the drivers/passengers require a valid first aid certificate. Disclose personal medical ailments to colleagues (in case of emergency), e.g. asthma, diabetes. Ensure sufficient personal medicines are available e.g. insulin, inhalers. Ensure First Aid kit is stocked / complete Check use by date of protective helmet (2 years), condition of safety glasses and PPE. Replace as necessary.		A	1	Negligible
Depthing bore	Abrasion of skin, cuts	B	4	Low	Wear gloves, appropriate PPE, when lowering probes into bore. Consider use of tactile gloves to minimise loss of agility / deftness of movement		A	2	Negligible
Slips and trip hazards	On both operational and closed sites there is potential for slips and trips to occur due to misplaced objects or topography.	A	2	Negligible	Ensure that all areas are free of objects or substances that may pose tripping or slipping hazards. Keep sampling site tidy and free of clutter.	HSG27 (Slips and Trips)	A	1	Negligible



Work area set up	Potential for workers to be hit by moving vehicles, other site workers, pedestrian management	D	3	Significant	Isolate work area / establish no go zones. Use traffic cones / tape to isolate area. Consider flashing lights, parking vehicle close to bore as a buffer for protection. High visibility traffic vests must be worn by all surveying workers on site. Traffic barriers and signage should be employed where appropriate.	HSG33 (Working around Traffic)	C	2	Low
Activity: VWP Installation									
Numbering lengths and VWP sensor setup	Poor housekeeping may result in personal injury or entanglement in cabling.	B	3	Low	Housekeeping. Keep cables on trestles and spooling to one side of the work area. Apply manual handling when lifting long cable drums.	HSG21 (Manual Handling)	B	2	Negligible
Installing lengths of PVC casing / conduit	Muscular injury or strain when handling casing. Pinch points on casing clamps.	C	3	Moderate	Where possible, use the winch on the rig to hoist and lower casing. Suitable sized and rated casing clamps. Alternatively a suitably rated crane should be used to lift casing and manoeuvre into position. The cable to be attached using rated lifting sleeves / clamps.	HSG21 (Manual Handling)	B	2	Negligible
Installing tremmie lines	Muscular injury or strain when tremmie line	C	3	Moderate	If possible, move away from area whilst lifting is being undertaken. Use rig wireline to hold tremmie line up to facilitate running into borehole.	HSG21 (Manual Handling)	B	2	Negligible
Concrete dust and bentonite	Contact with potentially toxic materials	B	3	Low	Cement and bentonite will be transferred slowly as to minimise dust generation. Nitrile gloves should be worn at all times when handling cement. Situate yourself upwind while transferring cement to avoid dust inhalation. Use of dust masks	HSG03 (Biological Hazards)	B	2	Negligible



Injection of grout	High pressure fluids	B	3	Low	Circulate hole to lift heavy muds. Tie back grouting hoses to rig to prevent uncontrolled whip. Avoid headworks area / establish exclusion zone. Apply low injection rates to minimise injection pressures. Monitor injection pressures.	HSG21 (Manual Handling)	B	2	Negligible
VWP hole completion	Personal injury or entanglement in cabling.	B	3	Low	Cut excess cabling to tie around headworks to maintain work area.		A	2	Negligible



Appendix C
Equipment Requirements



This list is a general check list for installation requirements for VWP installations.

1. Vibrating Wire Sensors
 - Pressure ranges to match installation depths;
 - Cable lengths to match installation depths
2. Class 18, 25 mm, 32 mm or 40 mm diameter PVC pipe with fusion welded or threaded joints, 25 mm HDPE tremmie pipe.
3. Cleaning fluid and solvent cement for PVC if non-threaded.
4. Permanent marker pens for labelling casing lengths
5. Self-tapping screws
 - typically 6g x 6 mm or longer depending upon casing wall thickness
 - quantity of at least 150.
6. Duct tape
 - Plenty of spare rolls (at least five rolls per 100 m)
7. Cement (GP).
8. Bentonite – Ensure there is sufficient bentonite powder on-site for the required ratio stated in Section 2.2, Step 12. Ensure that bentonite is a pure bentonite (Wyoming), not a bentonite grout containing additives (e.g. some Aus-GEL).
9. A good supply of water for mixing grout.
10. A 100 m tape to accurately measure the pipe before it is inserted into the borehole and to accurately position sensors.
11. A VW 'reader' to test the sensors before, during, and after the installation.
12. Spare batteries for VWP 'reader'. Commonly 9V (rectangular shape)
13. Calibration Sheets specific to the sensors being installed. The pressure and temperature coefficients are very individual to each sensor and it is necessary to know these to obtain an accurate reading.
14. Portable drill with holesaw bit or hacksaw or air saw.
15. Heat gun, soldering iron, generator, heat shrink tube and tapes if cable splicing is required.
16. Poly fittings and camlocks etc. to connect driller's pumps to the PVC carrier pipe and/or poly tremmie lines for grouting.



Appendix D
Example VWP Installation Diagram



Appendix E
Casing Tally Sheet



Table 4 VWP Installation Tally Sheet

Length	Top	Bottom	Comment	Length	Top	Bottom	Comment
	0	6					
	6	12			204	210	
	12	18			210	216	
	18	24			216	222	
	24	30			222	228	
	30	36			228	234	
	36	42			234	240	
	42	48			240	246	
	48	54			246	252	
	54	60			252	258	
	60	66			258	264	
	66	72			264	270	
	72	78			270	276	
	78	84			276	282	
	84	90			282	288	
	90	96			288	294	
	96	102			294	300	
	102	108			300	306	
	108	114			306	312	
	114	120			312	318	
	120	126			318	324	
	126	132			324	330	
	132	138			330	336	
	138	144			336	342	
	144	150			342	348	
	150	156			348	354	
	156	162			354	360	
	162	168			360	366	
	168	174			366	372	
	174	180			372	378	
	180	186			378	384	
	186	192			384	390	
	192	198			390	396	
	198	204			396	402	



VWP3 Pad 46

GL.O.O

Length No.	Top	Bottom
45	0	6
44	6	12
43	12	18
42	18	24
41	24	30
40	30	36
39	36	42
38	42	48
37	48	54
36	54	60
35	60	66
34	66	72
33	72	78
32	78	84
31	84	90
30	90	96
29	96	102
28	102	108
27	108	114
26	114	120
25	120	126
24	126	132
23	132	138
22	138	144
21	144	150
20	150	156
19	156	162
18	162	168
17	168	174
16	174	180
15	180	186
14	186	192
13	192	198
12	198	204

poly →

Length No.	Top	Bottom
4	204	210
10	210	216
9	216	222
8	222	228
7	228	234
6	234	240
5	240	246
7	246	252
3	252	258
2	258	264
1	264	270
SMP	270	276
	276	282
	282	288
	288	294
	294	300
	300	306
	306	312
	312	318
	318	324
	324	330
	330	336
	336	342
	342	348
	348	354
	354	360
	360	366
	366	372
	372	378
	378	384
	384	390

0.5m off bottom

0.5m off top

1m off bottom

VWP3/1 16401 Deep 269.0
 3/2 16399 Mid 246.5
 3/3 16433 Shallow 221.5



Appendix F
Installation photographs



Drill site of VWP installation.

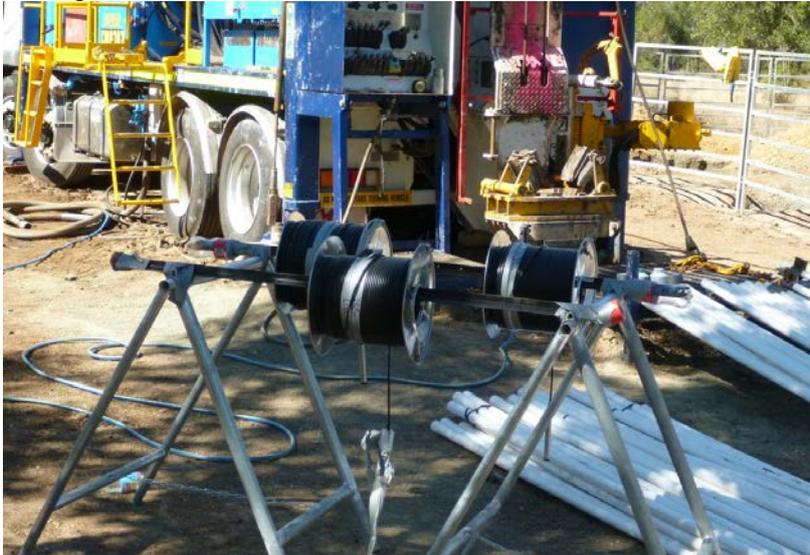


Preparing and numbering PVC pipes (keep aligned with manufacturers stamp). Note sump with slots or 'bird beaks' cut at approximate 0.15 m intervals on left hand side.

Formatted Table



Markings on the PVC where each VWP should be installed



Set up cable reels for installation



Slot or 'bird beak' cut into sump



Filling of VWP sensor (after removal of sintered cap)



VWP sensor and reader unit



VWP Strapped to casing. Note it is taped with sintered cap facing uphole.



Poly tremmie line being attached (and supported by wireline).



Managing the poly tremmie line for easier handling



Casing landed into position. Note casing joint level with outer PVC surface casing. Note short length of pipe added to enable clamping and holding.



Final landed PVC carrier clamped and resting on table. Note, short length of stick-up added to enable resting of clamp on table. Note also the cables are extending over the rotary table. These will need to be cut prior to enabling rig move.



