# REPORT

TO
THE OWNERS STRATA PLAN 1977

ON
GEOTECHNICAL ASSESSMENT

FOR
PROPOSED COASTAL PROTECTION WORKS

AT
1114 PITTWATER ROAD, COLLAROY, NSW

25 August 2017
Ref: 30443ZRrpt

JK Geotechnics
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

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Date: 25 August 2017
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Revision No: 1

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For and on behalf of
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# 1 INTRODUCTION

This report presents our geotechnical assessment of the proposed coastal protection works at 1114 Pittwater Road, Collaroy, NSW (known as 'Flight Deck'). A site location plan is presented as Figure 1. The assessment was commissioned on behalf of The Owners Strata Plan 1977, by Crystal Ferris (Bright & Duggan), by signed 'Acceptance of Proposal' form dated 2 May 2017. The commission was on the basis of our fee proposal (Ref. P44670ZR ver2) dated 11 April 2017.

In June 2016, an East Coast Low Storm caused erosion over the seaward portions of the subject property. The affected property owners engaged Peter Horton (Horton Coastal Engineering Pty Ltd [HCEPL]) to provide advice on coastal protection works. The proposed coastal protection works will be submitted as a Development Application to Northern Beaches Council.

Based on a review of the provided coastal engineering drawings (Drawing Numbers S.01 to S.04, S.10 and S.20 Rev. B, dated 24 August 2017) prepared by HCEPL and information provided by Richard Yates (James Taylor and Associates), we understand that the proposed coastal protection works will include:

- An upgraded rock revetment formed over an existing rock revetment with a seaward face sloping typically at 1 Vertical (V) in 2.7 Horizontal (H) and a minimum crest level of RL6m AHD. Locally, over the southern end of the site, the seaward face of the proposed revetment will be slightly steeper, i.e. 1V in 2.4H. The landward margin of the revetment will coincide with the seaward margin of the existing paved area lining the seaward side of the unit building.
- A new lightweight open riser staircase extending down to the beach from the existing paved deck area. The landward and central sections of the staircase will be respectively supported on a strip and pad footing, and the seaward section, at the base of the staircase, will be supported by a 0.45m diameter pile founded at RL -4m AHD. However, the pile footing may be substituted with a concrete footing founded over a suitable boulder, subject to approval by the coastal engineer. The maximum footing loadings will be 125kN.
- No upgraded coastal protection works are to be provided over the neighbouring site to the north (No. 1122 Pittwater Road ['Shipmates']) at this time, and upgraded coastal protection works over the neighbouring site to the south (No. 1 Frazer Street and No. 1112 Pittwater Road) have already been constructed.

In addition, we understand that the Collaroy – Narrabeen Beach Coastal Protection Works Design Specifications require that "*The seawall shall have a minimum factor of safety of 1.5 against global slope stability failure. The global slope stability shall be demonstrated using a recognised slope* *stability program. Slope stability analysis shall be conducted by a suitably qualified engineer. Factors to consider in the analyses should include, but not necessarily be limited to: beach scour in front of the seawall, elevated landward groundwater table level, and surcharge behind the seawall”*.

We note that we have completed a previous geotechnical investigation report on behalf of Patterson Britton & Partners Pty Ltd for the Collaroy/Narrabeen Sea Wall Upgrade (Ref. 15048WDrpt) dated 11 July 2000.

The purpose of the assessment herein was to:

1. Complete a stability analysis with regard to the ‘global’ stability of the proposed coastal protection works; and
2. Based on the results of our analyses provide our comments and recommendations on the geotechnical aspects of the proposed coastal protection works.

## 2 ASSESSMENT PROCEDURE

The assessment included a walkover inspection of the site and a review of available desk top information, which included our previous geotechnical report dated 11 July 2000.

A Senior Associate level engineering geologist completed an inspection of the topographic, surface drainage and geological conditions of the site and its immediate environs from the beach and road reserves on 14 June 2017. Features described in Section 3 below have been measured by hand held inclinometer and tape measure techniques and hence are only approximate.

## 3 RESULTS OF ASSESSMENT

### 3.1 Site Description

The site is located on the flat crest area of the sand dunes lining the landward margin of Collaroy Beach and has a western frontage onto Pittwater Road.

The site is occupied by a twelve storey concrete frame and brick residential unit building with lower and upper parking levels accessed via concrete paved driveways. The provided information indicated that:

- The lower parking level surface was at RL4m AHD, and

- The unit building was supported on pile footings; these were exposed following the storm erosion in 1967, as indicated on historical photographs provided by Peter Horton (HCEPL).

Landscaped garden beds lined the northern and southern sides of the building. A concrete paved and tiled surface (approximately 3m wide) lined the seaward side of the building. From the south-eastern corner of the building, a rendered wall lining the landward side of the paved area extended south to the southern site boundary. A planter bed (approximately 1.5m wide) lined the seaward margin of the paved area and formed the crest area of the existing sandstone boulder revetment.

The boulder revetment included sandstone boulders up to 4m maximum dimension. Sand and gravel was exposed at surface level between the boulders. The revetment face sloped down to the east to the beach surface at a maximum of approximately 20$^{o}$. A set of steps extended down the revetment to the beach from the paved area lining the seaward margin of the building.

The boulder revetment extended north and south beyond the site boundaries. A neighbouring dilapidated timber stair case to the north extended down the revetment from the landscaped yard area of No. 1122 Pittwater Road (‘Shipmates’).

The neighbouring ‘Shipmates’ comprised a seven storey brick residential unit building with landscaped and concrete paved surrounds and was set-back at least approximately 1m from the northern site boundary of ‘Flight Deck’.

South of the seaward portion of ‘Flight Deck’ there was a beach access area for No. 1112 Pittwater Road. South of the beach access, a neighbouring single storey weatherboard clad house (No. 1 Frazer Street) with grass surfaced yard areas was set-back approximately 2.5m from the southern site boundary of No. 1112 Pittwater Road.

Based on a cursory inspection from the foreshore and street frontage, the buildings and structures, within and neighbouring the site, where observations were possible, appeared to be in good condition.

### 3.2 Subsurface Conditions

Based on our site observations and review of the nearby BH201, BH202, TP7, TP111 to TP114 from our previous report dated 11 July 2000, the pertinent subsurface conditions were as follows:

- Sandy fill extending to depths between 0.5m and 3.5m. The fill was originally assessed to be of variable compaction ranging between moderately to well, and poorly compacted.

- Natural loose sands extending to depths between about 1.5m and 5.9m (RL 3.2m AHD to RL 0m AHD) underlain by generally medium dense sands extending to 4.5m depth (RL 0.2m AHD).
- We note that following the storms in 1967, the natural sand profile on the seaward side of the unit building was eroded down to about RL 0.3m AHD. Reinstatement works included placing sandstone boulders as erosion protection works although no specific details are available.
- Very dense sands with cemented bands, with a top surface at RL 0.4m AHD (TP111), RL 0.6m AHD (TP112), RL -0.4m (TP114) and RL -1m (TP113), which presented 'hard digging' conditions for a bucket attachment to a 20 tonne excavator. TP7 also encountered very dense sands at RL – 0.2m AHD. All the test pits were terminated in the cemented/very dense sands. Very dense sands were also encountered at about RL 0.2m AHD (BH201) and RL 0m AHD (BH202).
- Sands of variable density (loose, medium dense and dense) below about RL - 2.3m AHD (BH201) and RL - 3.1m AHD (BH202). BH201 encountered a 1.5m thick band of firm to stiff sandy clay within the sands at RL - 5.5m AHD.
- BH201 encountered interbedded silty clay and sandy clay at 19.5m depth and was terminated within the interbedded clays at 19.95m depth (RL - 15.25m).
- BH202 encountered weathered sandstone bedrock at RL - 5.1m AHD and extended to the borehole termination depth at 15.3m (RL - 9.4m AHD).
- BH201 and BH202 respectively encountered groundwater seepage at RL 0.2m AHD and RL 0.4m AHD. Standing tidal groundwater levels were recorded in the test pits at about RL - 0.2m AHD (TP7 and TP113), RL 0.4m AHD (TP111), RL 1m AHD (TP112) and RL 0m AHD (TP114).

We also note that a UNSW Water Research Laboratory drone survey immediately after the June 2016 storm indicated cemented sand levels on the beach area of around RL -0.2m to RL - 0.3m AHD, between Ramsay Street and Stuart Street, to the north of 'Flight Deck'.

## 4 STABILITY ANALYSIS

### 4.1 Stability Analysis Procedure

The location of the cross section (Figure 3) selected for the analysis is indicated on the attached Figure 2 based on the provided Drawing Number S.10 prepared by HCEPL.

