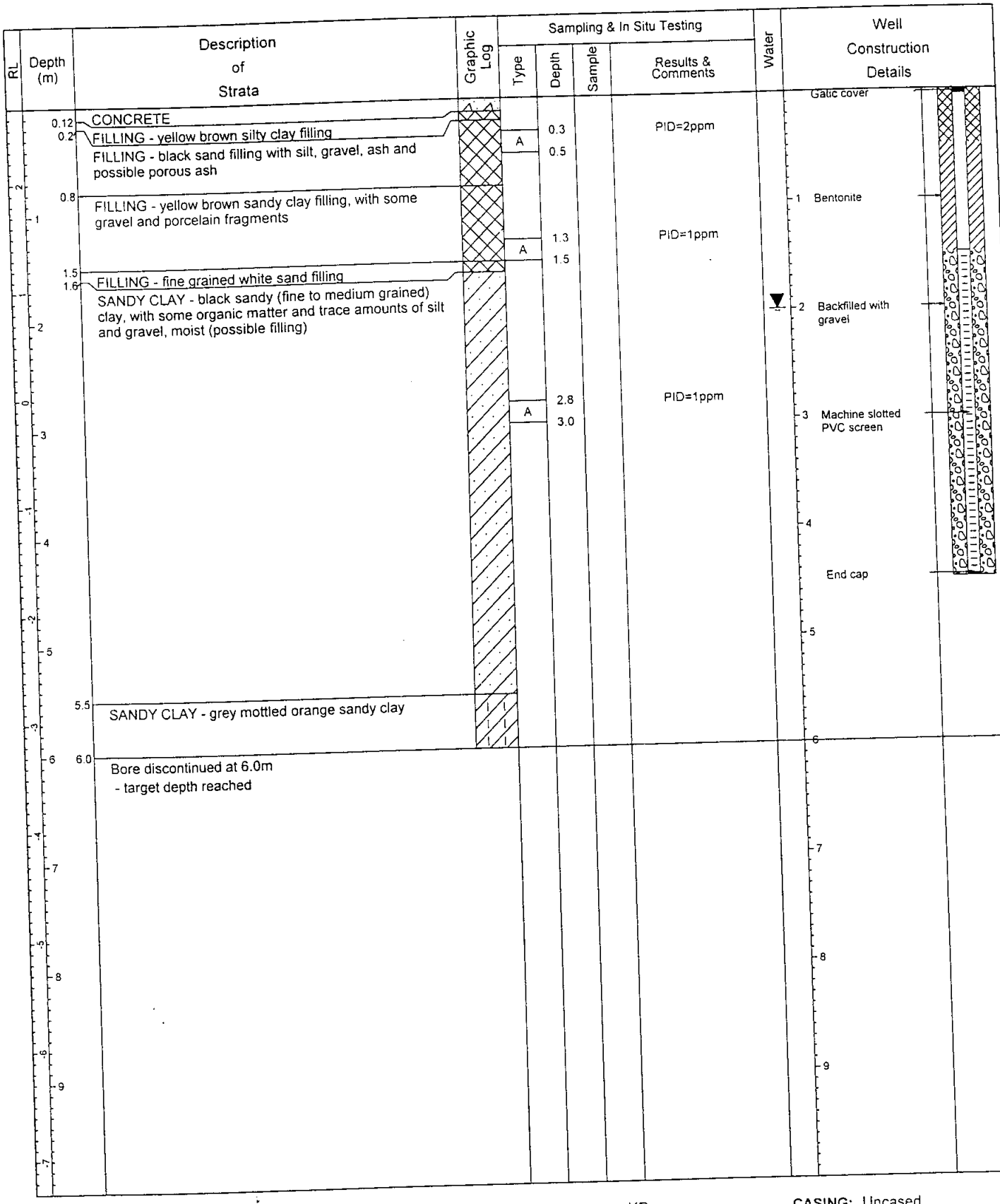
APPENDIX D
Borehole Logs and Notes Related to This Report

BOREHOLE LOG

CLIENT: Greencliff CPL Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Princess Hwy & Arncliffe St, Arncliffe

SURFACE LEVEL: 2.7 RL (approx)
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 101
PROJECT No: 43034
DATE: 12 May 05
SHEET 1 OF 1



RIG: Bobcat
DRILLER: B Ellis
LOGGED: KP
CASING: Uncased

TYPE OF BORING: Solid flight auger to 6.0m
WATER OBSERVATIONS: Free groundwater observed at 2.0m. Groundwater observed in piezometer at 2.5m on 30/5/05
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: KP
Date: 27/6/05

