DM Certifiers

Notice to council of determination of application for a certificate

Council Copy

RECEIVED
7 JUL 2014
PITTWATER COUNCIL

NOTICE TO (Insert council's details and address)

Council name
Pittwater Council

SECTION A. NOTICE

As required by clause 142(2) of the EP&A Regulation 2000 (the Regulation), notice is hereby given of the determination of the following application:

Applicants name	Jake Wall		
Development address	Lot 74 DP 737370 No 174 Prince Alfred Parade Newport 2106		
Date received	21/05/2014	**Date determined**	04/07/2014

SECTION B. Attachments (tick appropriate box(es))

- ☑ Application for construction certificate
- ☑ Determination of application
- ☑ Construction Certificate
- ☑ Record of inspection made under clause 143B of the Regulation
- ☑ Other endorsed documents lodged with the application for the certificate or received under clause 140 of the Regulation

SECTION C. Certifying Authority

Name
Domenic Di Matteo **Signature** [signature]

Accreditation No.
1869 **Date** 04/07/2014

R 362554
7/7/14

DM Certifiers

ABN: 92 161 548 625
PO Box 80, Thornleigh NSW 2120
ph: 9473 5488 fax: 9980 2166

Council Copy

CONSTRUCTION CERTIFICATE No: X2014-/00670

Signature: Dom Di Matteo **Approval Date:** 04/07/2014

I certify that work completed in accordance with documentation accompanying the application for the Certificate (with such modifications verified by the certifying authority as may be shown on that documentation) will comply with the requirements of this Regulation as are referred to in Section 81A(5) of the Act. Issued in accordance with the provisions of the Environmental & Assessment Act of 1979 under Sections 109C(1)(b) and 109F

Date Application Received: 21/05/2014

Application Date: 04/06/2014

Council: Pittwater Council

Development Consent No: N0451/09 **Approval Date:** 02/03/2010
Name of Certifying Authority: Dom Di Matteo
Accreditation No: 1869
Accreditation Body: BUILDING PROFESSIONALS BOARD

Applicant: Jake Wall
Address: 18 Molong Street North Curl Curl 2099
Contact Number: 0411 961 642

Owner: Jake Wall & Jennifer Hawkins
Address: 18 Molong Street North Curl Curl 2099
Contact Number: 0411 961 642

Site Address: Lot 74 DP 737370 No 174 Prince Alfred Parade Newport 2106

Description of Development: Demolition of Local Heritage Item - Jacaranda Cottage

Building Code of Australia Classification: 1a **Value of Work:** $10000.00

Builder Details
Name: Jake Wall
Licence / Permit Number: 257272C
Address: 18 Molong Street North Curl Curl 2099
Contact Number: 0411 961 642

Approved Plans and Documents

Plans Prepared By	Drawing Nos.	Dated
David Parsons	Survey	30/01/2009
Traffix	Construction Traffic Management Plan	21/05/2014

Engineer Details	Drawing Nos.	Dated
JK Geotechnics	Letter RE: Form 2	15/05/2014
JK Geotechnics	Geotechnical Assessment	30/05/2014

DM Certifiers

Council Copy

1-3 Thornleigh St,
Thornleigh NSW 2120
P: 9473 5488
F: 9980 2166

SECTION 1: APPLICATION FORM
1. APPLICATION FOR CONSTRUCTION/COMPLYING DEVELOPMENT CERTIFICATE
2. CONTRACT FOR THE PERFORMANCE OF BUILDING CERTIFICATION WORK
3. PRINCIPAL CERTIFYING AUTHORITY AGREEMENT

Privacy policy – The information you provide in this application will enable your application to be assessed by the certifying authority under the Environmental Planning and Assessment Act 1979. If the information is not provided, your application may not be accepted. The application can potentially be viewed by members of the public. Please contact D M Certifiers if the information you have provided in your application is incorrect or requires modification.

- [x] Construction Certificate
- [ ] Complying Development Certificate
- [x] Contract agreement for the performance of Building Certification Work
- [x] Engagement as Principal Certifying Authority

Deffered Commencement: 2 March 2010

Date of Receipt of Application: 20 Oct 2009
Development Consent No: N0451/09 Approval Date: 9 Dec 2009
Name of Consent Authority: Pittwater Council Related Development Consent No: ....

APPLICANT (This MUST be the Owner/Authorised Agent)
Name/s: JAKE WALL
Postal Address: 18 MOLONG ST, NORTH CURLCURL
Ph: 0411 961 642 Email: jw@jgroupprojects.com

LAND TO BE DEVELOPED
No: 174 Street: Prince Alfred Parade, Newport
Lot: 74 DP: 737370 SP: ....

DETAILS OF DEVELOPMENT
Description of work: Demolition of Local Heritage Item - Jacaranda Cottage
Estimated cost of works: $10,000.00 Class of building: n/a.

DETAILS OF BUILDER
Name: Jake Wall Licence No: 257772C
Address: 18 MOLONG STREET, NORTH CURL CURL Phone No: 0411 961 642

Owners/applicants signature(s): [signature] 4/06/14
Dated: ....

DM Certifiers

1-3 Thornleigh St,
Thornleigh NSW 2120
P: 9473 5488
F: 9980 2166
E: admin@fbcc.com.au

INSPECTION REPORT FORM

Applicant:	Inspection Type: P.A.e
	Date Of Inspection: 6/6/2014
	Contact on Site: Jake Wall
	Ph: 0411961642 | Fax:
Booked By:	Email:

Address: 174 Prince Alfred Parade, Newport

Notes:

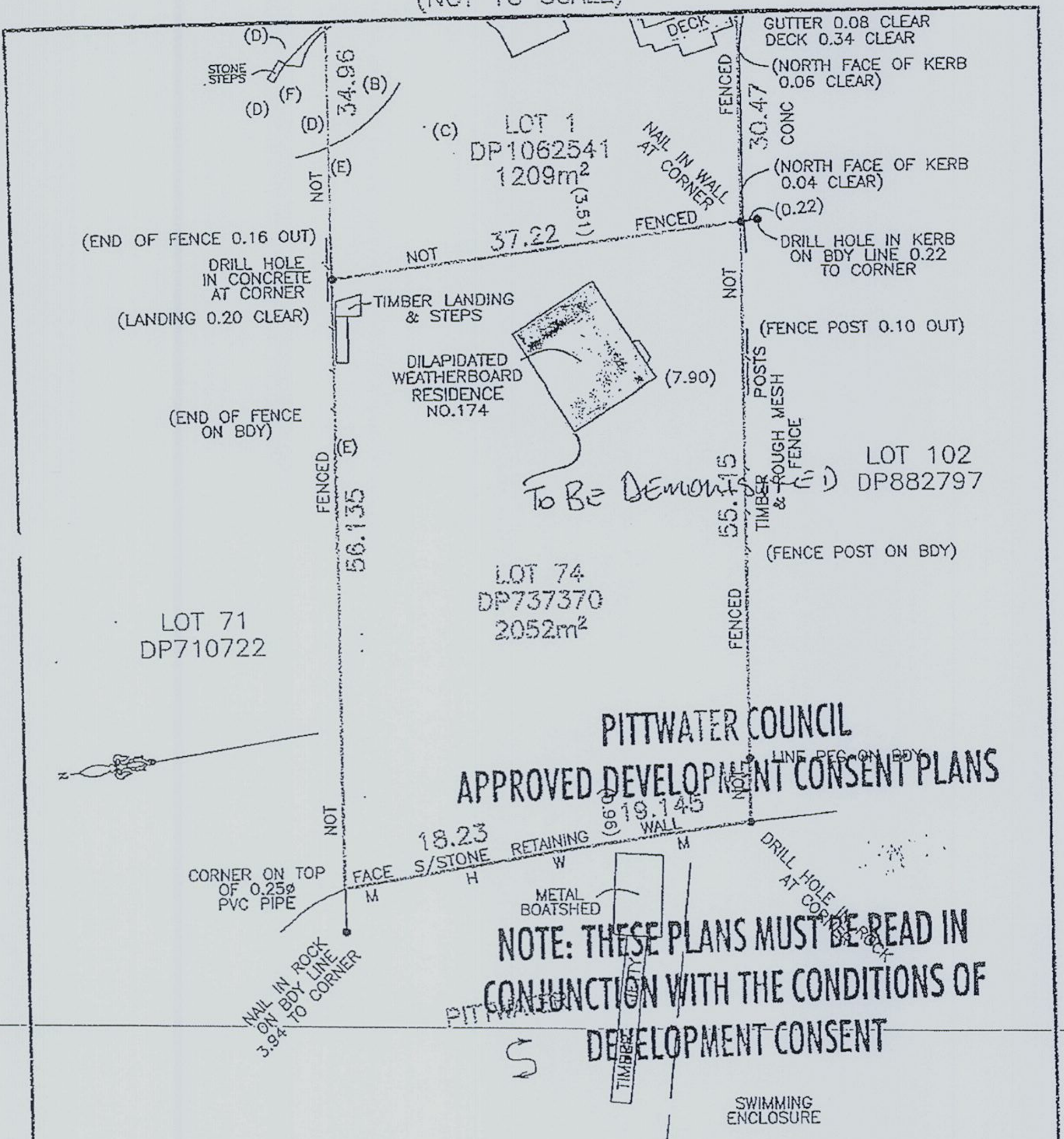
Result:

- The work is satisfactory ☑
- Complete the works below and proceed with construction ☐
- Complete the works below and request a re-inspection ☐
- Contact us immediately prior to proceeding ☐
- Provide certificate for ______________________ ☐

Comments:

Inspector: Sean Curtis Date: 6/6/2014
Accreditation No: 1796 Signature: [signature]

Sketch
(NOT TO SCALE)



THIS IS THE SKETCH REFERRED TO IN MY REPORT WITH REFERENCE NO. 1979 AND DATED 30 JANUARY, 2009.

D. Par

DAVID PARSONS
REGISTERED SURVEYOR

This plan/document forms part of the Approved Construction Certificate

2014/00670

Issued by DM Certifiers P/L BPB 1869

THIS SURVEY HAS BEEN MADE FOR IDENTIFICATION PURPOSES ONLY.
IF IT IS INTENDED TO ERECT ANY IMPROVEMENTS ALONG OR NEAR THE BOUNDARY OF THE SUBJECT LAND, A FURTHER SURVEY SHOULD BE MADE TO MARK THESE BOUNDARIES.

15 May 2014
Ref No 27333SYLet

JK Geotechnics
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

PO Box 976, North Ryde BC NSW 1670
115 Wicks Rd, Macquarie Park NSW 2113
Tel: 02 9888 5000 Fax: 02 9888 5001
www.jkgeotechnics.com.au

J Group Projects Pty Ltd
18 Molong Street
CURL CURL NSW 2099

ATTENTION: Mr Jake Wall

Dear Sir

PROVISION OF FORM 2
PROPOSED DEMOLITION OF JACARANDA HOUSE
172-174 PRINCE ALFRED PARADE, NEWPORT, NSW

Reference to the Conditions of Consent provided by Pittwater Council with regards to the proposed demolition of Jacaranda House indicates under D2 that prior to the commencement of work that Form 2 must be completed and presented to the Principal Certifying Authority. Form 2 of the Geotechnical Risk Management Policy for Pittwater requires the geotechnical engineer to review the structural drawings and confirm that the structural design for the proposed structure complies with the recommendations set out in the geotechnical report or the intent of the report. In this regard the form requires the geotechnical engineer to nominate which one of the two options they are confirming. These options are that:

- the structural design meets the recommendations as set out in the Geotechnical Report or any revision thereto,

  or

- the structural design has considered the requirements set out in the Geotechnical Report for Excavation and Landfill.

In this instance there is no structural design – the consent is for the demolition of the existing house on site. Consequently, while the consent conditions require Form 2 to be completed prior to commencement of works on site this form is not appropriate for the proposed demolition activities. In this regard it appears that its inclusion as Condition D4 is an oversight on Council's behalf. We can however confirm that demolition of the existing structure will not result in any increased risk of slope instability which may be Council's concern.

Should you require any further information regarding the above, please do not hesitate to contact the undersigned.

Yours faithfully

For and on behalf of
JK GEOTECHNICS

Woodie Theunissen

This plan/document forms part of the
Approved Construction Certificate

2014/00670

Issued by DM Certifiers P/L BPB 1869

Reference: 14.168l01v01

traffix
traffic & transport planners

suite 3.08
level 3 46a macleay street
potts point nsw 2011
po box 1061
potts point nsw 1335
t: +61 2 8324 8700
f: +61 2 9380 4481
w: www.traffix.com.au
director graham pindar
acn: 065132961
abn: 66065132961

21 May 2014

J Group Projects
c/-
Koichi Takada Architects Pty Ltd
Suite 41 & 42 (Level 4)
61 Marlborough Street
SURRY HILLS NSW 2010

Attention: Jake Wall,

Re: 174 Prince Alfred Parade, Newport – Proposed Demolition Works (DA No: N0451/09) Construction Traffic Management Plan

Dear Jake,

We refer to the proposed demolition works at 174 Prince Alfred Parade and, in particular, Council's condition 10 of Council's consent (DA No: N0451/09) which requires the preparation of a Construction Traffic Management Plan (CTMP). This CTMP relates to the demolition works only. Subsequent construction works are not included within the current conditions of consent and will therefore be subject to a separate application. Nevertheless, the traffic management principles of this CTMP will equally apply to any subsequent construction stage works.

In this regard, we have undertaken site inspections and reviewed all relevant information and now advise as follows:

Implementation

The construction traffic management plan that is included in this report should be implemented taking due account of on-site conditions as will occur over the construction period. Accordingly, construction crew are expected to respond in a pro-active manner to ensure that the plan is implemented to maximum effect and with no obvious safety issues being overlooked.

Please note, Traffix is responsible for the preparation of this Plan only and not for its implementation, which is the responsibility of the project manager/builder.

Existing Site

The site is located 174 Prince Alfred Parade, Newport and is known as Jacaranda Cottage. It is legally described as Lot 74 in DP737370.

Vehicular access to the site is provided via a Right of Carriageway (ROW) that serves 5 residential dwelling lots, including the subject site. This ROW extends from the northern end of Prince Alfred Parade to the southern end of Hudson Parade. A large tree encroaches within the ROW, to the south of the site, which restricts the access width to 2.5 metres in width from Prince Alfred Parade.