The subsurface profile adopted for the analysis was based on the results of our previous geotechnical investigation and the geotechnical model is presented on Figure 3. The borehole logs, test pit cross sections and location plan from our previous report are presented in the attached Appendix A. Our analysis also included the following assumptions:

- The Highest Astronomical Tide (HAT) is about RL 1.0m AHD and the Lowest Astronomical Tide (LAT) is RL -1m AHD at present. HCEPL advised that it was more appropriate to design for the 100 year ARI still water level which is RL 1.5m AHD, or RL 2m AHD when adding 0.5m to account for sea level rise (SLR), and representing a groundwater level. HCEPL also assumed that wave setup effects were not significant in defining groundwater levels.
- The landward RL 2m AHD groundwater level was further increased to RL 2.5m AHD to conservatively account for short term additional groundwater levels, should heavy rainfall occur at the same time as elevated ocean water levels and for some wave overtopping extending landward of the revetment and infiltrating into the sandy soil profile. However, in reality it would be expected that most of the return flow from wave overtopping would preferentially travel through the revetment itself, rather than infiltrating into areas landward of the revetment, particularly over the paved area on the seaward side of the unit building.
- The groundwater level was raised to RL -0.5m on the seaward side to account for a 0.5m SLR above LAT.
- The beach erosion scour extended down to the top surface of the cemented sand layer present at about RL 0.3m below the seaward side of the unit building (the beach scour level after the 1967 storm erosion) and gently sloping up to the east to RL 0.5m at the toe of the proposed revetment then gently sloping down to the east to RL -0.3m AHD at the eastern end of the model.
- A paved area surcharge of 10kPa was applied.
- A building surcharge was not applied as the unit building is supported on piles that extend below RL 0.3m AHD and any building surcharge would therefore be below this level and have no impact on the stability analysis.
- Loadings of 62.5kN and 125kN over the landward and central sections of the proposed staircase were applied. The seaward end of the staircase will be supported on a pile footing embedded to RL -4.0m AHD, well below any potentially critical theoretical failure surface and was therefore ignored. However, the alternative footing over a boulder case was also checked by applying a 62.5kN loading at this location.
- We understand from Peter Horton (HCEPL) that sandstone boulders were placed after the 1967 storm. These boulders, and those forming the current boulder revetment, have been included on the seaward side of the unit building, from the top surface of the cemented sand layer to the existing revetment surface.

The stability analysis in this assessment was completed using the computer program “SLOPE/W” which applies circular slip surface analyses to the model. The analysis considered a worst case post beach erosion scenario down to the cemented sand layer, with ‘rapid ‘drawdown’ groundwater levels including the elevated landward groundwater level of RL 2.5m AHD and a seaward LAT groundwater level of RL -0.5m. We note that this 'rapid drawdown' assumption is conservative as the sandy soils and revetment will be relatively 'free draining' and so a build-up of landward groundwater levels is unlikely to occur to the extent assumed. It is more likely that the landward groundwater levels will drain as the tidal water level recedes, such that there will be little, if any, difference in water levels from landward to seaward of the revetment.

The slip circle analysis was run for the above scenario in order to determine the lowest Factor of Safety (FOS) for a theoretical global circular failure plane passing under the base of the revetment.

The parameters adopted in the analysis are provided in the table below. The soil strength parameters were assessed from our previous geotechnical report and our past experience of similar material types.

| Layer / Strata | Unit Weight ($kN/m^3$) | Effective Cohesion (kPa) | Effective Friction Angle (°) |
|---|---|---|---|
| Old Boulder Revetment | 16 | 0 | 40 |
| Cemented SAND | 20 | 5 | 40 |
| Medium Dense SAND | 18 | 0 | 33 |
| Boulder Revetment | 18 | 0 | 40 |

The weathered sandstone bedrock and the concrete forming the building and pile footings were input as 'high strength' materials.

### 4.2 <u>Stability Analysis Results</u>

The results of the stability analysis are presented on the attached Figures 4 and 5. The results have indicated that the minimum FOS for a theoretical global circular failure plane passing under the base of the revetment for the worst case 'rapid drawdown' scenario with beach scour erosion was 1.9. The analyses included for two scenarios; no staircase surcharge loads and including the staircase surcharge loads (and the pile footing at the toe of the staircase substituted with a footing over a boulder). A check was also made for the localised areas of slightly steeper revetment slope of 1V in 2.4H and a minimum FOS of 1.5 was obtained. This FOS is considered to be a conservative value as this takes no account of three dimensional effects associated with the interaction with adjacent less-steep sections of the revetment.

### 4.3 Conclusion

Based on the results of the analysis, we consider that the Collaroy – Narrabeen Beach Coastal Protection Works Design Specifications requirement for a minimum FOS of 1.5 *against global slope stability failure''* has been met.

## 5 GEOTECHNICAL ADVICE

### 5.1 Site Preparation

#### 5.1.1 General

We recommend that the contractor prepares a Construction Methodology Plan (CMP) prior to works commencing which should be completed with due regard to the geotechnical advice provided in this report, the coastal engineering drawings prepared by HCEPL and any relevant Council DA Consent Conditions. The CMP must include, but not be limited to, proposed excavation techniques, the proposed excavation equipment, sequencing of the excavation and placement of the rock revetment, required inspections by the geotechnical and coastal engineers, hold points etc, if required. The geotechnical and coastal engineers should review and approve the CMP.

Prior to works commencing, consideration should be given to preparing a detailed dilapidation report on the seaward side of the subject property. The property owners should be asked to confirm that the reports present a fair record of existing conditions as the reports may assist the clients in pursuing any claims against the contractor for damage.

#### 5.1.2 Excavation Conditions

Excavation recommendations provided below should be completed by reference to the Safe Work Australia Code of Practice 'Excavation Work', dated July 2015.

Bulk excavations locally required to achieve design subgrade levels will extend to a maximum depth of 3m below the existing beach surface level and typically a maximum of between about 1m and 1.5m below the existing boulder revetment surface. The seaward margin of the excavations are not expected to extend any lower than about RL 0.5m AHD, i.e. the top surface of the cemented sand layer. The excavations will extend through the sandy soil profile and encounter gravel, cobble and boulder sized inclusions. The excavations are expected to be readily completed using tracked excavators but with over excavation to remove obstructions. Any topsoil or root affected soils should be stripped and separately stockpiled for re-use in landscape areas as such soils are not suitable for re-use as engineered fill.

Care will need to be exercised in order to maintain the stability of the adjacent sections of neighbouring rock revetment to the north and south. This work will need to be completed using suitably experienced (and insured) contractors and supervised by a suitably qualified engineer.

#### 5.1.3 Potential Ground Surface Movement Risks

Due to the loose natural sands (including beach sands), which we expect will extend across the general area, we advise that sudden stop/start movements of tracked excavators and dropping of items causing ground impacts should be avoided in order to reduce transmission of ground vibrations to the adjacent sections of buildings and structures within and neighbouring the site.

#### 5.1.4 Groundwater Seepage and Tidal Levels

Groundwater inflow is expected within the excavations within the sandy soil profile, due to tidal fluctuations. Consideration of appropriate sequencing of the works in relation to tidal levels will be required.

In general, we expect any groundwater inflows to be of small volume and managed by infiltration into the sandy subgrade. Inspection and monitoring of groundwater seepage during excavations is recommended, so that any unexpected conditions, which may be revealed, can be incorporated into the drainage design.

The Highest Astronomical Tide (HAT) is about RL 1.0m AHD and excavations over the toe area of the proposed revetment will extend below tidal water levels and some instability can be expected; further advice is presented in Section 5.1.5, below.

#### 5.1.5 Temporary Batter Slopes

Temporary excavation batters no steeper than 1 Vertical (V) in 1.5 Horizontal (H) are considered feasible for the sandy soils above the groundwater levels. These temporary batter slopes are only expected to be accommodated over the landward and seaward sides of the proposed works, although care will need to be exercised close to the seaward margin of the existing paved area. These temporary batter slopes will not be achievable over the northern and southern end of the proposed works, where there are existing rock revetments.

The excavations should be carefully completed in order to expose the basal profile of the rock revetments to the north and south. The coastal engineer will need to inspect the exposed profile in order to assess the extent of any additional boulders to support the neighbouring revetments and provide a smooth transition between the two sections of coastal protection works. Such details will need to be confirmed by initially excavating test pits which should be inspected by the coastal engineer and possibly the geotechnical engineer.

We note that the bulk excavations over the seaward side of the works will extend below the tidal groundwater level and will affect the stability of the excavation sides. Allowance should be made for use of sand bags to support temporary batters close to, and below, the groundwater levels.

### 5.2 Staircase Footings

The proposed staircase beach access will be founded on a combination of high level footings and a pile footing over the lower (seaward) end of the staircase. However, the pile footing may be substituted with a concrete footing founded over a suitable boulder, subject to approval by the coastal engineer.

The soil profile below the existing boulder revetment surface will include sandstone boulders with some sandy infill materials. There may be voids between the boulders. The boulders have the potential to move when impacted by waves and we forewarn that following severe storms, some damage to the staircase could occur, which would require localised repairs.

The proposed strip and pad footings should be dimensioned to achieve a maximum bearing pressure of 100kPa and embedded a minimum depth of 0.5m below the existing revetment surface. Locally, the removal of boulders will be necessary. We recommend that additional vertical starter bars are provided and drilled and grouted into the surfaces of competent boulders below the footing base and tied into the footing reinforcement. The surface of the existing boulder revetment exposed at the base of the pad footing excavation should be inspected by the geotechnical and structural engineers to confirm the locations of the starter bars. The purpose of the starter bars is to 'lock in' the pad footing to the boulders and reduce the potential for movement under wave action. The design of the strip and pad footings should be checked in relation to bridging over a potential void in the old revetment of the order of 0.3m width.

For the pile footing proposed to be founded at RL -4.0m AHD, the cemented sands will need to be penetrated and the pile will be founded in medium dense (or denser) sands. We assume the proposed pile founding depth has been nominated with regard to design scour levels. We note that the existing boulders will pose problematic pile drilling conditions and some allowance for their removal and re-positioning has been noted on the drawings.

Bored piles are not suited to the site due to the collapsible nature of the sands and the high tidal groundwater levels. Grout injected continuous flight auger (CFA) piles are suitable, but their cost is expected to be prohibitive for a project of this size. Steel screw piles may therefore be used and designed for a maximum allowable end bearing pressure of 800kPa. The advantage of screw piles is that they may be removed and reinstalled if large boulder obstructions are encountered.

Steel screw piles have negligible resistance to lateral forces, and will need to be considered in relation to scour which would remove lateral support. We recommend that consideration be given to installing an additional raking steel screw pile into the medium dense (or denser) natural sands on the landward side of the proposed staircase support. The steel screw pile would need to be designed assuming a pull out cone defined by an angle projected up from the perimeter of the screw pile flange at 45°, an angle of internal friction of 33°, and the bulk densities above and below groundwater level provided in Section 4.1, above.