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BOREHOLE LOG

CLIENT: Greencliff CPL Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Princess Hwy & Arncliffe St, Arncliffe

SURFACE LEVEL: 2.4 RL (approx)
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 102
PROJECT No: 43034
DATE: 12 May 05
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	BITUMEN							
		FILLING - brown sandy clay filling with some gravel, blue metal, sandstone and concrete fragments		A	0.3 0.5		PID=2ppm		
	0.7	FILLING - grey and dark grey shale filling		A	1.3 1.5		PID=2ppm		
	1.5	Bore discontinued at 1.5m - refusal on shale filling							

RIG: Bobcat
DRILLER: KP/BE
LOGGED: KP
CASING: Uncased

TYPE OF BORING: Solid flight auger to 1.5m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: [illegible]
Date: 27/6/05

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BOREHOLE LOG

CLIENT: Greencliff CPL Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Princess Hwy & Arncliffe St, Arncliffe

SURFACE LEVEL: 2.2 RL (approx)
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 103
PROJECT No: 43034
DATE: 12 May 05
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	GRAVEL							
		FILLING - brown sandy clay filling, with some sandstone gravel		A	0.3 0.5		PID=1ppm		
	1.1	SILTY CLAY - grey mottled red and yellow brown silty clay, with trace amounts of sand (possible filling)		A	1.3 1.5		PID=1ppm	▼	
	2.0	SANDY CLAY - black sandy clay with fine tree roots and organic matter, very moist (possible filling)		A	2.8 3.0		PID=2ppm		
	3.0	Bore discontinued at 3.0m - target depth reached							

RIG: Bobcat
DRILLER: KP/BE
LOGGED: KP
CASING: Uncased

TYPE OF BORING: Solid flight auger to 3.0m
WATER OBSERVATIONS: Free groundwater observed at 1.3m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: MP
Date: 27/6/05

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BOREHOLE LOG

CLIENT: Greencliff CPL Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Princess Hwy & Arncliffe St, Arncliffe

SURFACE LEVEL: 2.5 RL (approx)
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 104
PROJECT No: 43034
DATE: 12 May 05
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	BLUE METAL							Gatic cover
		FILLING - brown and black silty clay filling with some gravel and sand and trace amounts of possible porous ash		A	0.3 0.5		PID=2ppm		Bentonite
	0.7	FILLING - grey mottled orange and red silty clay filling, with trace of amounts of sand, moist at 1.2m		A	1.3 1.5		PID=0ppm	▼	Backfilled with gravel
	1.7	SILTY CLAY - dark grey silty clay with sand, roots and organic matter, very wet		A	2.8 3.0		PID=1ppm		Machine slotted PVC screen
	3.5	SANDY CLAY - light grey sandy clay							End cap - hole collapsing
	4.5	Bore discontinued at 4.5m - piezometer to 4.0m only due to hole collapse							

RIG: Bobcat DRILLER: B Ellis LOGGED: KP CASING: Uncased

TYPE OF BORING: Solid flight auger to 4.5m

WATER OBSERVATIONS: Free groundwater observed in piezometer at 1.1m on 30/5/05

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: KP
Date: 26/6/05

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BOREHOLE LOG

CLIENT: Greencliff CPL Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Princess Hwy & Arncliffe St, Arncliffe

SURFACE LEVEL: 3.8 RL (approx)
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 105
PROJECT No: 43034
DATE: 12 May 05
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	CONCRETE							
	0.11	PLASTIC LINER							
	0.25	CONCRETE		A	0.3		PID=0ppm		
	0.4	VOID SPACE			0.5				
	0.6	FILLING - dark brown sandy clay filling, with sandstone gravel and rubble							
		FILLING - yellow and dark brown sand filling		A	1.3		PID=1ppm		
					1.5				
	1.8	Bore discontinued at 1.8m - refusal on weathered white sandstone bedrock		A	1.8				

RIG: Bobcat
DRILLER: B Ellis
LOGGED: KP
CASING: Uncased

TYPE OF BORING: Solid flight auger to 1.8m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: KP
Date: 27/6/05

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BOREHOLE LOG

CLIENT: Greencliff CPL Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Princess Hwy & Arncliffe St, Arncliffe