A location plan is provided in **Figure 1** below. Reference should also be made to the Photographic Record included in **Attachment 1** which provides a general appreciation of the site and traffic conditions in the locality.

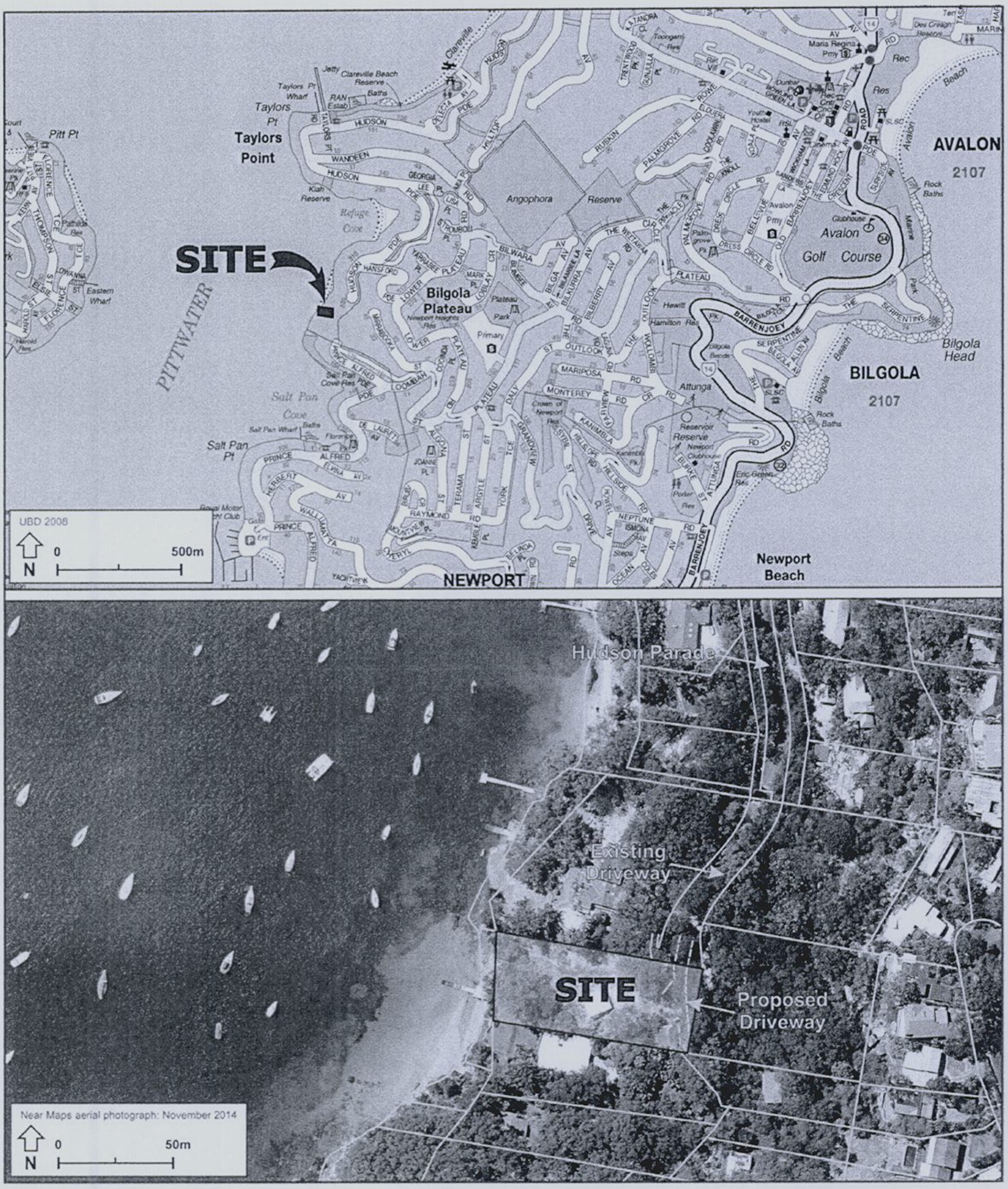


Figure 1: Site Location

Overview of Works

The proposed demolition primarily relates to the removal of the existing weatherboard residence and shed located on-site which are already in a dilapidated condition. Due to the relatively small quantity of material to be removed from the site, it is anticipated that demolition works will occur over a period of approximately two (2) days.

It is envisaged that a total of 10 truck loads will be required, which equates to an average of 5 trucks per day during demolition. Truck volumes during subsequent construction are expected to be less.

Proposed hours of construction works are generally in accordance with the conditions of consent, as follows:

- 7.00am – 5.00pm Monday to Friday
- 7.00am – 1.00pm Saturdays, and
- No work Sundays or Public Holidays

All demolitions works will be undertaken wholly on-site, with truck access provided via the ROW from Hudson Parade. Truck access is discussed further below.

Traffic Control Plans

Due to the relatively steep falls on-site, it is proposed to load directly from the ROW during demolition, as indicated by the Traffic Control Plan included in **Attachment 2**. The loading area is to be located such that through access along the ROW is to be maintained at all times.

It is recommended that advanced warning signage be provided to advise other ROW users of the potential for contractors and loading vehicles within the ROW.

On-site speed restrictions are not required due to the constrained nature of the ROW which results in a self enforcing low speed environment.

Truck Access Routes

As discussed above, the access to the site from Prince Alfred Parade is restricted due to the encroachment of a large tree within the existing ROW carriageway to the south of the site. As such, all truck access is proposed via Hudson Parade, as indicated by the proposed truck routes provided in **Figures 2 & 3** below. These routes generally seek to provide the most direct route to the site whilst avoiding local roads with 3 Tonne Load Limit restrictions which include:

- Grandview Drive, and
- Plateau Road, to the west of Barrenjoey Road

The preferred route, via Avalon Parade and Hudson Parade, forms part of an existing bus route (Route 191 and E89) and it is therefore considered that a minor increase in truck movements along this route will have less impact on residential amenity than the alternative route via local residential roads to the south of the site via Bardo Road.

Notwithstanding, either route is considered acceptable having regard for the relatively small scale of the demolition and construction works which will generate up to 10 truck movements (5 in, 5 out) per day and therefore have minimal impact on the surrounding road network.

Figure 2: Truck Routes (Option 1)

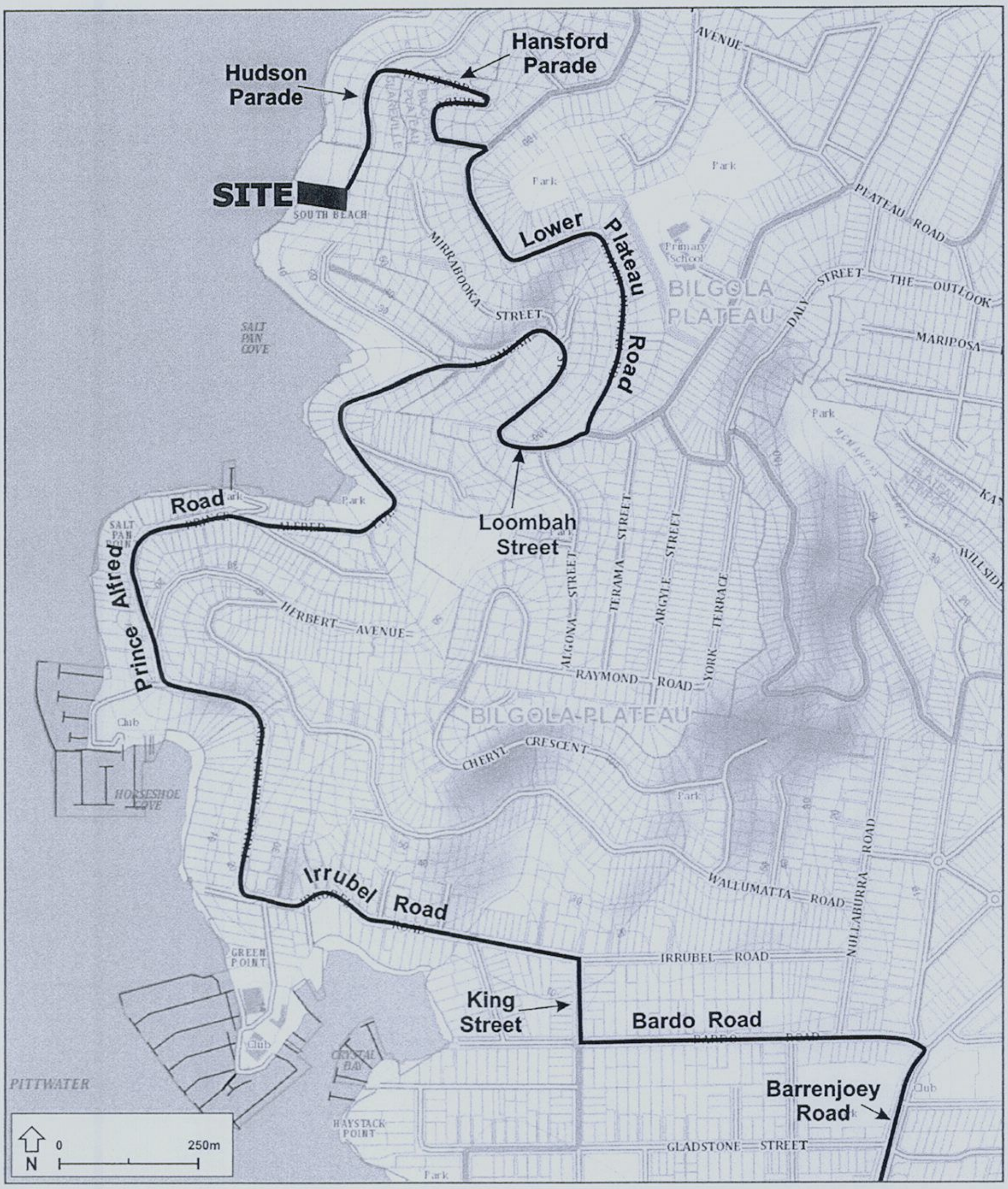


Figure 3: Truck Routes (Option 2)

The size of trucks entering the ROW and site shall be limited to small rigid trucks (SRV) only, being no longer than 6.4 metres in length. A swept path demonstrating access and egress from the proposed Loading Zone within the ROW is provided in **Attachment 3**.

Conclusions

This report should be read in conjunction with other documentation prepared by J Projects relating to internal construction activities. The plan outlined above is considered adequate and will minimise any disruptions to residents and pedestrians in the area. This plan meets all requirements of AS2890.2 and AS1742.3 and is recommended for adoption. Any minor variation to these standards is considered acceptable having regard to the constraints inherent by the site and proposed works.

Please contact the undersigned should you have any queries or require any further information regarding the above.

Yours faithfully,

traffix

Tim Lewis
Senior Engineer

RMS Select / Modify TCP (Red Card) Certificate No: *2252 050 125*

RMS Design & Inspection TCP (Orange Card) Certificate No: *2253 014 992*

Attachments: 1) Photographic Record
2) Traffic Control Plan(s)
3) Swept Paths

Attachment 1

Photographic Record

View looking north at the ROW access from Prince Alfred Parade.

View looking north along the ROW at the tree which restricts the width of the ROW to approximately 2.5 metres.

View looking south at the existing ROW access from Hudson Parade.

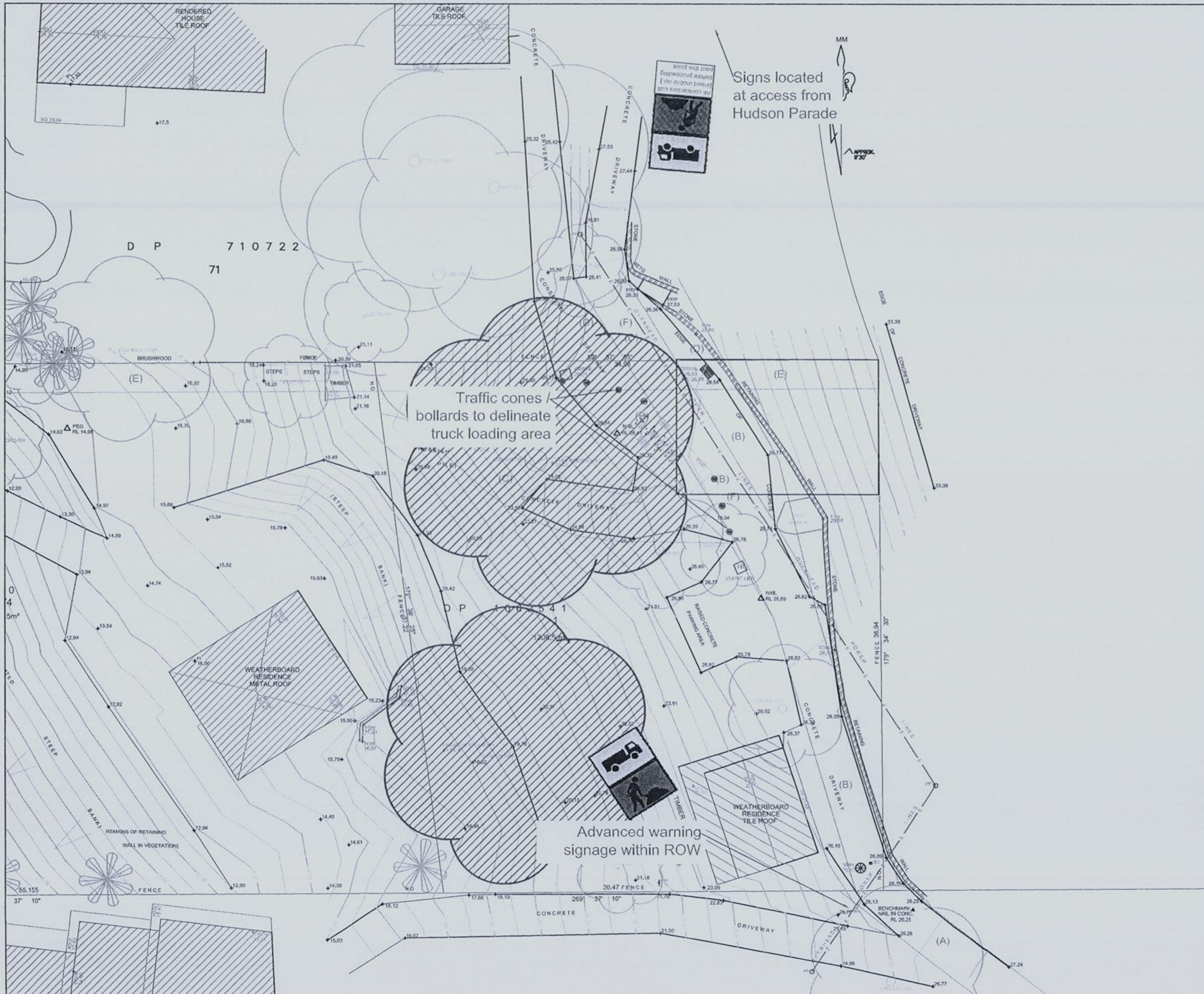
View looking south along the ROW on approach to the site.