If a concrete footing is used instead of a pile footing for the lower support of the staircase, we recommend that additional vertical starter bars are provided and drilled and grouted into the surface of the underlying boulder (selected by a coastal engineer) below the footing base and tied into the footing reinforcement. The boulder should also be inspected by the geotechnical and structural engineers to confirm the locations of the starter bars. The purpose of the starter bars is to 'lock in' the footing to the boulder and reduce the potential for movement under wave action.

### 5.3 Wave Inundation Erosion Protection

Any potential inundation of the rear yard area due to wave overtopping is expected to naturally infiltrate through the old and new rock revetments. There is the potential for some localised erosion at the interface between the seaward margin of the paved area and the landward margin of the revetment. However, this may be reduced by establishing a vegetative cover suitable for this marine environment. Any localised erosion can be reinstated, if required.

## 5.4 Further Geotechnical Input

The following summarises the scope of further geotechnical work recommended within this report. For specific details reference should be made to the relevant sections of this report.

- Review of contractors CMP.
- Dilapidation report on the seaward portion of the building and structures within the subject property.
- Inspection of excavations exposing the neighbouring revetments to the north and south.
- Monitoring of groundwater seepage into bulk excavations.

# 6 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and JK Geotechnics accepts no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

Occasionally, the subsurface conditions may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

A waste classification will need to be assigned to any soil excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), General Solid, Restricted Solid or Hazardous Waste. Analysis takes seven to 10 working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then substantial further testing (and associated delays) should be expected. We strongly recommend that this issue is addressed prior to the commencement of excavation on site.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

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

| | |
|---|---|
| Title: | **SITE LOCATION PLAN** |
| Location: | 1114 PITTWATER ROAD<br>COLLAROY, NSW |
| Report No: 30443ZR | Figure No: 1 |
| | **JK Geotechnics** |

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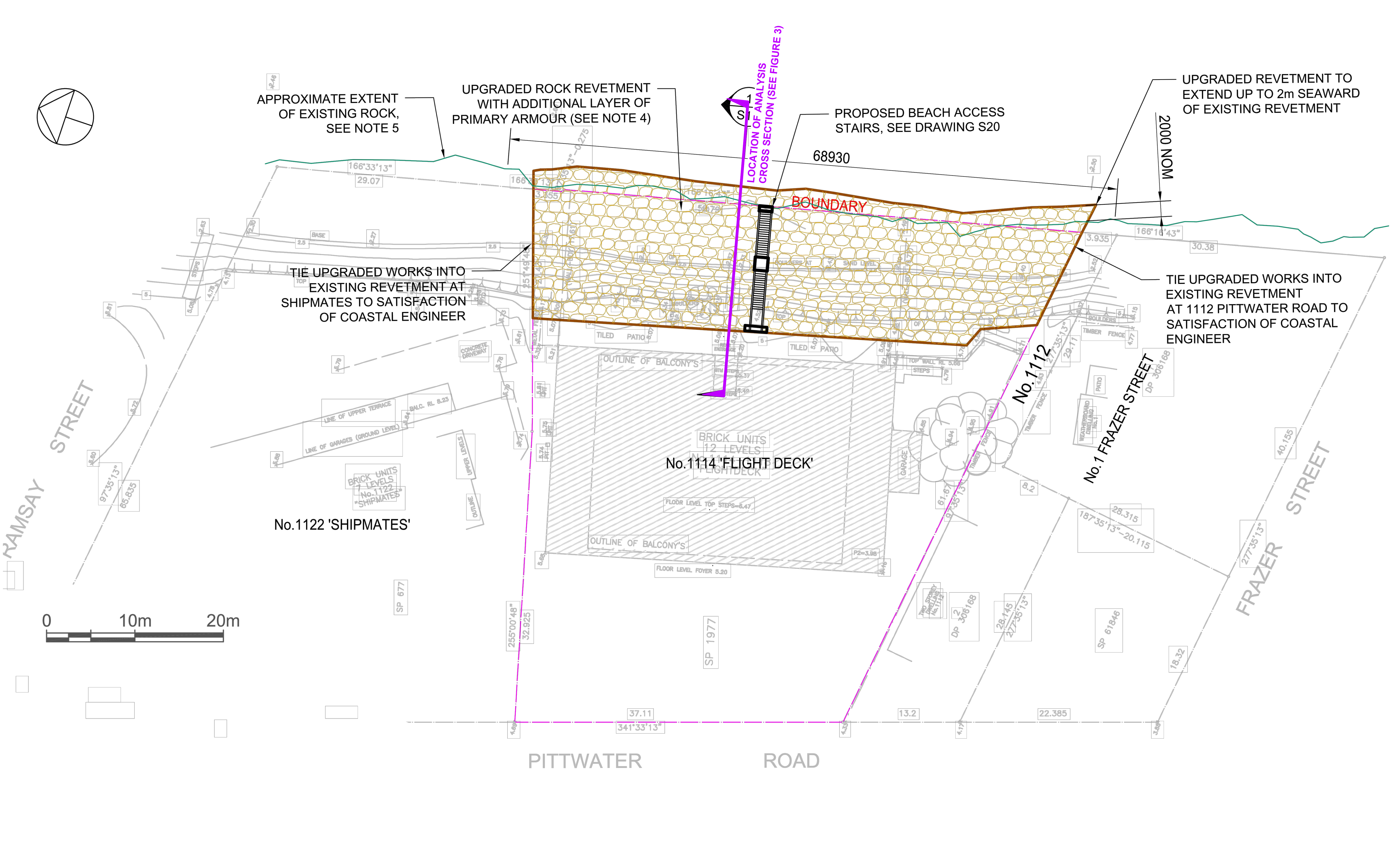


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| | Location: 1114 PITTWATER ROAD COLLAROY, NSW |
| | Report No: 30443ZR — Figure No: 2 |
| This plan should be read in conjunction with the JK Geotechnics report. | **JK Geotechnics** |

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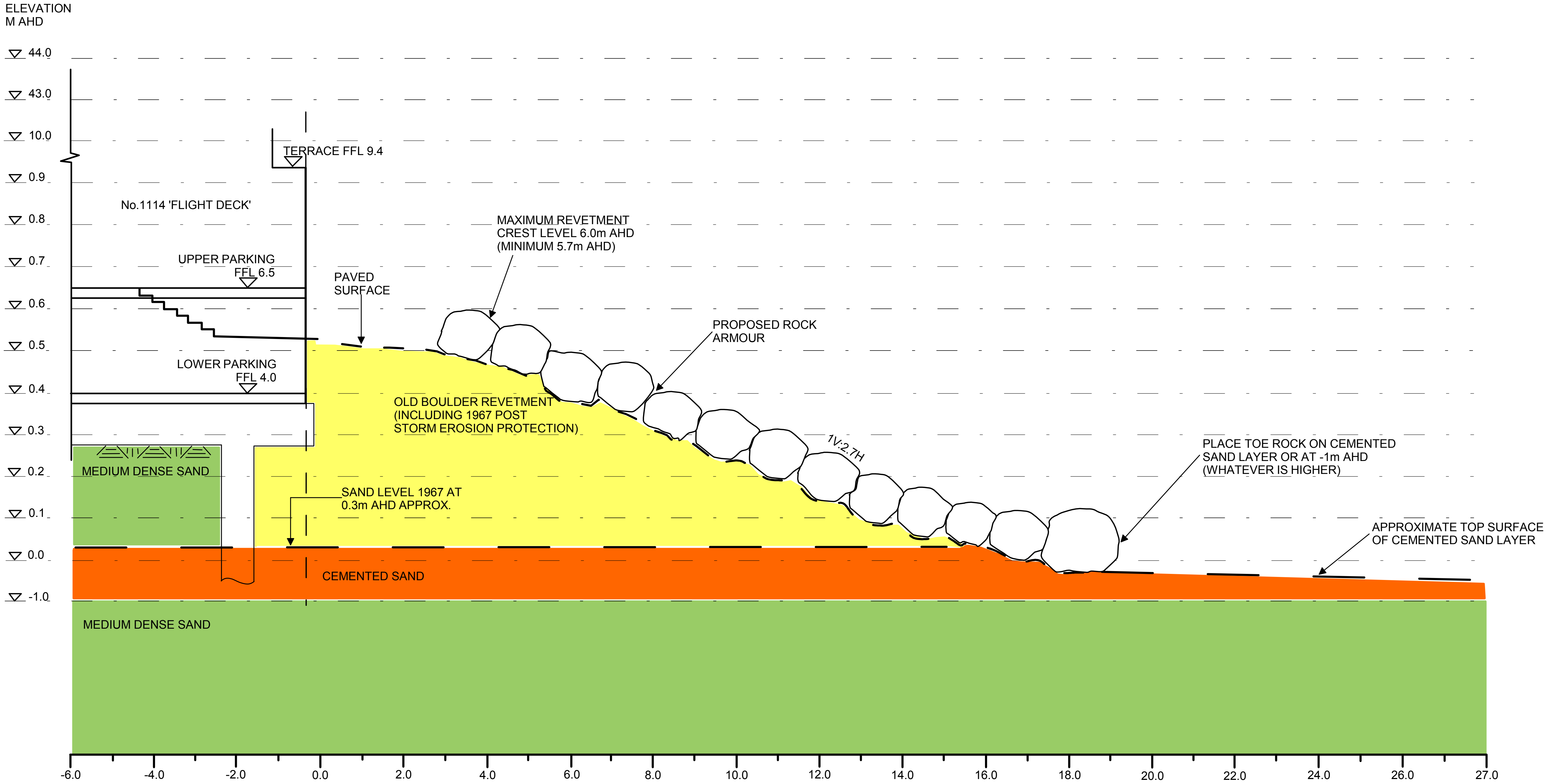


