



Borehole No.
109
 1 / 1

BOREHOLE LOG

Client: HEALTH INFRASTRUCTURE
Project: PROPOSED HOSPITAL REDEVELOPMENT
Location: 130 GOLDSMITH STREET, GOULBURN, NSW

Job No.: 30116V2 **Method:** SPIRAL AUGER **R.L. Surface:** ~652.6 m
Date: 24/8/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.B./F.V.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks	
	ES	U50	DB	DS											
DRY ON COMPLETION					N = 7 3,3,4	652	1		CL	ASPHALTIC CONCRETE: 30mm.t FILL: Gravelly clay, low plasticity, light brown, fine to medium grained igneous gravel, with fine to medium grained sand.	MC<PL				
									CH	SILTY CLAY: medium plasticity, brown, trace of fine grained ironstone gravel.	MC>PL	St	110 180	POSSIBLY FILL	
													H		RESIDUAL
														H	
					651				SILTSTONE: orange brown.	DW					
						2			END OF BOREHOLE AT 1.90 m						
						650									
						3									
						649									
						4									
						648									
						5									
						647									
						6									
						646									

JK_LIB_CURRENT - V8.00.GLB Log J & K AUGERHOLE - MASTER 30116V2 GOULBURN.GPJ <<DrawingFiles>> 22/09/2017 15:23 Produced by gINT Professional. Developed by Datgel



Borehole No.
110
 1 / 1

BOREHOLE LOG

Client: HEALTH INFRASTRUCTURE
Project: PROPOSED HOSPITAL REDEVELOPMENT
Location: 130 GOLDSMITH STREET, GOULBURN, NSW

Job No.: 30116V2 **Method:** SPIRAL AUGER **R.L. Surface:** ~651.5 m
Date: 24/8/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.B./F.V.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	U50	DB	DS										
DRY ON COMPLETION					N = 3 1,2,1	651	[Cross-hatched pattern]		FILL: Silty sand, fine to coarse grained, dark grey and brown, with fine grained igneous gravel, trace of ash, slag and clay.	M			GRASS COVER APPEARS POORLY COMPACTED	
					N = 18 0,8,10	650								
						649	[Dotted pattern]	-	SANDSTONE: fine grained, blue grey and light brown.	XW	EL		MODERATE 'TC' BIT RESISTANCE	
						648			END OF BOREHOLE AT 3.00 m					
						647								
						646								
						645								

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Borehole No.
111
 1 / 1

BOREHOLE LOG

Client: HEALTH INFRASTRUCTURE
Project: PROPOSED HOSPITAL REDEVELOPMENT
Location: 130 GOLDSMITH STREET, GOULBURN, NSW

Job No.: 30116V2 **Method:** SPIRAL AUGER **R.L. Surface:** ~649.7 m
Date: 24/8/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.B./F.V.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	U50	DB	DS										
DRY ON COMPLETION 					N > 8 4.8/ 60mm REFUSAL	649	1			ASPHALT SPRAY SEAL: 5mm.t over FILL: Gravel, fine to coarse grained, dark grey, with fine grained sand. FILL: Silty sand, fine to medium grained, grey brown, with fine to coarse grained sandstone, igneous and ironstone gravel, trace of ash and silty clay nodules.	D			APPEARS MODERATELY COMPACTED
					N > 12/ 50mm REFUSAL	648	2		GC	CLAYEY GRAVEL: fine to medium grained ferruginous gravel, light brown, low plasticity silty clay.	D	MD - D		
						647	3			SANDSTONE: tuffaceous, fine to coarse grained, orange brown.	XW	EL		
						646	4			CLAYSTONE: light brown.	DW	M		LOW TO MODERATE 'TC' BIT RESISTANCE
						645	5						H	HIGH RESISTANCE
						644	6				END OF BOREHOLE AT 6.00 m			
					643									

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Borehole No.
112
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BOREHOLE LOG

Client: HEALTH INFRASTRUCTURE
Project: PROPOSED HOSPITAL REDEVELOPMENT
Location: 130 GOLDSMITH STREET, GOULBURN, NSW

Job No.: 30116V2 **Method:** HAND AUGER **R.L. Surface:** ~653.3 m
Date: 24/8/17 **Datum:** AHD
Plant Type: **Logged/Checked By:** A.B./F.V.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	U50	DB	DS										
DRY ON COMPLETION					REFER TO DCP TEST RESULTS	653			-	CONCRETE: 340mm.t				12mm DIA. REINFORCMENT, 290mm TOP COVER
									-	MUDSTONE COBBLE FILL: Silty clay, high plasticity, light brown, with fine to medium grained mudstone gravel.				APPEARS POORLY COMPACTED
										VOID END OF BOREHOLE AT 0.92 m				HAND AUGER REFUSAL
						652	1							
						651	2							
						650	3							
						649	4							
						648	5							
						647	6							