View looking north along Barrenjoey Road on approach to its intersection with Plateau Road and Old Barrenjoey Road. Note the Load Limit restriction applying to Plateau Road, to the left.

View looking west along Grandview Drive from Seaview Avenue. Note that Load Limit restriction applying to Grandview Drive.

Attachment 2

Traffic Control Plan(s)

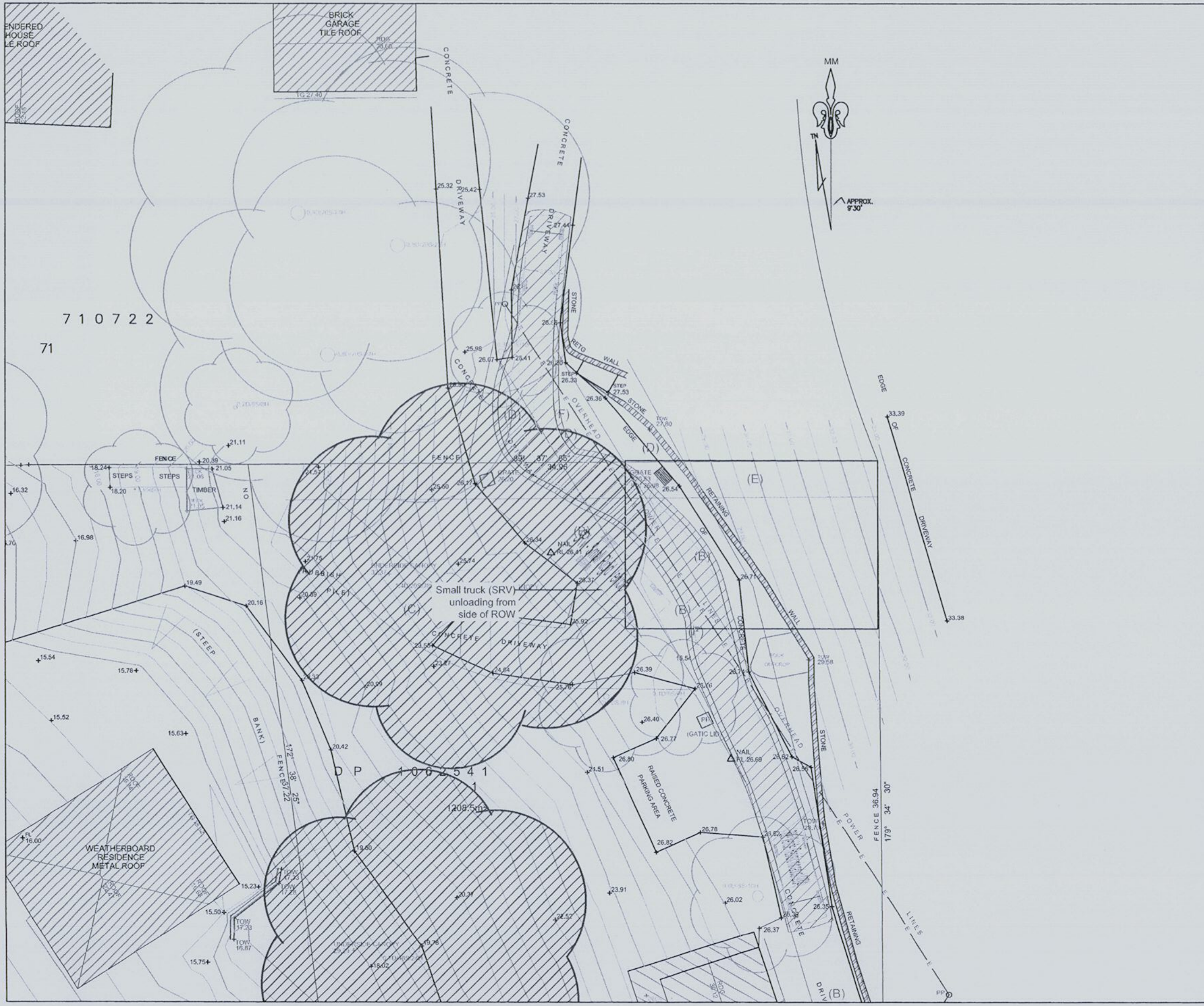


no. revision note	by. date
architect	Koichi Takada Architects
client	Jake Wall & Jennifer Hawkins
scale	1:250 @ A3 (0m 2.5 5.0 7.5 10.0)
project	174 Prince Alfred Parade, NEWPORT
drawing prepared by	TRAFFIX traffic and transport planners; suite 3.08 46a macleay street potts point NSW 2011; PO Box 1061 potts point nsw 1035; t: +61 2 8324 8700; f: +61 2 9380 4481; e: info@traffix.com.au
drawing title	Construction Traffic Management Plan Traffic Control Plan - Loading from ROW
drawn: TL	checked: -
date:	21-May-14
project no.	14.168
drawing phase.	CTMP
drawing no.	TCP01
rev	-

traffix
traffic & transport planners

Attachment 3

Swept Paths & Design Comments



no. revision note | by. date

architect
Koichi Takada Architects

client
Jake Wall & Jennifer Hawkins

scale
1:200 @ A3

project
174 Prince Alfred Parade, NEWPORT

drawing prepared by
TRAFFIX
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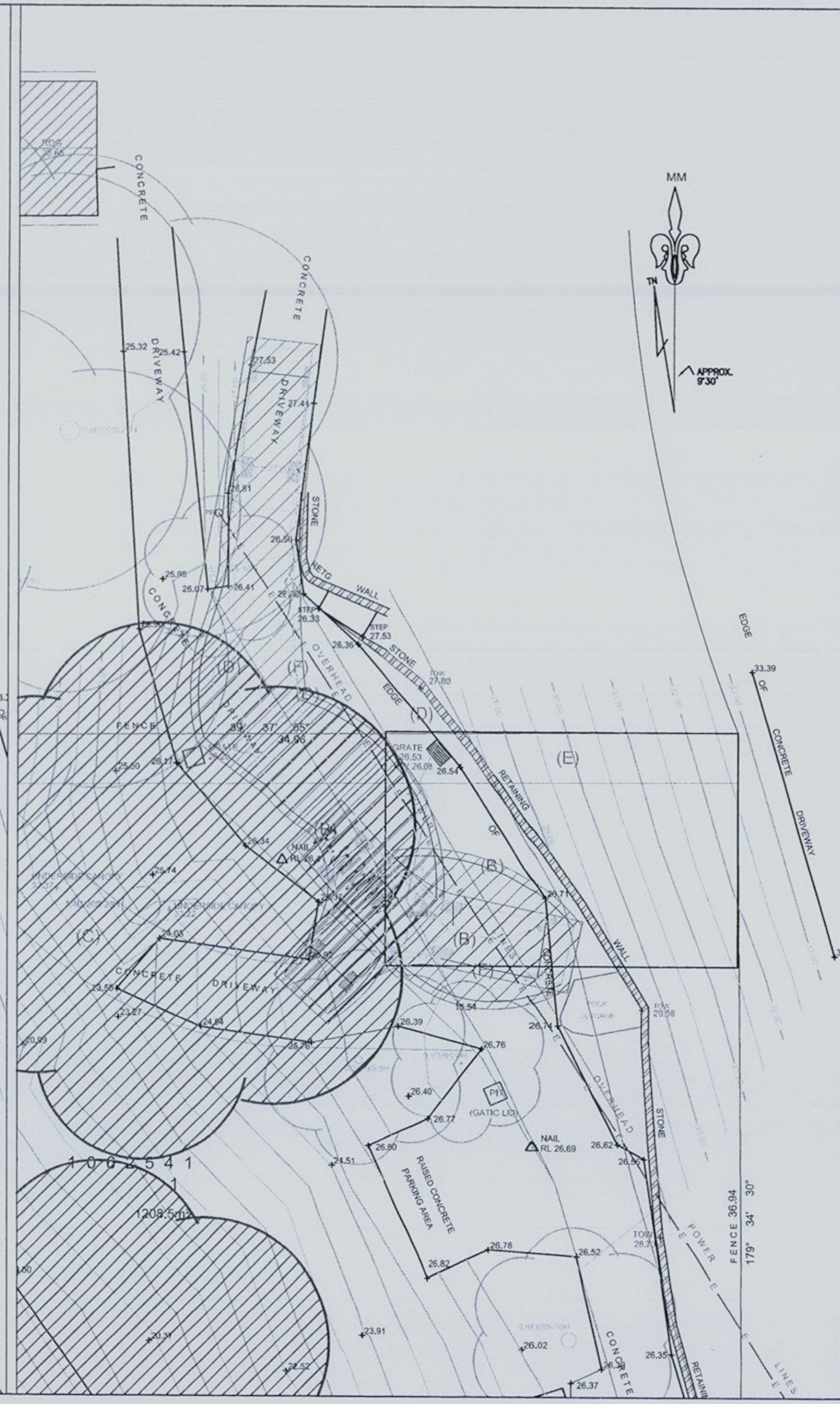
e: info@traffix.com.au
traffix
traffic & transport planners

drawing title
Construction Traffic Management Plan
B99 passing a loading truck (SRV)

drawn: TL	checked: -	date: 21-May-14

project no.	drawing phase.	drawing no.	rev
14.168	CTMP	TMP.1	-



no.	revision note	by.	date

architect
Koichi Takada Architects

client
Jake Wall & Jennifer Hawkins

scale
1:200 @ A3

project
174 Prince Alfred Parade.
NEWPORT

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traffix
traffic & transport planners

drawing title
Construction Traffic Management Plan
Small rigid truck (SRV) access & egress

drawn: TL	checked: -	date: 21-May-14

project no.	drawing phase.	drawing no.	rev
14.168	CTMP	TMP.2	-

REPORT

TO
J GROUP PROJECTS PTY LTD

ON
GEOTECHNICAL ASSESSMENT
(In Accordance with Pittwater Council Risk Management Policy)

FOR
PROPOSED ALTERATIONS AND ADDITIONS

AT
172-174 PRINCE ALFRED PARADE, NEWPORT, NSW

30 May 2014
Ref: 27333SYrptrev1

JK Geotechnics
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

PO Box 976, North Ryde BC NSW 1670
Tel: 02 9888 5000 Fax: 02 9888 5001
www.jkgeotechnics.com.au
Jeffery & Katauskas Pty Ltd, trading as
JK Geotechnics ABN 17 003 550 801

Date: 30 May 2014
Report No: 27333SYrpt
Revision No: 1

Report prepared by:

Woodie Theunissen
Associate

Report reviewed by:

Paul Stubbs
Principal Geotechnical Engineer

For and on behalf of
JK GEOTECHNICS
PO Box 976
NORTH RYDE BC NSW 1670

This Report (which includes all attachments and annexures) has been prepared by JK Geotechnics (JK) for its Client, and is intended for the use only by that Client.

This Report has been prepared pursuant to a contract between JK and its Client and is therefore subject to:

a) JK's proposal in respect of the work covered by the Report;
b) the limitations defined in the Client's brief to JK;
c) the terms of contract between JK and the Client, including terms limiting the liability of JK.

If the Client, or any person, provides a copy of this Report to any third party, such third party must not rely on this Report, except with the express written consent of JK which, if given, will be deemed to be upon the same terms, conditions, restrictions and limitations as apply by virtue of (a), (b), and (c) above.

Any third party who seeks to rely on this Report without the express written consent of JK does so entirely at their own risk and to the fullest extent permitted by law, JK accepts no liability whatsoever, in respect of any loss or damage suffered by any such third party.

TABLE OF CONTENTS

1 INTRODUCTION

This report presents the results of our geotechnical assessment of the site at 172 and 174 Prince Alfred Parade, Newport, NSW. The assessment was commissioned by Mr Jake Wall of J Group Projects Pty Ltd and was completed in accordance with our proposal (Ref: P38408SYMemail, dated 11 March 2014). The site was inspected by our Associate, Mr Woodie Theunissen, on 21 March 2014, to assess the existing stability of the site and the effect on stability of the proposed development.

Reference to the plans prepared by Koichi Takada Architects (Project Number: 14188, Drawing No: A101 to 103, Revision G dated 1/5/2014) indicates that the proposed new house comprises four levels stepping down the hillside. The house spans the middle portion of the site with a driveway snaking down from the private road to a turning area and garage. The driveway will drop approximately 7m from the private road to the garage. The house will step down the hillside with cuts ranging up to about 7m. A pool will be constructed to the west of the house with maximum cuts expected to be no greater than about 2m.

This report has been prepared in accordance with the requirements of the Geotechnical Risk Management Policy for Pittwater (2009) as discussed in Section 5 below. It is understood that the report will be submitted to Council as part of the DA documentation. Our report is preceded by the completed Council Forms 1 and 1a.

2 ASSESSMENT METHODOLOGY

2.1 Walkover Survey

This stability assessment is based upon a detailed inspection of the topographic, surface drainage and geological conditions of the site and its immediate environs. These features were compared to those of other similar lots in neighbouring locations to provide a comparative basis for assessing the risk of instability affecting the proposed development. The attached Appendix A defines the terminology adopted for the risk assessment together with a flowchart illustrating the Risk Management Process based on the guidelines given in AGS 2007c (Reference 1).

A summary of our observations is presented in Section 3 below. Our specific recommendations regarding the proposed development are discussed in Section 6, following our geotechnical assessment.

The attached Figure 1 presents our Investigation Location and Geotechnical Mapping Plan showing the principal geotechnical features present at the site. These figures are based on the survey plan prepared by Project Surveyors (Ref: B1570, Drawing No: B1570-1 dated March 2014). Additional features on these figures have been measured by hand held inclinometer and tape measure techniques and hence are only approximate. Should any of the features be critical to the proposed development, we recommend they be located more accurately using instrument survey techniques. Figures 2A and 2B present a typical cross-section through the site based on the survey data augmented by our mapping observations. The mapping symbols used are defined in Figure 3.