# GEOTECHNICAL MODEL

| | | | |
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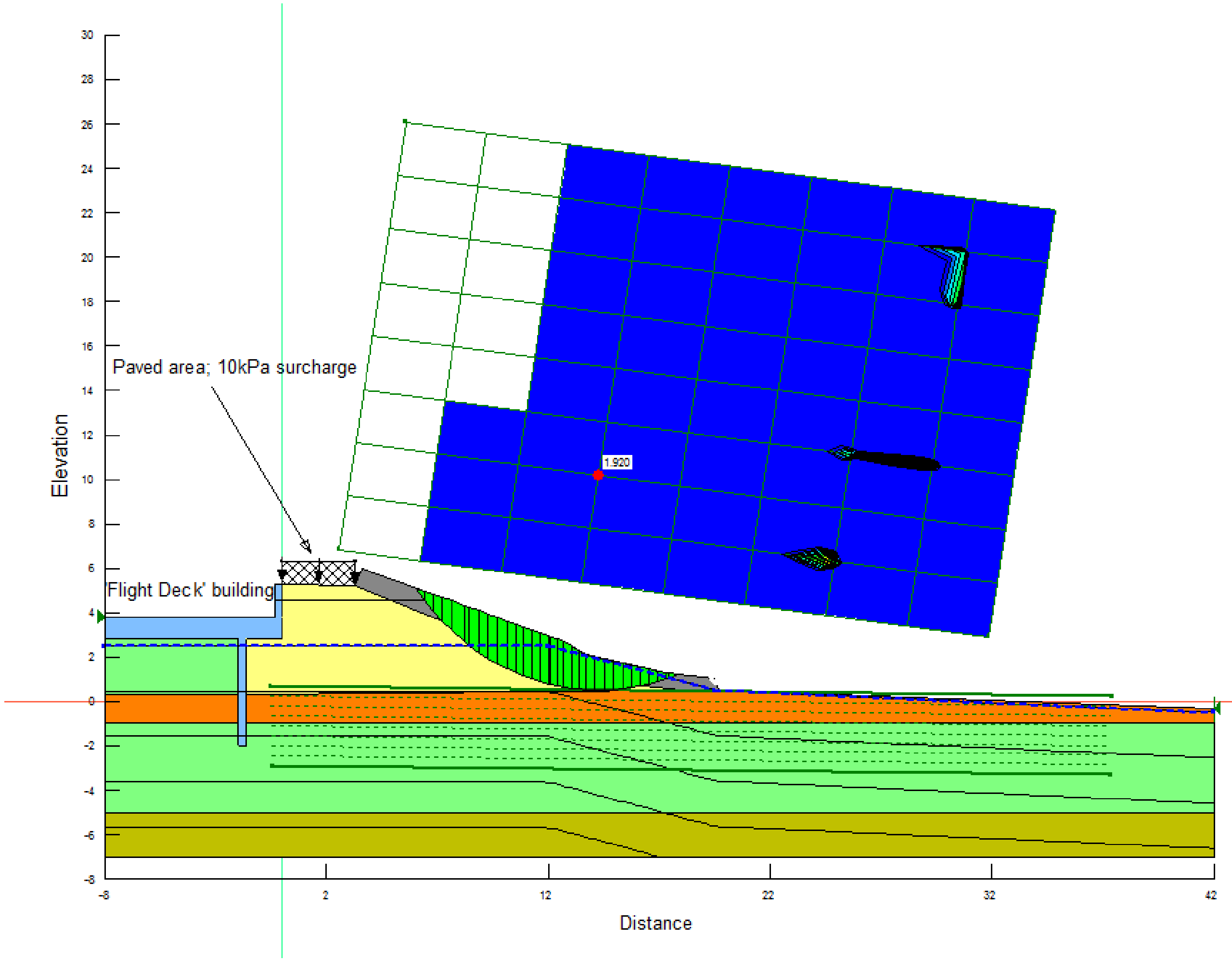
| | Location: 1114 PITTWATER ROAD COLLAROY | | |
| | Report No: 30443ZR | Figure No: 3 | |
| | **JK Geotechnics** | | |



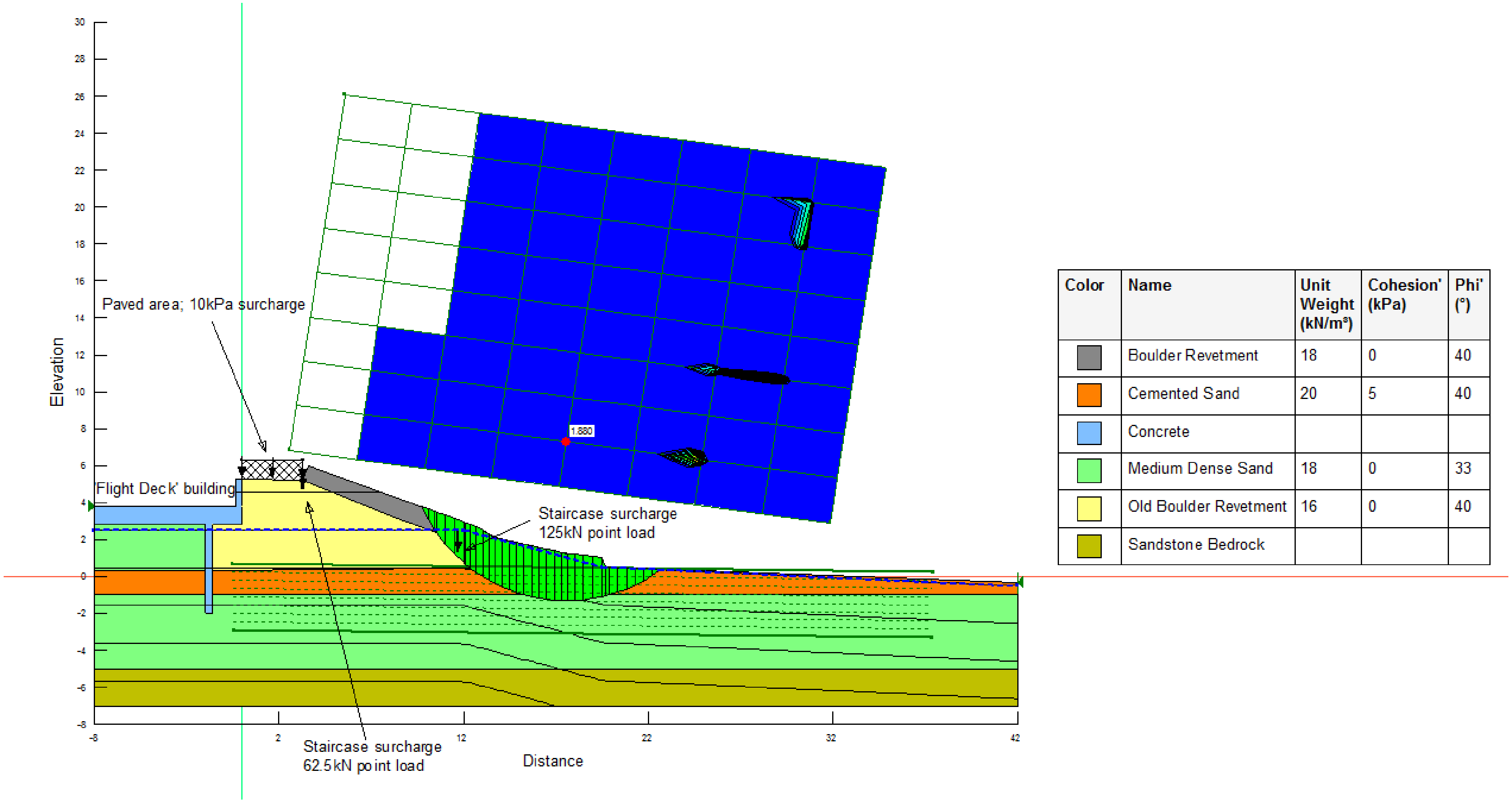

| Color | Name | Unit Weight (kN/m³) | Cohesion' (kPa) | Phi' (°) |
|---|---|---|---|---|
| | Boulder Revetment | 18 | 0 | 40 |
| | Cemented Sand | 20 | 5 | 40 |
| | Concrete | | | |
| | Medium Dense Sand | 18 | 0 | 33 |
| | Old Boulder Revetment | 16 | 0 | 40 |
| | Sandstone Bedrock | | | |

# THEORETICAL SLIP CIRCLE – GLOBAL FAILURE

**JK Geotechnics**
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

Report No. 30443ZR

Figure No. 4




| Color | Name | Unit Weight (kN/m³) | Cohesion' (kPa) | Phi' (°) |
|---|---|---|---|---|
| | Boulder Revetment | 18 | 0 | 40 |
| | Cemented Sand | 20 | 5 | 40 |
| | Concrete | | | |
| | Medium Dense Sand | 18 | 0 | 33 |
| | Old Boulder Revetment | 16 | 0 | 40 |
| | Sandstone Bedrock | | | |

# THEORETICAL SLIP CIRCLE – GLOBAL FAILURE AT STAIRCASE LOCATION

**JK Geotechnics**
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

Report No. 30443ZR Figure No. 5

# APPENDIX A


LEGEND

- ● Borehole
- ▬ Test Pit
- ○ Previous Borehole – Refer DPWS Report MHL 974 dated July, 1999
- ▭ Previous Test Pit – Refer DPWS Report MHL 974 dated July, 1999

SCALE

0 100m

# TEST LOCATION PLAN

**Jeffery and Katauskas Pty Ltd**

Report No. 15048WD Figure No. 121

# Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

# BOREHOLE LOG

Borehole No.
**201** 1/3
FRAZER STREET

**Client:** PATTERSON BRITTON & PARTNERS PTY LTD
**Project:** PROPOSED SEAWALL UPGRADING
**Location:** COLLAROY / NARRABEEN BEACH SEAWALL, NSW.

