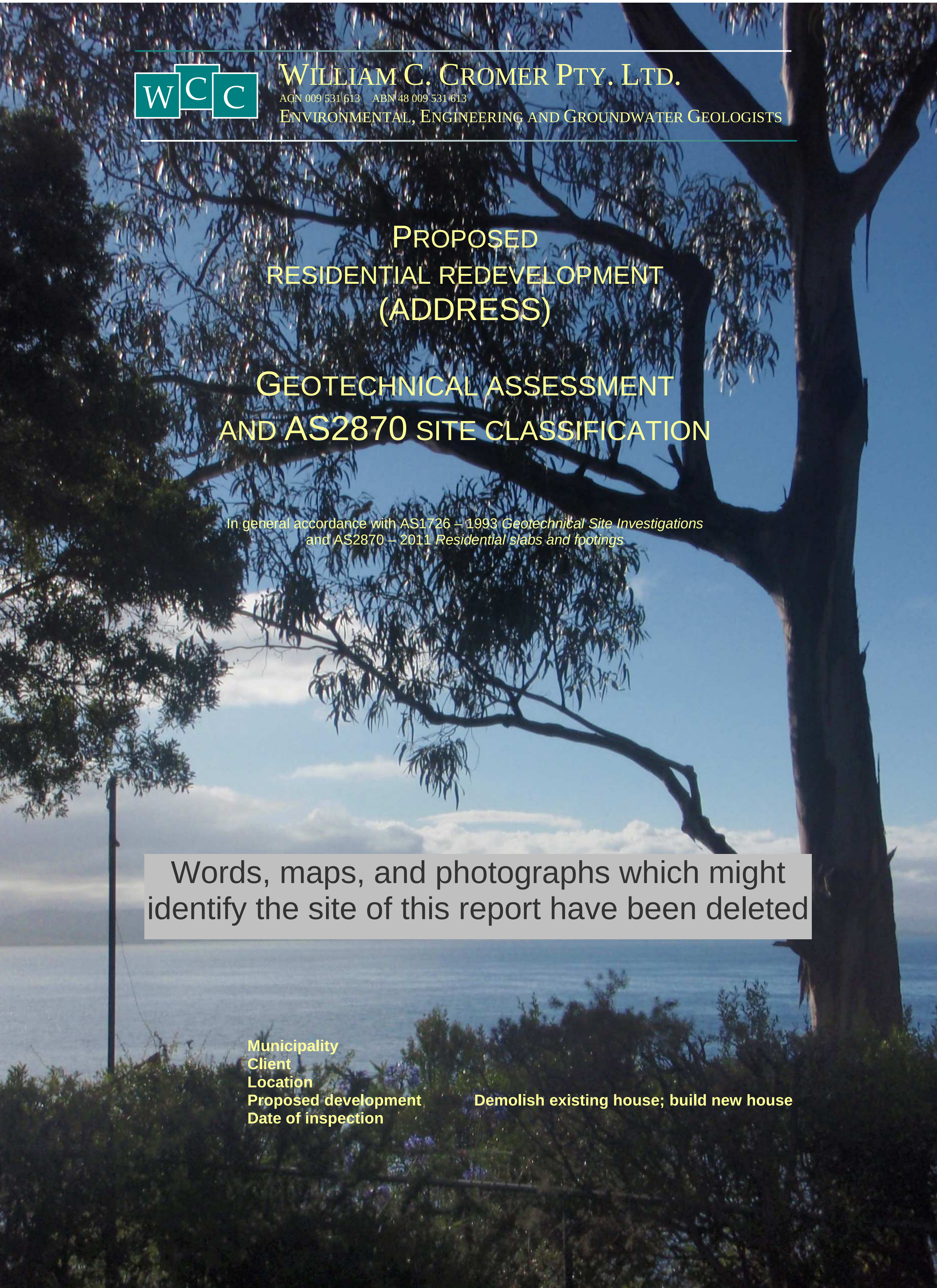

WCC

WILLIAM C. CROMER PTY. LTD.