2.2 Subsurface Investigation

The subsurface investigation comprised the drilling of three hand augered boreholes, BH1, BH4 and BH5, to depths vary from 0.8m to 0.9m. Six Dynamic Cone Penetration (DCP) tests were completed across the site to refusal at depths ranging from 0.45m and 3.56m. The hand augered boreholes were drilled to identify the soils present, while the DCP tests were used to probe the depth to the underlying bedrock, although it should be noted that the underlying bedrock was neither penetrated nor proved and its depth inferred from the DCP refusal depth. The DCP tests were also used to assess the degree of compaction of the fill and the strength of the natural clays. The strength of the natural clays was also assessed by hand penetrometer tests completed on remoulded samples recovered from the hand auger.

The test locations, as shown on the attached Figure 1, were set out by taped measurements from the apparent site boundaries and surface features, as shown on the survey plan. The reduced levels were interpolated from the spot heights shown on the survey plan and should be considered approximate only. The datum of the levels is Australian Height Datum (AHD).

Groundwater observations were made during and shortly after the drilling of the boreholes. No longer term groundwater monitoring was carried out.

The borehole logs and DCP test results are attached to this report, together with a glossary of the logging terms and symbols used. For more details of the investigation procedures and their limitations, reference should be made to the attached Report Explanation Notes.

3 SUMMARY OF OBSERVATIONS

The site is located on the western side of a hill that drops down steeply from Bilgola Plateau to Pittwater. The site extends across the mid to lower reaches of the slope and runs down to Pittwater over a horizontal length of about 90m. Over this distance the drop in elevation from one end to the other end of the site is about 30m.

The site falls to the south-west at an average slope of about 20°. However, site slopes have been modified in places so that the site steps down to the water through a series of retaining walls and flatter terraces. Running across the upper portion of the site is a private concrete road.

Above the road the gradients are typically in the order of about 20° but range up to 40°. This portion of the site is heavily vegetated and slopes to a dry packed sandstone block retaining wall which marks the eastern side of the private concrete road. Sandstone floaters and outcrops are visible in this portion of the site and it is anticipated that the locally steeper part of this slope represents a predominantly buried cliffline. Beyond the eastern site boundary the site slopes up steeply at about 15-25° through a series of low height sandstone outcrops before increasing in angle to about 40° and running up to the sandstone cliffline located towards the crest of the hill. This cliffline is heavily overgrown and difficult to observe. From what could be observed the bedrock appeared fairly massive, horizontally bedded and of at least low to medium strength. The slope is vegetated with mature trees that generally don't show signs of basal curvature although many of the trees lean downslope.

The dry packed sandstone retaining wall forms the eastern side of the private concrete road which provides access to the properties further to the north. The retaining wall varies in height from about 0.9m to 2.7m and appears in good condition displaying no signs of distress in the form of cracking, bulging or outward rotation. A large boulder, around which the wall has been constructed is located midway along the length of the wall.

From the private concrete road the site then slopes down at between about 5° to 25° to the middle of the site with relatively narrow flatter terraces located between the steeper sections. The first of the two houses located present on the site is located in the upper south-eastern corner of the site. It is a one to two storey clad frame house and is located adjacent to the western side of the private concrete road. Although it is in a dilapidated state it appears to have not suffered any distress as the result of slope instability. An elevated concrete parking platform, similarly adjoining the private concrete road is located just to the north of this house and is in good condition showing no signs of distress. Further to the north of the elevated parking platform is a concrete driveway that slopes down into the site from the road and has a slope of about 20°. To form this driveway some cut and fill has been completed and slopes are locally steeper and range up to about 40° to 50°.

From the private concrete road the site grades down to a levelled area located towards the middle of the site where the second single storey house is located. To form this level area cuts with a maximum depth of about 4.5m have been formed. Over the southern end of these cuts, brick and sandstone block retaining walls have been constructed, although the brick wall has failed further along the excavation and here the cutting has slopes typically in the order of 40°, although in places slope angles range up to about 90°.

The house is timber clad and similarly in a dilapidated condition although there are no signs that the house has suffered damage due to slope instability. To the west of the house is a brick retaining wall that has a maximum height of about 1.4m and has been constructed to allow filling for the building platform. The retaining wall is also in a dilapidated condition showing distress in the form of both cracking and outward rotation, with both the cracking and outward rotation varying up to about 0.1m in width and relative displacement.

From this level building platform the topography then falls to the south-west at an angle of between 30° and 55°. At the base of the slope the site flattens out and runs down to Pittwater at between about 10° and 15°. Along the northern side of the western site boundary runs a rough hewn sandstone block sea wall that has a maximum height of about 0.8m. This sea wall does not run the full length of the boundary and over the southern end and the site simple runs out to the sandy beach.

The site is predominantly unvegetated with the exception weeds and ferns. There are some trees, generally located over the lower portion of the site. Where trees are present in the steep slope located over the lower portion of the site between Pittwater and the building platform at the middle of the site, basal curvature and a downhill slope of the trees was apparent, suggestive of soil creep. In the steep slope immediately above the single storey house a mature gum shows a downward lean and slight curvature of the trunk although it is possible that this a result of it being located at the crest of a locally steeper portion of the slope rather than long term creep and instability of the slope itself. Above the dry packed sandstone retaining wall to the east of the concrete paved private road the site is heavily vegetated, with the trees in this portion of the site generally straight.

To the north the adjoining site has a similar landform to that of the site although greater modification of site slopes has been completed with a series of retaining walls used to terrace the site. A two-storey masonry and clad frame house and suspended concrete pool occupy this property and appeared in good condition when viewed from the site.

The property to the south is located in a gully that drains the hillside above; although along the common boundary the topography is similar to that of the site with the creek located to the south of the adjoining house. The adjoining house is a three storey masonry house that appeared in good condition when viewed from the site. A sandstone block retaining wall that has a maximum height of about 1.8m, appeared in good condition and runs to the north and north-east of the house, providing access for a footpath located just to the south of the common boundary.

To the west the site is bounded by a beach that runs out to Pittwater. Over approximately the northern half of this beach sandstone bedrock is exposed while over the southern half no bedrock outcrops and the sandy beach runs uninterrupted out to Pittwater.

4 SUBSURFACE CONDITIONS

The subsurface investigation revealed topsoil and fill overlying natural silty clays that in turn overlie inferred sandstone bedrock. The fill extended to depths ranging from 0.2m to 0.4m and comprised silty sands and silty clays. Underlying the fill, silty clays were encountered that ranged in plasticity from low to medium-high plasticity and in strength from stiff to hard

The DCP tests refused at depths ranging from 0.45m to 3.56m, although it is believed that DCP 2 and DCP3 prematurely refused on obstructions within the fill. While additional tests were completed in the close vicinity of the original tests at these two locations they too refused at shallow depth. Consequently, excluding the results from DCP2 and DCP3, bedrock is inferred to be present across the proposed building footprint at depths ranging from 1.35m to 3.56m. Sandstone bedrock is outcropping on the beach immediately to the west of the site and above the sandstone block retaining wall at the eastern extremity of the site.

While the sandstone at the eastern region of the site appears to be Hawkesbury Sandstone the Narrabeen Group underlies the Hawkesbury Sandstone and is present at sea level around Pittwater. The Narrabeen Group predominantly comprises sandstone but also contains shale and siltstone bands. Due to its mineralogy it tends to weather faster than Hawkesbury Sandstone resulting in a more deeply weathered, more variable bedrock with generally poor quality bedrock extending for some depth. It also tends to contain high strength ironstone bands that may be underlain by extremely low strength bedrock or clay bands in this upper poorer portion of the bedrock.

No groundwater was encountered during or on completion of drilling of the boreholes.

5 GEOTECHNICAL ASSESSMENT

5.1 Potential Landslide Hazards

We consider that the potential landslide hazards associated with the site to be the following:

A Boulders detaching from the cliffline and rolling downslope,

B Stability of slopes ranging up to 30°,

C Stability of dry packed sandstone block retaining wall on eastern side of concrete paved driveway,

D Stability of locally steeper slopes such as that located behind the house present towards the middle of the site,

E Stability of sandstone block and brick retaining walls located to the west, east and south of the house located towards the middle of the site,

F Stability of the low height sandstone block retaining seawall.

These potential hazards are indicated in schematic form on the attached Figures 2A and 2B.

5.2 Risk Analysis

The existing site is currently unoccupied and the existing buildings in a dilapidated state and ready for demolition. Similarly, while the private concrete paved road runs through the upper portion of the site there are only a couple of properties further to the north of the site and consequently the total time people spend on that portion of the road on the site is minimal. As a result, in its current state the risk posed to both life and property is considered to be tolerable, which is acceptable in accordance with Pittwater Council's policy.

The attached Table A summarises our qualitative assessment of each potential landslide hazard and of the consequences to property for the proposed development should the landslide hazard occur. Use has been made of data in MacGregor *et al* (2007) to assist with our assessment of the likelihood of a potential hazard occurring. Based on the above, the qualitative risks to property have been determined. The terminology adopted for this qualitative assessment is in accordance with Table A1 given in Appendix A. The assessed risk to property for the hazards is "Very Low" or "Low", which is considered acceptable in accordance with the criteria given in Reference 1 and the Pittwater Council Risk Management Policy.

We have also used the indicative probabilities associated with the assessed likelihood of instability to calculate the risk to life. The temporal and vulnerability factors that have been adopted are given in the attached Table B together with the resulting risk calculation. Our assessed risk to life for the person most at risk is about 1×10^{-7} when all hazards are included. This would be considered to be acceptable in relation to the criteria given in Reference 1 and the Pittwater Council Risk Management Policy.

The assessments made above for both risk to property and life assumes that the comments and recommendations provided below in Sections 6 are followed during design, construction and over the life of the proposed development.

5.3 Risk Assessment

The Pittwater Risk Management Policy requires suitable measures 'to remove risk'. It is recognised that, due to the many complex factors that can affect a site, the subjective nature of a risk analysis, and the imprecise nature of the science of geotechnical engineering, the risk of instability for a site and/or development cannot be completely removed. It is, however, essential that risk be reduced to at least that which could be reasonably anticipated by the community in everyday life and that landowners are made aware of reasonable and practical measures available to reduce risk as far as possible. Hence, where the policy requires that 'reasonable and practical measures have been identified to remove risk', it means that there has been an active process of reducing risk, but it does not require the geotechnical engineer to warrant that risk has been completely removed, only reduced, as removing risk is not currently scientifically achievable.

Similarly, the Pittwater Risk Management Policy requires that the design project life be taken as 100 years unless otherwise justified by the applicant. This requirement provides the context within which the geotechnical risk assessment should be made. The required 100 years baseline broadly reflects the expectations of the community for the anticipated life of a residential structure and hence the timeframe to be considered when undertaking the geotechnical risk assessment and making recommendations as to the appropriateness of a development, and its design and remedial measures that should be taken to control risk. It is recognised that in a 100 year period external factors that cannot reasonably be foreseen may affect the geotechnical risks associated with a site. Hence, the Policy does not seek the geotechnical engineer to warrant the development for a 100 year period, rather to provide a professional opinion that foreseeable geotechnical risks to which the development may be subjected in that timeframe have been reasonably considered.

Our assessment of the probability of failure of existing structural elements such as retaining walls (where applicable) is based upon a visual appraisal of their type and condition at the time of our inspection. Where existing structural elements such as retaining walls will not be replaced as part of the proposed development, where appropriate we identify the time period at which reassessment of their longevity seems warranted.

In preparing our recommendations given below we have adopted the above interpretations of the Risk Management Policy requirements. We have also assumed that no activities on surrounding land which may affect the risk on the subject site would be carried out. We have further assumed that all Council's buried services are, and will be regularly maintained to remain, in good condition.

We consider that our risk analysis has shown that the site and existing and proposed development can achieve the 'Acceptable Risk Management' criteria in the Pittwater Risk Management Policy provided that the recommendations given in Section 6 below are adopted. These recommendations form an integral part of the Landslide Risk Management Process.

6 COMMENTS AND RECOMMENDATIONS

The site in its current condition contains some failing retaining walls and over-steep slopes. Provided these hazards are addressed in the design and development of the site the risk posed by the site will be acceptable in accordance with the criteria given in Reference 1 and the Pittwater Council Risk Management Policy. Pittwater Council's Landslide risk Management policy also requires that every reasonable and practicable step be taken to remove risk even if the site is considered to pose an acceptable risk.

Below we have set out the geotechnical design parameters that may be adopted for the proposed development, the geotechnical requirements for the obtaining of a construction certificate, works required during construction and the ongoing maintenance of the site. These recommendations are based on the assumed nature of the proposed alterations and additions as detailed in Section 1. These recommendations will need to be reviewed and an updated report prepared once the details of the proposed alterations and additions have been determined.

6.1 Conditions Recommended to Establish the Design Parameters

6.1.1 The existing failing retaining walls must either be removed, and the slopes regraded to an acceptable angle or the walls must be replaced with engineered retaining walls. Where it is decided to regrade the existing slopes permanent batters through natural silty clays of at least stiff strength should be formed at no steeper than 1 Vertical (V):2 Horizontal (H). These slopes must be protected from erosion by vegetating or by the provision of some type or protective coating such as shotcrete or similar. Where the walls are reconstructed the new walls must be engineered. Advice on the parameters to be adopted for the design of these walls is provided below.

6.1.2 All proposed footings must be founded in the underlying sandstone bedrock. The footings should be designed for an allowable bearing pressure of 600kPa, subject to inspection by a geotechnical engineer prior to pouring. Where excavations are carried out the use of pad or strip footings may be appropriate, but within other areas where rock is not exposed bored piers would be required. Bored piers appear appropriate for use on this site although allowance should be made for the possibility of striking buried boulders, groundwater inflows and some possible instability of the pile shafts. Should footings be required to be installed below sea level, it is possible that large, uncontrolled groundwater inflows may occur. In this instance test piers should be drilled to confirm that they are appropriate for this part of the site prior to their adoption.