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BOREHOLE LOG

Borehole No.
1
 1/2

Client: HEALTH INFRASTRUCTURE
Project: PROPOSED NEW ACUTE SERVICES BUILDING
Location: GOULBURN HOSPITAL, 130 GOLDSMITH STREET, GOULBURN, NSW

Job No. 30116V **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 652.2m
Date: 31/1/17 **Datum:** AHD
Logged/Checked by: A.B./F.V.

Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	U50	DB	DS									
DRY ON COMPLETION						0		-	ASPHALTIC CONCRETE: 20mm.t FILL: Sandy gravel, fine to coarse grained igneous gravel, dark grey, fine to medium grained sand, light grey.	D			APPEARS WELL COMPACTED
					N = 18 6,10,8	1			FILL: Silty sand, fine to coarse grained, dark grey, with fine to coarse grained igneous gravel, orange and red, trace of slag.	M			
					N = 10 5,4,6	2		CH	SILTY CLAY: high plasticity, light brown.	MC<PL	H	400 410 520	RESIDUAL
					N >39 10,18, 21/90mm REFUSAL	3		-	SANDSTONE: tuffaceous, fine to medium grained, yellow brown, with clay seams.	XW	EL		
					4								
					5					DW	VL-L		LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
					6								
					7								



BOREHOLE LOG

Borehole No.
1
 2/2

Client: HEALTH INFRASTRUCTURE
Project: PROPOSED NEW ACUTE SERVICES BUILDING
Location: GOULBURN HOSPITAL, 130 GOLDSMITH STREET, GOULBURN, NSW

Job No. 30116V **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 652.2m
Date: 31/1/17 **Datum:** AHD
Logged/Checked by: A.B./F.V.

Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	U50	DB	DS									
								SANDSTONE: tuffaceous, fine to medium grained, yellow brown, with clay se	DW	VL-L		LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
						8							
						9							
						10							
						11							
						12							
						13							
						14							



BOREHOLE LOG

Borehole No.

2

1/1

Client: HEALTH INFRASTRUCTURE
Project: PROPOSED NEW ACUTE SERVICES BUILDING
Location: GOULBURN HOSPITAL, 130 GOLDSMITH STREET, GOULBURN, NSW

Job No. 30116V **Method:** SPIRAL AUGER **R.L. Surface:** ≈ 653.3m
Date: 31/1/17 JK305 **Datum:** AHD
Logged/Checked by: A.B./F.V.

Groundwater Record	SAMPLES			Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks	
	ES	U50	DB										DS
DRY ON COMPLETION					0		-	ASPHALTIC CONCRETE: 45mm.t	D			APPEARS WELL COMPACTED	
					0.5		CH	FILL: Sandy gravel, fine to coarse grained, dark grey, igneous, fine to medium grained sand, light grey. FILL: Silty clay, low to medium plasticity, brown, with fine grained sand, trace of fine grained igneous gravel.	MC<PL	H	>600 >600	RESIDUAL	
					1		CH	GRAVELLY CLAY: high plasticity, light brown, fine to medium grained, black and red brown, ferruginous gravel.	MC<PL				
					1.5		CH	SILTY CLAY: high plasticity, light brown, with fine to medium grained ferruginous gravel, black and red brown.	MC<PL			>600 580 450	
					2		-	SANDSTONE: tuffaceous, fine to coarse grained, green grey.	XW-DW	EL-VL			LOW 'TC' BIT RESISTANCE
					3		-	as above, but orange brown.	DW	VL			LOW RESISTANCE WITH MODERATE BANDS
				4		-			L			MODERATE RESISTANCE	
				5		-			M				
				6				END OF BOREHOLE AT 6.0m					
					7								



BOREHOLE LOG

Borehole No.

3

1/1

Client: HEALTH INFRASTRUCTURE
Project: PROPOSED NEW ACUTE SERVICES BUILDING
Location: GOULBURN HOSPITAL, 130 GOLDSMITH STREET, GOULBURN, NSW

Job No. 30116V **Method:** SPIRAL AUGER **R.L. Surface:** ≈ 654.7m
Date: 31/1/17 **JK305** **Datum:** AHD
Logged/Checked by: A.B./F.V.