SURFACE LEVEL: 2.7 RL (approx)
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 106
PROJECT No: 43034
DATE: 12 May 05
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.15	CONCRETE							
		FILLING - blue mottled grey and yellow brown silty clay filling with sand		A	0.3 0.5		PID=2ppm		
	0.6	SANDY CLAY - yellow brown mottled grey sandy clay, with trace silt and organic matter		A	1.3 1.5		PID=2ppm	▼	
	1.9	SANDY CLAY - white sandy clay with some silt (possibly weathered sandstone from 2.1m)		A	2.0 2.1		PID=0ppm		
	2.2	Bore discontinued at 2.2m - refusal on weathered white sandstone bedrock							

RIG: Bobcat
DRILLER: B Ellis
LOGGED: KP
CASING: Uncased

TYPE OF BORING: Solid flight auger to 2.2m
WATER OBSERVATIONS: Free groundwater observed at 1.5m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: KP
Date: 28/6/05

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BOREHOLE LOG

CLIENT: Greencliff CPL Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Princess Hwy & Arncliffe St, Arncliffe

SURFACE LEVEL: 2.2 RL (approx)
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 109
PROJECT No: 43034
DATE: 12 May 05
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.12	CONCRETE							Gatic cover
		FILLING - red brown silty clay filling mottled grey and orange with gravel		A	0.3 0.5		PID=3ppm		
	0.6	FILLING - dark grey to black sandy clay filling							Bentonite
				A	1.2 1.4		PID=1ppm		
	1.4	SANDY CLAY - light grey sandy clay, moist						▼	Backfilled with gravel
				A/ASS	2.8 3.0	*Z4	PID=1ppm		Machine slotted PVC screen
	4.5	Bore discontinued at 4.5m - target depth reached							End cap

RIG: Bobcat
DRILLER: B Ellis
LOGGED: KP
CASING: Uncased

TYPE OF BORING: Solid flight auger to 4.5m

WATER OBSERVATIONS: Free groundwater observed at 2.0m. Groundwater observed in piezometer at 3.2m on 30/5/05

REMARKS: *Z4 denotes field replicate sample taken

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: KP
Date: 29/6/05

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BOREHOLE LOG

CLIENT: Greencliff CPL Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Princess Hwy & Arncliffe St, Arncliffe

SURFACE LEVEL: 2.3 RL (approx)
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 108
PROJECT No: 43034
DATE: 12 May 05
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.12	CONCRETE							
		FILLING - dark grey/black sand filling, with silt and organic matter		A	0.3 0.5	*Z2	PID=0ppm		
	1.3	SAND - yellow brown/white medium grained sand (possible filling)		A	1.3 1.5		PID=1ppm		
	1.8	SANDY CLAY - grey to white sandy clay, moist		A	2.8 3.0		PID=1ppm		
	3.0	Bore discontinued at 3.0m - target depth reached							

RIG: Bobcat
DRILLER: B Ellis
LOGGED: KP
CASING: Uncased

TYPE OF BORING: Solid flight auger to 3.0m
WATER OBSERVATIONS: No free groundwater observed
REMARKS: *Z2 denotes field replicate sample taken

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: KP
Date: 29/6/05

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BOREHOLE LOG

CLIENT: Greencliff CPL Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Princess Hwy & Arncliffe St, Arncliffe

SURFACE LEVEL: 2.1 RL (approx) BORE No: 110
EASTING: PROJECT No: 43034
NORTHING: DATE: 12 May 05
DIP/AZIMUTH: 90°/-- SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	FILLING - medium grained red yellow brown sand		A	0.0		PID=0ppm		
					0.1				
		Bore discontinued at 0.1m							
		- Surface sample only							

RIG: Bobcat DRILLER: B Ellis LOGGED: KP CASING: Uncased

TYPE OF BORING: Solid flight auger to 0.1m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface level taken from base of concrete slab

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penatrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: KP
Date: 27/6/05

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BOREHOLE LOG

CLIENT: Greencliff CPL Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Princess Hwy & Arncliffe St, Arncliffe

SURFACE LEVEL: 2.7 RL (approx)
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 107
PROJECT No: 43034
DATE: 12 May 05
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.15	CONCRETE			0.2		PID=2pm		
		FILLING - dark grey sandy clay filling with gravel		A	0.3		PID=1ppm		
	0.4			A	0.4				
	0.45	SANDY CLAY - yellow brown to white sandy clay to white weathered sandstone (possible filling)			0.5				
	0.5	SANDSTONE - extremely low to very low strength, yellow brown sandstone (possible filling)							
		Bore discontinued at 0.5m - refusal on sandstone (possible sandstone boulder within filling)							