ACN 009 531 613 ABN 48 009 531 613

ENVIRONMENTAL, ENGINEERING AND GROUNDWATER GEOLOGISTS

PROPOSED RESIDENTIAL REDEVELOPMENT (ADDRESS)

GEOTECHNICAL ASSESSMENT AND AS2870 SITE CLASSIFICATION

In general accordance with AS1726 – 1993 *Geotechnical Site Investigations*
and AS2870 – 2011 *Residential slabs and footings*

Words, maps, and photographs which might identify the site of this report have been deleted

Municipality
Client
Location
Proposed development **Demolish existing house; build new house**
Date of inspection

Cover photo View looking east from (name) over the coastal escarpment to the (name) River

Refer to this report as
Cromer, W. C. (date). *Geotechnical assessment, proposed residential redevelopment, (address).* (Unpublished report for (client) by William C. Cromer Pty. Ltd.

William C Cromer Pty Ltd may submit hard or electronic copies of this report to Mineral Resources Tasmania to enhance the geotechnical database of Tasmania.

SUMMARY STATEMENTS

Geotechnical risk

Risks associated with a variety of geotechnical issues potentially affecting residential redevelopment at (address) are mostly in the Low to Moderate range (see Attachments 7 and 8). Higher risks are associated with reactive soils and localised areas of low strength, uncontrolled fill. All risks can be treated to acceptable levels by standard management techniques. Some specific recommendations are made.

AS2870 Site Classification

The property is classified **Class P** in terms of AS2870 – 2011 *Residential Slabs and Footings*, because of the varying thickness of reactive clay soil over the site, and potential slope instability issues. Footings for Class P sites require certification by a suitably experienced engineer.

AS4055 Wind Classification

In accordance with AS4055 (2006) *Wind loads for housing*, the following wind load classification applies to the property:

Wind Region	**A**
Terrain Category classification	**TC2**
Topographic classification	**T3**
Shielding classification	**PS**
Wind classification	**N3**
Max. Design Gust Wind Speed	**32m/s** ($V_{h,s}$); **50m/s** ($V_{h,u}$)

Main recommendation

From a geotechnical perspective, the property is capable of supporting residential redevelopment subject to the general recommendations of this report.

1 INTRODUCTION

1.1 BACKGROUND

It is proposed to demolish the existing weatherboard house at (address) (Attachment 1), and replace it with the design shown in Attachment 2.

The property is located on gently-sloping ground at the rear of (deleted) coastal cliffs.

William C. Cromer Pty. Ltd. was commissioned by the proponent (client) to provide (a) a geotechnical assessment of the property with particular reference to potential slope instability, and (b) AS2870 site and AS4055 wind classifications.

1.2 BASIS OF ASSESSMENT

This report is based on:

- a review of available reports, and regional-scale geological and engineering geology maps,
- several geotechnical inspections, and photography, excavator test pitting and soil sampling on (date),
- office assessment of field data, including geotechnical risk assessment.

Where applicable, this report is in general accordance with the following guidelines and Australian/New Zealand Standards:

- Australian Geomechanics Society (2007). *Landslide Risk Management*
- Institute of Engineers Australia Tasmania Division (1996) *Recommended Practice for Site Classification to AS 2870 in Tasmania*
- AS4055 – 2006 *Wind loads for housing*
- AS1726 – 1993 *Geotechnical Site Investigations*
- AS2870 – 2011 *Residential Slabs and Footings*
- AS/NZS4360 – 2004 *Risk Management*

This is a summary report supported by Attachments 1 – 9. The Attachments are an integral part of the report and shall not be separated from it.

2 SITE DESCRIPTION

2.1 LOCATION, TOPOGRAPHY AND DRAINAGE

The property (Attachments 1 and 4) is a rhomboidal block measuring about 35m long and 25m wide (0.09ha). It is the last of a row of residential properties on (street), and the existing weatherboard house (Plates 2, 3 and 4 in Attachment 5) was built probably in the 1960s. Apart from very minor cracking of brickwork, the house has suffered no obvious stress since that time.