**Job No.** 15048WD
**Date:** 10-5-00
**Method:** SPIRAL AUGER INTERTECH 550
**R.L. Surface:** 4.7m
**Datum:** AHD
**Logged/Checked by:** W.T./

| Groundwater Record | SAMPLES (ES, U50, DB, DS) | Field Tests | Depth (m) | Graphic Log | Unified Classification | DESCRIPTION | Moisture Condition/ Weathering | Strength/ Rel. Density | Hand Penetrometer Readings (kPa.) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | | TOPSOIL/FILL: Silty sand, fine grained, brown, with rootlets. | M | | | GRASS COVER |
| | | N = 4 4,3,1 | | | | FILL: Silty clayey sand, fine to medium grained, dark yellow brown, with a trace of fine grained sandstone gravel. | M | L | | - |
| | | | 1 | | SP | SAND: fine to medium grained, pale brown. | | | | |
| | | N = 15 3,8,7 | | | | | | MD | | |
| | | | 2 | | | | | | | |
| | | N = 10 3,3,7 | 3 | | | as above, but with a trace of shell fragments. | | L-MD | | |
| | | | 4 | | | | | | | |
| ▶ | | N > 35 35/ 100mm R | | | SP | SAND: fine to medium grained, yellow brown, with shell fragments, with cemented bands and silt fines. | W | VD | | SOME BANDS OF VERY LOW 'TC' BIT RESISTANCE |
| | | | 5 | | | | | | | |
| | | N > 30 16,30/ 150mm R | 6 | | | | | | | START WASHBORING |
| | | | 7 | | | | | | | |

# Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

# BOREHOLE LOG

Borehole No. **201** 2/3

FRAZER STREET

**Client:** PATTERSON BRITTON & PARTNERS PTY LTD
**Project:** PROPOSED SEAWALL UPGRADING
**Location:** COLLAROY / NARRABEEN BEACH SEAWALL, NSW.

**Job No.** 15048WD
**Date:** 10-5-00
**Method:** SPIRAL AUGER INTERTECH 550
**R.L. Surface:** 4.7m
**Datum:** AHD
**Logged/Checked by:** W.T./

| Groundwater Record | Samples (ES, U50, DB, DS) | Field Tests | Depth (m) | Graphic Log | Unified Classification | DESCRIPTION | Moisture Condition/ Weathering | Strength/ Rel. Density | Hand Penetrometer Readings (kPa.) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 7 | | SP | SAND: fine to medium grained, yellow brown, with a trace of cemented bands. | W | MD | | |
| | DS | N = 12 4,6,6 | 8 | | | | | | | |
| | | | | | SP | SAND: fine to medium grained, pale brown, with dark brown bands and a trace of silt fines. | | | | LOW 'TC' BIT RESISTANCE |
| | DS | N > 36 8,11,25/ 100mm R | 9 | | | | | D | | |
| | | | 10 | | CH | SANDY CLAY: high plasticity, grey, with silty clay bands, high plasticity, grey. | MC>PL | F-St | | CHANGE IN WATER COLOUR |
| | DS | N = 1 1,1/ 300mm | 11 | | | | | | 50 100 160 190 | |
| | | | | | SM | SILTY SAND: fine grained, grey, with a trace of clayey sand/sandy clay bands. | W | MD | | LOW 'TC' BIT RESISTANCE |
| | DS | N = 18 6,8,10 | 12 | | | | | | | |
| | | | 13 | | | | | | | |
| | DS | N = 19 6,9,10 | | | | | | | 250 | |

# Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

# BOREHOLE LOG

Borehole No. **201** 3/3
FRAZER STREET

**Client:** PATTERSON BRITTON & PARTNERS PTY LTD
**Project:** PROPOSED SEAWALL UPGRADING
**Location:** COLLAROY / NARRABEEN BEACH SEAWALL, NSW.

**Job No.** 15048WD
**Date:** 10-5-00
**Method:** SPIRAL AUGER INTERTECH 550
**R.L. Surface:** 4.7m
**Datum:** AHD
**Logged/Checked by:** W.T./

| Groundwater Record | Samples (ES, U50, DB, DS) | Field Tests | Depth (m) | Graphic Log | Unified Classification | DESCRIPTION | Moisture Condition/ Weathering | Strength/ Rel. Density | Hand Penetrometer Readings (kPa.) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 14 | | SM | SILTY SAND: fine grained, grey brown, with occasional sandy clay/clayey sand bands. | W | MD | | |
| | DS | N = 11 5,5,6 | 15 | | | | | | | |
| | | | 16 | | | | | | | |
| | DS | N = 39 11,18,21 | | | SP | SAND: fine to medium grained, yellow brown with orange brown bands. | | D | | |
| | | | 17 | | | | | | | |
| | DS | N = 23 3,11,12 | 18 | | | | | MD | | |
| | | | 19 | | | | | | | |
| | DS | N = 11 5,5,6 | | | CH | INTERBEDDED SILTY CLAY: high plasticity, grey and SANDY CLAY: high plasticity, grey. | MC>PL | St | 150 120 100 | |
| | | | 20 | | | END OF BOREHOLE AT 19.95m | | | | SLOTTED PVC STANDPIPE INSTALLED |

**Jeffery and Katauskas Pty Ltd**
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

# BOREHOLE LOG

Borehole No. **202** 1/3
RAMSAY STREET

**Client:** PATTERSON BRITTON & PARTNERS PTY LTD
**Project:** PROPOSED SEAWALL UPGRADING
**Location:** COLLAROY / NARRABEEN BEACH SEAWALL, NSW.

**Job No.** 15048WD
**Date:** 8-5-00
**Method:** SPIRAL AUGER INTERTECH 550
**R.L. Surface:** 5.9m
**Datum:** AHD
**Logged/Checked by:** S.E./

| Groundwater Record | Samples (ES, U50, DB, DS) | Field Tests | Depth (m) | Graphic Log | Unified Classification | DESCRIPTION | Moisture Condition/ Weathering | Strength/ Rel. Density | Hand Penetrometer Readings (kPa.) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | | FILL: Sand, fine to medium grained, brown, with silt fines, clay nodules and fine to medium grained sandstone gravel. | | | | GRASS COVER<br>APPEARS MODERATELY TO WELL COMPACTED |
| | DS | N = 17<br>5,6,11 | | | | | | | | |
| | | | 1 | | | FILL: Clayey gravelly sand, fine to medium grained, brown, with fine to medium grained ironstone and sandstone gravel, and a trace of cobbles. | | | | |
| | DS | N = 16<br>4,6,10 | | | | | | | | |
| | | | 2 | | | FILL: Sand, fine to medium grained, brown, with fine to medium grained ironstone gravel and a trace of slag. | | | | APPEARS POORLY COMPACTED |
| | DS | N = 5<br>1,2,3 | 3 | | | | | | | |
| | | | | | SP | SAND: fine to medium grained, pale brown and yellow, with a trace of fine shell fragments. | M | L | – | – |
| | | | 4 | | | | | | | |
| | DS | N = 8<br>3,3,5 | 5 | | | | | | | |
| ▶ | | | | | | SAND: fine to coarse grained, with shell fragments, frequent cemented bands and silt fines. | W | | | BOREHOLE COLLAPSING AT 5.5m |
| | DS | N > 15<br>15/50mm | 6 | | | | | D | | START WASHBORING |
| | | | 7 | | | | | | | |

**Jeffery and Katauskas Pty Ltd**
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

# BOREHOLE LOG

Borehole No. 202 2/3
RAMSAY STREET

**Client:** PATTERSON BRITTON & PARTNERS PTY LTD
**Project:** PROPOSED SEAWALL UPGRADING
**Location:** COLLAROY / NARRABEEN BEACH SEAWALL, NSW.

**Job No.** 15048WD
**Date:** 8-5-00
**Method:** SPIRAL AUGER INTERTECH 550
**Logged/Checked by:** S.E./
**R.L. Surface:** 5.9m
**Datum:** AHD

| Groundwater Record | SAMPLES (ES, U50, DB, DS) | Field Tests | Depth (m) | Graphic Log | Unified Classification | DESCRIPTION | Moisture Condition/ Weathering | Strength/ Rel. Density | Hand Penetrometer Readings (kPa.) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 7 | | SP | SAND: fine to medium grained, pale brown, with a trace of shell fragments and fine quartz gravel. | W | | | |
| | | N > 20 20/ 150mm | | | | | | | | |
| | | | 8 | | | | | | | |
| | | N = 18 4,6,12 | 9 | | | | | MD-D | | |
| | | | | | | SAND: fine to medium grained, with clayey sand bands and cemented sand bands/extremely weathered sandstone bands. | | | | |
| | | | 10 | | | | | | | |
| | | N > 20 12,20/ 50mm | | | | | | | | |
| | | | 11 | | - | SANDSTONE: fine to medium grained, pale brown, with clay bands. | XW-DW | EL-VL | - | - |
| | | N > 20 20/50mm | 12 | | | | | | | |
| | | | | | | REFER TO CORED BOREHOLE LOG | | | | SLOTTED PVC STANDPIPE INSTALLED |
| | | | 13 | | | | | | | |

Jeffery and Katauskas Pty Ltd
Job No 15048WP BH202 Start Coring at 12.20m
12
12.20m
core loss 0.15m
13
14
15
End of Borehole at 15.3m

# Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

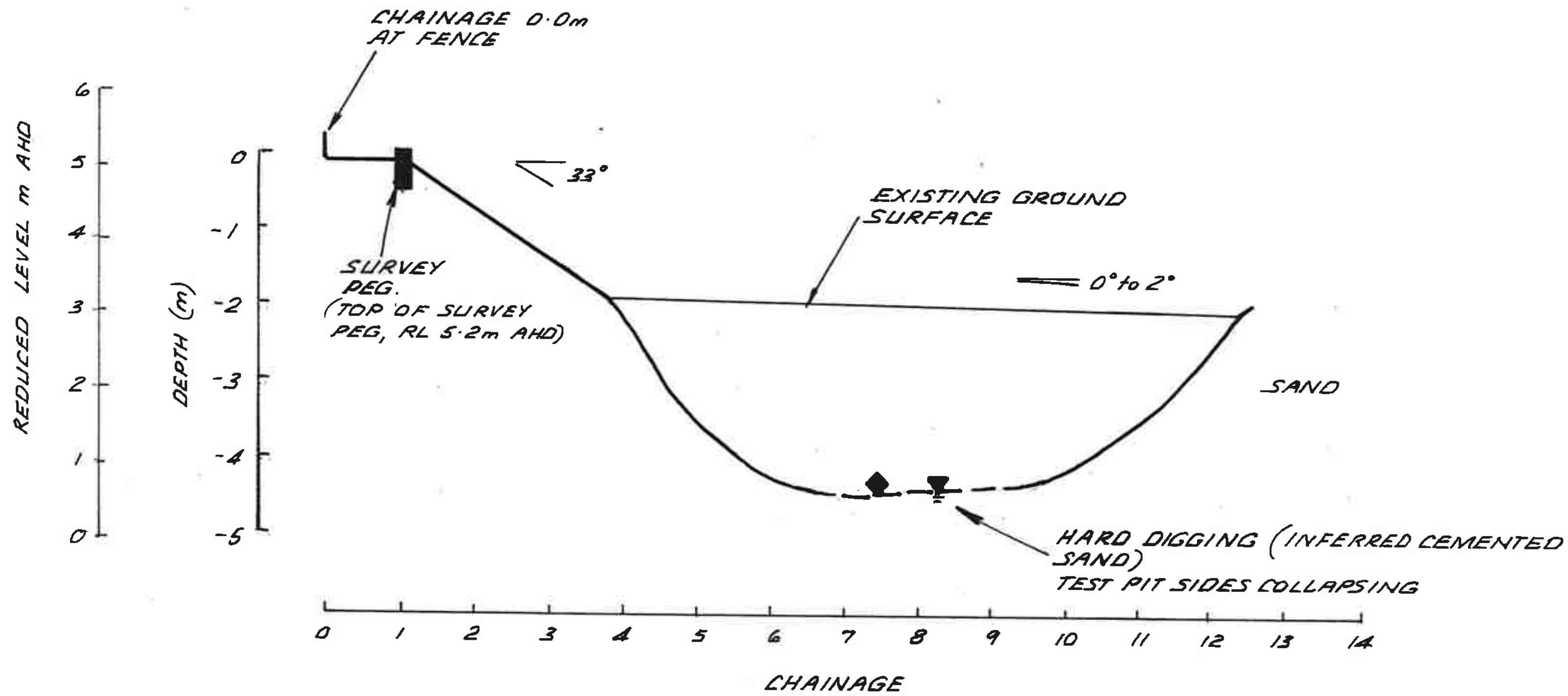
# CORED BOREHOLE LOG

Borehole No. **202** 3/3
RAMSAY STREET

**Client:** PATTERSON BRITTON & PARTNERS PTY LTD
**Project:** PROPOSED SEAWALL UPGRADING
**Location:** COLLAROY / NARABEEN BEACH SEAWALL

**Job No.** 15048WD **Core Size:** NMLC **R.L. Surface:** 5.9m
**Date:** 8-5-00 **Inclination:** VERTICAL **Datum:** AHD
**Drill Type:** INTERTECH 550 **Bearing:** – **Logged/Checked by:** S.E./

| Water Loss/Level | Barrel Lift | Depth (m) | Graphic Log | CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components. | Weathering | Strength | POINT LOAD INDEX STRENGTH $I_s(50)$ EL VL L M H VH EH | DEFECT SPACING (mm) 500 300 100 50 30 10 | DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific | General |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | START CORING AT 12.2m | | | | | | |
| 80% RETURN | | | | SANDSTONE: fine to medium grained, red brown. | DW | L-M | × | | CS, 60mm.t | |
| | | | | CORE LOSS 150mm.t | | | | | J, 65-85°, Ir, R | |
| | | | | SANDSTONE: fine to medium grained, pale grey and red. | DW | | | | | |
| | | 13 | | SILTY CLAY: high plasticity, grey. | MC>PL | VSt-H | | | | |
| | | | | SANDSTONE: fine grained, pale grey and pale brown. | DW | M-H | × × | | | |
| | | 14 | | | | L-M | | | XWS, 25mm.t | |
| | | | | as above, but grey, with dark grey laminae. | | | × × | | XWS, 20mm.t<br>J, 85-90°, P, S, IS | |
| | | 15 | | SANDSTONE: fine to medium grained, pale grey and pale brown. | | | | | | |
| | | | | END OF BOREHOLE AT 15.3m | | | | | | |
| | | 16 | | | | | | | | |
| | | 17 | | | | | | | | |
| | | 18 | | | | | | | | |




NOTE:

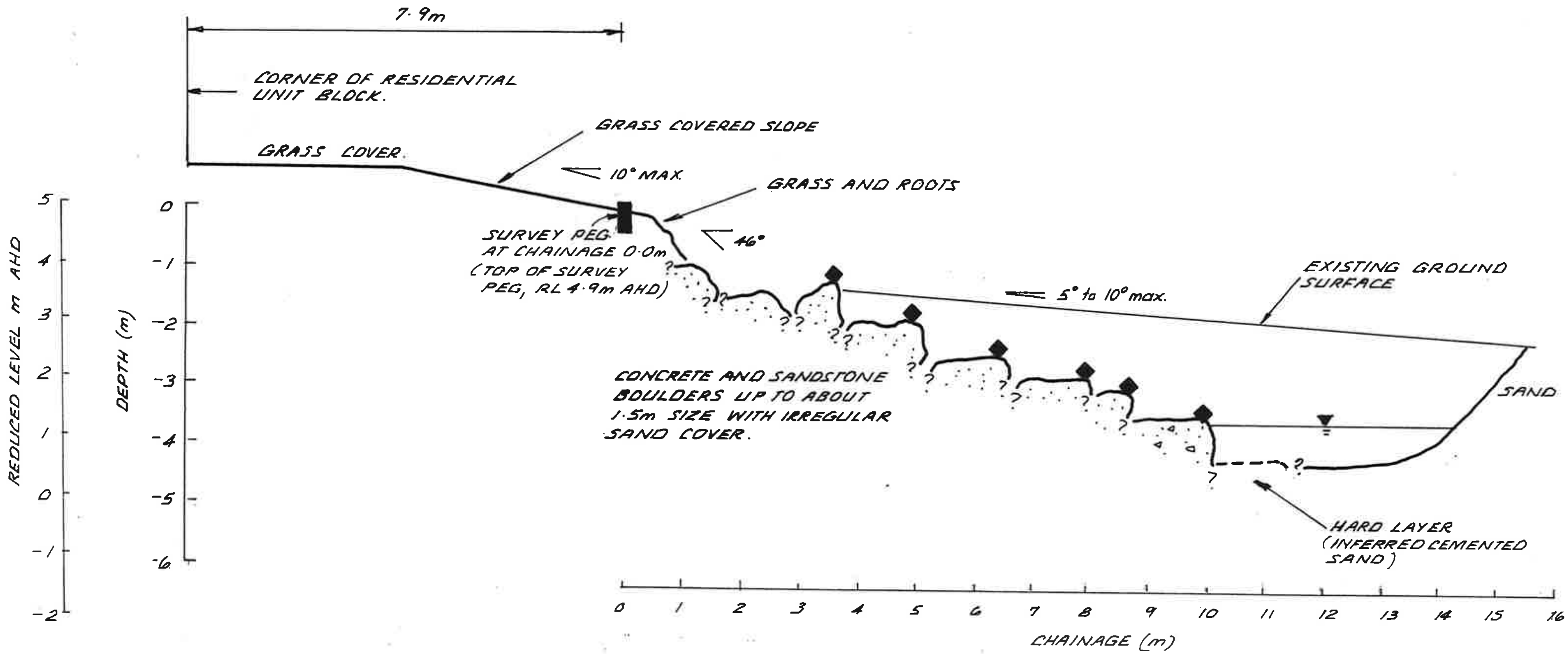
◆ INDICATES LEVEL TAKEN AT THIS POINT.

# TEST PIT 111

SCALE
0 5m

Jeffery & Katauskas Pty Ltd

Report No. 15048WD Figure No. 111




NOTE:

◆ INDICATES LEVEL TAKEN AT THIS POINT.

