SHIRLEY CONSULTING ENGINEERS PTY. LTD.
INVESTIGATIVE, REMEDIAL & GROUND ENGINEERING ABN 65 001 224 728

DIRECTOR:
A F SHIRLEY BE(Hons.), FIEAust, CPEng(Civil), M.CIRCEA, RPEQ
ASSOCIATE:
D P WILLOWS BE(Hons.), MIEAust, CPEng(Civil)

PYMBLE CORPORATE CENTRE
BUILDING 3, SUITE 2A, 20 BRIDGE STREET
PYMBLE, NSW 2073
PO BOX 439, PYMBLE NSW 2073

Phone: (02) 9449 5577
Fax: (02) 9449 5136
www.shirley.net.au

MCMILLAN DEVELOPMENTS PTY LTD
15 Bay Street
DOUBLE BAY NSW 2028

EMAIL TRANSMISSION

Email: dunrath139@yahoo.com.au

Original to be sent by: mail / express post

Attention: Robert McMillan

Dear Robert,

Re: Objection to The Hills Shire Council Land Zoning
143-145 Castle Hill Road, West Pennant Hills
COMMENTS ON HILLS SHIRE COUNCIL GEOTECHNICAL POLICIES RELATED TO PLANNING

We refer to your instructions of 30 April 2013 to provide some background information and comments on the following to assist in your submissions to the Hills Shire Council *[Council]* and the NSW Government in May 2013.

1. The 1977 Soil Conservation Service *[SCS]* Report.
2. The Council's current policies in relation to geotechnical matters.
3. Geotechnical constraints on the land development.
4. The planning and hazard zone practices adopted by other Councils, with particular regard to the Gosford City Council's DCP 163.

We now provide some background information and comments on the above on the basis of our experience in:

- geotechnical issues & land development;
- land stability / hazard mapping of the geotechnical issues associated with land development for the Warringah, Gosford & Wyong Councils;
- the preparation of development control plans *[DCP]* for the geotechnical hazards existent in the Gosford & Wyong Council areas.

In addition, we note that the writer of this report has published a number of technical papers on the issues.

1. 1977 SCS Report

In the mid-1970s, the SCS undertook a number of Urban Capability assessments for various Local Councils for the purpose of providing advice to the Councils as to the development potential of land areas within a given Council area. These assessments were based on what is known as the 'Surface Soil Association' approach, and were performed largely by agricultural soil scientists.

At the time, the assessments were criticised by a number of geotechnical engineers and geologists, and primarily because the SCS approach:

1. Did not adopt the underlying 'geology' as the fundamental base of the classification system.
2. Separated the land into slope categories based on 'arithmetically convenient' categories, rather than on categories which were related to the landform itself.

The SCS approach was also publicly criticised by the writer of this report [Andrew Shirley] in a paper presented to the 1983 annual conference of the Association of Consulting Engineers [copy attached].

Later, and because many of the Councils who had commissioned and paid for the SCS reports found them to be of little assistance in the development of their local environment plans *[LEP]*, together with the criticism then being received from the geotechnical fraternity, the SCS discontinued undertaking the studies and preparing the assessments in the early 1980s.

Note: In 1985 the Australian Geomechanics Society published its first guidelines on hillside construction and land use planning.

It is also noted that Andrew Shirley published some guidelines on the geotechnical classification of land in 1975 [copy attached] at the Australia & New Zealand conference on Geomechanics; in principle, the approaches suggested in these guidelines have now been substantially adopted by the Australian Geomechanics Society *[AGS].*

In relation to the SCS assessments generally, the principal reason for the technical community rejecting the SCS approach is that it 'assumes' a certain type of development, and classifies the land accordingly, rather than the currently accepted approach for planning which in essence:

- identifies the various hazards and constraints of the particular area;
- requires any development proposals to properly take into account the identified hazards and constraints of the area.

As a consequence, most Councils have now developed various hazard maps for their areas, with these hazard maps including flood, bush fire risk and geotechnical hazard. These maps then form the basis for a Council to call for certain types of reports from appropriately qualified persons prior to considering any development proposal.

It is also to be particularly noted that:

a) Emeritus Prof Robin Fell *[Fell]* recommended to the Council that it adopt the AGS guidelines for land stability assessment and planning purposes in 2005.

   Note: A copy of the relevant extracts from the Fell report are also attached [Doc A].

b) This is the approach recommended by Andrew Shirley in 1975 and again in 1983, and later adopted by the AGS in 2000 / 2002.

   Note: Relevant extracts from the March 2007 guidelines by the AGS are attached [Doc B].

2. Council's Current Policies

Whilst the Council's policy in relation to geotechnical reports and the geotechnical 'peer review' process associated with development, are not available on the website, it would appear that the Council:

1. Has identified a number of areas within its area as 'Geotechnically Sensitive Land'.

   Note: These land areas appear to accord with the land areas identified in the 1977 SCS study and classified as *"Not Recommended For Development"* and / or *"Extreme Hazard"* [SK101].

2. Requires reports from appropriately qualified geotechnical consultants as a part of the development approval process.

The Council has also developed a 'peer review panel' of expert geotechnical consultants on the basis of its own knowledge in 2007 & 2010, and later by advertisement in March 2013. In essence, the qualifications to be on the panel are demonstrated experience and appropriate insurances [see attached Doc E].

On receipt of a report in connection with a particular development from the relevant consultant, and where the Council sees fit, the Council then:

- selects one or more of the consultants on the peer review panel, and obtains quotations for undertaking the peer review from the consultants;
- forwards the quotations from the consultants to the applicant;
- requests the applicant to select the consultant, and then engage and pay for the consultant from the Council's 'Peer Review Panel'.

It is also our view that there is considerable legal risk to the Council adopting this approach as in essence, the Council is selecting a consultant to undertake work and then recommending to a third party that particular consultant. Thus, should there be any defect in the advice provided, then an applicant may have a 'cause of action' against the Council.

3. Geotechnical Aspects of the Development on Land

Whilst there have been many land stability problems in the Council area, the majority of the problems can be attributed to poorly designed structures and inappropriate land development. In particular, many of the problems along Old Northern Road are related to the way in which the road drainage has been constructed by the Council and / or RTA.

In addition, as most of the land instability is of the 'surficial soil' type, where development involves the removal of the surficial soil and construction / excavation within bedrock, the land instability issues are removed by the construction.

Note: In the context of the land in the Hills District, the term 'surficial soil' indicates sandy and silty clay strata that has a depth of typically between 1 and 3 m.

It is for this reason that the AGS has adopted the approach of 'hazard recognition' at the planning stage, with the detailed risk assessment / full geotechnical evaluation at the development application stage.

In the case of the McMillan properties, the surficial soil instability would be completely eliminated by the construction of a development that involves removal of the surficial soil, possibly in conjunction with an excavation into the bedrock.

4. Approaches adopted by other Councils

To the writer's knowledge, the Council is currently the only Council continuing to rely on the SCS Urban Capability assessment approach, with all the Councils with which SCE have worked over the past 10 years adopting the approach as recommended by the AGS.

In particular, SCE are aware that the following Councils use the AGS approach:

> Hornsby Council, Gosford City Council, Wyong Shire Council, Pittwater Council, Manly Council, Warringah Council, Wollongong City Council, Marrickville Council.

In addition, the Otway Shire Council in Victoria also use the AGS guidelines.

Further, the 'hazard identification' approach was, to the writer's knowledge, first adopted by the Wollongong City Council in the late 1960s with the Council gradually developing and improving its hazard maps over the years.

In relation to the peer review process, SCE have been employed by a number of Councils, [viz: Marrickville Council, Warringah Council, Gosford City Council *[GCC]* and Wyong Shire Council] to peer review any geotechnical reports that they receive with a particular development application over which they may have some concern. In this regard, the writer notes:

1. SCE have been paid direct by the Council.
2. Where there is a technical disagreement between an applicant's geotechnical consultant and SCE, then the Council arranges a facilitation meeting to resolve the issues.
3. If the issues are not able to be resolved, then the Council refuses the application.