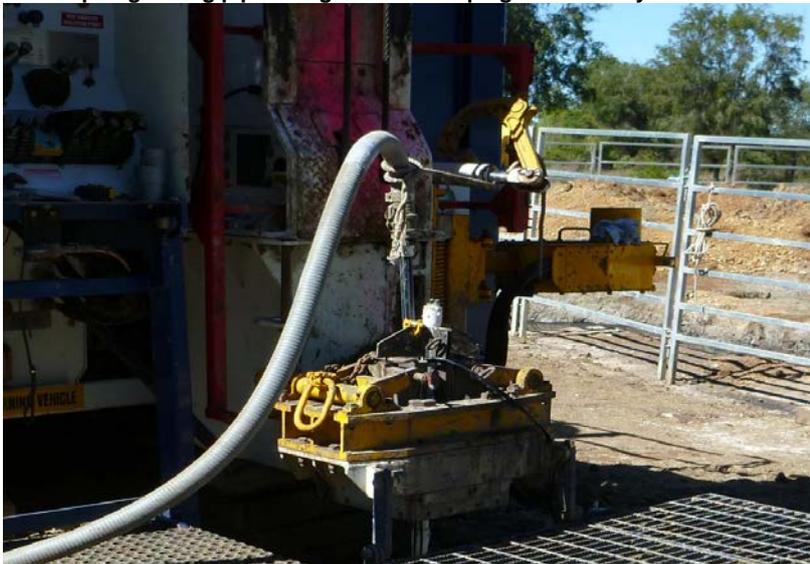
Mixing and grouting bore after installation



Grouting via carrier pipe



Close up of grouting pipe fittings. Note clamping below rotary table.



Grouting second batch via tremmie pipe



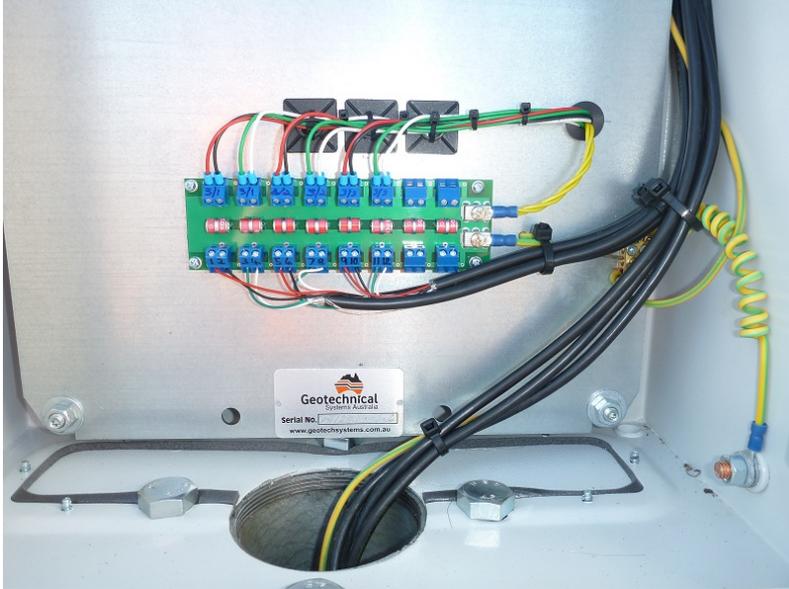
Top of hole after installation



Installation of head works



Newer style logger boxes. Note cabling looped around inside of box.



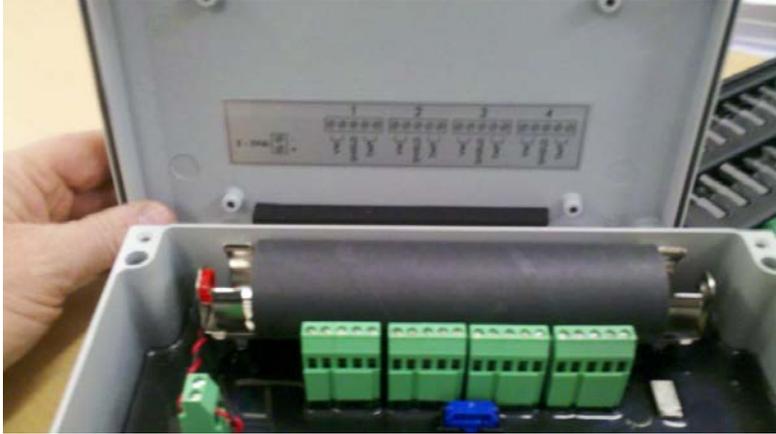
Close up of wiring



All ready!



Slope Indicator Company logger boxes



Wiring diagram legend for the Slope Indicator Company loggers



Appendix G
Example of Grout Calculations



CALCULATIONS

Client Job no. Sheet of ...
Project Calcs by Date ...
Subject Checked by Date ...

Say HQ core. 96.1 mm ϕ

$$\begin{aligned} \text{Hole volume} &= \pi r^2 h && \text{check } \frac{12'' \times 4''}{2} \\ &= \pi \left(\frac{96.1}{2000} \right)^2 && = 8 \text{ L/m} \\ &= 7.2 \text{ L/m} \end{aligned}$$

(less cable + carrier pre wall thickness)
(plus formation losses)

Say 300 m deep.

$$\begin{aligned} \text{Total Volume} &= 7.2 \times 300 \\ &= 2160 \text{ L} \end{aligned}$$

For an 8% bentonite mix

$$8\% \text{ yield} = 90 \text{ L}$$

$$\therefore \frac{2160}{90} = 24.1$$

Materials required

$$\text{Cement} = 24.1 \times 2 = 48.2 \text{ bags} \times 20 \text{ kg}$$

$$\text{Bentonite} = 24.1 \times 3.2 = 77.1 \text{ kg}$$

$$\text{Water} = 24.1 \times 75 = 1810 \text{ L}$$



GHD

180 Lonsdale Street
Melbourne, Victoria 3000
T: (03) 8687 8000 F: (03) 8687 8111 E: melmail@ghd.com.au

© GHD 2013

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
V2	J Learmonth	B Llewellyn				
V3	T Anderson	B Llewellyn G Foley				24/8
V4	J Learmonth / TR Anderson	T Cauchi				27/2/13
V5	T Anderson					6/6/2013

Appendix E – Installation of Permanent Survey Monuments by PDA Surveyors

Q784U - GHD
 Stage 2 Taroonalandslip Project
 Additional Ground Control Point Coordinate File

New Ground Control Marks

Pt ID	Easting	Northing	Reduced Level	Desc
PDA100	528944.316	5245325.507	25.447	S/Steel Rod in conc
PDA101	528977.691	5245535.362	16.204	S/Steel Rod in conc
PDA102	528946.306	5245611.419	16.102	S/Steel Rod in conc
PDA103	528910.550	5245565.436	16.844	S/Steel Rod in conc
PDA104	528911.176	5245649.518	21.372	S/Steel Rod in conc
PDA105	528994.154	5245679.789	12.587	S/Steel Rod in conc
PDA107	529083.546	5245489.706	8.364	S/Steel Rod in conc
PDA108	529154.850	5245451.867	5.537	S/Steel Rod in conc
PDA109	529043.717	5245274.726	4.932	S/Steel Rod in conc
PDA110	529014.284	5245171.307	6.942	S/Steel Rod in conc
PDA112	529075.184	5245330.005	5.304	S/Steel Rod in conc
PDA115	528793.696	5245199.135	30.790	S/Steel Rod in conc
PDA116	528705.900	5245200.603	36.775	S/Steel Rod in conc
PDA118	528853.388	5245077.149	15.214	S/Steel Rod in conc
PDA119	528673.343	5245068.028	32.562	S/Steel Rod in conc
PDA124	528758.196	5245278.887	33.751	S/Steel Rod in conc
PDA125	528828.900	5245279.706	32.925	S/Steel Rod in conc
SPM9432	528535.546	5244997.760	44.410	Brass SPM Plaque

Note: Horizontal Accuracy = ±0.004m Vertical Accuracy = ±0.001m
 MGA94 & AHD83 Datum = SPM9432 per SurCom

New Borehole Coordinates

Pt ID	Easting	Northing	Reduced Level	Desc
IBH_2013	528943.628	5245344.855	25.734	Top of bore tube
VWP_2013	528943.14	5245346.117	na	Centre of steel post



SURVEYOR AC/JW	GEOCIVIL Q784U
DRAWN HC/MK	CHECKED HC
DATE 19 FEBRUARY 2014	

**SURVEY CONTROL NETWORK AND BOREHOLES
TAROONA LANDSLIP MONITORING
TAROONA
for GHD**



PDA
PEACOCK DARCEY & ANDERSON PTY. LTD.
Surveyors, Engineers & Planners.
127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
Also at: Kingston, Launceston & Burnie

PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SCALE 1: 2,500	PAPER (A3)
JOB NUMBER Q874U - 2	DRAWING

Q784U – TAROONA LANDSLIP MONITORING SURVEY – STAGE 2

Ground Control Point Survey Report

Overview

As part of Stage 2 of the landslip monitoring project, additional Ground Control Points (GCP) were requested to be placed in various locations surrounding and within the known Taroon landslip area. This work was undertaken in November and December 2013.

Summary of Results

The final coordinates obtained from the least squares adjustment of the control network yielded results that were as expected in terms of relative accuracy for the network, that is to say that the horizontal coordinates for the control network are accurate to $\pm 4\text{mm}$ whilst the vertical accuracy actually $\pm 1\text{mm}$ for all control points, which is the same as the results obtained in the Stage 1 monitoring survey, undertaken in mid-2011.

Placement of GCP

The GCP's were located approximately as per marked-up plan supplied by MRT's Colin Mazengarb, however the final location was adjusted in consultation with GHD's Kate McIntosh & MRT's Colin Mazengarb to optimise measurement parameters of the network, in particular for inter-visibility and unobstructed view of the sky to optimise GNSS observations.

All GCP's are 2m lengths of 20mm dia. 316 Grade Stainless Steel rod driven flush to the surface (or rejection for PDA107) and centre punched. A 1m deep high strength concrete collar surrounds each GCP, for added stability

Coordination Methodology

All marks were observed by multiple GNSS observations legs utilising 4 Trimble R8-Model 2 GNSS receivers to at least three other GCP's as well as a new GNSS base station observing point located on bed rock at the Mt Nelson Signal Station. Geoscience Australia's GNSS post processing facility "AusPOS" was used to determine MGA94 & AHD83 coordinates for this point.