Groundwater Record	SAMPLES			Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/Weathering	Strength/Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	U50	DB									
DRY ON COMPLETION					0		CH	FILL: Silty clay, low plasticity, dark brown, with fine to medium grained igneous and ironstone gravel.	MC<PL	VSt		GRASS COVER
				N = 10 3,5,5	0.5			GRAVELLY CLAY: high plasticity, light brown and orange, fine to medium grained, black and red brown, ferruginous gravel.	MC>PL		240 260	RESIDUAL
				N = 24 6,8,16	1.5			GRAVELLY CLAY: high plasticity, light grey, fine to coarse grained, orange brown, siliceous gravel.	MC<PL	H	470 430	
				N > 15 12,15/ 100mm REFUSAL	2.5			SANDSTONE: tuffaceous, fine to coarse grained, yellow brown.	XW	EL		
					3.5				XW-DW	EL-VL		
					4.0			as above, but iron indurated bands.	DW	L		LOW 'TC' BIT RESISTANCE
				6.0			END OF BOREHOLE AT 6.0m					
					7.0							



BOREHOLE LOG

Borehole No.

4

1/1

Client: HEALTH INFRASTRUCTURE
Project: PROPOSED NEW ACUTE SERVICES BUILDING
Location: GOULBURN HOSPITAL, 130 GOLDSMITH STREET, GOULBURN, NSW

Job No. 30116V **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 652.8m
Date: 31/1/17 **Datum:** AHD
Logged/Checked by: A.B./F.V.

Groundwater Record	SAMPLES			Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/Weathering	Strength/Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks	
	ES	U50	DB										DS
DRY ON COMPLETION					0			FILL: Silty sand, fine to medium grained, dark brown, with fine to medium grained igneous gravel.	M			RESIDUAL	
					0.5		CH	SILTY CLAY: high plasticity, light brown.	MC>PL	VSt	370 330 260		
					1								
					N = 11 3,6,5								
					N > 15 7,15/ 100mm REFUSAL			-	MUDSTONE: grey, with sandstone, fine grained, grey seams and clay seams.	XW	EL		LOW 'TC' BIT RESISTANCE
									MUDSTONE: grey, with iron indurated bands.	DW	L-M		
								MUDSTONE: brown and grey, with iron indurated bands.		M		MODERATE RESISTANCE WITH HIGH BANDS	
												MODERATE RESISTANCE	
												HIGH RESISTANCE	
												LOW TO MODERATE RESISTANCE	
					6			END OF BOREHOLE AT 6.0m					
					7								



DYNAMIC CONE PENETRATION TEST RESULTS

Client:		HEALTH INFRASTRUCTURE					
Project:		PROPOSED HOSPITAL REDEVELOPMENT					
Location:		130 GOLDSMITH STREET. GOULBURN, NSW					
Job No.		30116V2			Hammer Weight & Drop: 9kg/510mm		
Date:		24-8-17			Rod Diameter: 16mm		
Tested By:		A.B.			Point Diameter: 20mm		
Number of Blows per 100mm Penetration							
Test Location	RL ~654.0m	RL ~6.53.3m		Test Location			
Depth (mm)	101	112		Depth (mm)	112		
0 - 100	SUNK	SUNK		3000-3100	3		
100 - 200	2			3100-3200	1		
200 - 300	↓			3200-3300	↓		
300 - 400	1			3300-3400	6/70mm		
400 - 500	3			3400-3500	REFUSAL		
500 - 600	9			3500-3600			
600 - 700	1			3600-3700			
700 - 800	↓			3700-3800			
800 - 900	1			3800-3900			
900 - 1000	1			3900-4000			
1000 - 1100	2			4000-4100			
1100 - 1200	2			4100-4200			
1200 - 1300	1	↓		4200-4300			
1300 - 1400	2	2		4300-4400			
1400 - 1500	↓			4400-4500			
1500 - 1600	1			4500-4600			
1600 - 1700	2			4600-4700			
1700 - 1800	2			4700-4800			
1800 - 1900	12/70mm			4800-4900			
1900 - 2000	REFUSAL	↓		4900-5000			
2000 - 2100		1		5000-5100			
2100 - 2200		↓		5100-5200			
2200 - 2300		1		5200-5300			
2300 - 2400		4		5300-5400			
2400 - 2500		1		5400-5500			
2500 - 2600		1		5500-5600			
2600 - 2700		1		5600-5700			
2700 - 2800		1		5700-5800			
2800 - 2900		↓		5800-5900			
2900 - 3000		↓		5900-6000			
Remarks:		1. The procedure used for this test is similar to that described in AS1289.6.3.2-1997, Method 6.3.2. 2. Usually 8 blows per 20mm is taken as refusal 3. Survey datum is AHD.					