5. Gosford City Council's DCP 163

As a result of the extensive land stability issues in the Central Coast area, the GCC engaged SCE in 1996 to undertake a comprehensive *'hazard identification'* and mapping of the Council's area so that they might implement an appropriate risk management strategy for the various landslides and other geotechnical hazards in their area.

Subsequently, GCC engaged SCE to assist with the formulation of an appropriate DCP which was then adopted by the GCC as DCP 163 in 2003.

Note: This DCP was modelled on the Wollongong City Council DCP published in the late 1980s.

Subsequently, GCC approached SCE to assist with the training of GCC staff in the application of the DCP, and the development of internal risk management procedures, checklists and flowcharts to assist in the implementation of the DCP.

This DCP adopted the 'four step' approach wherein the geotechnical hazards in the GCC area were classified as:

a) Hazard is so low that no development controls are necessary.
b) Where some prescriptive controls such as limits to the heights of cuts and fills are necessary.
c) Where detailed geotechnical assessment of the hazard and risk is required before development can be approved.
d) Where the hazard is so high no development is possible.

It is also to be noted that this approach was recommended to GCC in 1999, with the AGS guidelines in 2000 / 2002 adopting essentially the same approach. The approach was also confirmed in the AGS 2007 guidelines.

As an overview, GCC development personnel have reported to SCE that as a consequence of the instigation of the DCP, stability issues in the area have reduced and the process of approving development applications has become more efficient.

We trust the information provided in this report is sufficient for your present purposes and note the various investigation and report limitations set out in the following section. Further, should you have any questions in relation to this report, or require additional assistance, please contact the undersigned.

REPORT LIMITATIONS

This 'Limitations' section is to be read in conjunction with the attached notes headed 'SCE Engineering Reports : Information and Limitations'.

This report has not been prepared for the use by parties other than the client [McMillan Developments Pty Ltd] and the client's consulting advisers; as such, it may not contain sufficient information for purposes of other parties, or for other uses.

No other warranty, expressed or implied, is made as to the professional advice included in this report.

Yours faithfully,
SHIRLEY CONSULTING ENGINEERS PTY LIMITED

Andrew Shirley
Director

David Willows
Associate

Encl: SCE Engineering Reports : Information and Limitations

Attach: 2x Shirley Papers
Doc A, Doc B & Doc E
SK 101

SCE ENGINEERING REPORTS : INFORMATION AND LIMITATIONS

1. Limited Scope of Report

The report to which this information sheet is attached is a 'limited scope' report; this information sheet is also to be read in conjunction with the 'Report Limitations' section of the report prepared by Shirley Consulting Engineers Pty Ltd *[SCE].*

The report has been prepared for the Client stated in the report, for the specific purposes stated in the 'Introduction' section of the report. The 'scope of work' undertaken to enable the preparation of the report was also limited to that defined in SCE's Letter of Offer, and any subsequent variations agreed to by the Client. As a consequence, the report may not have addressed all of the engineering and / or geotechnical issues at the site.

Where the SCE report is a 'geotechnical report', the report is also subject to the limitations and accuracy of the information gained from a limited amount of site mapping, geological research & subsurface investigation. The geotechnical report should thus be regarded as an 'interpretive' document of limited accuracy. Geotechnical reports are also limited by the amount / accuracy of information provided by a Client, and / or the extent of information available at the time of writing the report.

2. Report for a Specific Purpose and/or Client

The report has been prepared to address the specific needs of a specific Client at a specific site, and usually for a specific project or development; as such, the report should not be used for other projects on the same site, neither should the report be used by persons other than the Client named in the report without prior permission from SCE.

SCE cannot accept any responsibility for how the information in the report is used by other parties / persons.

3. The Report can be Misinterpreted

Engineering & geotechnical reports are technical documents that often require specialist knowledge to understand and interpret. As such, there may be occasions where further elucidation of some parts of the report may be required for some Clients or third parties. Geotechnical & ground engineering is also a 'less exact' science than other engineering disciplines [e.g. structural engineering].

In view of the above, some Clients / design professionals / other parties can misinterpret parts of a report and the implications of a particular engineering or geotechnical issue, and so prepare a design that is not suited for the site.

Problems can also arise when design professionals develop their plans / designs for a particular project without reference to SCE; this is because the design professional will not be fully aware of the technology & thinking behind the various recommendations in the report. As such, it is recommended that SCE work with the other design professionals during the planning and construction stages of a project.

4. Substrata / Subsurface Conditions

The subsurface conditions predicted in a geotechnical report should be regarded as an 'interpretation' of the substrata, rather than a specific, or accurate assessment.

Also, where the subsurface conditions predicted in the report are based on site observations, surface mapping and the general geology of the area without a detailed site investigation, the actual subsurface conditions may vary significantly from those predicted in the report.

Where a detailed site investigation has been undertaken [e.g. test pits, boreholes, etc.] to establish the subsurface conditions, the predicted subsurface conditions still have a 'margin of error' despite the detailed work. This 'margin of error' comes about because the prediction is based on an 'interpretation' of the materials that are likely to exist under the ground between the discrete sampling points [viz: the test pits / boreholes] or other subsurface probing.

Should additional information on the ground conditions come to light after the SCE report has been issued which indicates that the subsurface conditions appear to be significantly different from those envisaged in the SCE report [e.g. during the course of construction], the Client or other party identifying the difference should immediately notify SCE, and request SCE to advise on the apparent difference, or anomaly.

SCE reserves the right to modify any of the conclusions / recommendations in the SCE report in the light of the additional information, or revealed subsurface conditions.

5. Construction Issues

As many construction problems / failures arise from a misunderstanding of a site's geotechnical & engineering issues, it is prudent for both the report's recommendations and the predicted subsurface conditions to be confirmed by SCE during the construction processes. Further, where the actual subsurface conditions are different to those predicted in the SCE report, the SCE recommendations may need adjustment [with consequent design changes] as a result of the different subsurface conditions [see item 4].

Where a Client decides to use a different geotechnical engineer [or allied professional] to undertake the construction review process rather than SCE, significant difficulties [and associated cost issues] can arise with the interpretation of site conditions. This is because SCE [as the author of the original report], is more likely to have a fuller understanding of the site's substrata and its potential effects on the construction processes.

SCE also consider that a Client should be wary of accepting geotechnical advice from non-geotechnical professionals [e.g. civil engineers, structural engineers, etc.], or engineering advice from non-engineers [e.g. engineering geologists, soil technicians, etc].

6. Site Contamination and Environmental Issues

SCE reports do not usually provide information on the findings, conclusions, or recommendations about potentially hazardous materials occurring at a site; this is because the equipment, techniques and personnel used to undertake environmental studies & exploration differ substantially from those used in geotechnical and civil engineering studies.

As site contamination from any source can create major problems, should a Client suspect that the site has any contamination, then it is prudent for the Client to engage a specialist environmental consultant to advise on the possible site environmental and contamination issues.

7. Reproduction of Information

Where the information contained in a geotechnical report prepared by SCE is to be provided for contract or tender purposes, SCE recommends that ALL the information contained in the report [including the written text and any appendix material] be made available to potential tenderers / contractors. Also, to avoid misinterpretation, SCE strongly advises against a Client being 'selective' about the geotechnical information to be provided to third parties.

Any party wishing to rely on the information contained a SCE report should contact SCE to establish the suitability of the report for their particular purpose or use.

Where a Client considers that some sections of a report are not relevant to a third party in a particular situation, then it may be appropriate for SCE to prepare an especially edited document for the third party.

ELECTRONIC

THE THEORETICAL & PRACTICAL ASPECTS OF

LAND STABILITY CLASSIFICATION

Reprint

of a Paper Presented

at a Technical Conference

of

THE INSTITUTION OF ENGINEERS, AUSTRALIA

PROCEEDINGS OF 2ND AUSTRALIA-NEW ZEALAND

CONFERENCE ON GEOMECHANICS

BRISBANE 1975

pp. 303-307

The Theoretical and Practical Aspects of Land Stability Classification

by

A. F. SHIRLEY, B.E., M.I.E.Aust.

Director, Andrew Shirley & Associates Pty. Limited

SUMMARY. The relevance and accuracy of various theoretical concepts and practical procedures adopted in the assessment of the stability of land, is discussed in a manner suited for direct comprehension by non-specialist Engineers. The necessity for the detailed understanding of the site Geological and Environmental processes is emphasised, and guidelines for the undertaking of Land Stability Assessments are presented. Finally, Land Stability Classification systems are suggested for both "Regional" and "Specific Project" type of assessments.