A precise theodolite traverse was then undertaken utilising a Trimble S8 robotic theodolite to further strengthen the GCP network. All data was then processed in CompNET least squares processing software to rigorously adjust all observations for optimum network strength and thus increase confidence in derived coordinates.

A precise digital level run was then undertaken using a Trimble DiNi level to ensure all levels were to the same accuracy as stage 1 results, which were $\pm 1\text{mm}$ on 1km two way levelling run.

Summary

All GCP's were coordinated to an accuracy of $\pm 4\text{mm}$ horizontally and $\pm 1\text{mm}$ vertically with SPM9432 being adopted as having the same coordinates as the original Stage 1 survey to allow direct comparison of all coordinates when next surveyed. Published coordinates per SurCOM (Survey Mark Register controlled by DPIWPE) of SPM9432 E 528,535.544, N 5,244,997.760 RL 44.41.

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA100

E: 528944.316

N: 5245325.478

RL: 25.446

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

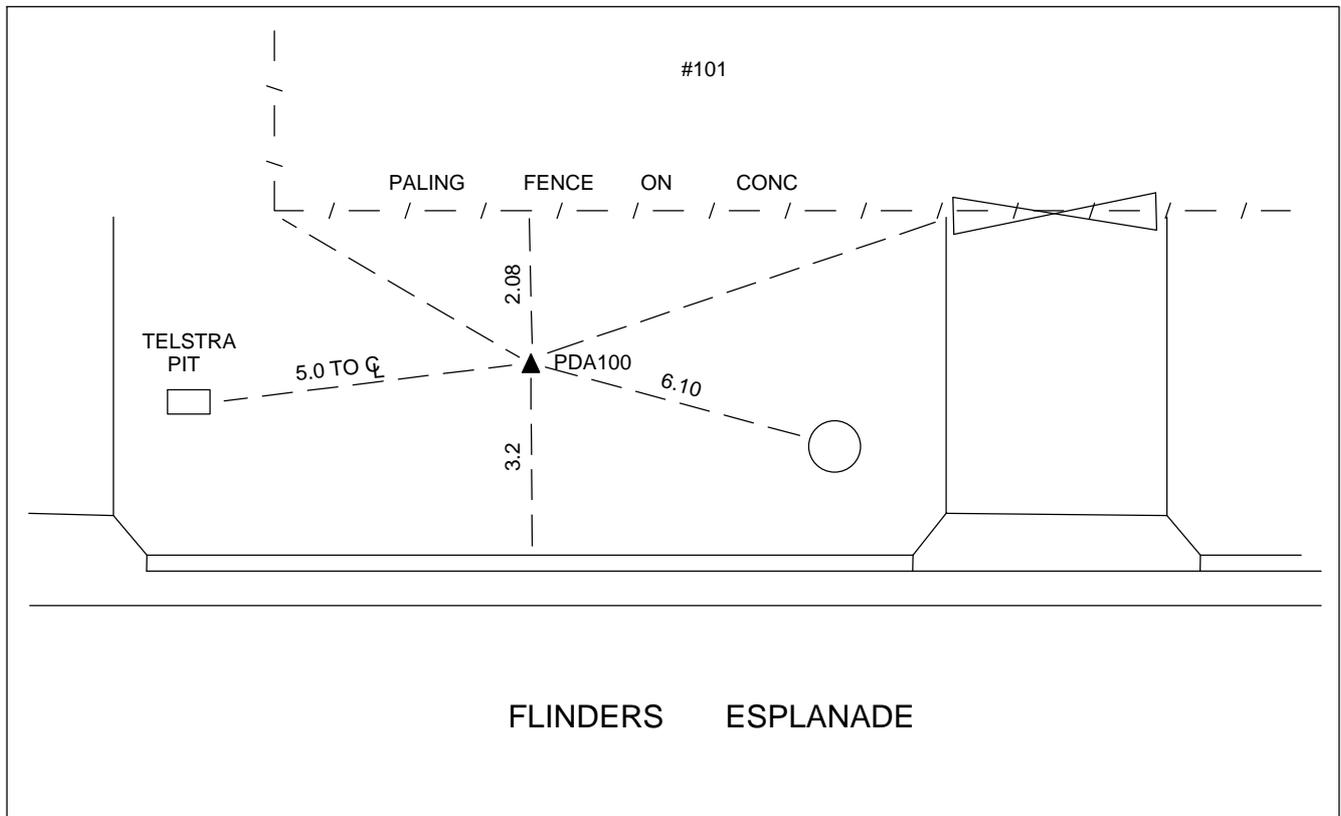
General location: In front of No.101 Flinders Esplanade

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
Surveying, Engineering & Planning

ABN 71 217 806 325

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA101

E: 528977.691

N: 5245535.333

RL: 16.204

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

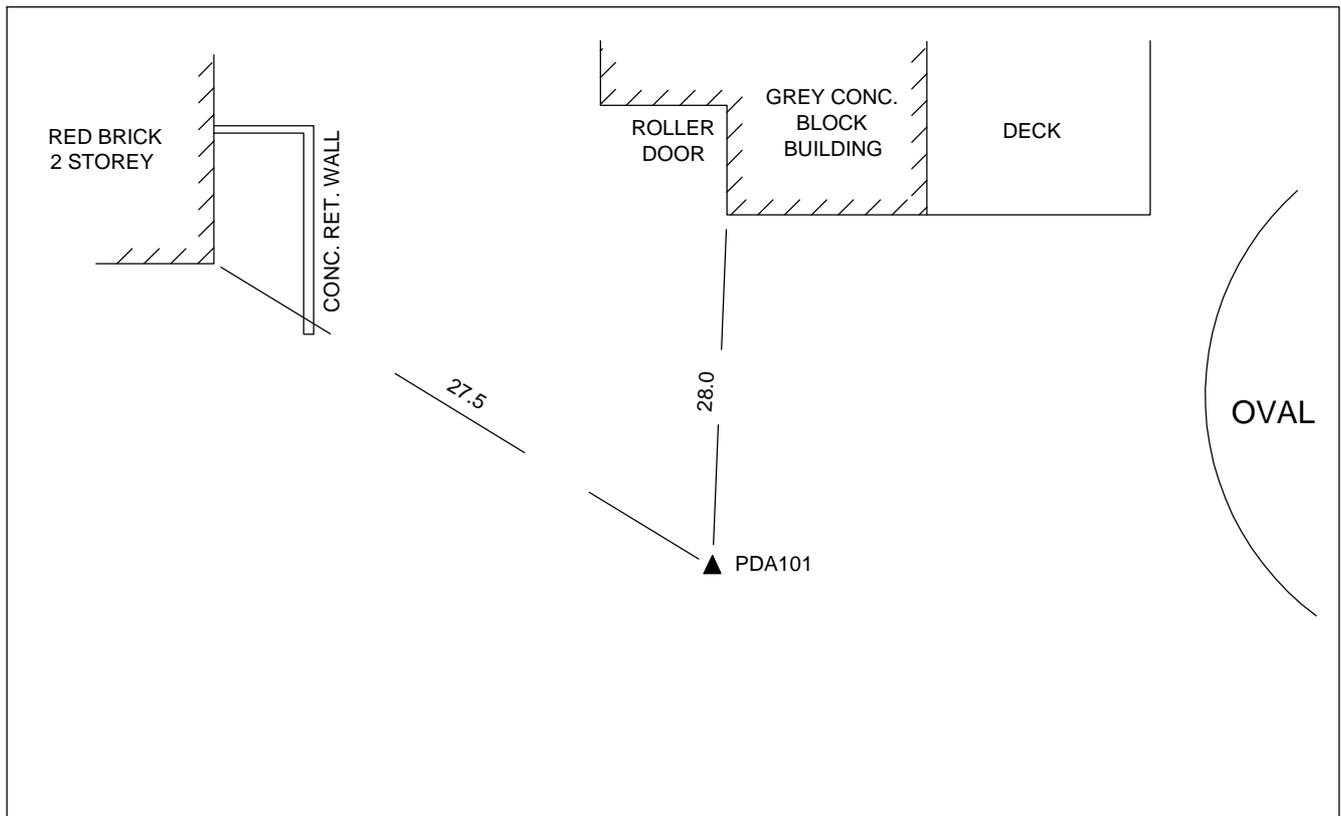
General location: Taroona High School - Below Football Oval

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
ASBN 71 217 806 325
Surveying, Engineering & Planning