RIG: Bobcat
DRILLER: B Ellis
LOGGED: KP
CASING: Uncased

TYPE OF BORING: Solid flight auger to 0.5m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: KP
Date: 29/6/05

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BOREHOLE LOG

CLIENT: Greencliff CPL Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Princess Hwy & Arncliffe St, Arncliffe

SURFACE LEVEL: 0.5 RL (approx) BORE No: 110A
EASTING: PROJECT No: 43034
NORTHING: DATE: 20 May 05
DIP/AZIMUTH: 90°/-- SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	CONCRETE		D	0.15	*Z3	PID=232ppm		
	0.45	FILLING - yellow brown sand filling with some surficial black clay							
0	0.5	(Note: black clay heavily altered in properties by gluey chemicals)		D	0.5		PID=214ppm		
		FILLING - well compacted, dark grey fine crushed rock filling							
		Bore discontinued at 0.5m - refusal on fine crushed rock filling							

RIG: Hand tools DRILLER: LOGGED: Boyd CASING:

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Z3 denotes field duplicate sample taken

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: KP
Date: 27/6/05

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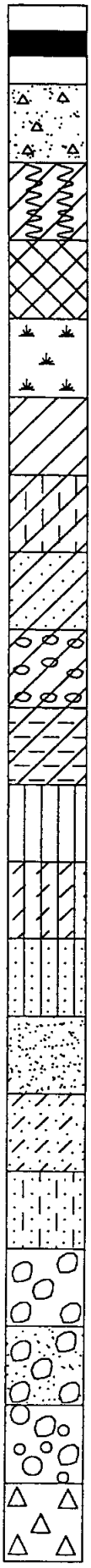
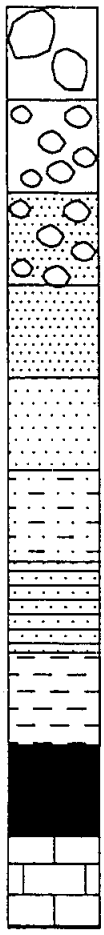
GRAPHIC SYMBOLS FOR SOIL & ROCK

SOIL



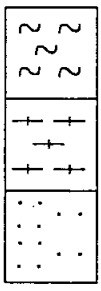
BITUMINOUS CONCRETE
CONCRETE
TOPSOIL
FILLING
PEAT
CLAY
SILTY CLAY
SANDY CLAY
GRAVELLY CLAY
SHALY CLAY
SILT
CLAYEY SILT
SANDY SILT
SAND
CLAYEY SAND
SILTY SAND
GRAVEL
SANDY GRAVEL
COBBLES/BOULDERS
TALUS

SEDIMENTARY ROCK



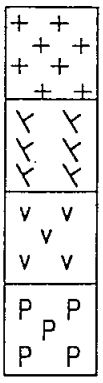
BOULDER CONGLOMERATE
CONGLOMERATE
CONGLOMERATIC SANDSTONE
SANDSTONE FINE GRAINED
SANDSTONE COARSE GRAINED
SILTSTONE
LAMINITE
MUDSTONE, CLAYSTONE, SHALE
COAL
LIMESTONE

METAMORPHIC ROCK



SLATE, PHYLLITE, SCHIST
GNEISS
QUARTZITE

IGNEOUS ROCK



GRANITE
DOLERITE, BASALT
TUFF
PORPHYRY

SEAMS

SEAM >10mm
SEAM <10mm

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NOTES RELATING TO THIS REPORT

Introduction

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

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, Geotechnical Site Investigations Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

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

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing with a sample of the soil 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 are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descent into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in

clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is 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.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond-tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining 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 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm 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 150 mm of say 4, 6 and 7

  as 4, 6, 7
  N = 13

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

  as 15, 30/40 mm.

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

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test 6.4.1.

In the tests, a 35 mm diameter rod with a cone-tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical 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 20 mm per second) the information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: —

- 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 in percent.

There are two scales available for measurement of cone resistance. The lower scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0—50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%—2% are commonly encountered in sands and very soft clays rising to 4%—10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:—

q_c (MPa) = (0.4 to 0.6) N (blows per 300 mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:—

q_c = (12 to 18) c_u

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat-ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is 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.

Bore Logs

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

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems;

- In low permeability soils, ground water although present, 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. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or 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 a perched water table.

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 condition, 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 depend partly on bore spacing and sampling frequency
- changes in policy or interpretation of policy by statutory authorities
- the actions of contractors responding to commercial pressures.

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

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 than 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.