1 INTRODUCTION

Mankind today has a desire to build relatively permanent structures for his place of abode. The system of private land ownership, combined with a fast-growing population, has caused a very large demand for residential land. Consequently, land sub-division has taken place in areas not always suited to conventional Urban Development. It has been the experience of the author that most land instability in residential sub-divisions, is caused by development groups acting without an appreciation of the possible consequences of their actions.

Although the examination of the stability of natural slopes has been major field for scientific endeavour over a considerable number of years, the majority of "State of the Art" reporters (Refs. 6, 8,11,12 & 13), have concluded that we are still largely unable to precisely determine the state of stability of a particular site. Consequently, the various theoretical and practical aspects of land stability classification have been brought together so that the probability approach to the classification process might be more fully understood.

2 NATURAL SETTING

The recognition of areas prone to instability, or actively undergoing movement, requires a detailed understanding of the nature of earth movements. Earth movements occur in a number of ways, and include such phenomena as earthquakes, subsidences, and landslides; however the discussion of the nature and causes of such events is beyond the scope of this paper, and Refs. 3,6,11,12 & 14, are suggested for further study. Suffice to say that, the assessment of actual or potential earth movements at a particular site embraces a number of scientific disciplines such as geology, botany, & hydrology. Whilst it should be obvious that the accuracy with which the scientific base data is collected will greatly influence the correctness of a stability assessment, there are far too many examples of inaccurate data collection that have given rise to a poor evaluation of land stability.

The Frank Slide in Alberta Canada, is an example of how the poor understanding of site geology can lead investigators to be very confused as to the causes of instability. This slide involved approximately 90 million tonnes of rock which moved down the East face of Turtle Mountain, across the entrance of the Frank Mine, the Crowsnest River, the southern end of the town of Frank, the main road from the East, and the Canadaan Pacific Mainline through Crowsnest Pass. The rock mass continued up the opposite side of the valley before coming to rest 120m above the valley floor. The slide event lasted 100s. Immediately after the slide in 1903, an inspection was made by McConnell and Brock and their report was issued a month later. Subsequently a commission was appointed (Daly et al 1912) to investigate the possibility of further movements. The report of this commission has appeared in many recent texts (Refs. 7,12 & 14), and in these texts various theories are advanced as to the possible failure modes. Due to the nature of the failure modes proposed, i.e. failure across joint planes rather than along bedding or joint planes, considerable controversy has surrounded the cause of the slide. It is extremely unfortunate that these recent texts overlooked the geological work undertaken in 1913 (J.D.McKenzie), 1932 (MacKay), & 1933 (Allan) which all indicated that the geology of the area was quite different from that assumed by the commission under Daly in 1912. This later geological work indicated that Turtle Mountain was in reality an anticline, and that failure would have taken place along the bedding planes. It is hoped that the careful investigation of Cruden & Krahn (Ref. 2) will give an impetus to theoretical investigators to carefully check their field data.

Whilst similar geological conditions will generally give rise to similar movements, it is important to recognise that the nature and form of earth movement at a particular site is dependant upon the detailed geological situation. It is considered therefore that the Natural Site Setting, i.e. geology, topography, botany & climate, must be accurately determined before the stability of a particular piece of land can be assessed.

3 THEORETICAL CONCEPTS

(a) Failure Mechanisms

Many Engineers involved in the design process for Urban Development unfortunately do not have an adequate appreciation of the geological processes which cause the instability of land, and as a consequence many developments in Urban areas have been subject to landslip. In the past there has been too much emphasis on theoretical approaches which are not related to the physical field conditions, and consequently undue credence has been placed upon the results of the theoretical analyses.

It is disturbing that so many technical articles are still published using terminologies such as "The Classical Cylindrical Form" when referring to natural slope failures, because Cylindrical Failures are extremely rare occurrences. The necessary condition for a cylindrical slide is homogeneous material, and such materials do not generally occur on natural slopes. There is a great deal of field evidence to suggest that it is the natural planes of weakness within the soil or rock mass that determines the failure surface, and such planes are usually far from circular. Stability analyses, based upon "Cylindrical Form of Slide", must therefore be treated with the utmost caution.

Any stability assessment analysis requires the determination of potential failure planes and the evaluation of the forces causing and resisting failure. Because of the difficulty in determining failure planes and the forces upon them, the interpretation of these analyses often give rise to considerable divergences of opinion. It is considered that stability analyses should be undertaken using a variety of computational assumptions and procedures, so that an insight may be gained into the failure mechanisms which are possible at the site. Field evidence of these failure modes should then be sought and the stability assessment related to field observations in the immediate vicinity.

(b) Mathematical Models

Recent literature on the stability of natural slopes, has placed considerable emphasis on theoretical concepts such as "Residual Friction", "Progressive Failure" etc., and such concepts are extremely important to the proper understanding of possible failure mechanisms; however, unless the applicability of the concept is established beyond conjecture at each site, any resultant conclusions as to the site stability will be misleading.

For example, many statements on the stability of the Talus material in the Sydney Basin, have depended upon a "Residual Friction" failure concept, in spite of inconclusive laboratory test programs. It should be recognised that Talus is generally a lightly over-consolidated to normally-consolidated material, and would not normally exhibit "Residual Friction", (Refs. 9 & 10). The use therefore of a "Residual Friction" concept with Talus would have to be treated with suspicion.

Again, the validity of the "Effective Stress Principle" depends upon individual soil particles being sensibly inert during changes in stress. Because Civil Engineering structures generally only cause small changes in soil or rock stress level, the fact that individual soil particles are not always inert has not caused many problems. However, the excavations undertaken in sloping land subdivisions often cause radical changes in the stress level of the near surface materials. In such cases it may be necessary to take into account the possible variation in particle size, and structure, as a result of the change in stress level.

(c) Planning

It should be recognised that not all property owners will be aware of the technical problems associated with sloping land development, and so may undertake projects which can create instability in an otherwise stable area. In view of this, it is considered that any developments planned in sloping areas should ensure that an unwise action on the part of one owner, does not cause problems for other owners. The planning requirements will naturally be unique to each geographical area, but will need to embody special provisions to minimise the alteration to water movement patterns, and the changes in soil and/or rock stress.

Generally, the steeper the slope the shallower the excavation for roads and houses ought to be. It is considered that the present practice of constructing wide suburban streets in hillside areas is a major factor in the development of instability in such areas, and consequently it is essential that planning schemes embody a provision for the variation in road formation width with steepness of hillside. Again, the allotment size and location needs to be related to the detailed local geology; in some areas the simple provision of large allotments will be sufficient to prevent problems between adjacent property owners as a result of land instability, whereas in other areas the allotment boundaries must be precisely determined by the outcropping geology. Fig. No.1 has been prepared to