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA103

E: 528910.550

N: 5245565.407

RL: 16.844

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

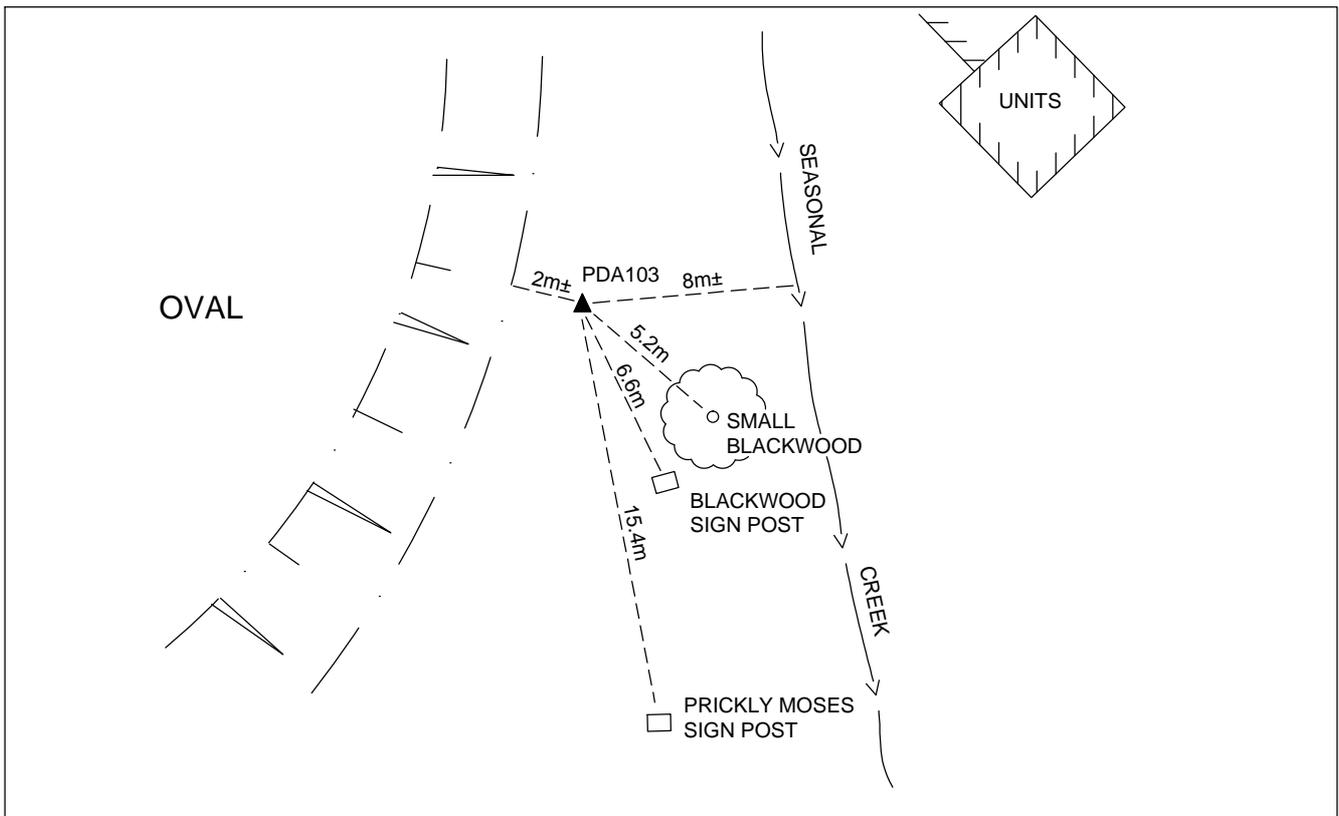
General location: Taroona High School - North of Football Oval, near creek line

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
AS/NZS 71 217 808 325
Surveying, Engineering & Planning

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA104

E: 528911.176

N: 5245649.489

RL: 21.372

Est'd Accuracy:

Horizontal: 0.004

Vertical: 0.001

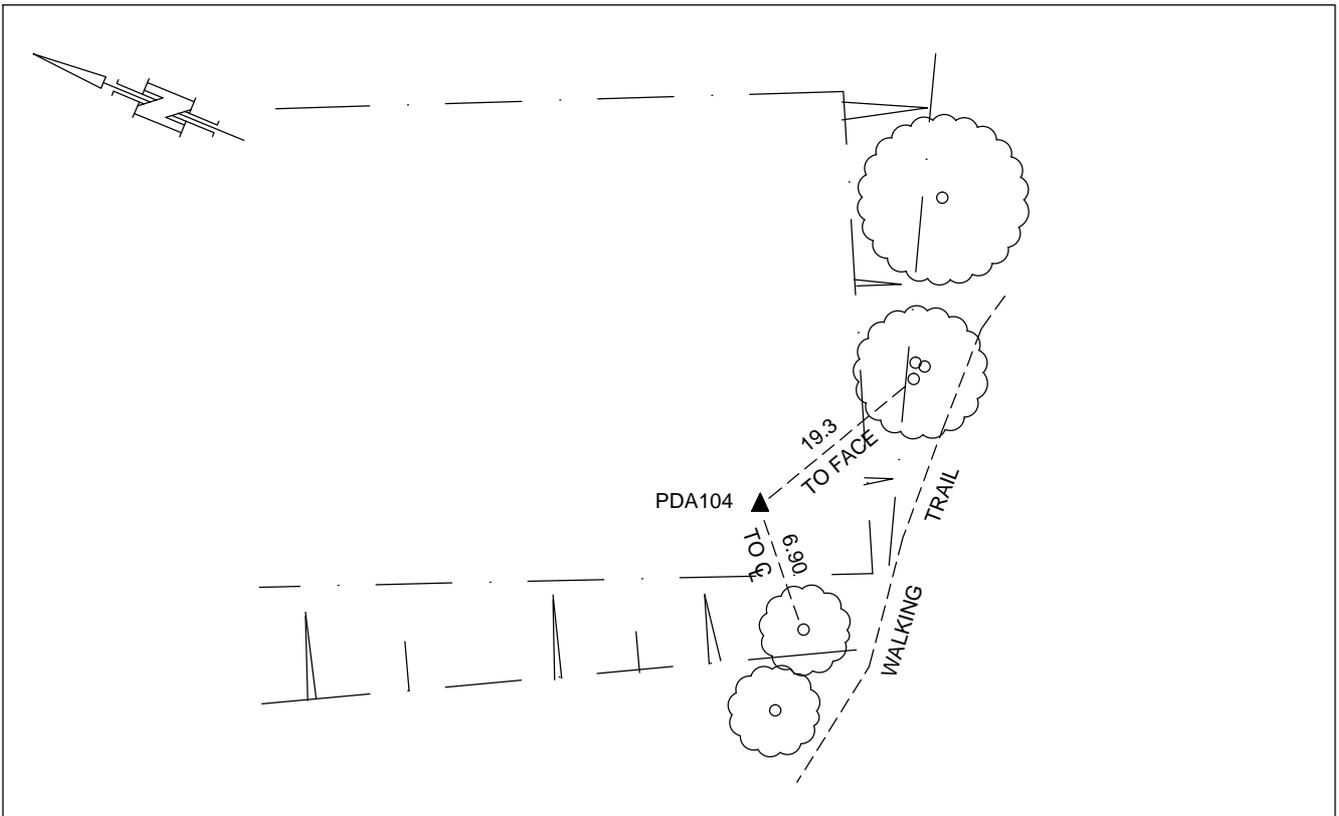
General location: Old Archery Field - (upper level)

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
ASBN 71 217 808 325
Surveying, Engineering & Planning

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA105

E: 528994.154

N: 5245679.760

RL: 12.587

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

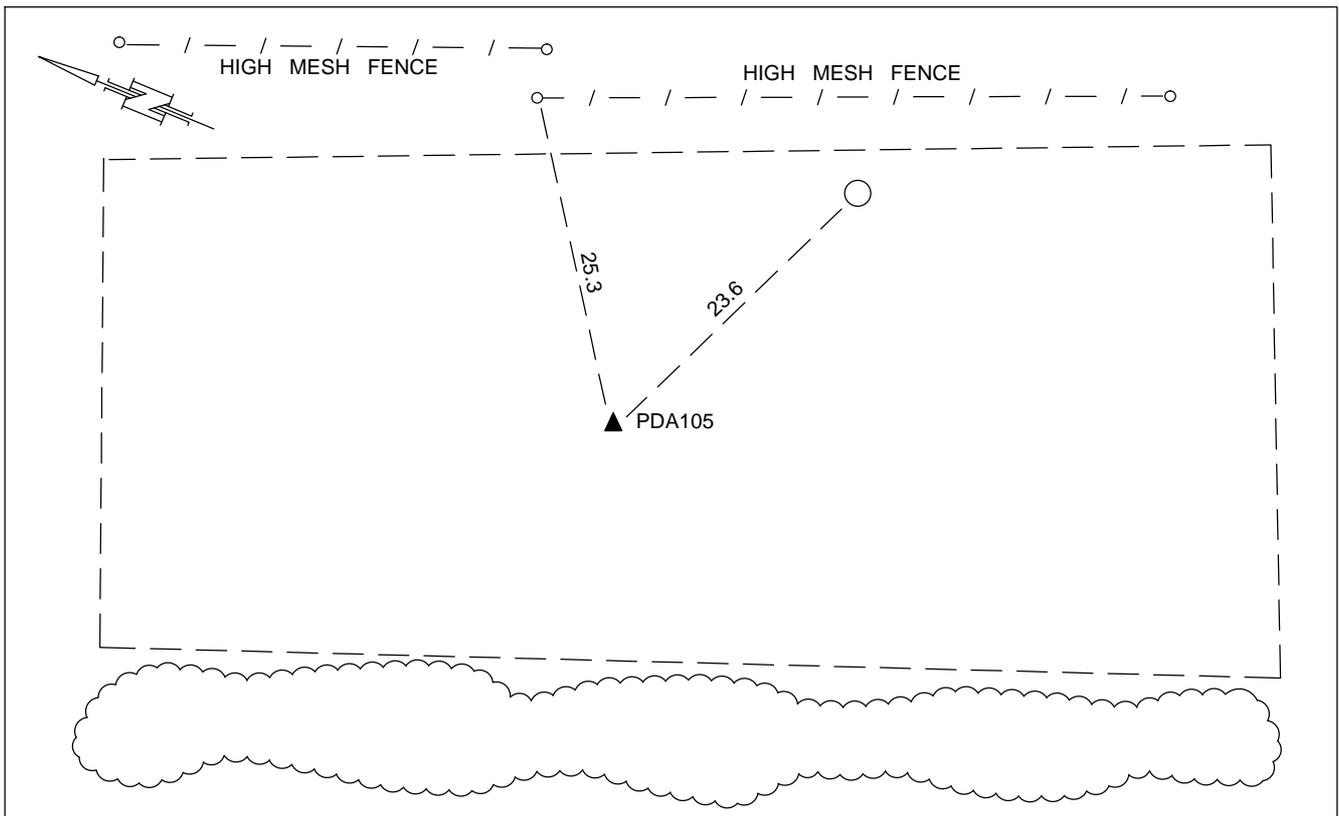
General location: Old archery field (lower level)