6.1.3 Excavation of the overlying soils can be completed using conventional earthmoving equipment such as tracked excavators or similar. Sandstone bedrock of low strength or less is expected to similarly be able to be excavated using tracked excavators with tiger teeth attached to the bucket. Where bedrock of low strength or better is encountered it will represent "hard rock" excavation conditions. Hard rock excavation techniques typically comprise percussive excavation methods using rock hammers. Where percussive excavation techniques (ie rock hammers) are adopted periodic or continuous vibration monitoring must be carried out. The ground vibration measured as peak particle velocity must not exceed 5mm/sec at the nearby movement sensitive structures. Consideration should also be given completing dilapidation surveys on the adjoining properties, in particular the house to the south. The purpose of these dilapidation reports is to record the condition of the structure prior to the commencement of the works. In this way should a claim be made that the construction works on site have resulted in damage to the structure a record of the baseline condition of the adjoining property is available to test the veracity of the claim. In this way the builder is protected from spurious claims.

6.1.4 Subject to inspection by a geotechnical engineer temporary batters for any proposed excavations should be no steeper than 1 Vertical (V) in 1 Horizontal (H) within the soil profile and extremely weathered rock and vertical in competent rock. While it may be possible to form vertical cuts through the underlying bedrock our experience in this area is that the bedrock is generally quite fractured and jointed and requires support. Consequently, we recommend that the structural design allow for the installation of piles to below bulk excavation level rather than assume that the bedrock will be competent and can be cut vertically and left unsupported. It is likely that powerful piling rigs will be required to penetrate the underlying bedrock in the vicinity of the 7m deep excavation and that a pendulum attachment on an excavator is unlikely to be suitable. Whilst additional costs may be incurred in the piling we feel that it will lead to savings during construction as the program will not need to be halted to allow for remedial stabilisation measures. To gain a better understanding of the quality of the bedrock in the vicinity of the 7m deep cut we recommend that a number of cored boreholes be completed. All surcharge and footing loads must be kept well clear of the excavation perimeter. Where adversely inclined joints are exposed in the cut faces all footing loads located behind the retaining wall must be extended to below these adversely orientated joints.

6.1.5 Where the required batters cannot be accommodated within the site geometry, or where not preferred, a retention system will be required and should be installed prior to excavation commencing. We recommend the retention system comprise a cantilevered soldier pile wall (provided excavation depths do not exceed 3m) with reinforced shotcrete infill panels. The infill panels must be progressively installed as excavation proceeds (i.e. at maximum 1.8m depth intervals). Where excavation depths are greater than 3m or where high surcharge loads are present at the crest of the retention system, an anchored retaining wall rather than a cantilevered retaining wall will be required. Particularly where there are steep slopes it may be more economical to anchor the walls than use large piles with long rock sockets as would be required for a cantilevered design.

6.1.6 Where anchors are to run below adjoining properties permission from the owners must be obtained before installation.

6.1.7 The surface water discharging from the new roof and paved areas must be diverted to outlets for controlled discharge to Pittwater. In addition, a dish drain or similar must be installed on the western side of the private concrete road to collect all runoff flowing across the road and prevent it from flowing down the site. This collected runoff should similarly be piped to Pittwater for controlled discharge.

6.1.8 The proposed new retaining walls should be designed using the following parameters:

- For cantilever walls, adopt a triangular lateral earth pressure distribution and an 'active' earth pressure coefficient, K_a, of 0.35, for the retained height, assuming a horizontal backfill surface.
- For anchored walls, adopt a trapezoidal pressure distribution of 6H kPa (where H is the retained height in meters) which is uniform over the middle 50% of the distribution and linearly decreases to zero over the top and bottom 25% of the distribution.
- A bulk unit weight of $20kN/m^3$ should be adopted for the soil profile and $24kN/m^3$ for the sandstone profile.
- Any surcharge loads affecting the walls (e.g. sloping backfill (as is the case for this site), traffic loading, live loading, compaction stresses, etc) should be added to the above pressures in the design.
- The retaining walls should be provided with complete and permanent drainage of the ground behind the walls. The subsoil drains should incorporate a non-woven geotextile fabric (eg. Bidim A34), to act as a filter against subsoil erosion.
- Toe resistance of the wall may be achieved by keying the footing into bedrock. An allowable lateral stress of 200kPa may be adopted for design.

6.1.9 The guidelines for Hillside Construction given in Appendix B should also be adopted.

6.2 Conditions Recommended to the Detailed Design to be Undertaken for the Construction Certificate

6.2.1 All structural design drawings must be reviewed by the geotechnical engineer who should endorse that the recommendations contained in this report have been adopted in principle.

6.2.2 All hydraulic design drawings must be reviewed by the geotechnical engineer who should endorse that the recommendations contained in this report have been adopted in principle.

6.2.3 All landscape design drawings must be reviewed by the geotechnical engineer who should endorse that the recommendations contained in this report have been adopted in principle

6.2.4 Depending on the nature of the proposed works dilapidation surveys may be required. Where required, a copy of the dilapidation report must be provided to the neighbours and Council or the Principle Certifying Authority.

6.2.5 An excavation/retention methodology may need to be prepared prior to bulk excavation commencing. The methodology must include but not be limited to proposed excavation techniques, the proposed excavation equipment, excavation sequencing, geotechnical inspection intervals or hold points, vibration monitoring procedures, monitor locations, monitor types, contingency plans in case of exceedances.

6.2.6 The excavation/retention methodology must be reviewed and approved by the geotechnical engineer.

6.3 Conditions Recommended During the Construction Period

6.3.1 The geotechnical engineer must inspect all footing excavations prior to placing reinforcement or pouring the concrete.

6.3.2 If required, the approved excavation/retention methodology must be followed.

6.3.3. Where material is to be used for backfilling behind retaining walls it must be approved by the geotechnical engineer prior to placement.

6.3.4 Compaction density of the backfill material must be checked by a NATA registered laboratory to at least Level 2 in accordance with, and to the frequency outlined in, AS3798, and the results submitted to the geotechnical engineer.

6.3.5 If they are to be retained, the existing stormwater system, sewer and water mains must be checked for leaks by using static head and pressure tests under the direction of the hydraulic engineer or architect, and repaired if found to be leaking.

6.3.6 The geotechnical engineer must inspect all subsurface drains prior to backfilling.

6.3.7 An 'as-built' drawing of all buried services at the site must be prepared (including all pipe diameters, pipe depths, pipe types, inlet pits, inspection pits, etc).

6.3.8 Where used, all anchors must be proof-tested to 1.3 times the working load. In addition, the anchors must be subjected to lift-off testing no sooner than 24 hours after locking off at the working load. The proof-testing and lift-off tests must be witnessed by the geotechnical engineer. The anchor contractor must provide the geotechnical engineer with all field records including anchor installation and testing records.

6.3.9 The geotechnical engineer must confirm that the proposed alterations and additions have been completed in accordance with the geotechnical reports.

We note that all above Conditions must be complied with during construction. Where this has not been done it may not be possible for Form 3, which is required for the Occupation Certificate, to be signed.

6.4 Conditions Recommended for Ongoing Management of the Site/Structure(s)

The following recommendations have been included so that the current and future owners of the subject property are aware of their responsibilities:

6.4.1 All existing and proposed surface (including roof) and subsurface drains must be subject to ongoing and regular maintenance by the property owners. In addition, such maintenance must also be carried out by a plumber at no more than ten yearly intervals; including provision of a written report confirming scope of work completed (with reference to the 'as-built' drawing) and identifying any required remedial measures.

6.4.2 No cut or fill in excess of 0.5m (e.g. for landscaping, buried pipes, retaining walls, etc), is to be carried out on site without prior consent from Pittwater Council.

6.4.3 Where the structural engineer has indicated a design life of less than 100 years then the structure and/or structural elements must be inspected by a structural engineer at the end of their design life; including a written report confirming scope of work completed and identifying the required remedial measures to extend the design life over the remaining 100 year period.

7 OVERVIEW

We consider that the proposed development can be completed on the site achieving acceptable risk in accordance with Pittwater Council's policy provided the above comments and recommendations are followed. In particular, the proposed development must include measures to support the over-steep slopes and failing sandstone block retaining walls.

The subsurface soil, rock or groundwater conditions encountered during construction may be found to be different (or may be interpreted to be different) from those inferred from our surface observations in preparing this report. Also, we have not had the opportunity to observe surface run-off patterns during heavy rainfall and cannot comment directly on this aspect. If conditions appear to be at variance or cause concern for any reason, then we recommend that you immediately contact this office.

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. 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.

Reference 1: Australian Geomechanics Society (2007c) *'Practice Note Guidelines for Landslide Risk Management'*, Australian Geomechanics, Vol 42, No 1, March 2007, pp63-114.

Reference 2: MacGregor, P, Walker, B, Fell, R, and Leventhal, A (2007) *'Assessment of Landslide Likelihood in the Pittwater Local Government Area'*, Australian Geomechanics, Vol 42, No 1, March 2007, pp183-196.

TABLE A
SUMMARY OF RISK ASSESSMENT TO PROPERTY

POTENTIAL LANDSLIDE HAZARD	A	B	C	D	E	F
	Boulders detaching from the cliffline and rolling downslope	Stability of slopes ranging up to 30°	Stability of dry packed sandstone block retaining wall on eastern side of concrete paved driveway	Stability of locally steeper slopes such as that located behind the house located towards the middle of the site	Stability of sandstone block and brick retaining walls located to the west, east and south of the house located towards the middle of the site	Stability of the low height sandstone block retaining seawall
Assessed Likelihood	Unlikely	Possible	Possible	Barely Credible	Barely Credible	Barely Credible
Assessed Consequences	Medium	Insignificant	Insignificant	Minor	Minor	Insignificant
Risk	Low	Very Low	Very Low	Very Low	Very Low	Very Low
Comments	Above the site all floaters are well embedded and have typically not reached the site after detaching and falling from the cliff faces above.	No signs of slope instability.	Retaining wall appears in good condition and has been in place for many years.	These slopes will be engineered or retained.	These walls will be engineered retaining walls.	Failure of this wall will result in minimal property damage.

TABLE B
SUMMARY OF RISK ASSESSMENT TO LIFE

POTENTIAL LANDSLIDE HAZARD	A	B	C	D	E	F
	Boulders detaching from the cliffline and rolling downslope	Stability of slopes ranging up to 30°	Stability of dry packed sandstone block retaining wall on eastern side of concrete paved driveway	Stability of locally steeper slopes such as that located behind the house located towards the middle of the site	Stability of sandstone block and brick retaining walls located to the west, east and south of the house located towards the middle of the site	Stability of the low height sandstone block retaining seawall
Assessed Likelihood	Unlikely	Possible	Possible	Barely Credible (engineered slope or retaining wall)	Barely Credible (engineered slope or retaining walls)	Barely Credible (engineered retaining walls or slope)
Indicative Annual Probability	1×10^{-4}	1×10^{-3}	1×10^{-3}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Duration of Use of Area Affected (Temporal Probability)	(i) Outside of the house 1.75 minutes/day 1.2×10^{-3} (ii) Inside the house 2.5 minutes/day 1.725×10^{-3}	5 minutes/day 3.47×10^{-3}	(i) Above wall 5 minutes/month - 2.89×10^{-4} (ii) Below wall 5 minute/day – 3.47×10^{-3}	10 minutes/day 6.94×10^{-3}	(i) Above wall 5 minutes/day - 3.47×10^{-3} (ii) Below wall 5 minute/day – 3.47×10^{-3}	5 minutes/week 4.96×10^{-4}
Probability of Not Evacuating Area Affected	(i) 0.1 likely to have warning (ii) 1.0 unlikely to have any warning	0.01	(i) 0.1 (ii) 0.1	0.5	(i) 0.1 (ii) 0.1	0.01
Vulnerability to Life if Failure Occurs Whilst Person Present	(i) 0.5 (ii) 1.0	0.01	(i) and (ii) 0.05 unlikely to be buried	0.1 unlikely to be buried	(i) and (ii) 0.1 unlikely to be buried	0.01 unlikely to be buried
Risk to Person Most at Risk	(i) 6×10^{-9} (ii) 1.725×10^{-7}	3.47×10^{-10}	(i) 1.445×10^{-9} (ii) 1.735×10^{-8}	3.47×10^{-10}	(i) & (ii) 3.47×10^{-11}	4.96×10^{-14}
Total Risk to Person Most at Risk	1.8×10^{-7}					

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BOREHOLE LOG

Borehole No.
1

Client: J GROUP PROJECTS
Project: PROPOSED HOUSE
Location: 172-174 PRINCE ALFRED PARADE, NEWPORT, NSW

Job No. 27333SY
Date: 26-3-14
Method: HAND AUGER
Logged/Checked by: D.F./W.T.
R.L. Surface: 4.0m
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
DRY ON COMPLETION					REFER TO DCP TEST RESULTS	0			FILL: Silty clay topsoil, low plasticity, dark brown, trace of roots.	MC PL			GRASS COVER APPEARS POORLY COMPACTED
								CL	SILTY CLAY: low plasticity, light brown and orange brown, with fine to coarse grained sand.	MC>PL	St-VSt		RESIDUAL
						0.5			SILTY CLAY: medium plasticity, grey and brown, trace of fine to coarse grained sand.		VSt-H		
									END OF BOREHOLE AT 0.8m				HAND AUGER REFUSAL
						1							
						1.5							
						2							
						2.5							
						3							
						3.5							

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BOREHOLE LOG

Borehole No.
4
1/1

Client: J GROUP PROJECTS
Project: PROPOSED HOUSE
Location: 172-174 PRINCE ALFRED PARADE, NEWPORT, NSW

Job No. 27333SY **Method:** HAND AUGER **R.L. Surface:** ≈ 16.5m
Date: 26-3-14 **Datum:** AHD
Logged/Checked by: D.F./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
DRY ON COMPLET-ION					REFER TO DCP TEST RESULTS	0			FILL: Silty clay topsoil, low to medium plasticity, dark brown, trace of fine to medium grained sand.	MC≈PL			MOSS COVER APPEARS POORLY COMPACTED
						0.5		CH	SILTY CLAY: high plasticity, light brown and orange brown, trace of ironstone gravel.	MC>PL	H		RESIDUAL
									as above, but light grey mottled orange brown.				
						1			END OF BOREHOLE AT 0.9m				HAND AUGER REFUSAL AT 0.5m AND 0.9m ON SECOND ATTEMPT
						1.5							
						2							
						2.5							
						3							
						3.5							