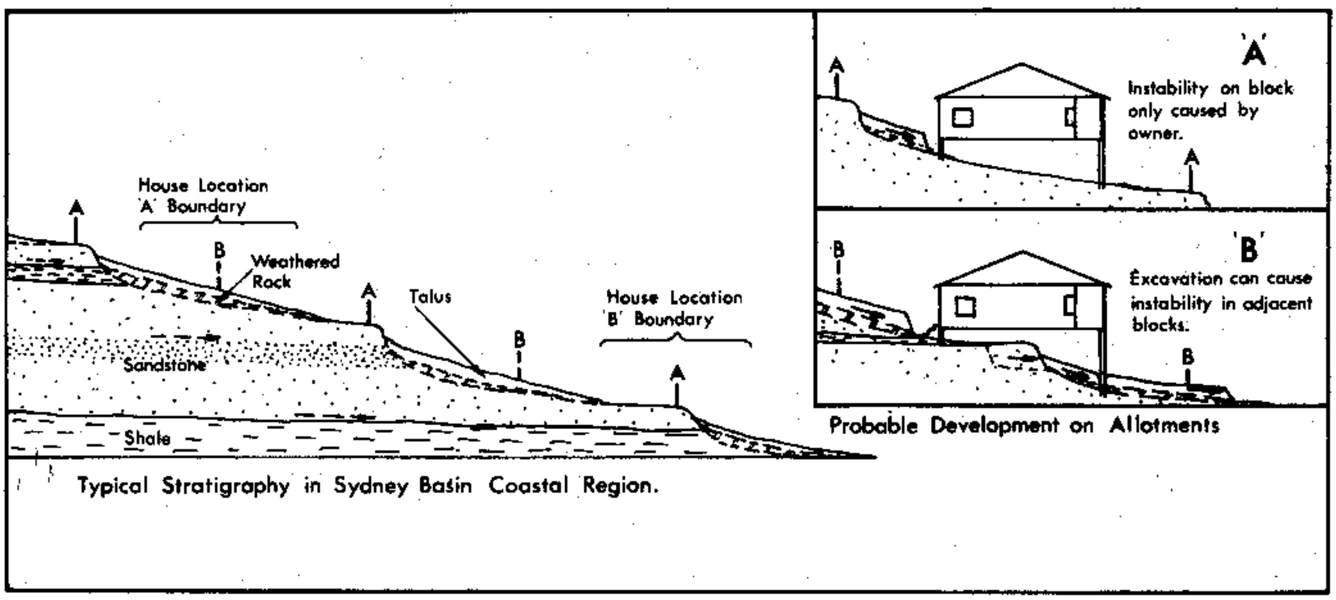


Figure 1

demonstrate the likely consequences of poor positioning of allotment boundaries in relation to the site geology. The boundary positions marked "A" are considered to have less potential problems than the boundary positions marked "B".

Further, since the actual subsurface conditions can never be determined in advance with absolute precision, the planning scheme must make allowance for future variations to the scheme as more information is revealed.

4 COLLECTION OF DATA

In the assessment of the stability of land, it should be recognised that the assessment will be an opinion based upon data obtained from the site, and as this data is only a sample of the available site information, the opinion will only be as good as the quality of the site sample. Further, the degree to which the probable earth movement mode is understood, will depend upon the care and accuracy with which the base-data is established.

Adamson (Ref. 1), has prepared some useful comments on the manner of undertaking geological investigations, however there are some aspects which are particularly relevant to land stability assessment. The flow chart presented in Figure 2 is an example of how a typical "Project Type" stability assessment would be undertaken. Some of the items referred to in the flow chart are briefly discussed hereunder.

(a) Air Photo Interpretation

Before any assessment can be made of an area, a proper base plan is required. However some difficulty is often encountered in establishing the proper scale and contour interval for the base plan. If the region is first examined from the aerial view, then it is usually possible to establish areas for intensive study. This procedure permits considerable economies to be achieved in the preparation of base plans, as small scale maps will generally suffice for a large proportion of the area, with a large scale being only used over a limited area. Some useful comments on Air Photo interpretation are contained in Ref. 3, however, the procedure of working from the "whole" to the "detail" cannot be too strongly emphasised, because proper appreciation of the site natural setting is usually only gained by observation of the "whole". Further, old slips and vegetation changes are often only apparent in Aerial Photographs.

(b) Geobotanical Mapping

In view of the fact that it is not usually possible for data to be assembled over a lengthy period, a study of the site vegetation can yield much information about subsurface conditions and the movements that have occurred, and are occuring, at the site.

Many writers have pointed to observations on shape of trees as indicators of ground movement (Ref. 3,6,7 & 14); however it should be recognised that many other facts can be established from the vegetation. Many species are tolerant of widely varying subsurface conditions, however others will only thrive under particular soil conditions. Such species are therefore particularly good indicators of water-logged soil, heavy clays, shaley clays etc. Also dead or dying trees are often the result of root suffocation caused by filling or slide debris, and can therefore indicate topographic changes in the very recent past.

Geobotanical mapping is thus an important phase of the data collection because it often provides data not available from other sources. The geobotanical map needs to be prepared in a manner that will provide the requisite specific data, and this can be achieved by plotting those plants and trees that require particular subsoil conditions to thrive; species tolerant to wide ranging sub-soil conditions should be simply "listed".

(c) Site Geology

Prior to any subsurface investigations, a surface geological map should be prepared, based upon the outcrop geology, published sources and the geobotanical map. It is unfortunate that in recent years there has been a growth towards undertaking subsurface investigations such as seismic surveys, drilling, and trenching, prior to the detailed surface mapping. The surface geological map will usually indicate where subsurface work is most needed for either exploration or verification of interpreted features. Further, because most earth movements occur on "planes of weakness" it is essential to collect as much data as possible about these planes, including statistically meaningful observations on the spacing and extent of discontinuities within each rock and/or soil unit.

When the geological map is completed, it is important that the Geologist interprets his findings to the Engineer. Unfortunately, many first rate

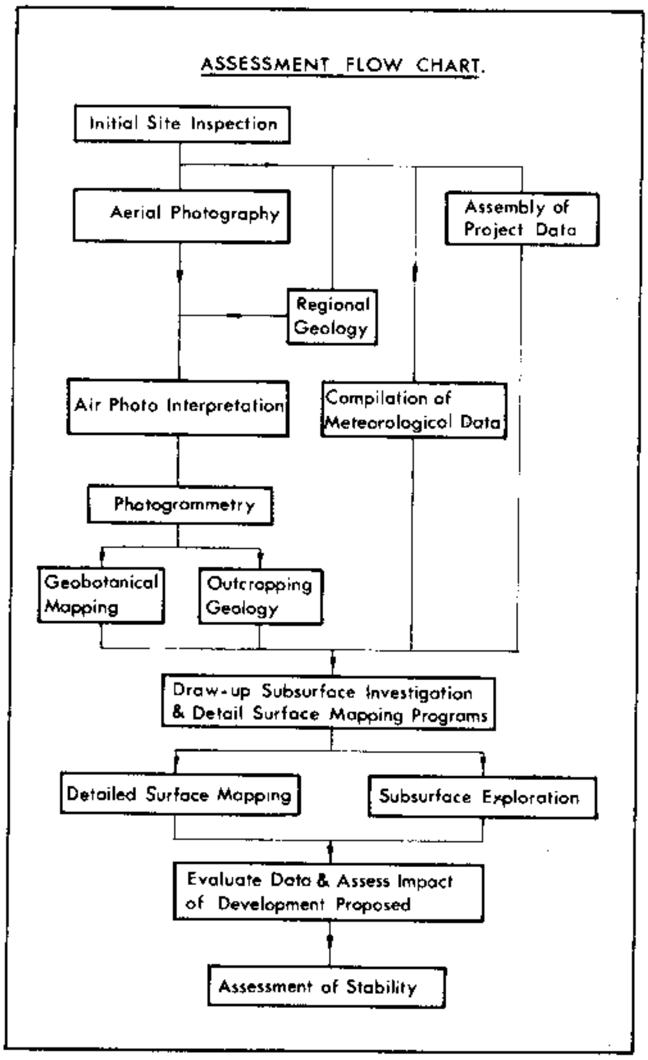


Figure 2

geological plans are little used by Engineers, because the significance of many of the documented features is not fully understood. The determination of the engineering significance is usually the most difficult phase of the project, and is often best accomplished by the Geologist and Engineer working in close collaboration.

5 STABILITY CLASSIFICATION OF LAND

The purposes of any investigation into land stability can be outlined as:-

(i) To assess the stability of the natural slope.

(ii) To assess to what extent the stability of the slope will be altered by the development proposed.

There is however, a further requirement placed upon those who assess the stability of land for Urban Development:-

(iii)To isolate those areas in which the improper actions of the "ill-advised" or "uninformed", could have extensive detrimental effects on the surrounding countryside.