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



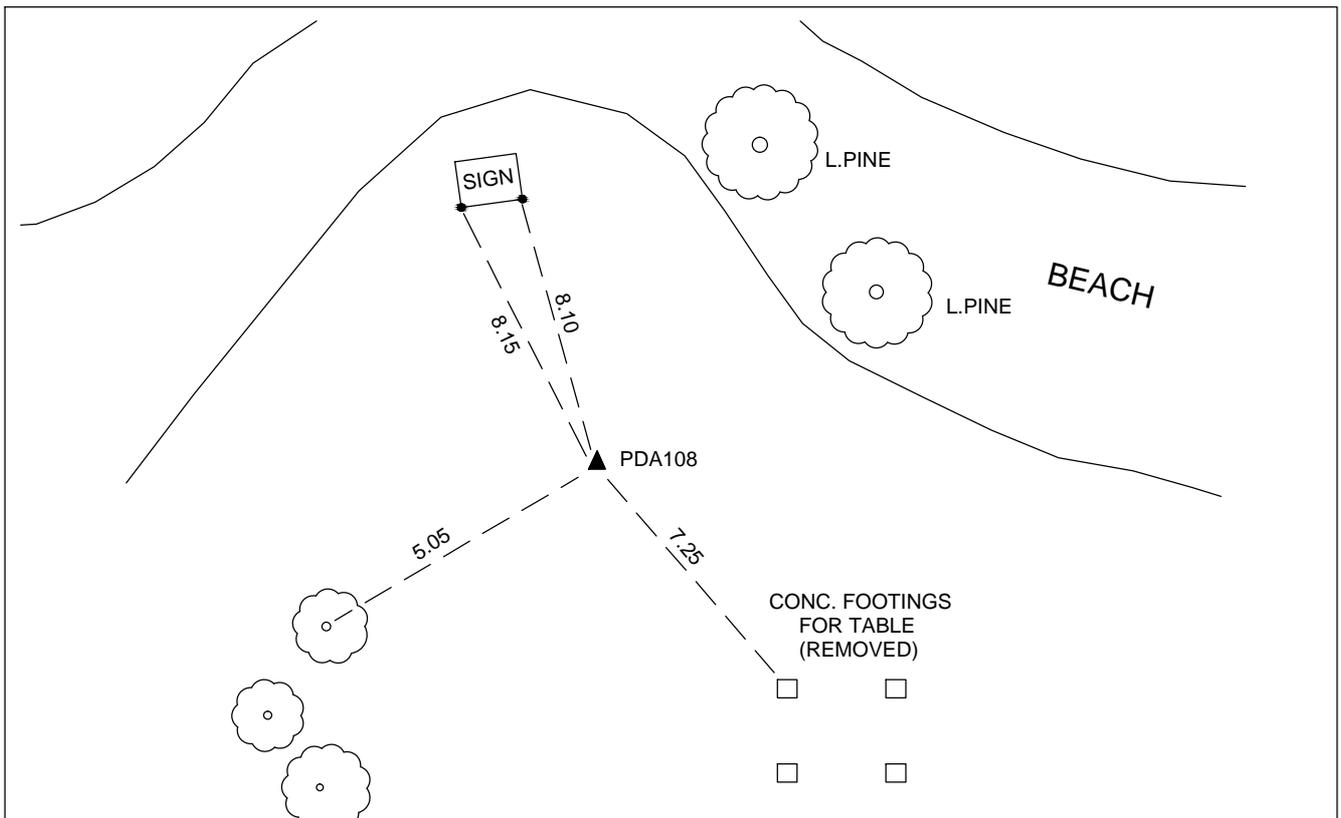
PDA Surveyors
ASBN 71 217 806 325
Surveying, Engineering & Planning

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA108	E: 529154.850	N: 5245451.838	RL: 5.537
Est'd Accuracy:	Horizontal: 0.003	Vertical: 0.001	
General location: Taroona High School - Foreshore			
Mark type: S/Steel Rod in concrete	Placed by: HC	Instrument: S8 / DiNI / R8	
Reference Station: Mt Nelson (AusPOS)			
Remarks:			



PDA Surveyors
 AS/N 71 217 806 325
 Surveying, Engineering & Planning

127 Bathurst Street
 Hobart, Tasmania, 7000
 www.pda.com.au
 PHONE: +61 03 6234 3217
 FAX: +61 03 6234 5085
 EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA109

E: 529043.717

N: 5245274.696

RL: 4.932

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.004

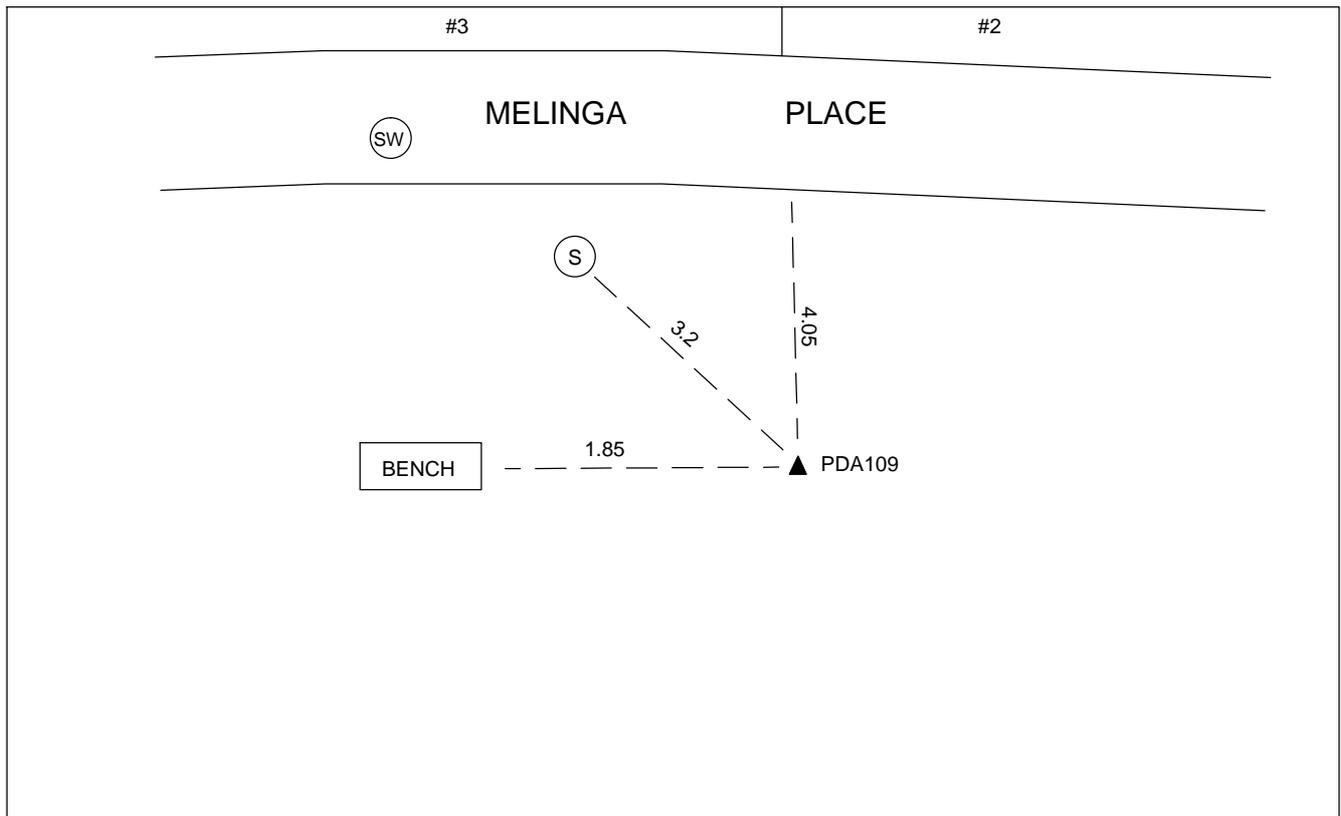
General location: Opposite #3 Melinga Place - Foreshore

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
AS/NZS 71:217 806 325
Surveying, Engineering & Planning