2.2 TOPOGRAPHY AND DRAINAGE

The property slopes gently east at an angle of about 6^0, from an elevation of about 15m above mean sea level (amsl) along the (street) frontage, to about 12m amsl. Its eastern, boundary lies about 10m inland from subvertical coastal cliffs. Its southern boundary similarly lies within about 10m of steep, locally subvertical slopes up to 12 – 14m high on the northern bank of a deeply-incised (name) creek. The same creek swings inland in a northwesterly direction, so that slopes to the west remain steep and subvertical, and the house and property are in fact bordered on three sides by steep, cliff-like slopes (Attachment 4, and Plate 1 in Attachment 5).

The (name) creek is joined by a second (name creek) near the end of (street).

Possible flood plain

The first creek has cut through a subtle, high level surface which is evident on (addresses) as gently-sloping ground of varying width (but up to 20m or so wide), backed by slightly to moderately steeper ground. The flatter ground is interpreted as a flood plain, which crosses the lower end of (street). Most (if not all) of (street number) is on it. It is possible that the flood plain dates from the Last Interglacial period (between about 70,000 and 130,000 years ago) when sea level is though to have been between about 10 and 20m above current sea level. Sea level fall since then has lowered the erosion base level and caused the creek to cut through the underlying sedimentary rocks.

There are two issues arising from the flood plain inference. First, Mineral Resources Tasmania infers a landslide exists, facing southwest into (name) creek, near (addresses). I argue in Attachment 7 that this is a misinterpretation: the feature is in fact the flood plain and the landslide does not exist. Second, I have interpreted several metres of unconsolidated materials on (house number) overlying older (Tertiary) conglomerate as colluvium or valley fill, presumably deposited as part of the flood plain.

2.3 GEOLOGY AND SOILS

Bedrock geology

The published geological map (Attachment 1) shows the site as wholly underlain by Tertiary-age sedimentary rocks (principally conglomerate). Site inspection supports the published geology. See Attachments 4, 5 and 6 for more details.

Quaternary colluvium or valley fill

(Address) is covered with a veneer of unconsolidated, presumably Quaternary-age colluvium or valley fill up to at least several metres thick in places. See Attachments 4, 5 and 6 for more details.

Soils

Soils are clays and gravelly clays (CH, GC) of variably moderate to high plasticity and low to moderate reactivity up to about 0.9m thick. . See Attachments 4, 5 and 6 for more details.

Fill

Uncontrolled fill comprises disturbed on-site clay soil behind retaining walls and on landscaped areas, and on the lawn between the house and cliff line.

Bearing capacities of materials

Fill	Inadequate for house
Clay soil	Mostly adequate for house
Quaternary colluvium	Adequate for house
Tertiary conglomerate	Adequate for house

Groundwater

Not observed. Permanent unconfined groundwater is probably present in fractured Tertiary sediments near sea level.

AS2870 site classification

Class P. See Attachment 6.

AS4055 wind classification
N3. Maximum Design Gust Wind Speed 32m/s ($V_{h,\ s}$); 50m/s ($V_{h,\ u}$). See Attachment 6.

Soil dispersion
No field evidence of tunnel erosion. Soils are inferred to be non-dispersive.

2.3 SLOPE STABILITY ISSUES

The Mineral Resources Tasmania Landslide Hazard maps in Attachments 3 and 7 show:

- several small shallow landslides on the coastal escarpment and the steep slopes of (name) creek
- (name) creek is at potential risk of debris flow runout but the house site is at a lower risk because of its elevation
- potential rock fall hazards along the coastal escarpment and the steeper slopes of the creeks to the west, and
- the property and neighbouring ones are potentially at risk of deep seated landsliding

Recent field evidence (see Attachments 6 and 7 for more detail)
Relatively recent field evidence of instability includes instances of small-scale landsliding of soil and/or colluvium from the lip of the escarpment. Most failures are less than a metre or so wide, and involve probably less than a cubic metre of material.

Rock falls from the cliff line are inevitable but are not very common.

A landslide in Tertiary sandstone occurred perhaps 12 years or so ago on the cliff line south of (address).

The property lies outside the (recognised landslide district).