In view of the remarks made so far in this paper, it can be seen that a most detailed understanding is required of the site geological and environmental factors, before an accurate assessment can be made of the land stability. As it is clearly not feasible, nor economically desirable, to fully investigate all potential Urban areas; two levels of land stability classification are required to separate those areas of land obviously requiring further detailed study, from the areas in which conventional sub-division practice may proceed without special restrictions. It is thought that this separation of areas should take place at the Town Planning stage, so that all the related socio-economic factors inherent in hillside development can also be considered. If the communities interests are best served by permitting development in areas requiring large scale detailed geotechnical studies, then the economic consequences are properly evaluated at the appropriate time.

Table I sets out a Regional Land Stability Classification scheme which is thought to be suitable for Town Planning purposes. The scheme embodies the "Extent of Investigation Required" principle, whilst providing specific land use catagories that could be applied to a Town Plan.

TABLE I - REGIONAL LAND STABILITY CLASSIFICATION
- for urban development -

CATEGORY	DEFINITION
1.	Stable Land - no land instability evident or likely
2.	Essentially Stable Land - some small areas of land instability. Most of the land may be safely utilised provided that adequate care is exercised in the nature and form of development. Detailed investigation required before development is undertaken.
3.	Less Stable Land - thorough investigation required before any development.
4.	Essentially Unstable Land - development of area, only after the most thorough assessment of area stability.

The "Extent of Investigation Required" type of classification, whilst being satisfactory for Town Planning purposes, has little practical application to a specific project. However, to be more specific the project type of classification system will need to take into account:-

(i) The extent to which geological processes occuring at the site are understood.

(ii)The extent to which theoretical and mathematical models explain the observed phenomena.

(iii)The nature and type of development to be undertaken.

(iv)The degree of development control that can be exercised after the major engineering works are completed.

A proposed "Project" type of land stability classification system is given in Table II, which uses the term "Degree of Confidence in Stability" because all the preceding matters are based upon sampling and probability. To be consistant therefore, the classification must be expressed in terms which are related to the scientific base data, that

TABLE II - PROJECT LAND STABILITY CLASSIFICATION
- for urban development.

Degree of Confidence in Stability	Usual Interpretation	Movements Expected	Development Restrictions
HIGH	Stable Land	None	No special requirements.
MEDIUM	Essentially Stable Land	Some minor movements can be expected if development undertaken without due regard for landform.	Building and any development subject to special requirements, including detailed appraisal of the effect of development on the land stability prior to development approval.
LOW	Generally Unstable Land	Localised landslips may occur in some areas during or after extreme climatic conditions.	No private development permitted, unless area, or parts thereof, can be re-rated after an intensive geological survey of the area. Public utilities should have the stability of the structure, as affected by the probable land movement properly investigated.
VERY LOW	Unstable	Areas of known active landslides, extensive land movements anticipated.	

is, in terms of confidence limits. Further, since the susceptibility to movement is a major consideration in urban development, it appears reasonable to relate the classification of an area to the nature of the expected movements.

During the course of field observations to classify land into stability zones, it must be borne in mind that stable areas can be made unstable by the actions of the "ill-advised" or "uninformed". It is therefore necessary to clearly differentiate those areas in which usual sub-divisional practice may be followed, from those areas in which special engineering and building techniques may be required. Also, in common with most other aspects of Urban Development, the real control over development is excercised by the Local Government Authority; such control can generally only be exercised effectively at the time of sub-divisional and building approval. In view of the fact that by giving permission to build or develop, Local Authorities tend to incur a non-specific legal or moral obligation, it is considered that these Authorities should only permit residential development in "Stable" areas. Further, such Authorities should ensure that the development is undertaken in such a way that the land susceptibility to movement is not increased; i.e. the land is not rendered "Unstable".

6 CONCLUSION

When the natural geological processes occuring in a given area are properly understood, it then is possible to classify the area into zones of similar stability, and to ascertain the stability of an area for a particular project; always provided that careful field observational procedures are diligently followed, and there is ample field evidence for the theoretical models.

The nature of the classification process inherently involves a degree of uncertainty, because every site will always have some unique features that will not be apparent to even the most skilled observer. The term "Degree of Confidence in the Stability" provides a measure of this uncertainty.

The classification of land into areas of similar susceptibility to movement could greatly assist Town Planners and Local Authorities to overcome some of the existing problems of landslip in Urban areas, and possibly prevent the development of landslip in developments in the future. The "two-stage" classification system outlined in this paper is considered to provide a suitable system.

7 ACKNOWLEDGEMENTS

The author is indebted to Mr. K.W. Francis, B.A., Jun.M.Aust.I.M.M., and Mr. J.H.G. Tankard, B.E., M.Eng.Sc., A.M.Aust.I.M.M., for their many useful comments and assistance.

8 REFERENCES

1. ADAMSON,C.L. Planning & Execution of Geological Site Investigations. Symposium on Site Investigation Sydney 1966. Institute of Engineers Australia. pp 31-39.

2. CRUDEN,D. & KRAHN,J. A Re-examination of the Geology of the Frank Slide. Canadian Geotechnical Journal. 10 1973 pp 581-591

3. ECKEL,E.B. (Ed) Landslides & Engineering Practice. Highway Research Board Special Report No. 29. Washington D.C. 1958.

4. HENKEL,David J. Local Geology and the Stability of Natural Slopes. Journal of Soil Mech. & Foundation Division A.S.C.E. Vol.93 1967 S.M.4 pp 437-466.

5. JAMES,P.M. The Role of Progressive Failure in Clay Slopes. Proceedings of 1st A.N.Z. Conference on Geomechanics Melb. 1971. pp 344-348.

6. LADD,G.E. Landslides, Subsidences & Rock Falls. Bull.of America Railway Engineering Association. Vol.37 1935 No. 377.

7. LEGGETT,R.F. Geology and Engineering. 2nd Edition McGraw-Hill. 1962.

8. PECK,R.B. The Stability of Natural Slopes. Journal of Soil Mech. & Foundation Division A.S.C.E. Vol.93 1967 SM 4. pp 403-417.

9. SKEMPTON,A.W. Long Term Stability of Clay Slopes. Geotechnique. 14. 1964 pp 77-101.

10. SKEMPTON,A.W. First Time Slides in Over-Consolidated Clay. Geotechnique. 20. 1970 NO.3. pp 320-324.

11. SKEMPTON,A.W. & HUTCHINSON,J. Stability of Natural Slopes & Embankment Foundations State of the Art Report. Proceeding Seventh International Conference on Soil Mechanics. Mexico 1969. pp 291-340.

12. TERZAGHI,K. Mechanisms of Landslides. Application of Geology to Engineering Practice. (Berkley Volume). New York Geol. Socy. America 1950. pp 82-123.

13. WILSON,S.D. Observational Data on Ground Movements related to Slope Instability. Journal of Soil Mechanics & Foundational Divisional A.S.C.E. Vol.96. 1970 S.M.5 pp 1521-1543.

14. ZARUBA,Q. & MENCL,V. Landslides and Their Control. Elsevier, Amsterdam. 1969.

TOWN PLANNING IN GEOLOGICALLY COMPLEX AREAS

AN ENGINEERS POINT OF VIEW

by A.F. SHIRLEY B.E. M.I.E. Aust

1. INTRODUCTION

Land is a valuable resource which normally increases in value during its transition from the rural to urban environment. The need for efficient and beneficial development of land (both privately and publicly) is consequently of high priority. Also, and as a result of the recent upsurge in "Conservation Concern" in our Community, the Local Council and Planning Authorities are becoming far more deeply involved in the development/subdivision of land. Consequently, a number of Government Departments have prepared 'Capability Maps' or 'Land Use Zoning Maps', which are then used by the Council when considering rezoning, and/or subdivision of land. The importance therefore of carefully compiled, accurate maps is a matter of some importance to a Local Council.