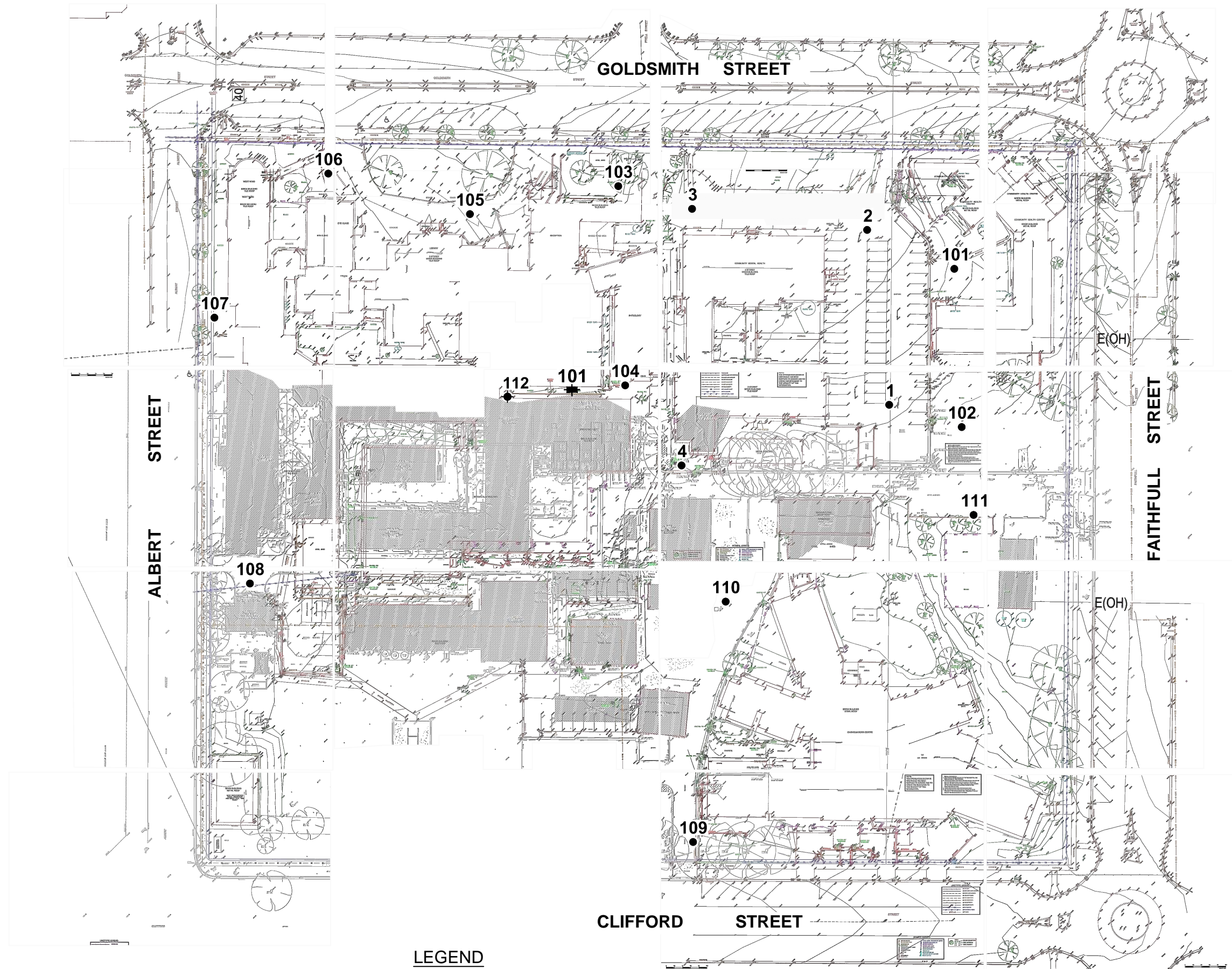
PLOT DATE: 27/09/2017 11:05:40 AM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL_JOBS\3000\S\30116V GOULBURN\CAD\30116V2.DWG

AERIAL IMAGE SOURCE: GOOGLE EARTH PRO 7.1.5.1557
 AERIAL IMAGE ©: 2015 GOOGLE INC.

Title: SITE LOCATION PLAN	
Location: GOULBURN HOSPITAL 130 GOLDSMITH STREET, GOULBURN, NSW	
Report No: 30116V2	Figure No: 1
JK Geotechnics	



This plan should be read in conjunction with the JK Geotechnics report.