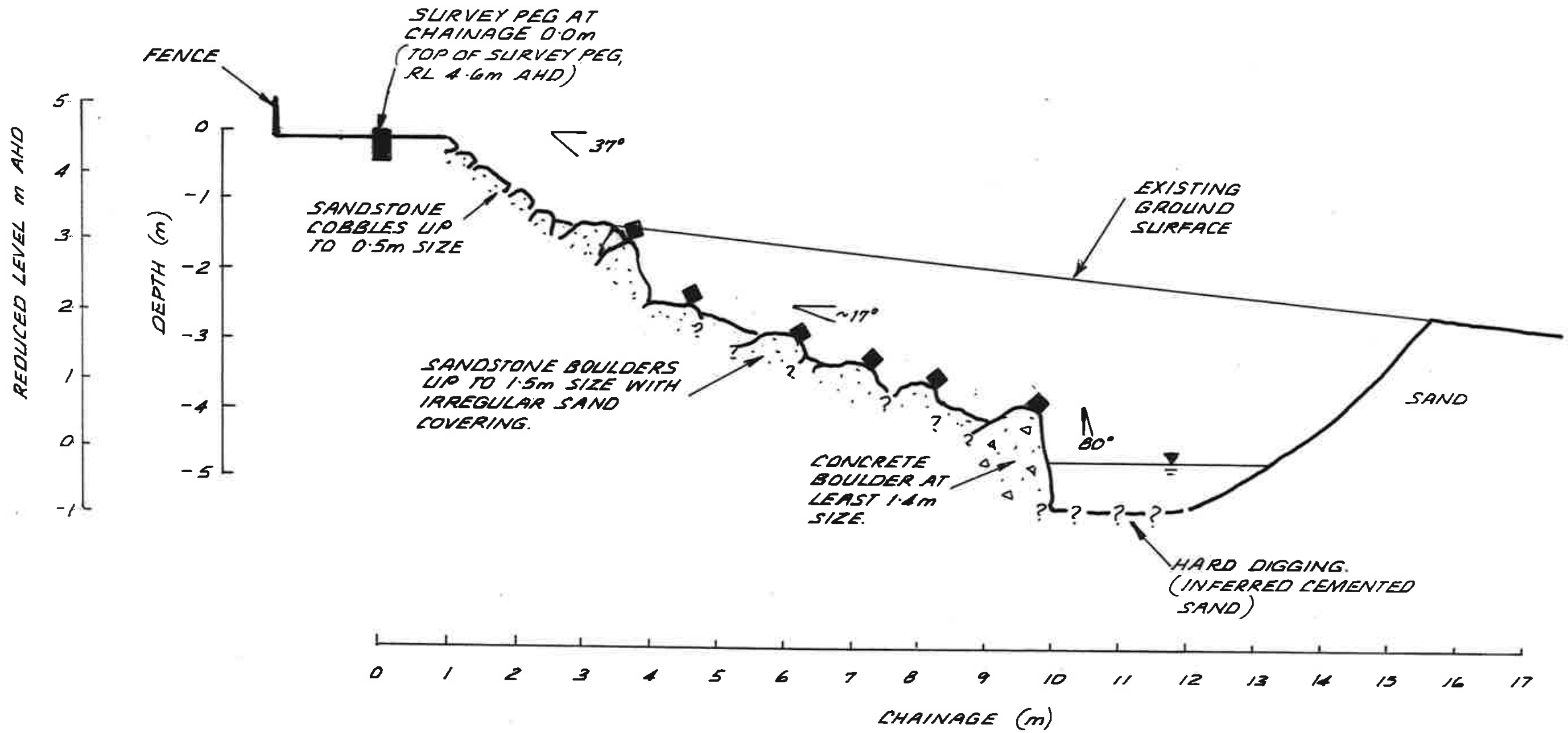
# TEST PIT 112

SCALE

0 5m

**Jeffery & Katauskas Pty Ltd**

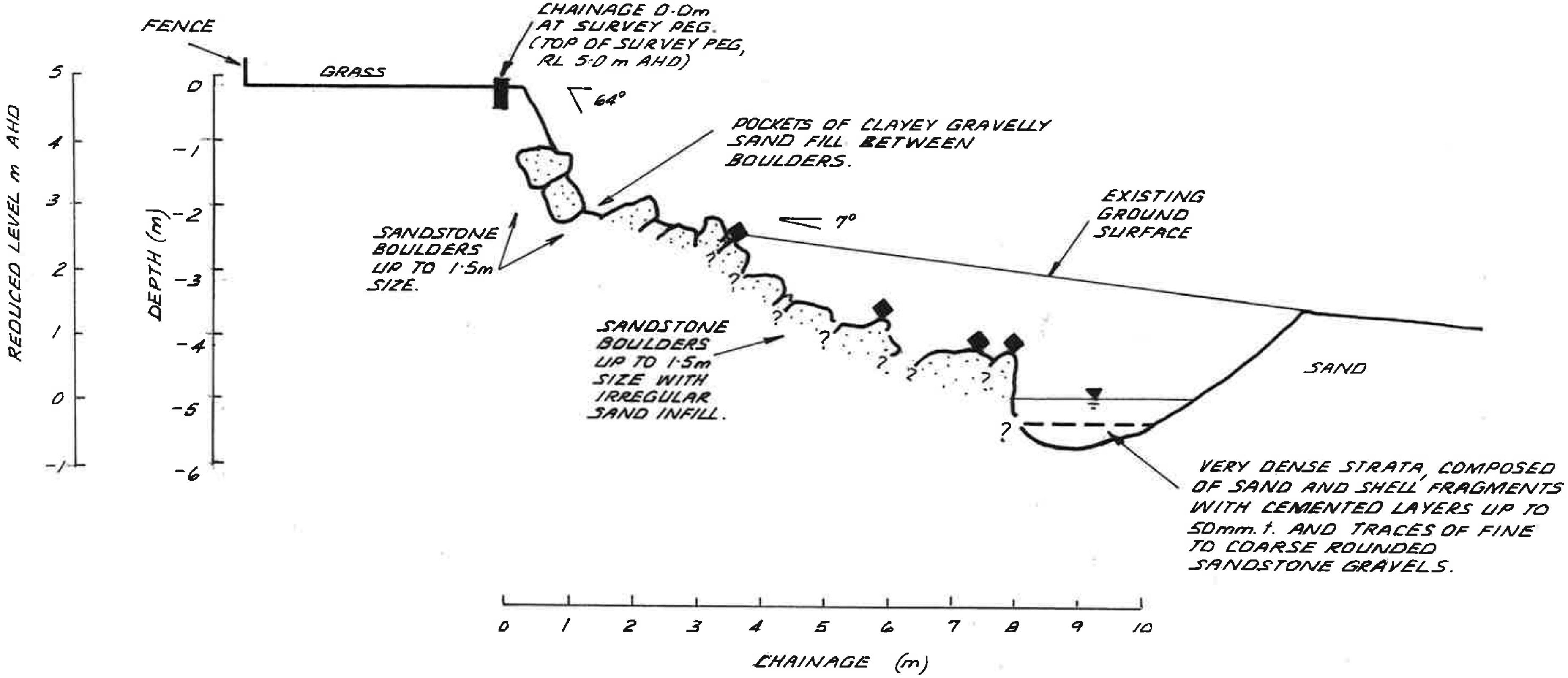
Report No. 15048WD Figure No. 112




# TEST PIT 113

SCALE
0 5m

Jeffery & Katauskas Pty Ltd
Report No. 15048WD Figure No. 113




NOTE:

◆ INDICATES LEVEL TAKEN AT THIS POINT.

# TEST PIT 114

SCALE
0 5m

Jeffery & Katauskas Pty Ltd

Report No. 15048WD Figure No. 114

## Surface Profile at Test Pit 7

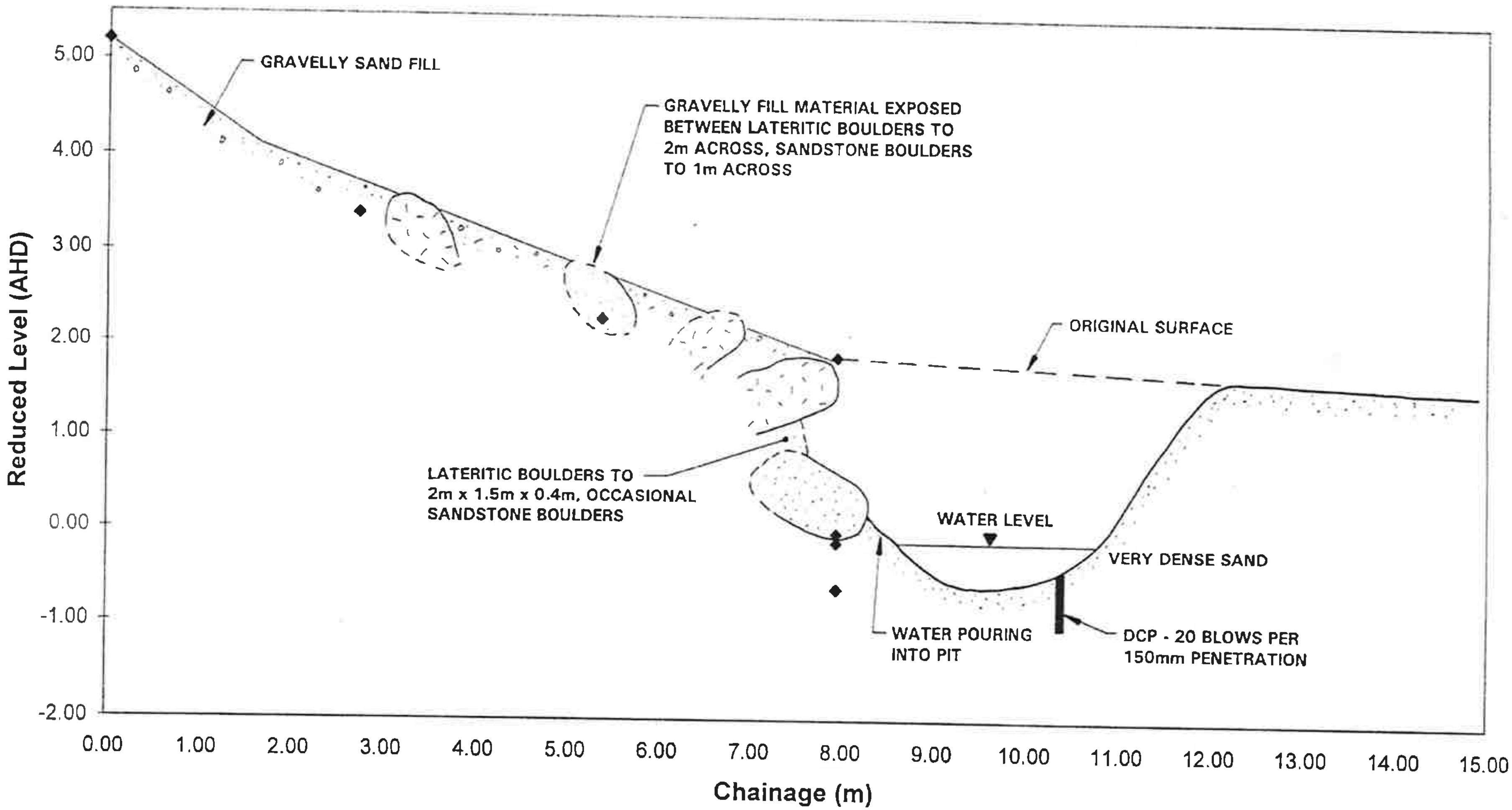



FIGURE A7

# 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 an 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

- FILL
- TOPSOIL
- CLAY (CL, CH)
- SILT (ML, MH)
- SAND (SP, SW)
- GRAVEL (GP, GW)
- SANDY CLAY (CL, CH)
- SILTY CLAY (CL, CH)
- CLAYEY SAND (SC)
- SILTY SAND (SM)
- GRAVELLY CLAY (CL, CH)
- CLAYEY GRAVEL (GC)
- SANDY SILT (ML)
- PEAT AND ORGANIC SOILS