2. LAND CAPABILITY ASSESSMENT METHODS

Presently there are a number of methods of assessing (in geological/geotechnical terms) the development capability of land, but principally all Land Capability Assessments are a type of technical information synthesis that implies:

a) The various components of the synthesis, including the land-system, geology, natural hazards, landform, slope, hydrology, vegetation, etc., have been properly researched and documented.

b) The data is presented in a carefully edited manner, specifically directed to the neo-urban proposals, with other non-relevant data excluded (e.g. detailed accounts of topsoil fertility or trace elements are not usually very relevant to planners in urban areas, whereas such data would be particularly relevant to non-urban [farming] areas).

The principal systems of Land Capability Assessment presently in use are:

1. The Geotechnical Terrain Classification

2. The Surface Soil Association approach

3. The Extent of Investigation Required approach

In the Geotechnical Terrain Classification approach, the available geological and topographic data is synthesised using the underlying geology as the BASIC unit which is then further classified by landform, slope, and geomorphological considerations. For relatively small scale maps (1:25,000, 1:100,000, etc.) it is usually only necessary to delineate the geology to the Formation level, but when dealing with the usual Town Planning Map (1:4000 or larger) it is necessary to define the geology to at least the Member level. The system has been widely used by the Geological Surveys in Tasmania & New South Wales, the C.S.I.R.O, and overseas (e.g. U.S.A., Sweden and New Zealand). Due to its 'geological' base the system lends itself to refinement after more detailed investigations, and results in a simple map presentation; thus as the particular causes of slope instability, soil reactivity, etc., are defined, suitable map changes can be made. The system does however have a significant time/cost limitation, because large- scale geological maps of an area are not often initially available. Therefore, it can take several years to produce a suitable scale Capability map assuming the usual budgetary constraints.

The Surface Soil Association approach has been developed by the Soil Conservation Service of N.S.W., because of the need to produce large-scale Capability maps in a short time combined with the Service's experience in Rural Area Soil Conservation. The approach classifies land primarily on the basis of soil type, slope, and landform categorized into a precise classification system (i.e. land slopes are always defined within certain gradients [e.g. 5-10%, or 15-20%, etc.] soil shrinkage as Critical or Non-Critical according to defined Linear Shrinkage values, and so on). The approach therefore gives rise to a large number of land areas (often quite small) with different classifications, and sometimes the fixed slope/soil categories are inappropriate to the geology of an area. The principal problems with using the approach are mainly the number of small areas classified on a particular map which have very different 'capability or hazard', and the difficulty of refining the maps as more data becomes available.

The system has however, been widely implemented in N.S.W. for the last few years, with the studies generally undertaken by Soil Conservationists.

The 'Extent of Investigation Required' approach was originally proposed by the Author in 1975 (ref:6) principally for Land Stability Investigations, and utilizes the Geotechnical Terrain Classification method to define (on a relatively small scale - say 1:10,000 or 1:25,000) areas within which detailed studies are required, and areas of land obviously unsuitable for development. Implicit in the approach is the recognition of the economic restraints upon any investigation, and the self evident fact that stability, soil reactivity, and other geotechnical problems are often only recognised after considerable knowledge of a particular area has been obtained.

In the light of more recent experience the table proposed in 1975 could be simply modified, as below, to suit the first stage of a Capability Assessment.

CATEGORY	DESCRIPTION
1.	Land Areas not susceptible to significant natural/man-made hazards, and within which conventional building/development practice can be applied with confidence.
2.	Land Areas within which there may occur small areas of significant natural or man-made hazard, principally of one type, and within which development should always be preceded by a careful site investigation and report by properly qualified persons.
3.	Land Areas within which there are a number of significant natural hazards, possibly of more than one type; within such areas all development proposals should be preceded by the most careful, detailed and thorough geotechnical study by properly qualified persons.
4.	Land areas considered generally unsuitable

A similar system is currently used by the Tasmanian Geological Survey (ref: 9), except that colours (Red, Yellow [2 levels], and green) are used rather than numbers. The four-tier classification was also advocated by Chestnut in 1974 (ref:2) as being appropriate to the Town Planning situation, and a similar (but six level) system was used by Bowman in 1972 (ref:1).

The principal problem with the system is that it does not provide an absolute classification for the Council to implement, but rather it provides a systematic approach to the recognition of the problems within a particular area, and an encouragement to prospective developers to carry out proper detailed investigations in the area.

3. DEVELOPMENT IN GEOLOGICALLY COMPLEX AREAS

Some of the most imaginative and inspiring works of man have been undertaken in the geologically complex areas, and often what appears to be impossible today, will prove to be very simple tomorrow. Therefore, whilst it is clear that Councils have a responsibility to prevent unsafe and environmentally damaging developments, our system of town planning must be sufficiently flexible to permit the adjustment of land-use zoning when better geological data becomes available. Any adjustment should however only be made when sufficient, appropriate geological data has been collected.

It is the Author's view that the assessment of Land Capability is primarily an Engineering and Geological Function, because Engineers and Engineering Geologists are trained to determine whether or not Unstable Areas can be Stabilised, the most appropriate guidelines for the construction of Roads, Drains, Building Structures, etc., whereas other professional persons are not.

It is also to be noted that many of the judgements made by investigating geologists, engineers and soil conservationists are based upon the facts and data available to them at the time of their particular investigation; such 'facts' may of course prove to be erroneous with the fullness of time, and consequently it is most necessary to provide a proper method of updating the maps; conversely, if a proper method of updating is not initially provided, then it is usually very difficult to get the zoning changed.

In view of the foregoing remarks it is the Author's view that the initial Land Capability Assessments should be carried out in a way that enables subsequent refinement by a number of technical people over a period of time; in addition, any Town Plan should incorporate provision for adjustment of the Zoning Scheme as better data becomes available. The adoption of the 'Extent of Investigation Required' approach to zoning in Geologically Complex Areas would therefore be appropriate, but would of course necessitate proper review of later reports and studies submitted to a Council (e.g. by qualified Experienced Engineers and Geologists engaged/employed by the Council), before the zoning is amended.

4. CONCLUSION

When the natural geological processes occurring in an area are properly understood, it is usually possible to classify the area into zones of similar stability/urban capability. As the effectiveness of any town plan depends upon the proper recognition of the Engineering/Geological constraints, it is very important that the constraints are accurately evaluated and mapped. However, because the time/cost of the detailed mapping and classification process will always be very large, the process must usually be carried out in stages.

The Geotechnical Terrain Classification approach is considered to be the most technically sound, and as it can be carried out in stages, it should be used for Urban Capability Assessments in Geologically Complex Areas.

The most appropriate first stage of the development of a Capability Map would appear to be an 'Extent of Investigation Required' assessment, as this assessment is simply an adaption of the Geological/Terrain Analysis approach, and permits the editing and refining of the maps as more data becomes available. In this way proper priorities can be established, and the cost of detailed studies borne by those who benefit from the work.

5. REFERENCES

1. Bowman H.N. (1972) — Natural Slope Stability in the City of Wollongong. Recs. Geol. Surv. N.S.W. - Vol. 14 Pt. 2

2. Chestnut W.S. (1974) — A Survey of Instability in the Illawarra District Symposium on Land Development in the Illawarra District – Wollongong University Sept. 1974.

3. Grant K. (1975) — The P.U.C.E programme for terrain evaluation engineering purposes. 2nd Ed. C.S.I.R.O Division of Applied Geomechanics. Tech. Publn. No. 15.

4. Ingles O.G. (1974) — Unstable Land Forms in Australia. Report No. 42 of The Water Research Foundation of Australia.

5. Ingles O.G. (ed) (1976) — Workshop Papers- Unstable Landforms Report No. 48 of the Water Research Foundation of Australia

6. Shirley A.F. (1975) — The Theoretical & Practical Aspects of Land Stability Classification. 2nd A.N.Z Conference on Geomechanics - Brisbane 1975 I.E. Aust.

7. Shirley A.F. (1977) — The Problems for Government Associated with Geological Hazards in the Urban Area 48th ANZAAS Conference Melbourne 1977 - Section 3 Geology in Urban and Regional Development

8. Stevenson P.C. (1975) — A Predictive Landslip Survey and its Social Impact 2nd ANZ Conference on Geomechanics - Brisbane 1975 I.E. Aust.