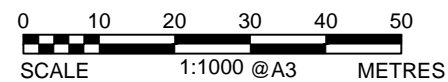


NOTE:

1. BHs 1 TO 4 ARE FROM OUR PREVIOUS JANUARY 2017 INVESTIGATION, REF: 30116Vrpt1.
2. BHs 101 TO 112 AND TP101 ARE FROM OUR CURRENTS INVESTIGATION.

LEGEND

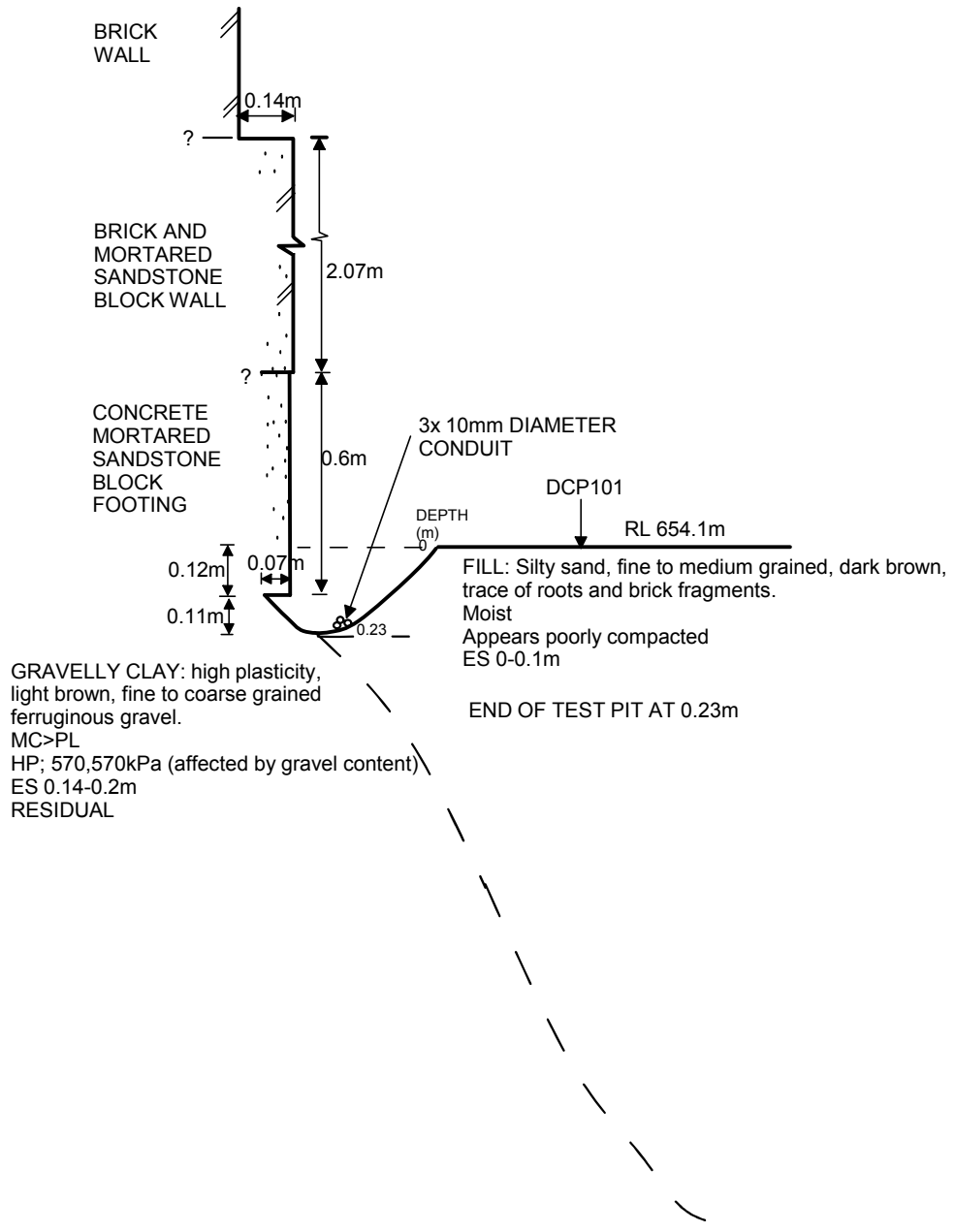
- BOREHOLE
- HAND AUGER AND DCP TEST
- ⊕ DCP TEST
- TEST PIT



This plan should be read in conjunction with the JK Geotechnics report.