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA110

E: 529014.284

N: 5245171.278

RL: 6.942

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

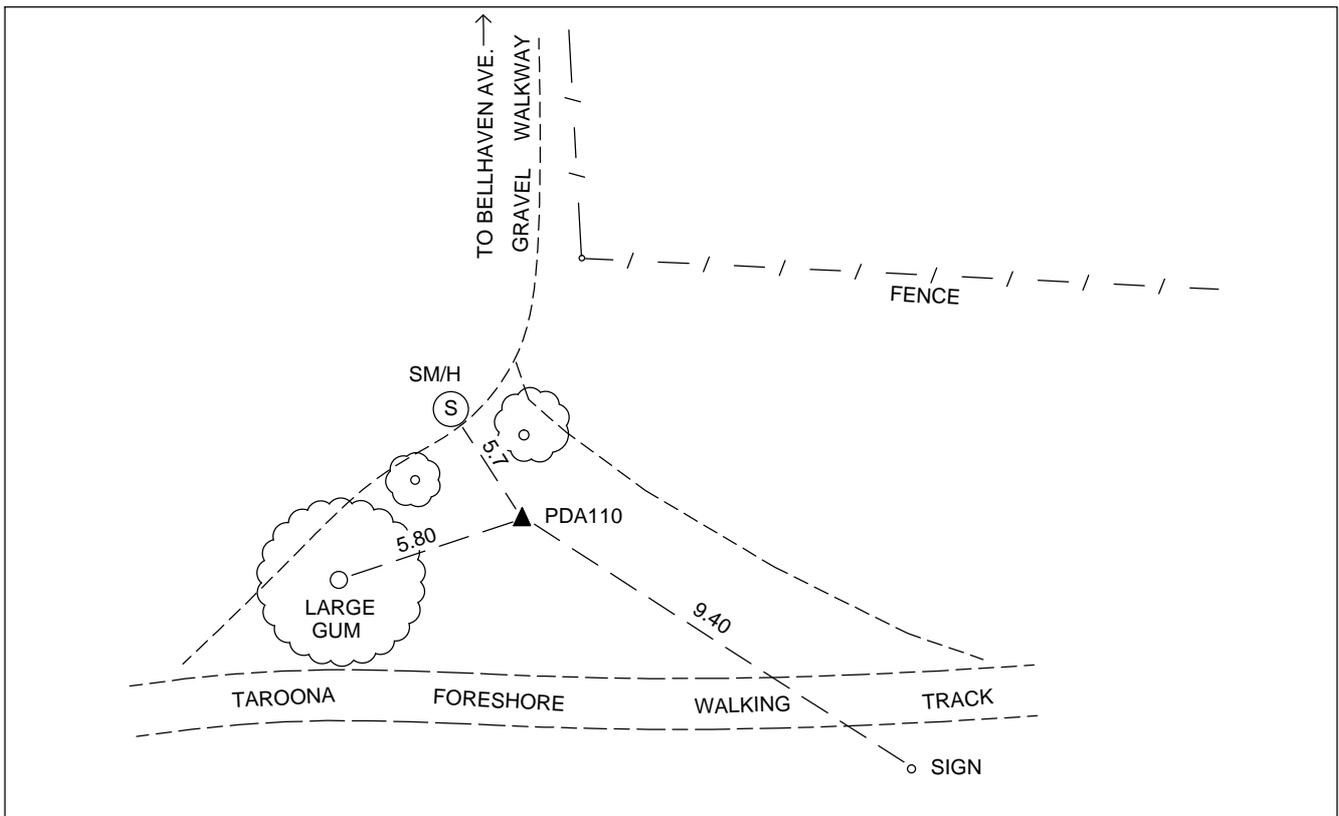
General location: Intersection of walkway from Bellhaven Ave & Taroona foreshore walking track

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
AS/NZS 71 217 806 325
Surveying, Engineering & Planning

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA112

E: 529075.184

N: 5245329.976

RL: 5.304

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

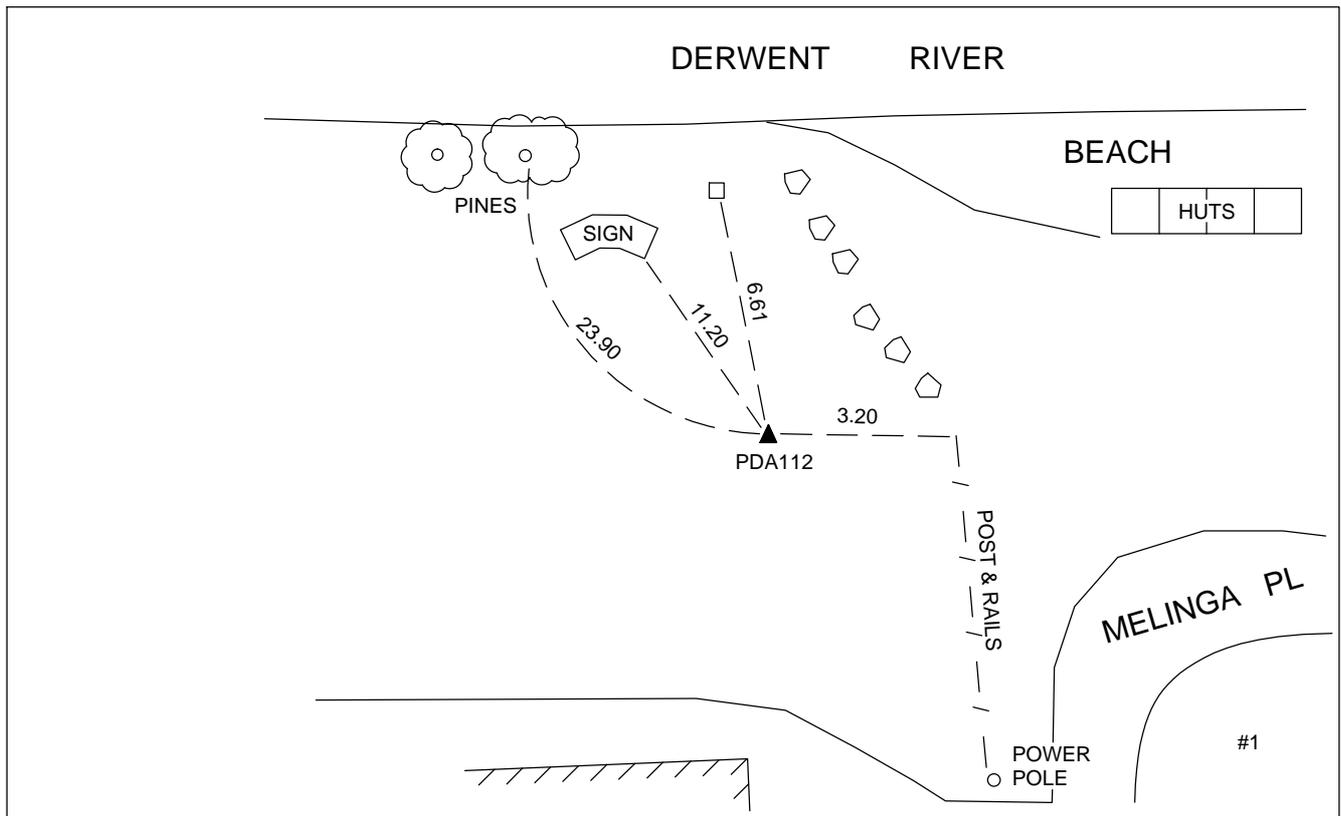
General location: Taroona High School - Foreshore - NE of No.1 Melinga Place

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
AS/NZS 71 217 806 325
Surveying, Engineering & Planning

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA115

E: 528793.696

N: 5245199.106

RL: 30.823

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

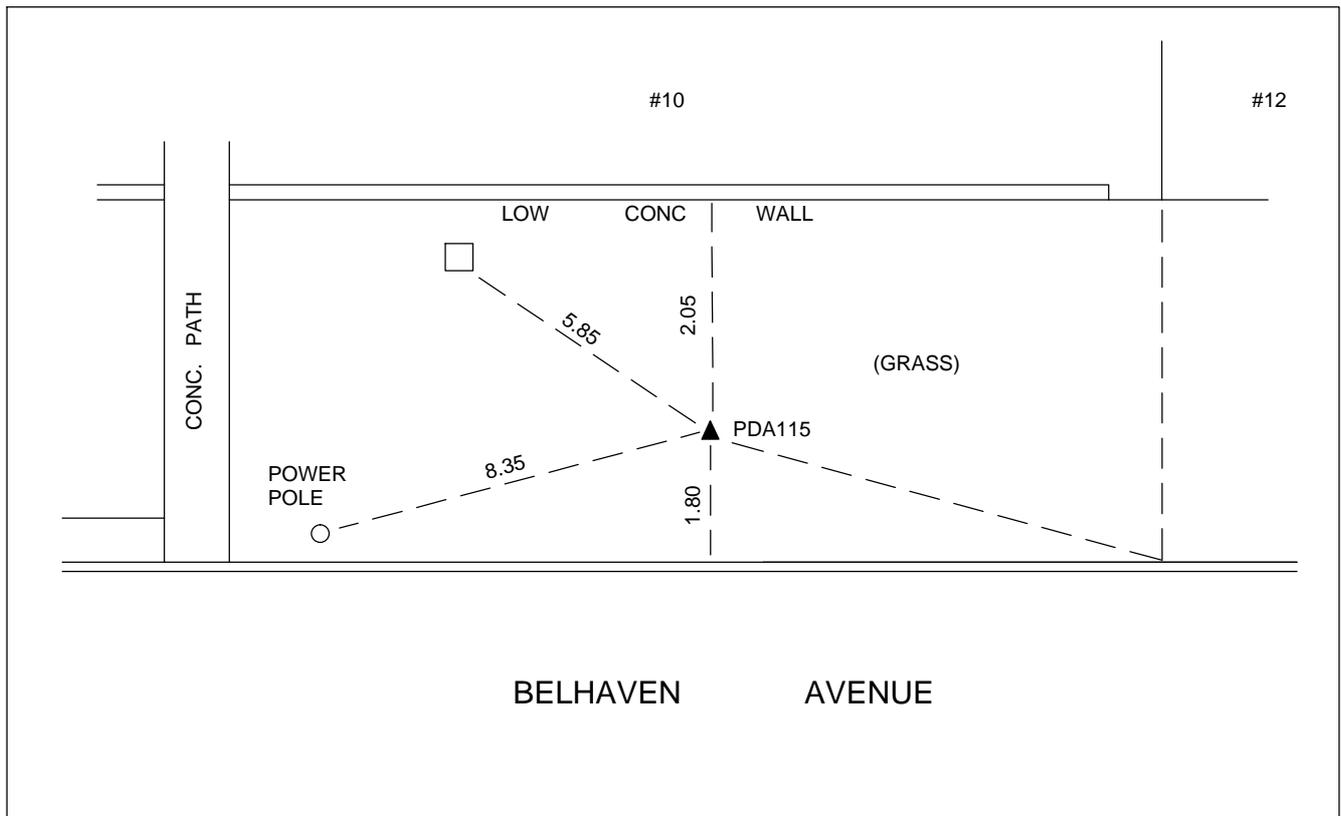
General location: No. 10 Belhaven Ave

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
Surveying, Engineering & Planning