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BOREHOLE LOG

Borehole No.
5
1/1

Client: J GROUP PROJECTS
Project: PROPOSED HOUSE
Location: 172-174 PRINCE ALFRED PARADE, NEWPORT, NSW

Job No. 27333SY **Method:** HAND AUGER **R.L. Surface:** ≈ 22.6m
Date: 26-3-14 **Datum:** AHD
Logged/Checked by: D.F./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
DRY ON COMPLETION					REFER TO DCP TEST RESULTS	0			FILL: Silty sand topsoil, fine to medium grained, dark brown.	M			MULCH COVER
								CL	SILTY CLAY: low to medium plasticity, brown.	MC>PL	VSt-H		RESIDUAL
						0.5		CH	SILTY CLAY: high plasticity, red brown and orange brown, trace of ironstone gravel.				
									as above, but light brown and orange brown.			370 340 300	
						1			END OF BOREHOLE AT 0.9m				HAND AUGER REFUSAL AT 0.5m AND 0.9m ON SECOND ATTEMPT
						1.5							
						2							
						2.5							
						3							
						3.5							

JK [redacted]

GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

[redacted]

[redacted]
[redacted]

Remarks:

1. The procedure used for this test is similar to that described in AS1289.6.3.2-1997, Method 6.3.2.
2. Usually 8 blows per 20mm is taken as refusal
3. Survey datum is AHD

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

DYNAMIC CONE PENETRATION TEST RESULTS

Client:	J GROUP PROJECTS		
Project:	PROPOSED HOUSE		
Location:	172-174 PRINCE ALFRED PARADE, NEWPORT, NSW		
Job No.	27333SY	Hammer Weight & Drop: 9kg/510mm	
Date:	26-3-14	Rod Diameter: 16mm	
Tested By:	D.F	Point Diameter: 20mm	

Number of Blows per 100mm Penetration

Test Location	RL ~	RL ~22.6m	RL ~26.1m	Test Location			
Depth (mm)	**4**	**5**	**6**	Depth (mm)	**4**		
0 - 100	2	1	2	3000-3100	17		
100 - 200	2	1	3	3100-3200	20		
200 - 300	1	3	2	3200-3300	14		
300 - 400	4	3	2	3300-3400	21		
400 - 500	9	10	3	3400-3500	21		
500 - 600	4	5	3	3500-3600	20/60mm		
600 - 700	6	5	4	3600-3700	REFUSAL		
700 - 800	6	7	3	3700-3800			
800 - 900	5	13	4	3800-3900			
900 - 1000	5	7	4	3900-4000			
1000 - 1100	7	12	3	4000-4100			
1100 - 1200	9	17	2	4100-4200			
1200 - 1300	10	13/50mm	5	4200-4300			
1300 - 1400	11	REFUSAL	3	4300-4400			
1400 - 1500	7		2	4400-4500			
1500 - 1600	8		3	4500-4600			
1600 - 1700	9		6	4600-4700			
1700 - 1800	6		16	4700-4800			
1800 - 1900	8		14/70mm	4800-4900			
1900 - 2000	7		REFUSAL	4900-5000			
2000 - 2100	15			5000-5100			
2100 - 2200	17			5100-5200			
2200 - 2300	13			5200-5300			
2300 - 2400	12			5300-5400			
2400 - 2500	12			5400-5500			
2500 - 2600	14			5500-5600			
2600 - 2700	15			5600-5700			
2700 - 2800	16			5700-5800			
2800 - 2900	21			5800-5900			
2900 - 3000	14			5900-6000			

Remarks:
1. The procedure used for this test is similar to that described in AS1289.6.3.2-1997, Method 6.3.2.
2. Usually 8 blows per 20mm is taken as refusal
3. Survey datum is AHD

INVESTIGATION LOCATION AND GEOTECHNICAL MAPPING PLAN

JK Geotechnics
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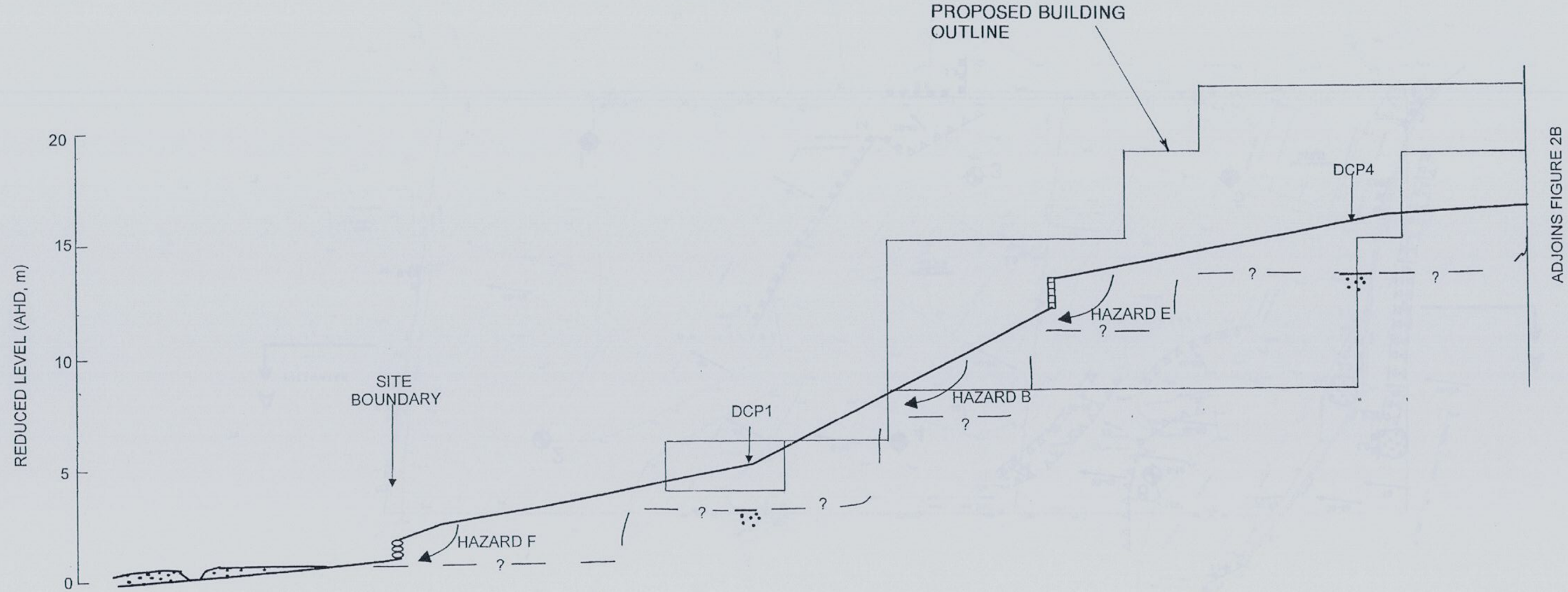
Report No. 27333SY Figure No. 1



SECTION A-A

SCALE (m)
0 10

JK Geotechnics
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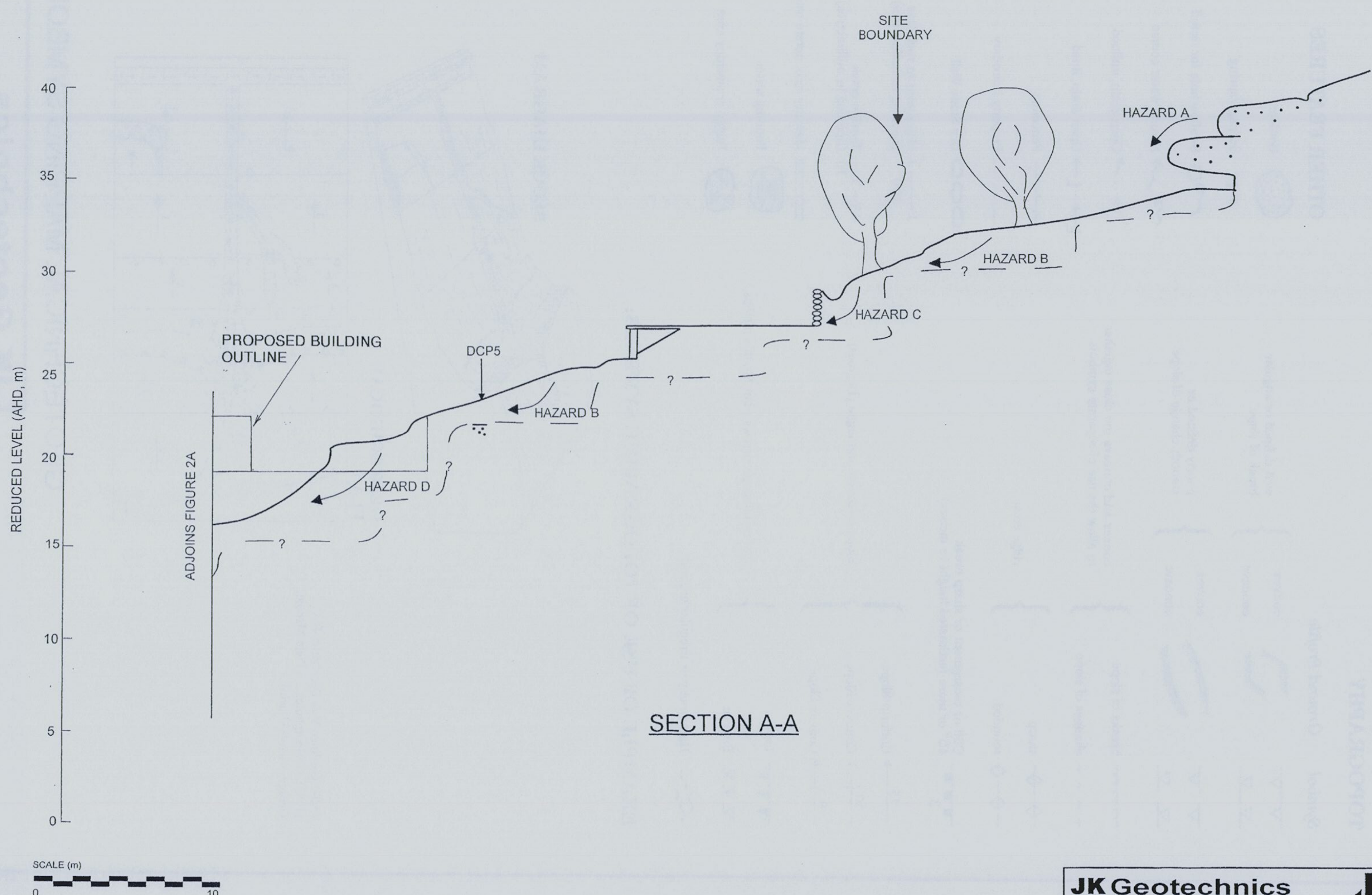
Report No. 27333SY Figure No. 2A



SECTION A-A

JK Geotechnics
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Report No. 27333SY Figure No. 2B

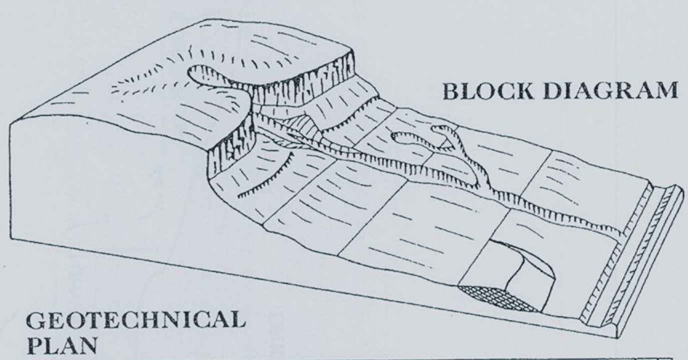
TOPOGRAPHY

Symbol	*Ground Profile*		
		convex concave	well defined or angular break of slope
		convex concave	poorly defined or smooth change of slope
breaks of slope changes of slope			convex and concave too close together to allow the use of separate symbols
sharp rounded			ridge crest
3	Cliff or escarpment or sharp break 40° or more (estimated height in metres)		
15 Uniform Slope 10 Concave Slope 8 Convex Slope			Slope direction and angle (Degrees)
Top Bottom			Cut or fill slope, arrows pointing down slope
Hummocky or irregular ground			

OTHER FEATURES

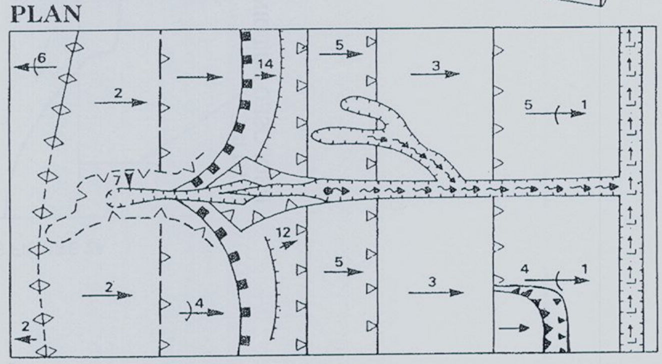
- Boulder
- Seepage/spring
- Swallow hole for runoff
- Natural water course
- Open drain, unlined
- Open drain, lined
- Fenceline
- Property boundary
- Dry Stone Wall
- J —— J Major joint in rock face; 200 (opening in millimetres)
- – T – T – Tension crack; 10 (opening in millimetres)
- Masonry or concrete wall
- Ponding water
- Boggy or swampy area

EXAMPLE OF USE OF TOPOGRAPHIC SYMBOLS:



BLOCK DIAGRAM

GEOTECHNICAL PLAN



(After Gardiner, V & Dackombe, R.V. (1983), Geomorphological Field Manual; George Allen & Unwin).