9. Stevenson P.C. (1980) — The Evolution of a Risk Zoning System for Landslide Areas in Tasmania, Australia 3rd ANZ Conference - New Zealand 1980 N.Z.I.E.

10. Viberg L. & Adestam L. (1980) — Geotechnical Terrain Classification for Physical Planning - A Swedish Research Project. Bulletin Int. Assoc. Eng. Geol. No. 21 June 1980

The proposed solution may result in a low risk, but would be improved if a genuine full removal approach was adopted. The difference in cost may not be great because the current proposal involves a lot of work in trenches.

The proposal fails to consider adequately the issue of support for the sides to the excavation. This will be an issue because the landslide almost certainly extends to A10, and may extend to near or outside the property boundary ar B10. Support will also be an issue at C10.

6.0 RECOMMENDED APPROACH TO MANAGEMENT OF THE SITES

6.1 OVERALL APPROACH

It is recommended that Council consider adopting the following approach in managing the landslide hazard on these sites:

(a) Council should adopt the AGS guidelines for landslide risk management, requiring an acceptable risk for loss of life for the person most at risk of 1 in a million per annum; and "low" in Table 1 (Appendix G of AGS 2002) for property loss. When estimating the risk for property loss, the whole of the property should be considered, not just the dwelling.

(b) Council should require proponents to demonstrate that their proposed remedial works will satisfy this requirement.

(c) Council should appoint an Independent Expert Review Panel to review the proposals, and advise Council and the proponents if in their opinion the proposal meets the risk acceptance criteria, and if not to suggest ways in which these might be met. It would be for the proponent and their Consultant then revise their proposal for resubmission to the Review Panel for further review.

(d) Having gained the opinion of the Review Panel that the risks would meet the acceptance criteria, Council should then accept that there are no reasons why the proposal should not proceed on the issue of landslide risk management, and should then consider the proposal from the proponent and the Consultant taking account all planning requirements. From a Geotechnical viewpoint, once the remedial works are done there is no reason why generally there should be limitations on the intensity of development. There is no particular benefit in lower density development.

There may need to be special controls on cuts, fills, swimming pool depths, services construction, etc; and special requirements to support cuts during construction; and long term monitoring and maintenance; and these should be part of the proposal to be put to the Expert Review Panel because these are vital to the management of risks.(f)Council should continue to require that investigations, design, construction supervision and monitoring after construction are carried out by experienced geotechnical professionals. They should require that the consultants inspect the works during construction so they can confirm the conditions are as they expected, that the design is satisfactory, and they should have control over the quality of the works.

6.2 Appointment of Independent Expert Review Panel

There is clearly a need for expert review of proposals. There are several examples in the data provided where the consultants had not understood the problems adequately (at least early in the process), or were proposing remedial works not providing the required low level of risk.
However it seems that the single peer reviewer approach often produces a difference of opinion between the reviewer and the consultant, with the peer reviewers sometimes taking a conservative approach. This may relate to the feeling that as peer reviewers they and their companies are accepting a lot of the risks in the project.

The peer reviewers who have been involved in these sites are very able and experienced professionals, so it seems the problem is the system not the personnel.

Experience in the dams area is that it is often valuable to use a panel of reviewers, say two or three persons. This gives a wider experience, more balanced reviews, and where the reviewers agree (as is usually the case after some discussion), they have the weight of numbers on their side to bring the consultant around to see their view. This is not to say the reviewers control the design; that is ultimately for the proponent consultant to "sign off" on.

It is recommended that Council consider appointing such a panel. The panel should report to Council, but the costs should be borne by the proponent, as is currently the case for the peer reviewers. The members should have a demonstrated expertise in landslides and slope stabilisation, not just geotechnical engineering or engineering geology.

It would be best if the review panel was able to meet with the proponent, their consultant and council representatives to present the results of their review, so errors of fact, and misunderstandings can be avoided.

A two or three person panel will cost proponents more than for one reviewer, but the greater degree of confidence in the outcome should hasten the approvals process, easily recovering the additional costs.

Professor Robin Fell
BE(Civil), MEngSc
School of Civil and Environmental Engineering
The University of New South Wales

finalised. This process is a basic form of quality control and a form of validation if the peer reviewer has appropriate wide experience.

9.2.2 Formal validation

For more important advanced level mapping projects there can be a process of validation within the study. To do this the landslide inventory is randomly split in two groups: one for analysis and one for validation. The analysis is carried out in part of the study area (model) and tested in another part with different landslides. An alternative approach for advanced mapping projects is for an analysis to be carried out with landslides that have occurred in a certain period whilst validation is performed upon landslides that have occurred in a different period. Validation can also be carried out by this process after the mapping and land use planning scheme has been in place for some time. This is really only practical for high frequency landsliding because of the time frame required to gather performance data.

9.3 POTENTIAL EFFECTS OF CLIMATE CHANGE

There is a developing knowledge of climate change and the effects of this on rainfall and snowfall. It could be anticipated that for example a decreased frequency of high intensity rainfall might reduce the frequency of shallow landslides on steep hill slopes. However the science of prediction of the effects of climate change and the prediction of the frequency of landslides from rainfall is not sufficiently advanced at this time to warrant consideration of climate change when carrying out zoning studies.

Those involved in landslide zoning studies should keep informed of developments which might alter this conclusion.

10 APPLICATION OF LANDSLIDE ZONING FOR LAND USE PLANNING

10.1 GENERAL PRINCIPLES

These guidelines are for landslide susceptibility, hazard and risk zoning. Those who are considering the introduction of land use management controls for landsliding need to decide the type and level of zoning which they require based on the purpose of the zoning. This is detailed in Section 6. They may choose to stage the zoning and implementation of land use controls.

It should be recognised that it is not possible to delineate zoning boundaries accurately with regional and local zoning using small and medium scale zoning maps. This can only be done using local or site-specific zoning and large to detailed scale maps.

It is critical that the local governmental authority or other organization requiring the zoning, clearly and fully define the purpose and nature of any zoning study, understand the existing availability of potential input data, assess the implications for acquisition of new data and then define realistic goals for the zoning study taking into account, timeframes, budgets and resource limitations.

It should be noted that mapping will usually result in lines on a map delineating for example the landslide hazard zones based on contours and geomorphologic boundaries. However, for land use planning and zoning purposes the zone boundaries are often re-drawn to coincide with allotment boundaries for administrative reasons. This may lead to adoption of conservative boundaries and should be avoided where practical.

10.2 TYPICAL DEVELOPMENT CONTROLS APPLIED TO LANDSLIDE ZONING

Examples of the types of development controls which are applied to landslide zoning are:

- If zoning is by susceptibility the controls usually require geotechnical assessment of hazard and risk of the proposed development for zones determined as susceptible to landsliding whilst only minimal requirements (such as adherence to good hillside practice) in areas determined as very low susceptibility or not susceptible.
- If zoning is by hazard and the study has been done at an intermediate or advanced level it should be possible to delineate land use zones where: (a) Hazard is so low that no development controls are necessary; (b) Where some prescriptive controls such as limits to the heights of cuts and fills are necessary; (c) Where detailed geotechnical assessment of the hazard and risk is required before development can be approved and (d) Where the hazard is so high no development is possible.
- Where zoning is by life loss risk and the study has been done at an intermediate or advanced level, it should be possible to delineate land use zones where (a) Life loss risk is so low no development controls are necessary; (b) Where site specific assessment of the risk is required prior to approval of development and (c) Where the risk is so high that no development is possible.

In practice those considering landslide zoning for land use management would be well advised to seek advice from a Geotechnical Professional who is familiar with landslide zoning and risk management to provide advice in planning the landslide zoning study and applying the outcomes to land use planning.