ABN 71 217 806 325

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA116

E: 528705.900

N: 5245200.574

RL: 36.812

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

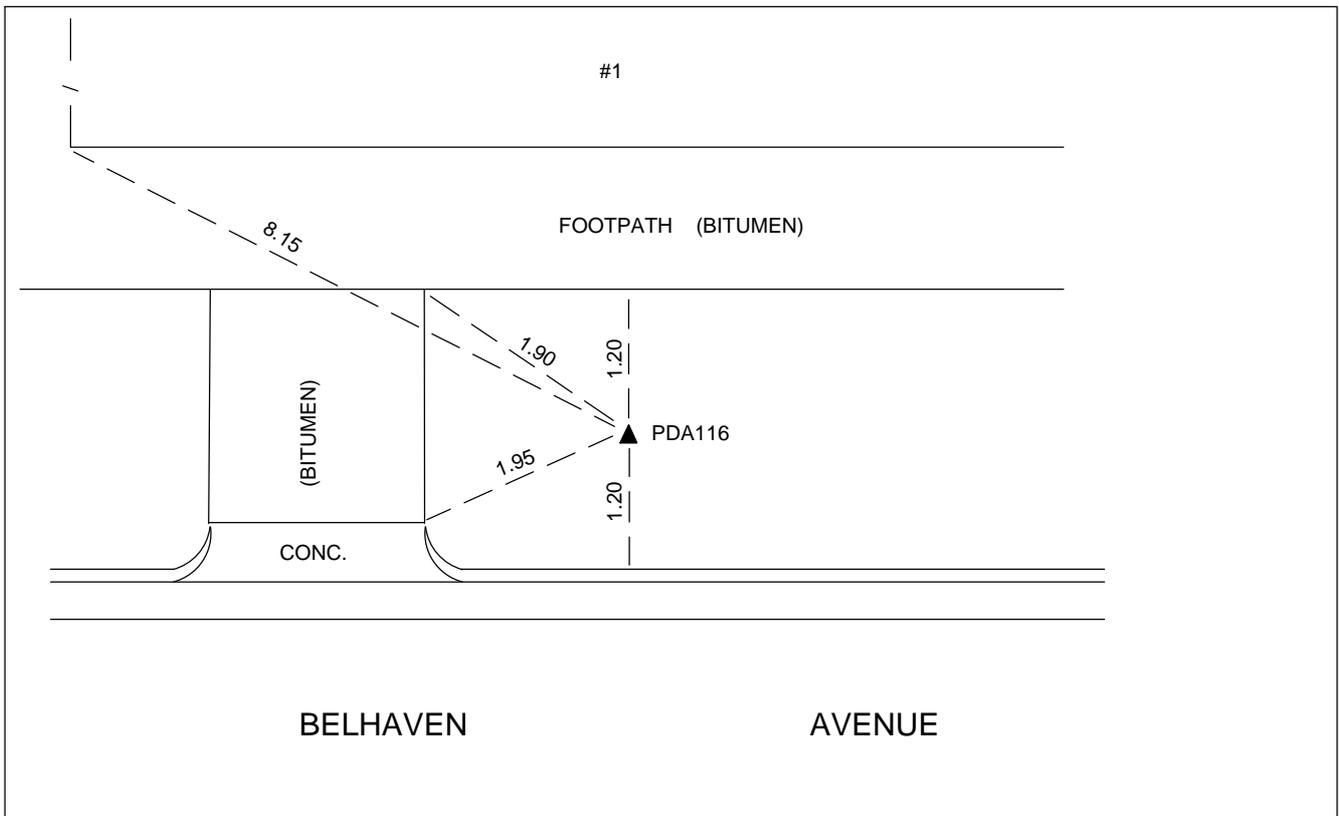
General location: No. 1 Belhaven Ave

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
Surveying, Engineering & Planning

ABN 71 217 806 325

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3517
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA118

E: 528853.388

N: 5245077.120

RL: 15.214

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

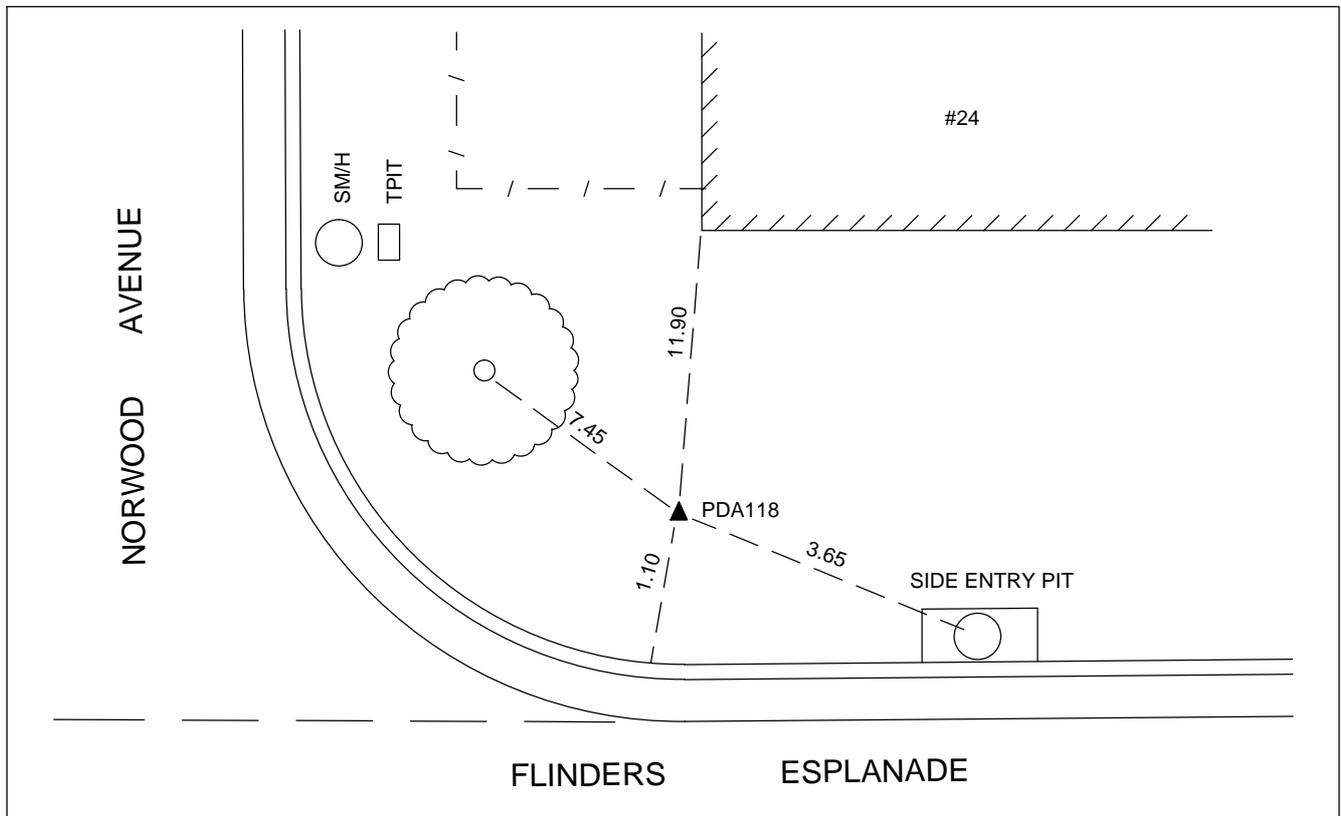
General location: No. 24 Norwood Ave

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument:

Reference Station:

Remarks:



PDA Surveyors
AS/NZS 217 806 325
Surveying, Engineering & Planning

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA119

E: 528673.343

N: 5245067.999

RL: 32.562

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

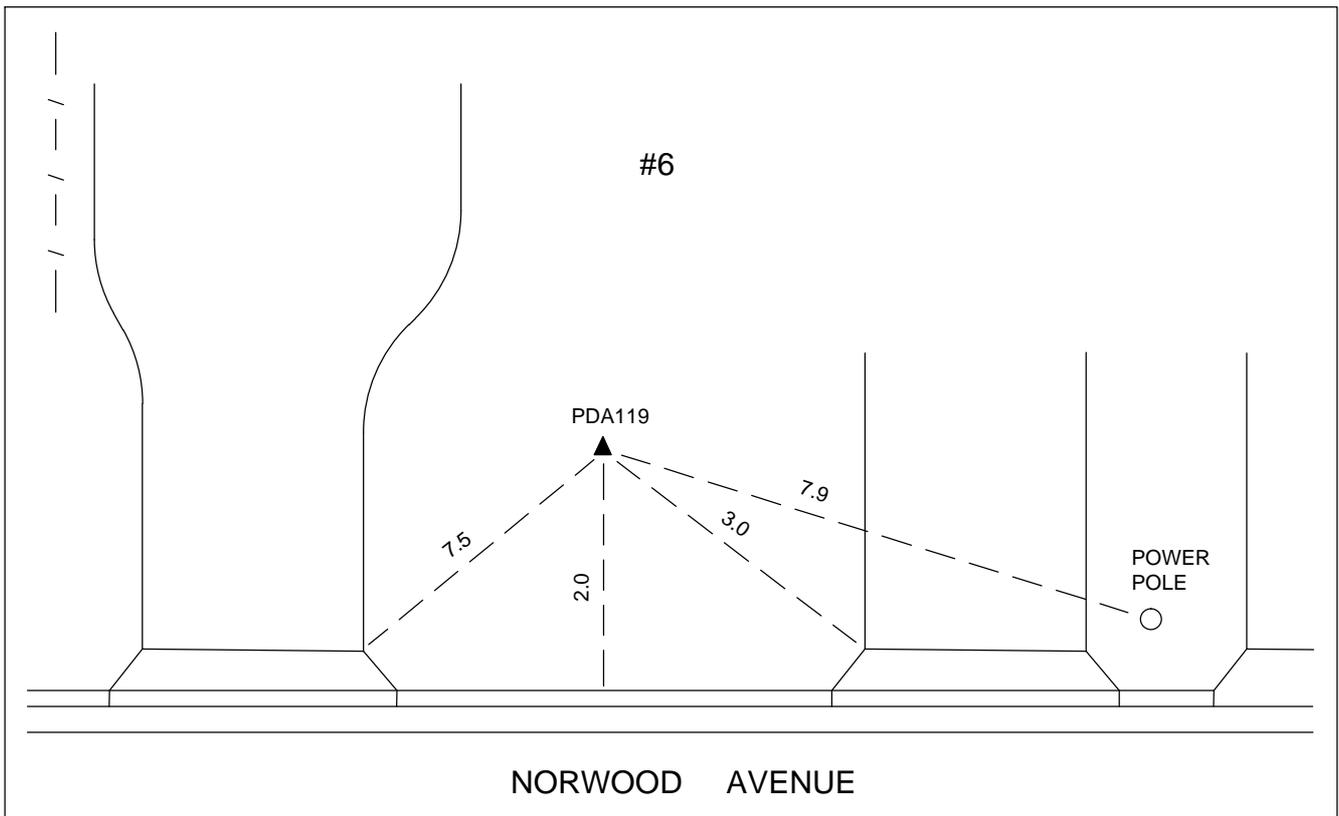
General location: No. 5 Norwood Ave

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
Surveying, Engineering & Planning