GEOTECHNICAL MAPPING SYMBOLS

JK Geotechnics
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Report No. 27190BY Figure No. 3

APPENDIX A

LANDSLIDE RISK

MANAGEMENT

TERMINOLOGY

APPENDIX A
LANDSLIDE RISK MANAGEMENT

Definition of Terms and Landslide Risk

Risk Terminology	Description
Acceptable Risk	A risk for which, for the purposes of life or work, we are prepared to accept as it is with no regard to its management. Society does not generally consider expenditure in further reducing such risks justifiable.
Annual Exceedance Probability (AEP)	The estimated probability that an event of specified magnitude will be exceeded in any year.
Consequence	The outcomes or potential outcomes arising from the occurrence of a landslide expressed qualitatively or quantitatively, in terms of loss, disadvantage or gain, damage, injury or loss of life.
Elements at Risk	The population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by landslides.
Frequency	A measure of likelihood expressed as the number of occurrences of an event in a given time. See also 'Likelihood' and 'Probability'.
Hazard	A condition with the potential for causing an undesirable consequence (the landslide). The description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the likelihood of their occurrence within a given period of time.
Individual Risk to Life	The risk of fatality or injury to any identifiable (named) individual who lives within the zone impacted by the landslide; or who follows a particular pattern of life that might subject him or her to the consequences of the landslide.
Landslide Activity	The stage of development of a landslide; pre failure when the slope is strained throughout but is essentially intact; failure characterised by the formation of a continuous surface of rupture; post failure which includes movement from just after failure to when it essentially stops; and reactivation when the slope slides along one or several pre-existing surfaces of rupture. Reactivation may be occasional (eg. seasonal) or continuous (in which case the slide is 'active').
Landslide Intensity	A set of spatially distributed parameters related to the destructive power of a landslide. The parameters may be described quantitatively or qualitatively and may include maximum movement velocity, total displacement, differential displacement, depth of the moving mass, peak discharge per unit width, or kinetic energy per unit area.
Landslide Risk	The AGS Australian GeoGuide LR7 (AGS, 2007e) should be referred to for an explanation of Landslide Risk.
Landslide Susceptibility	The classification, and volume (or area) of landslides which exist or potentially may occur in an area or may travel or retrogress onto it. Susceptibility may also include a description of the velocity and intensity of the existing or potential landsliding.
Likelihood	Used as a qualitative description of probability or frequency.
Probability	A measure of the degree of certainty. This measure has a value between zero (impossibility) and 1.0 (certainty). It is an estimate of the likelihood of the magnitude of the uncertain quantity, or the likelihood of the occurrence of the uncertain future event. These are two main interpretations: (i) Statistical – frequency or fraction – The outcome of a repetitive experiment of some kind like flipping coins. It includes also the idea of population variability. Such a number is called an 'objective' or relative frequentist probability because it exists in the real world and is in principle measurable by doing the experiment.

Risk Terminology	Description
Probability *(continued)*	(ii) Subjective probability (degree of belief) – Quantified measure of belief, judgment, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias. Subjective probability is affected by the state of understanding of a process, judgment regarding an evaluation, or the quality and quantity of information. It may change over time as the state of knowledge changes.
Qualitative Risk Analysis	An analysis which uses word form, descriptive or numeric rating scales to describe the magnitude of potential consequences and the likelihood that those consequences will occur.
Quantitative Risk Analysis	An analysis based on numerical values of the probability, vulnerability and consequences and resulting in a numerical value of the risk.
Risk	A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability x consequences. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form.
Risk Analysis	The use of available information to estimate the risk to individual, population, property, or the environment, from hazards. Risk analyses generally contain the following steps: scope definition, hazard identification and risk estimation.
Risk Assessment	The process of risk analysis and risk evaluation.
Risk Control or Risk Treatment	The process of decision-making for managing risk and the implementation or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.
Risk Estimation	The process used to produce a measure of the level of health, property or environmental risks being analysed. Risk estimation contains the following steps: frequency analysis, consequence analysis and their integration.
Risk Evaluation	The stage at which values and judgments enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental and economic consequences, in order to identify a range of alternatives for managing the risks.
Risk Management	The complete process of risk assessment and risk control (or risk treatment).
Societal Risk	The risk of multiple fatalities or injuries in society as a whole: one where society would have to carry the burden of a landslide causing a number of deaths, injuries, financial, environmental and other losses.
Susceptibility	See 'Landslide Susceptibility'.
Temporal Spatial Probability	The probability that the element at risk is in the area affected by the landsliding, at the time of the landslide.
Tolerable Risk	A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.
Vulnerability	The degree of loss to a given element or set of elements within the area affected by the landslide hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons, it will be the probability that a particular life (the element at risk) will be lost, given the person(s) is affected by the landslide.

NOTE: Reference should be made to Figure A1 which shows the inter-relationship of many of these terms and the relevant portion of Landslide Risk Management.

Reference should also be made to the paper referenced below for Landslide Terminology and more detailed discussion of the above terminology.

This appendix is an extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

Ref: Appendix A – Figure A1 Flowchart for Landslide Risk Management

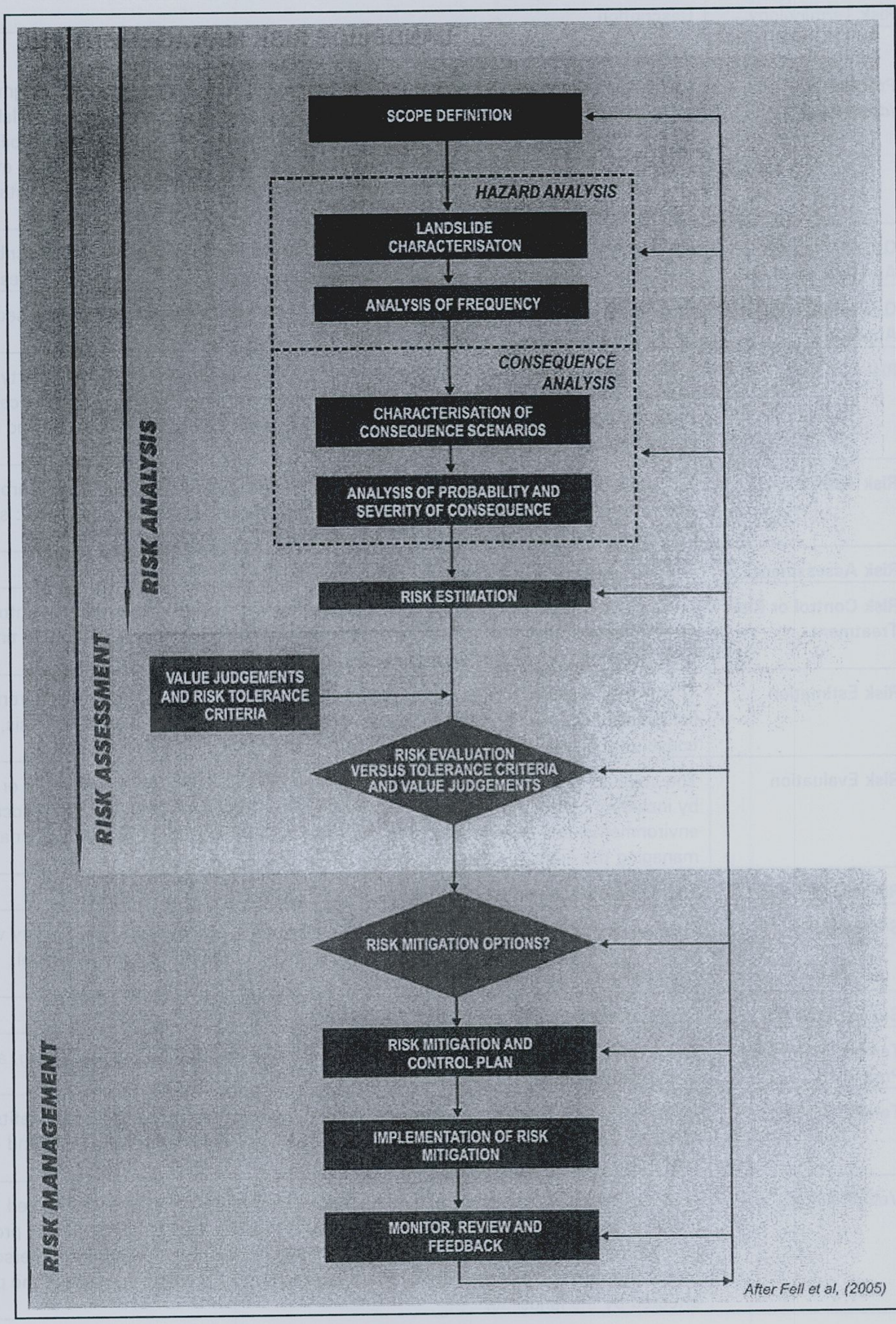


FIGURE A1: Flowchart for Landslide Risk Management.

This figure is an extract from GUIDELINE FOR LANDSLIDE SUSCEPTIBILITY, HAZARD AND RISK ZONING FOR LAND USE PLANNING, as presented in Australian Geomechanics Vol 42, No 1, March 2007, which discusses the matter more fully.

TABLE A1: LANDSLIDE RISK ASSESSMENT
QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa.

Extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

TABLE A1: LANDSLIDE RISK ASSESSMENT
QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (continued)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) Cell A5 may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

AUSTRALIAN GEOGUIDE LR2 (LANDSLIDES)

What is a Landslide?

Any movement of a mass of rock, debris, or earth, down a slope, constitutes a "landslide". Landslides take many forms, some of which are illustrated. More information can be obtained from Geoscience Australia, or by visiting its Australian landslide Database at www.ga.gov.au/urban/factsheets/landslide.jsp. Aspects of the impact of landslides on buildings are dealt with in the book "Guideline Document Landslide Hazards" published by the Australian Building Codes Board and referenced in the Building Code of Australia. This document can be purchased over the internet at the Australian Building Codes Board's website www.abcb.gov.au.

Landslides vary in size. They can be small and localised or very large, sometimes extending for kilometres and involving millions of tonnes of soil or rock. It is important to realise that even a 1 cubic metre boulder of soil, or rock, weighs at least 2 tonnes. If it falls, or slides, it is large enough to kill a person, crush a car, or cause serious structural damage to a house. The material in a landslide may travel downhill well beyond the point where the failure first occurred, leaving destruction in its wake. It may also leave an unstable slope in the ground behind it, which has the potential to fall again, causing the landslide to extend (regress) uphill, or expand sideways. For all these reasons, both "potential" and "actual" landslides must be taken very seriously. The present a real threat to life and property and require proper management.

Identification of landslide risk is a complex task and must be undertaken by a geotechnical practitioner (GeoGuide LR1) with specialist experience in slope stability assessment and slope stabilisation.

What Causes a Landslide?

Landslides occur as a result of local geological and groundwater conditions, but can be exacerbated by inappropriate development (GeoGuide LR8), exceptional weather, earthquakes and other factors. Some slopes and cliffs never seem to change, but are actually on the verge of failing. Others, often moderate slopes (Table 1), move continuously, but so slowly that it is not apparent to a casual observer. In both cases, small changes in conditions can trigger a landslide with series consequences. Wetting up of the ground (which may involve a rise in groundwater table) is the single most important cause of landslides (GeoGuide LR5). This is why they often occur during, or soon after, heavy rain. Inappropriate development often results in small scale landslides which are very expensive in human terms because of the proximity of housing and people.

Does a Landslide Affect You?

Any slope, cliff, cutting, or fill embankment may be a hazard which has the potential to impact on people, property, roads and services. Some tell-tale signs that might indicate that a landslide is occurring are listed below:

- Open cracks, or steps, along contours
- Groundwater seepage, or springs
- Bulging in the lower part of the slope
- Hummocky ground
- trees leaning down slope, or with exposed roots
- debris/fallen rocks at the foot of a cliff
- tilted power poles, or fences
- cracked or distorted structures

These indications of instability may be seen on almost any slope and are not necessarily confined to the steeper ones (Table 1). Advice should be sought from a geotechnical practitioner if any of them are observed. Landslides do not respect property boundaries. As mentioned above they can "run-out" from above, "regress" from below, or expand sideways, so a landslide hazard affecting your property may actually exist on someone else's land.

Local councils are usually aware of slope instability problems within their jurisdiction and often have specific development and maintenance requirements. **Your local council is the first place to make enquiries if you are responsible for any sort of development or own or occupy property on or near sloping land or a cliff.**

TABLE 1 – Slope Descriptions

Appearance	Slope Angle	Maximum Gradient	Slope Characteristics
Gentle	0° - 10°	1 on 6	Easy walking.
Moderate	10° - 18°	1 on 3	Walkable. Can drive and manoeuvre a car on driveway.
Steep	18° - 27°	1 on 2	Walkable with effort. Possible to drive straight up or down roughened concrete driveway, but cannot practically manoeuvre a car.
Very Steep	27° - 45°	1 on 1	Can only climb slope by clutching at vegetation, rocks, etc.
Extreme	45° - 64°	1 on 0.5	Need rope access to climb slope.
Cliff	64° - 84°	1 on 0.1	Appears vertical. Can abseil down.
Vertical or Overhang	84° - 90±°	Infinite	Appears to overhang. Abseiler likely to lose contact with the face.

Some typical landslides which could affect residential housing are illustrated below:

Rotational or circular slip failures (Figure 1) - can occur on moderate to very steep soil and weathered rock slopes (Table 1). The sliding surface of the moving mass tends to be deep seated. Tension cracks may open at the top of the slope and bulging may occur at the toe. The ground may move in discrete "steps" separated by long periods without movement. More rapid movement may occur after heavy rain.

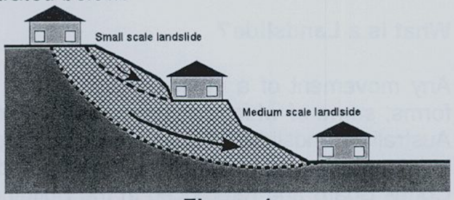


Figure 1

Translational slip failures (Figure 2) - tend to occur on moderate to very steep slopes (Table 1) where soil, or weak rock, overlies stronger strata. The sliding mass is often relatively shallow. It can move, or deform slowly (creep) over long periods of time. Extensive linear cracks and hummocks sometimes form along the contours. The sliding mass may accelerate after heavy rain.

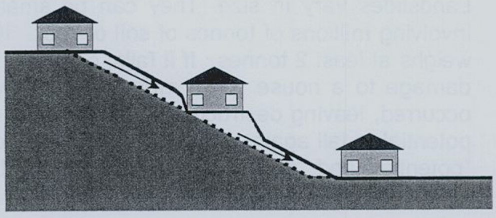


Figure 2

Wedge failures (Figure 3) - normally only occur on extreme slopes, or cliffs (Table 1), where discontinuities in the rock are inclined steeply downwards out of the face.

Rock falls (Figure 3) - tend to occur from cliffs and overhangs (Table 1).

Cliffs may remain, apparently unchanged, for hundreds of years. Collections of boulders at the foot of a cliff may indicate that rock falls are ongoing. Wedge failures and rock falls do not "creep". Familiarity with a particular local situation can instil a false sense of security since failure, when it occurs, is usually sudden and catastrophic.