Title: BOREHOLE LOCATION PLAN	
Location: GOULBURN HOSPITAL 130 GOLDSMITH STREET, GOULBURN, NSW	
Report No: 30116V2	Figure No: 2
JK Geotechnics	

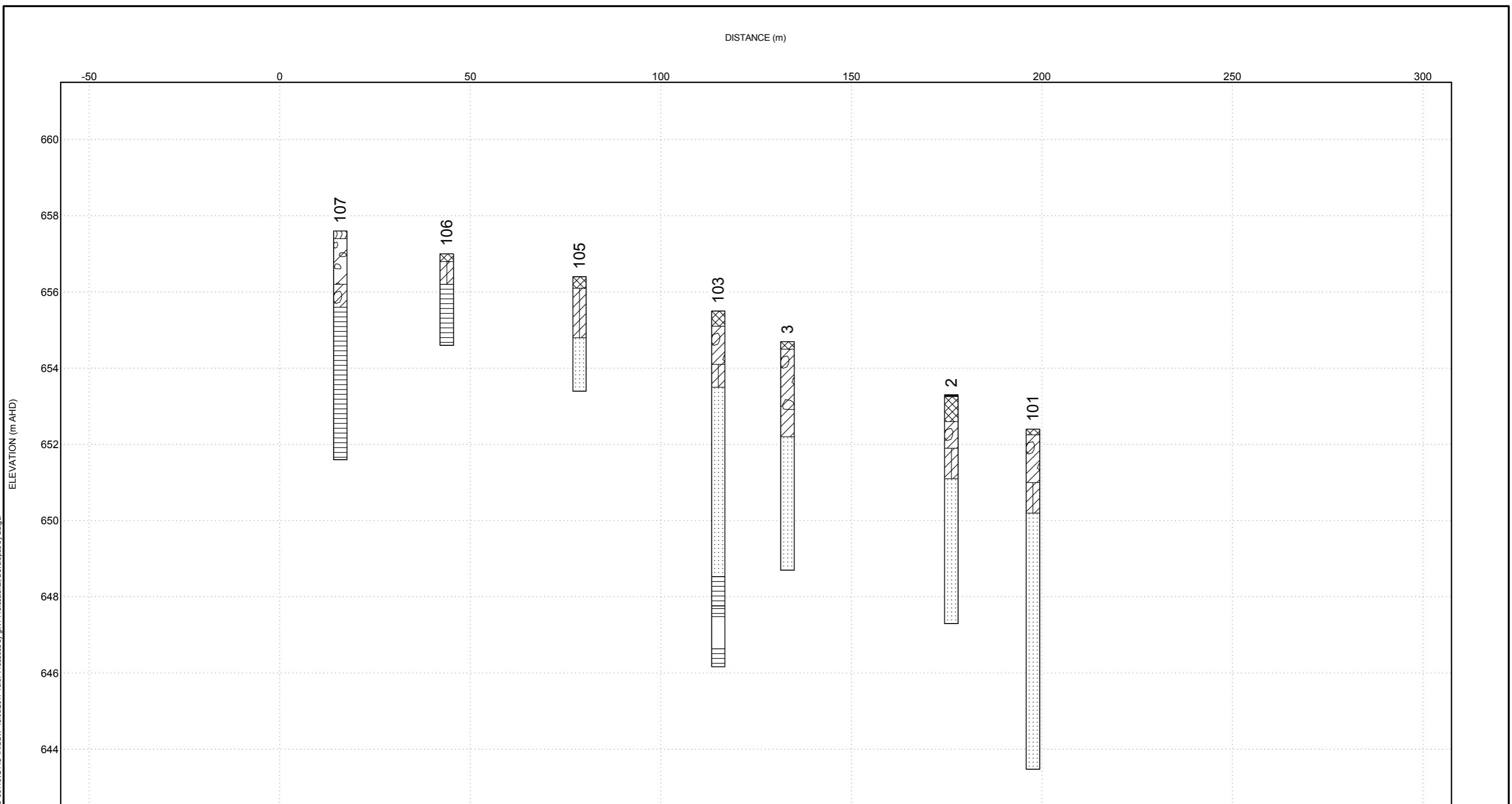




TEST PIT 101 CROSS SECTIONAL SKETCH



JK_LIB_CURRENT - v8.00.GLB Fence: FENCE.A3L NO PLAN 30116V2 GOULBURN.GPJ 30116V2 FIG 4A.GDW 18/09/2017 16:07 Produced by gINT Professional. Developed by Dalziel