ABN 71 217 806 325

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA124

E: 528758.196

N: 5245278.858

RL: 33.751

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

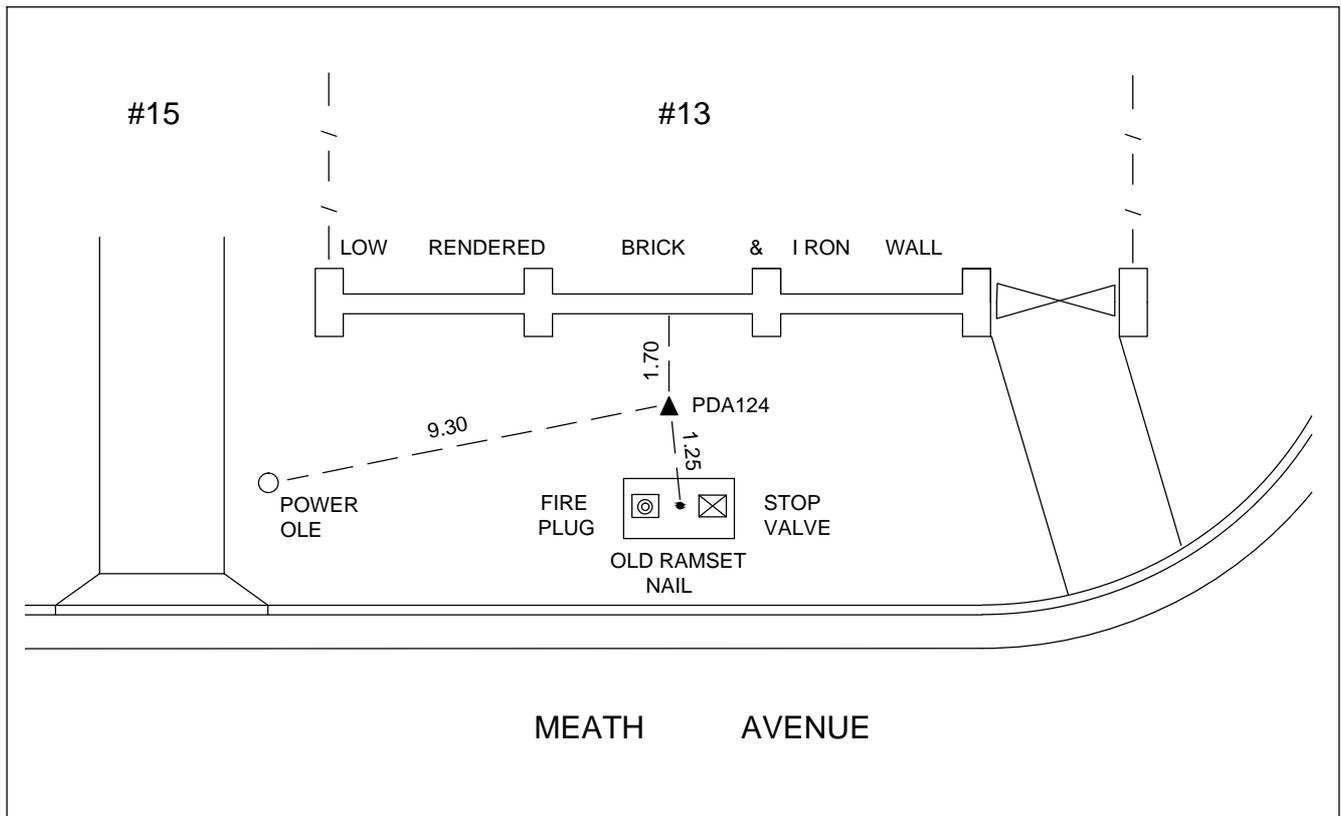
General location: No. 13 Meath Ave

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
AS/NZS 71 217 806 325
Surveying, Engineering & Planning

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

SURVEY CONTROL STATION

DATUM MGA (GDA94) ZONE 55/AHD

NAME: PDA125

E: 528828.900

N: 5245279.677

RL: 32.925

Est'd Accuracy:

Horizontal: 0.003

Vertical: 0.001

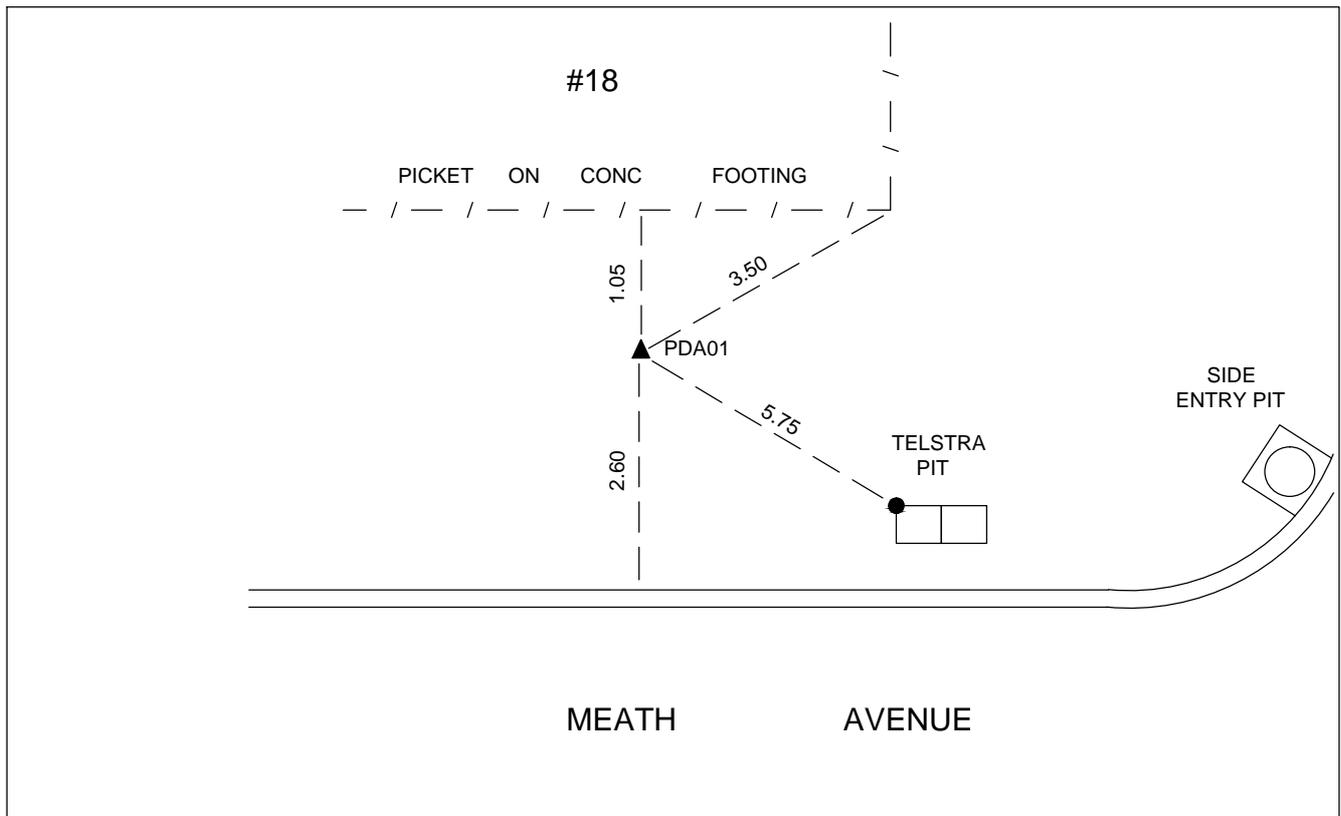
General location: No. 18 Meath Ave

Mark type: S/Steel Rod in concrete Placed by: HC

Instrument: S8 / DiNI / R8

Reference Station: Mt Nelson (AusPOS)

Remarks:



PDA Surveyors
ASBN 71 217 806 325
Surveying, Engineering & Planning

127 Bathurst Street
Hobart, Tasmania, 7000
www.pda.com.au
PHONE: +61 03 6234 3217
FAX: +61 03 6234 5085
EMAIL: pda.hbt@pda.com.au

GHD

2 Salamanca Square Hobart 7000
GPO Box 667 Hobart 7001
T: 03 6210 0600 F: 03 6210 0601 E: hbamail@ghd.com

© GHD 2014

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

G:\32\16698\WP\60230.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	J. Pene	P. Lyden		K. McIntosh		26.02.2014

www.ghd.com