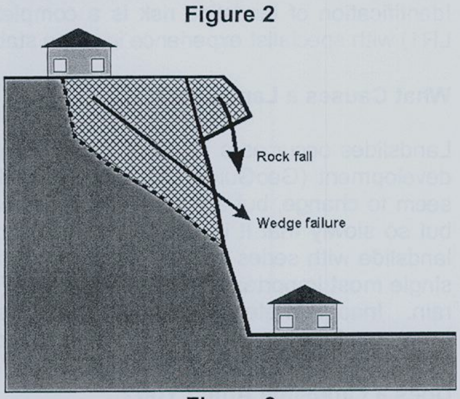


Figure 3

Debris flows and mud slides (Figure 4) - may occur in the foothills of ranges, where erosion has formed valleys which slope down to the plains below. The valley bottoms are often lined with loose eroded material (debris) which can "flow" if it becomes saturated during and after heavy rain. Debris flows are likely to occur with little warning; they travel a long way and often involve large volumes of soil. The consequences can be devastating.

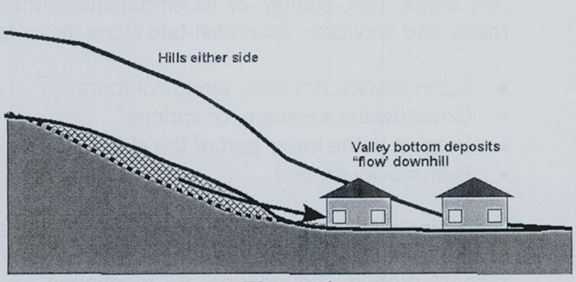


Figure 4

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR3 - Soil Slopes
- GeoGuide LR4 - Rock Slopes
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR8 - Hillside Construction
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)

Concept of Risk

Risk is a familiar term, but what does it really mean? It can be defined as *"a measure of the probability and severity of an adverse effect to health, property, or the environment."* This definition may seem a bit complicated. In relation to landslides, geotechnical practitioners (see GeoGuide LR1) are required to assess risk in terms of the likelihood that a particular landslide will occur and the possible consequences. This is called landslide risk assessment. The consequences of a landslide are many and varied, but our concerns normally focus on loss of, or damage to, property and loss of life.

Landslide Risk Assessment

Some local councils in Australia are aware of the potential for landslides within their jurisdiction and have responded by designating specific "landslide hazard zones". Development in these areas is normally covered by special regulations. If you are contemplating building, or buying an existing house, particularly in a hilly area, or near cliffs, then go first for information to your local council. If you have any concern that you could be dealing with a landslide hazard that your local council is not aware of you should seek advice from a geotechnical practitioner.

Landslide risk assessment must be undertaken by a geotechnical practitioner. It may involve visual inspection, geological mapping, geotechnical investigation and monitoring to identify:

- potential landslides (there may be more than one that could impact on your site);
- the likelihood that they will occur;
- the damage that could result;
- the cost of disruption and repairs; and
- the extent to which lives could be lost.

Risk assessment is a predictive exercise, but since the ground and the processes involved are complex, prediction inevitably lacks precision. If you commission a landslide risk assessment for a particular site you should expect to receive a report prepared in accordance with current professional guidelines and in a form that is acceptable to your local council, or planning authority.

Risk to Property

Table 1 indicates the terms used to describe risk to property. Each risk level depends on an assessment of how likely a landslide is to occur and its consequences in dollar terms. Likelihood is the chance of it happening in any one year, as indicated in Table 2. Consequences are related to the cost of the repairs and perhaps temporary loss of use. These two factors are combined by the geotechnical practitioner to determine the Qualitative Risk.

TABLE 1 – RISK TO PROPERTY

Qualitative Risk		Significance - Geotechnical engineering requirements
Very high	VH	**Unacceptable** without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low. May be too expensive and not practical. Work likely to cost more than the value of the property.
High	H	**Unacceptable** without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable level. Work would cost a substantial sum in relation to the value of the property.
Moderate	M	**May be tolerated** in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as possible.
Low	L	**Usually acceptable** to regulators. Where treatment has been needed to reduce the risk to this level, ongoing maintenance is required.
Very Low	VL	**Acceptable**. Manage by normal slope maintenance procedures.

TABLE 2 – LIKELIHOOD

Likelihood	Annual Probability
Almost Certain	1:10
Likely	1:100
Possible	1:1,000
Unlikely	1:10,000
Rare	1:100,000
Barely credible	1:1,000,000

The terms "unacceptable", "tolerable" etc. in Table 1 indicate how most people react to an assessed risk level. However, some people will always be more prepared, or better able, to tolerate a higher risk level than others. Some local councils and planning authorities stipulate a maximum tolerable risk level. This may be lower than you feel is reasonable for your block but it is, nonetheless, a pre-requisite for development. Reasons for this include the fact that a landslide on your block may pose a risk to neighbours and passers-by and that , should you sell, subsequent owners of the block may be more risk averse than you.

Risk to Life

Most of us have some difficulty grappling with the concept of risk and deciding whether, or not, we are prepared to accept it. However, without doing any sort of analysis, or commissioning a report from an "expert", we all take risks every day. One of them is the risk of being killed in an accident. This is worth thinking about, because it tells us a lot about ourselves and can help to put an assessed risk into a meaningful context. By identifying activities that we either are, or are not, prepared to engage in, we can get some indication of the maximum level of risk that we are prepared to take. This knowledge can help us to decide whether we really are able to accept a particular risk, or to tolerate a particular likelihood of loss, or damage, to our property (Table 2).

In Table 3, data from NSW for the years 1998 to 2002, and other sources, is presented. A risk of 1 in 100,000 means that, in any one year, 1 person is killed for every 100,000 people undertaking that particular activity. The NSW data assumes that the whole population undertakes the activity. That is, we are all at risk of being killed in a fire, or of choking on our food, but it is reasonable to assume that only people who go deep sea fishing run a risk of being killed while doing it.

It can be seen that the risks of dying as a result of falling, using a motor vehicle, or engaging in water-related activities (including bathing) are all greater than 1:100,000 and yet few people actively avoid situations where these risks are present. Some people are averse to flying and yet it represents a lower risk than choking to death on food. The data also indicate that, even when the risk of dying as a consequence of a particular event is very small, it could still happen to any one of us today. If this were not so, there would be no risk at all and clearly that is not the case.

In NSW, the planning authorities consider that 1:1,000,000 is the maximum tolerable risk for domestic housing built near an obvious hazard, such as a chemical factory. Although not specifically considered in the NSW guidelines there is little difference between the hazard presented by a neighbouring factory and a landslide: both have the capacity to destroy life and property and both are always present.

TABLE 3 – RISK TO LIFE

Risk (deaths per participant per year)	**Activity/Event Leading to Death** (NSW data unless noted)
1:1,000	Deep sea fishing (UK)
1:1,000 to 1:10,000	Motor cycling, horse riding , ultra-light flying (Canada)
1:23,000	Motor vehicle use
1:30,000	Fall
1:70,000	Drowning
1:180,000	Fire/burn
1:660,000	Choking on food
1:1,000,000	Scheduled airlines (Canada)
1:2,300,000	Train travel
1:32,000,000	Lightning strike

More information relevant to your particular situation may be found in other AUSTRALIAN GEOGUIDES:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR8 - Hillside Construction
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

APPENDIX B

SOME GUIDELINES

FOR

HILLSIDE CONSTRUCTION

APPENDIX B – SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	POOR ENGINEERING PRACTICE
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminant bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements.
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance (including onto properties below). Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc. in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on bedrock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within bedrock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide generous falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge of roof run-off into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use of absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by a geotechnical consultant.	
SITE VISITS	Site visits by consultant may be appropriate during construction.	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident seek advice. If seepage observed, determine cause or seek advice on consequences.	

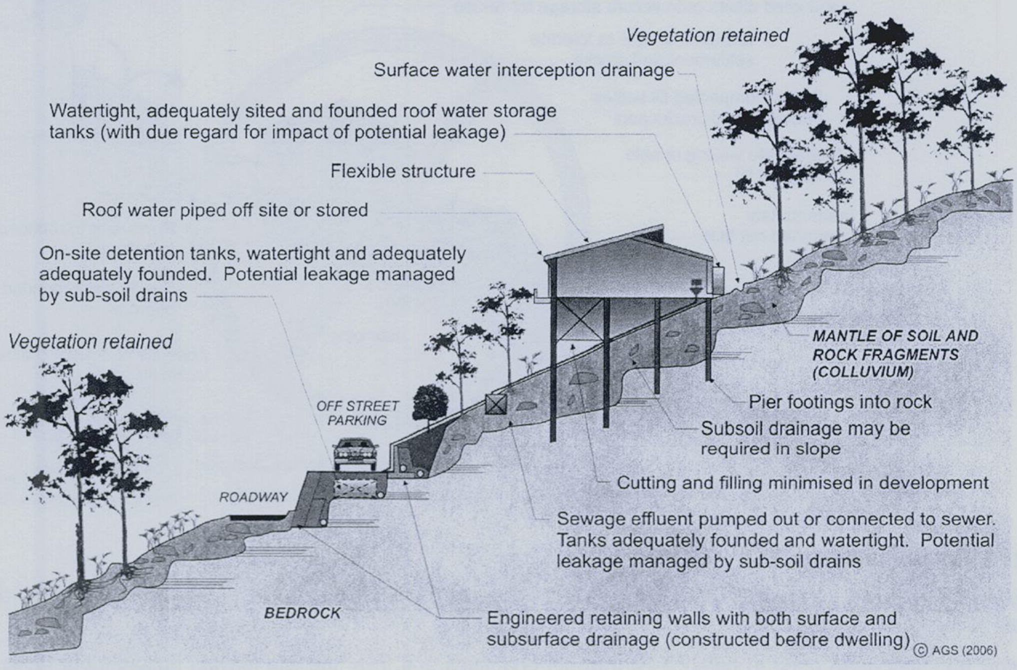
This table is an extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in *Australian Geomechanics*, Vol 42, No 1, March 2007 which discusses the matter more fully.

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.

EXAMPLES FOR **GOOD** HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that due to level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfill the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

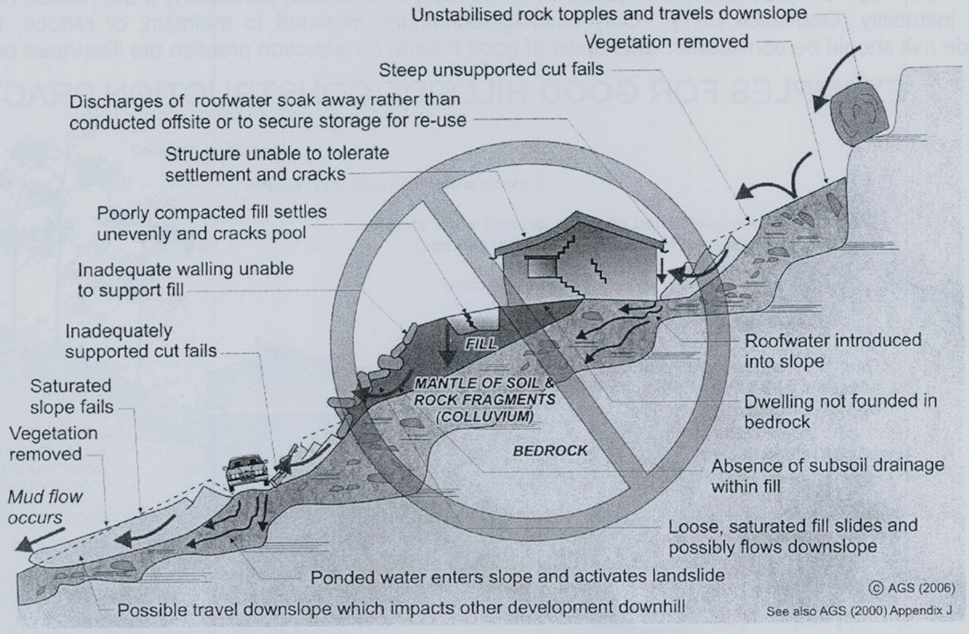
Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES
Extract from Geoguide LR8 – Hillside Construction Practice

EXAMPLES FOR **POOR** HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soaks into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herringbone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 Coastal Landslides
- GeoGuide LR11 - Record Keeping

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Extract from Geoguide LR8 – Hillside Construction Practice.

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 <u>or</u> where only a limited investigation has been completed <u>or</u> 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

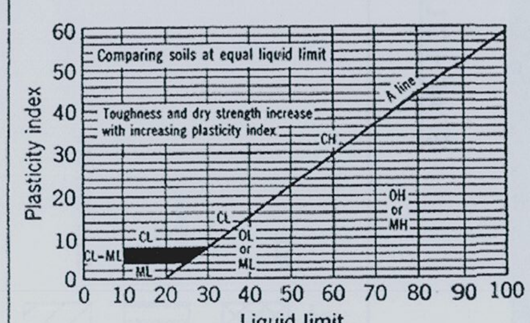
- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

Major division	Subdivision	Fines	Field Identification Procedures (Excluding particles larger than 75 μm 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 μm sieve size[b] (The 75 μm 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	$C_U = \frac{D_{60}}{D_{10}}$ 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	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	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	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*)	$C_U = \frac{D_{60}}{D_{10}}$ 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

Laboratory classification (coarse-grained soils): Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than 75 μm 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.

Use grain size curve in identifying the fractions as given under field identification

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 μm sieve size (The 75 μm sieve size is about the smallest particle visible to naked eye)	Identification Procedures on Fraction Smaller than 380 μm 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
		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	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
	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	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	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	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos screening.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 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	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY – Runs freely through fingers.
	M	MOIST – Does not run freely but no free water visible on soil surface.
	W	WET – Free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT – Unconfined compressive strength less than 25kPa
	S	SOFT – Unconfined compressive strength 25-50kPa
	F	FIRM – Unconfined compressive strength 50-100kPa
	St	STIFF – Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF – Unconfined compressive strength 200-400kPa
	H	HARD — Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** — **SPT 'N' Value Range (Blows/300mm)**
	VL	Very Loose <15 — 0-4
	L	Loose 15-35 — 4-10
	MD	Medium Dense 35-65 — 10-30
	D	Dense 65-85 — 30-50
	VD	Very Dense >85 — >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted 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	