10.3 NEED TO REVIEW AND UP-DATE LANDSLIDE ZONING

It should be recognised that there should be periodic reviews of landslide zoning because:

- The susceptibility, hazard and risk may be altered by development and land-use changes subsequent to the study.
- The state of knowledge of landsliding in the area will be improved with more detailed investigations carried out as part of the development.
- The elements at risk may change with time so landslide risk zoning should be reviewed to allow for this.
- Methods of landslide zoning are evolving so in combination with the factors listed above, improved zoning will be possible.

It is recommended that reviews be carried out at intervals no greater than about 10 years. In some cases more frequent reviews will be necessary.

11 HOW TO BRIEF AND SELECT A GEOTECHNICAL PROFESSIONAL TO UNDERTAKE A ZONING STUDY

11.1 PREPARING A BRIEF

The following are some matters which should be considered in preparing a brief for a landslide zoning study.

- Define the purpose of the zoning and how it will be used.
- Define the area to be zoned.
- Define what type of zoning is required: landslide susceptibility, hazard or risk.
- Define the level of zoning required and whether it will be staged.
- Identify the various stake holders and their interests.
- Describe what, if any, public consultation process will be required.
- State relevant legal and regulatory controls.
- Set out the documentation required for the results of the zoning, including details of what maps are required, map scales, and electronic formats and the supporting report describing the zoning processes, methods used, validation and limitations.
- Set a program for the study.
- Set a budget consistent with the scope and expectations of the study.
- Describe the peer review process which will apply.
- List the available data and the format it is in.
- Detail the expected method for the study.
- Define the terminology to be used to describe susceptibility, hazard and risk.

In so far as possible, this is best done in consultation with prospective consultants so there is a clear understanding of what is required.

11.2 SELECTING A CONSULTANT FOR THE ZONING

Landslide susceptibility, hazard and risk zoning is a science that should be done by well qualified geotechnical professionals who are experienced in mapping and who understand slope processes, risk assessment and geotechnical slope engineering. This will usually mean that a team of professionals will be needed including an engineering geologist, geomorphologist (for zoning of natural slopes where geomorphology mapping is required) and a geotechnical engineer. It should be noted that only a few engineering geologists and geotechnical engineers are experienced in geomorphologic mapping. It is essential that geotechnical engineers who understand the soil and rock mechanics of slope processes pre and post-failure are involved in the landslide susceptibility, hazard and risk assessments.

Consultants proposing to carry out landslide zoning should demonstrate they have personnel who will work on the project with the relevant skills and experience. It is not sufficient that a geotechnical company has done such studies because it is the personnel directly involved that are important.

Classifieds

DOC E

Tenders

Tuesday March 19, 2013, The Sydney Morning Herald

The Hills Shire Council

Call for Interest in: Independent Expert Review Panel, Geotechnically Sensitive Land

The Hills Shire Council is seeking experts in the fields of landslides, soil and rock mechanics, slope stability, stabilisation and residential development interested in joining Council's Independent Expert Review Panel. The Panel consists of experts, from which 1–3 are selected on a rotational basis as required, to peer review applications for development on geotechnically sensitive land. Applications may range in size from a single dwelling to major subdivision and development. The Panel is engaged by the applicant with administrative support provided by Council.

Submissions should provide evidence of the following:

- Demonstrated expertise in landslides and slope stabilisation, in addition to geotechnical engineering or engineering geology. Experience in the Hills District is desirable;
- Willingness to liaise and prepare joint reports with other members of the panel;
- Public liability and professional indemnity insurance cover of $10 million and $5 million respectively;
- Estimated hours per assessment and cost per hour; and
- Curriculum Vitae of suitable candidates.

For more detailed information contact Kate Clinton, Forward Planning Coordinator, (Mon/Tues/Wed), on 9843 0129.

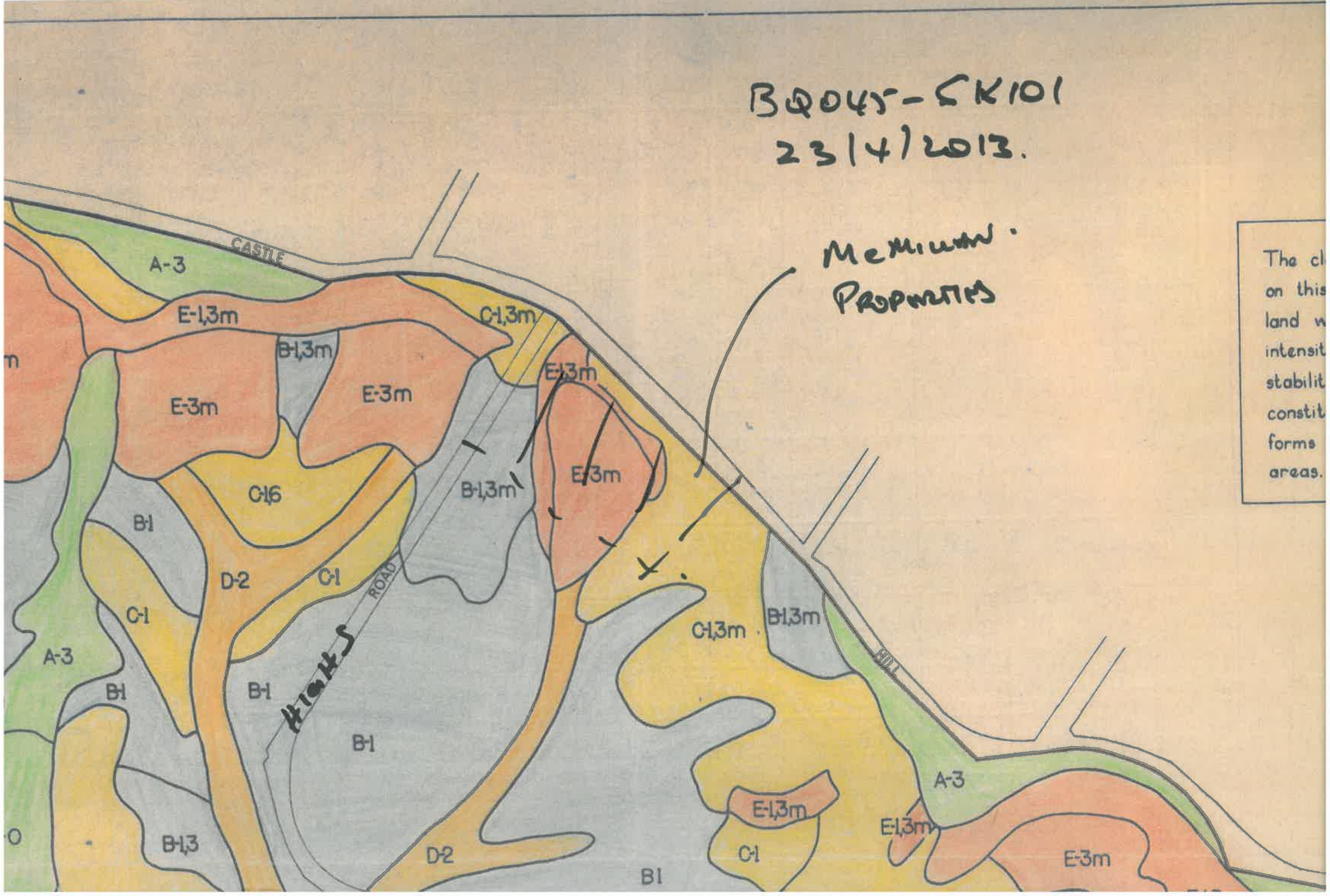
Deadline for Submissions: Friday, 5 April 2013.

Addressed to: The Hills Shire Council,
Forward Planning (FP132),
PO Box 75, Castle Hill NSW 1765.

✆ 9843 0555 | www.thehills.nsw.gov.au

THE HILLS Sydney's Garden Shire

Enlarge


BQ045-SK101
23/4/2013.
McMillan.
Properties
HIGHS
The cl
on this
land w
intensit
stabilit
constit
forms
areas.
CASTLE
HILL
ROAD
A-3
E-1,3m
C-1,3m
B-1,3m
E-3m
E-1,3m
C-1,6
B-1
D-2
C-1
B-1,3
B-1
C-1,3m
E-1,3m
D-2
B1