## ROCK

- CONGLOMERATE
- SANDSTONE
- SHALE
- SILTSTONE, MUDSTONE, CLAYSTONE
- LIMESTONE
- PHYLLITE, SCHIST
- TUFF
- GRANITE, GABBRO
- DOLERITE, DIORITE
- BASALT, ANDESITE
- QUARTZITE

## DEFECTS AND INCLUSIONS

- CLAY SEAM
- SHEARED OR CRUSHED SEAM
- BRECCIATED OR SHATTERED SEAM/ZONE
- IRONSTONE GRAVEL
- ORGANIC MATERIAL

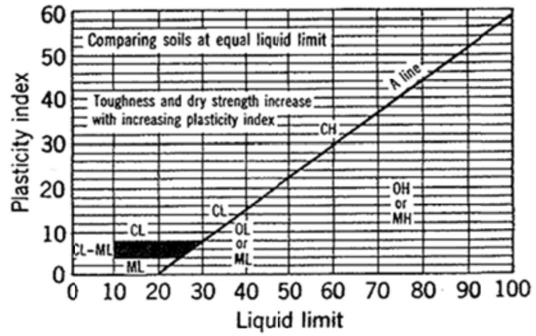
## OTHER MATERIALS

- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

| Major division | Subdivision | Subgroup | Field Identification Procedures (Excluding particles larger than 75 $\mu m$ and basing fractions on estimated weights) | Group Symbols [a] | Typical Names | Information Required for Describing Soils | Laboratory Classification Criteria | |
|---|---|---|---|---|---|---|---|---|
| Coarse-grained soils More than half of material is *larger* than 75 $\mu m$ sieve size[b] (The 75 $\mu m$ sieve size is about the smallest particle visible to naked eye) | Gravels More than half of coarse fraction is larger than 4 mm sieve size | Clean gravels (little or no fines) | Wide range in grain size and substantial amounts of all intermediate particle sizes | *GW* | Well graded gravels, gravel-sand mixtures, little or no fines | Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses. For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics. Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*) | Use grain size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than 75 $\mu m$ sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols | $C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 |
| | | | Predominantly one size or a range of sizes with some intermediate sizes missing | *GP* | Poorly graded gravels, gravel-sand mixtures, little or no fines | | | Not meeting all gradation requirements for *GW* |
| | | Gravels with fines (appreciable amount of fines) | Nonplastic fines (for identification procedures see *ML* below) | *GM* | Silty gravels, poorly graded gravel-sand-silt mixtures | | | Atterberg limits below "A" line, or *PI* less than 4. Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols |
| | | | Plastic fines (for identification procedures, see *CL* below) | *GC* | Clayey gravels, poorly graded gravel-sand-clay mixtures | | | Atterberg limits above "A" line, with *PI* greater than 7 |
| | Sands More than half of coarse fraction is smaller than 4 mm sieve size | Clean sands (little or no fines) | Wide range in grain sizes and substantial amounts of all intermediate particle sizes | *SW* | Well graded sands, gravelly sands, little or no fines | | | $C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 |
| | | | Predominantly one size or a range of sizes with some intermediate sizes missing | *SP* | Poorly graded sands, gravelly sands, little or no fines | | | Not meeting all gradation requirements for *SW* |
| | | Sands with fines (appreciable amount of fines) | Nonplastic fines (for identification procedures, see *ML* below) | *SM* | Silty sands, poorly graded sand-silt mixtures | | | Atterberg limits below "A" line or *PI* less than 5. Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols |
| | | | Plastic fines (for identification procedures, see *CL* below) | *SC* | Clayey sands, poorly graded sand-clay mixtures | | | Atterberg limits below "A" line with *PI* greater than 7 |

Identification Procedures on Fraction Smaller than 380 $\mu m$ Sieve Size

| Major division | Subdivision | Dry Strength (crushing characteristics) | Dilatancy (reaction to shaking) | Toughness (consistency near plastic limit) | Group Symbols | Typical Names | Information Required for Describing Soils |
|---|---|---|---|---|---|---|---|
| Fine-grained soils More than half of material is *smaller* than 75 $\mu m$ sieve size | Silts and clays liquid limit less than 50 | None to slight | Quick to slow | None | *ML* | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity | Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses. For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions. Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*) |
| | | Medium to high | None to very slow | Medium | *CL* | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays | |
| | | Slight to medium | Slow | Slight | *OL* | Organic silts and organic silt-clays of low plasticity | |
| | Silts and clays liquid limit greater than 50 | Slight to medium | Slow to none | Slight to medium | *MH* | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts | |
| | | High to very high | None | High | *CH* | Inorganic clays of high plasticity, fat clays | |
| | | Medium to high | None to very slow | Slight to medium | *OH* | Organic clays of medium to high plasticity | |
| Highly Organic Soils | | Readily identified by colour, odour, spongy feel and frequently by fibrous texture | | | *Pt* | Peat and other highly organic soils | |




Plasticity chart
for laboratory classification of fine grained soils

Note: 1 Soils possessing characteristics of two groups are designated by combinations of group symbols (eg. GW-GC, well graded gravel-sand mixture with clay fines).
2 Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

# LOG SYMBOLS

| LOG COLUMN | SYMBOL | DEFINITION |
|---|---|---|
| Groundwater Record | ▼ | Standing water level. Time delay following completion of drilling may be shown. |
| | —c— | Extent of borehole collapse shortly after drilling. |
| | ▶— | Groundwater seepage into borehole or excavation noted during drilling or excavation. |
| Samples | ES<br>U50<br>DB<br>DS<br>ASB<br>ASS<br>SAL | Soil sample taken over depth indicated, for environmental analysis.<br>Undisturbed 50mm diameter tube sample taken over depth indicated.<br>Bulk disturbed sample taken over depth indicated.<br>Small disturbed bag sample taken over depth indicated.<br>Soil sample taken over depth indicated, for asbestos screening.<br>Soil sample taken over depth indicated, for acid sulfate soil analysis.<br>Soil sample taken over depth indicated, for salinity analysis. |
| Field Tests | N = 17<br>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<br>7<br>3R | 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. |
| | 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<br>MC≈PL<br>MC<PL | Moisture content estimated to be greater than plastic limit.<br>Moisture content estimated to be approximately equal to plastic limit.<br>Moisture content estimated to be less than plastic limit. |
| (Cohesionless Soils) | D<br>M<br>W | DRY – Runs freely through fingers.<br>MOIST – Does not run freely but no free water visible on soil surface.<br>WET – Free water visible on soil surface. |
| Strength (Consistency) Cohesive Soils | VS<br>S<br>F<br>St<br>VSt<br>H<br>( ) | VERY SOFT – Unconfined compressive strength less than 25kPa<br>SOFT – Unconfined compressive strength 25-50kPa<br>FIRM – Unconfined compressive strength 50-100kPa<br>STIFF – Unconfined compressive strength 100-200kPa<br>VERY STIFF – Unconfined compressive strength 200-400kPa<br>HARD – Unconfined compressive strength greater than 400kPa<br>Bracketed symbol indicates estimated consistency based on tactile examination or other tests. |
| Density Index/ Relative Density (Cohesionless Soils) | <br>VL<br>L<br>MD<br>D<br>VD<br>( ) | **Density Index ($I_D$) Range (%)** — **SPT 'N' Value Range (Blows/300mm)**<br>Very Loose <15 — 0-4<br>Loose 15-35 — 4-10<br>Medium Dense 35-65 — 10-30<br>Dense 65-85 — 30-50<br>Very Dense >85 — >50<br>Bracketed symbol indicates estimated density based on ease of drilling or other tests. |
| Hand Penetrometer Readings | 300<br>250 | Numbers indicate individual test results in kPa on representative undisturbed material unless noted<br>otherwise. |
| Remarks | 'V' bit | Hardened steel 'V' shaped bit. |
| | 'TC' bit | Tungsten carbide wing bit. |
| | $T_{60}$ | 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 | | Easily remoulded by hand to a material with soil properties. |
| ---------------------- | -------------- | 0.03 | |
| Very Low: | VL | | May be crumbled in the hand. Sandstone is "sugary" and friable. |
| ---------------------- | -------------- | 0.1 | |
| Low: | L | | 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. |
| ---------------------- | -------------- | 0.3 | |
| Medium Strength: | M | | A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife. |
| ---------------------- | -------------- | 1 | |
| High: | H | | 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. |
| ---------------------- | --------------- | 3 | |
| Very High: | VH | | 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. |
| ---------------------- | --------------- | 10 | |
| 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 | |