- | | | |
|--------------------|---------------|--------------------------------|
| ASPHALTIC CONCRETE | GRAVELLY CLAY | SANDSTONE |
| CLAYEY GRAVEL | SILTY CLAY | SILTSTONE, MUDSTONE, CLAYSTONE |
| CORE LOSS | FILL | TOPSOIL |

Scales(A3)

H 1:1000

V 1:100

Title:

GRAPHICAL BOREHOLE SUMMARY

Location:

130 GOLDSMITH STREET, GOULBURN, NSW

Report No:

30116V2

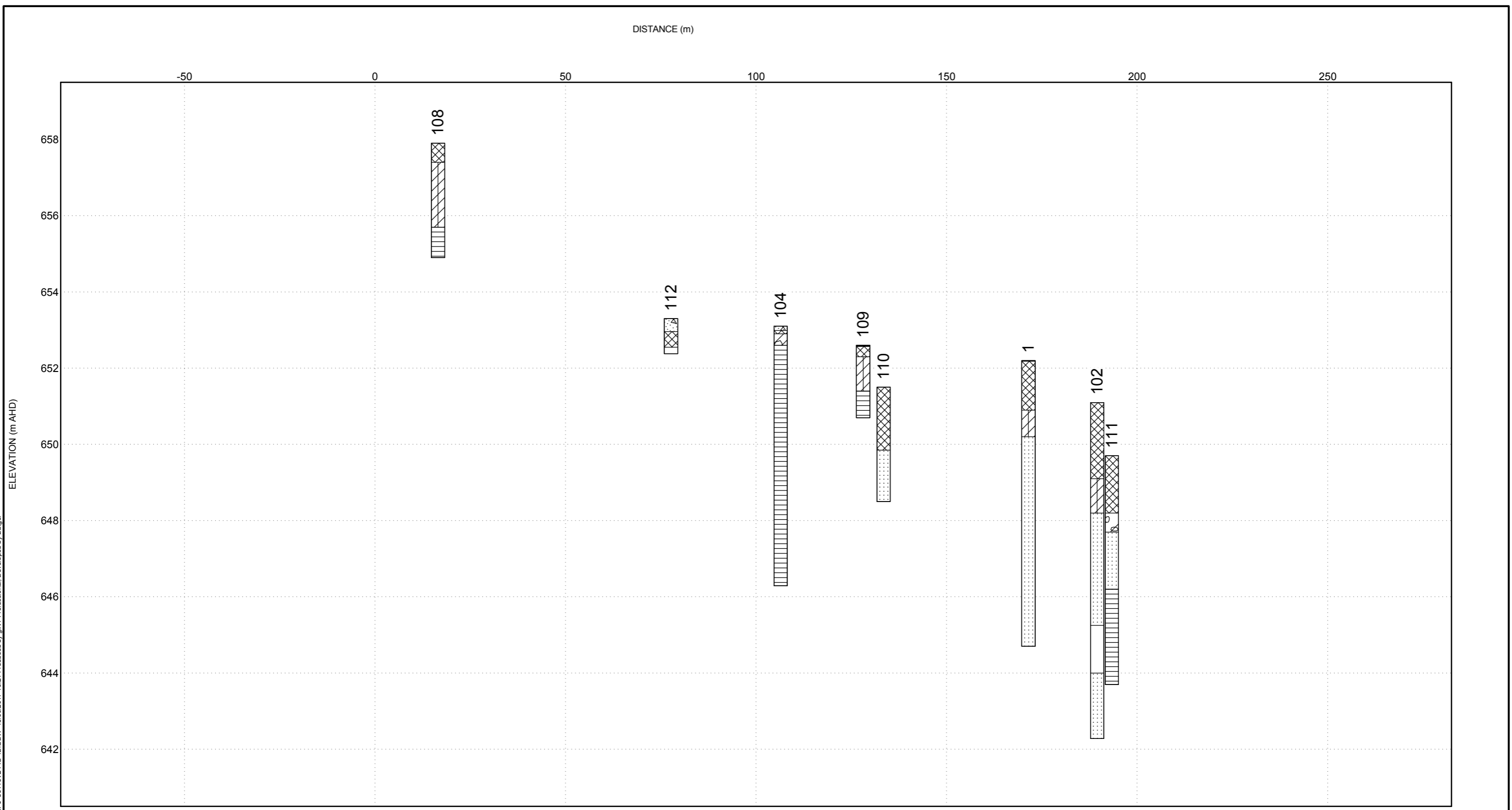
Figure No:

4A

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JK_LIB_CURRENT - v8.00.GLB Fence: FENCE.A3L NO PLAN 30116V2 GOULBURN.GPJ 30116V2 FIG 4B.GDW 18/09/2017 16:21 Produced by gINT Professional. Developed by Dalziel



- | | | | |
|--------------------|---------------|-----------|--------------------------------|
| ASPHALTIC CONCRETE | CORE LOSS | CONCRETE | SILTSTONE, MUDSTONE, CLAYSTONE |
| BLANK | GRAVELLY CLAY | FILL | |
| CLAYEY GRAVEL | SILTY CLAY | SANDSTONE | |

Scales (A3)

H 1:1000

V 1:100

Title: **GRAPHICAL BOREHOLE SUMMARY**

Location: **130 GOLDSMITH STREET, GOULBURN, NSW**

Report No: **30116V2**

Figure No: **4B**

JK Geotechnics





VIBRATION EMISSION DESIGN GOALS

German Standard DIN 4150 – Part 3: 1986 provides guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, OR, maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 1 below.

It should be noted that peak vibration velocities higher than the minimum figures in Table 1 for low frequencies may be quite ‘safe’, depending on the frequency content of the vibration and the actual condition of the structure.

It should also be noted that these levels are ‘safe limits’, up to which no damage due to vibration effects has been observed for the particular class of building. ‘Damage’ is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls. Should damage be observed at vibration levels lower than the ‘safe limits’, then it may be attributed to other causes. DIN 4150 also states that when vibration levels higher than the ‘safe limits’ are present, it does not necessarily follow that damage will occur. Values given are only a broad guide.

Table 1: DIN 4150 – Structural Damage – Safe Limits for Building Vibration

Group	Type of Structure	Peak Vibration Velocity in mm/s			
		At Foundation Level at a Frequency of:			Plane of Floor of Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design.	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use.	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 and 2 and have intrinsic value (eg. buildings that are under a preservation order).	3	3 to 8	8 to 10	8

Note: For frequencies above 100Hz, the higher values in the 50Hz to 100Hz column should be used.



REPORT EXPLANATION NOTES

INTRODUCTION

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

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

DESCRIPTION AND CLASSIFICATION METHODS

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

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

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

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

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

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

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

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

SAMPLING

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

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

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

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

INVESTIGATION METHODS

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



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

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

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

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

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

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

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

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

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

The test results are reported in the following form:

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

N = 13
4, 6, 7

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

N > 30
15, 30/40mm

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

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

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



Static Cone Penetrometer Testing and Interpretation:

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

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

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

The information provided on the charts comprise:

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

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

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

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

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

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

Two relatively similar tests are used:

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

LOGS

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

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

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

GROUNDWATER

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

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



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

FILL

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

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

LABORATORY TESTING

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

ENGINEERING REPORTS

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

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

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

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

SITE ANOMALIES

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

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

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

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

REVIEW OF DESIGN

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

SITE INSPECTION


































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

Requirements could range from:

- i) a site visit to confirm that conditions exposed are no worse than those interpreted, to
- ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
- iii) full time engineering presence on site.







GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL		ROCK		DEFECTS AND INCLUSIONS	
	FILL		CONGLOMERATE		CLAY SEAM
	TOPSOIL		SANDSTONE		SHEARED OR CRUSHED SEAM
	CLAY (CL, CH)		SHALE		BRECCIATED OR SHATTERED SEAM/ZONE
	SILT (ML, MH)		SILTSTONE, MUDSTONE, CLAYSTONE		IRONSTONE GRAVEL
	SAND (SP, SW)		LIMESTONE		ORGANIC MATERIAL
	GRAVEL (GP, GW)		PHYLLITE, SCHIST		
	SANDY CLAY (CL, CH)		TUFF		
	SILTY CLAY (CL, CH)		GRANITE, GABBRO		
	CLAYEY SAND (SC)		DOLERITE, DIORITE		
	SILTY SAND (SM)		BASALT, ANDESITE		
	GRAVELLY CLAY (CL, CH)		QUARTZITE		
	CLAYEY GRAVEL (GC)				CONCRETE
	SANDY SILT (ML)				BITUMINOUS CONCRETE, COAL
	PEAT AND ORGANIC SOILS				COLLUVIUM



LOG SYMBOLS

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



LOG SYMBOLS continued

ROCK MATERIAL WEATHERING CLASSIFICATION

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

ROCK STRENGTH

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

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

ABBREVIATIONS USED IN DEFECT DESCRIPTION

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