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

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APPENDIX E
Quality Assurance / Quality Control Analysis

QA/QC PROCEDURES AND RESULTS

FIELD QUALITY ASSURANCE AND QUALITY CONTROL

The field QC procedures for sampling as prescribed in Douglas Partners *Field Procedures Manual* were followed at all times during the validation assessment. Field sampling comprised replicate sampling, at a rate of approximately one replicate sample for every ten original samples.

RELATIVE PERCENTAGE DIFFERENCE

A measure of the consistency of results for field samples is derived by the calculation of relative percentage differences (RPDs) for replicate samples. A RPD of ± 30% is generally considered acceptable for inorganic analytes by EPA, although in general a wider RPD range may be acceptable for organic analytes.

The comparative results of analysis between original and replicates are summarised in the tables below.

RPD Results for Heavy Metals (Test Bores)

Sample ID	Arsenic	Cadmium	Chromium III	Copper	Lead	Mercury	Nickel	Zinc
108/0.3-0.5	2.5	<PQL	110	180	20	<PQL	280	420
Z2	2	<PQL	13	27	20	<PQL	27	230
Difference	0.5	0	97	153	0	0	253	190
RPD (%)	**22**	**0**	**158**	**148**	**0**	**0**	**165**	**58**
110A/0.15	<PQL	<PQL	2	13	3	<PQL	1	24
Z3	<PQL	<PQL	4	56	10	<PQL	3	72
Difference	0	0	2	43	7	0	2	48
RPD (%)	**0**	**0**	**67**	**125**	**108**	**0**	**100**	**100**
1-109W	1	<1	2	1	<1	0.2	2	8
ZW	<1	<1	2	1	<1	0.2	4	10
Difference	0	0	0	0	0	0	2	2
RPD (%)	**0**	**0**	**0**	**0**	**0**	**0**	**67**	**22**

<PQL Less than practical quantification limits

RPD Results for TRH and BTEX (Test Bores)

Sample ID	TRH		Benzene	Toluene	Ethyl-benzene	Xylene
	C_6-C_9	C_{10}-C_{36}				
110A/0.15	<PQL	96910	-	-	-	-
Z1	<PQL	46500	<PQL	<PQL	<PQL	<PQL
Difference	0	50410	-	-	-	-
RPD (%)	**0**	**70**	**-**	**-**	**-**	**-**

The calculated RPD values for the samples and their replicates were generally within the acceptable range of ± 30%. The following RPDs were greater than the acceptable range (±30%) (as indicated by shading):-

- Sample 108/0.3-0.5 and replicate Z2 Cr (158%), Cu (148%), Ni (165%) and Zn (58%)
- Sample 110A/0.15 and replicate Z3 (Cr 67%), Cu (125%), Pb (108%), Ni (100%) and Zn (100%)
- Sample 110A/0.15 and replicate Z3 C_9-C_{36} (70%)
- Sample 109W and replicate ZW Ni (67%)

The calculated RPD exceeding the acceptable range for heavy metals is not, however, considered to be of significant concern due to the generally low levels of metals detected (relative to the adopted guideline levels) and the low actual differences in concentration in most of the cases.

In the case of the RPD exceeding the expectable range for TRH and the relatively inconsistent nature of the material sampled, suggests that large differences within the material are in fact likely. Furthermore given that both samples are well in excess of the guideline levels the high RPD is not of significant concern.

It is therefore considered that the results indicate an acceptable consistency between the samples and their replicates and indicate that suitable field sampling methodology was adopted and laboratory precision was achieved.

LABORATORY QA/QC PROCEDURES

Intra-laboratory Procedures

The following QA/QC procedures were conducted by the laboratory.

Reagent Blank

This sample is prepared and analysed at the beginning of every analytical run, following calibration of the analytical apparatus. The laboratory results for reagent blanks for soil analyses indicated concentrations of all analytes to be below laboratory detection limits. These results are included in the laboratory report in Appendix C.

Spike Recovery

This is a sample replicate prepared by adding a known amount of analyte prior to analysis, and then treated exactly the same as all other samples. The recovery result indicates the proportion of the known concentration of the analyte that is detected during analysis. These results are included in the laboratory report in Appendix C. The spike recovery rates are compared with limits as specified in Envirolab Services Pty Ltd Quality Control System, and any exceedances are highlighted in the report.

As no comments were noted on the report, it is considered that the results indicate that the analytical results are not significantly affected by matrix interference.

Duplicates

These are additional portions of a sample which are analysed in exactly the same manner as all other samples. The duplicate sample results are included in the laboratory results in Appendix C.