3 GEOTECHNICAL RISK ASSESSMENT

In Table 8.1 in Attachment 8, a range of geotechnical issues has been canvassed for the site. The likelihood of each issue has been assessed, its consequences to the subject land are suggested, the level of risk associated with each is proposed, and where appropriate recommendations are made to treat (manage) the risk[1]. See page 2 of Attachment 8 for an explanation of terms used.

Most risks range from Low to Moderate[2], and are judged to be Acceptable. High risks are associated with reactive clay soil and low bearing strength uncontrolled fill.

Recommendations are made to reduce High risks to acceptable levels.

Specifically in relation to potential slope instability, Table 7.1 in Attachment 7 addresses seven scenarios involving rock falls, and shallow and deep seated landslides. Deep seated landsliding at and near (address) is rated as Unlikely, and so although its consequences would

[1] It is up to stakeholders to decide whether any evaluated risk is acceptable or not. A rough guide might be to consider all Very low and Low geotechnical risks as acceptable and not requiring treatment, Moderate risks to be acceptable or tolerable and may require treatment, and High and Very high risks as tolerable or intolerable, and generally requiring treatment. Treatment is designed to reduce risks to acceptable or tolerable levels. It may include Accepting the risk, Avoiding the risk (ie abandoning the project), Reducing the likelihood of the hazard occurring (ie stabilisation measures to control triggering circumstances), Reducing the consequences (eg suitable construction design), Monitoring and warning systems (which might help reduce the consequences of the hazard), Transferring the risk (eg requiring another authority to accept the risk or compensate for the risk, such as insurance companies), and Postponing a decision (eg if there is insufficient certainty about the risk, it might be better to do further investigations).
[2] Capitalised descriptive words like Low and Moderate have defined meanings. See Page 2 of Attachment 8.

be Major, the risk is judged Moderate. Shallower landsliding is more likely to occur, but with lesser consequences and Moderate risks.

4 RECOMMENDATIONS

From a geotechnical viewpoint, residential development as proposed on (address) should proceed subject to the generalised risk treatment suggestions in Table 8.1, and in particular relating to stormwater and general drainage controls, drained, engineered support for excavations, and appropriate footing design. Specifically,

- Development should proceed using good engineering practices. Examples for hillsides are presented in Attachment 8.
- House footings should be designed appropriately for Class P sites, and certified by a suitably experienced engineer. It is recommended that piered (and if concrete, re-enforced) footings extend through uncontrolled fill (if present) clay soil, Quaternary colluvium and into orange-yellow Tertiary-age conglomerate.
- Adequate stormwater controls should be incorporated in the development. Drainage from roofs and hardstands and from behind engineered, drained walls, should be collected and controlled, and piped over the escarpment or adjacent steep slopes to near sea level, preferably in flexible pipework.
- All excavations more than about 0.8m high which expose the clay soil profile or colluvium shall be supported by drained, engineered retaining walls.
- Placement of fill or other loads onto existing soil slopes shall be avoided unless the slopes can be adequately supported.
- Subsurface conditions encountered during construction which appear to differ significantly from those described here should be immediately brought to my attention.

Subject to discussion, it may be possible to vary some of these recommendations provided the variations do not result in unacceptable geotechnical risks.

W. C. Cromer
Principal

(Date)

This report is and must remain accompanied by the following Attachments

Attachment 1	Location, aerial photography and published geology (2 pages)
Attachment 2	Existing and proposed house plans and elevations (2 pages)
Attachment 3	Tasmanian Landslide Hazard Maps in relation to the proposal (4 pages)
Attachment 4	Satellite imagery, and plan and section sketches of (address) (3 pages)
Attachment 5	Site and geological photographs (11 pages)
Attachment 6	Test pits, geology and soils, and AS2870 site and AS4055 wind classifications (13 pages)

Attachment 7. Qualitative slope stability assessment, and Notes for Designers, Builders and Landowners (4 pages)

Attachment 8. Summary of geotechnical issues, risks and consequences to the property, and suggested risk treatment practices (1 page)
Terminology used in geotechnical risk assessment (1 page), and
Examples of good and poor hillside engineering practices (2 pages)

Attachment 9. Three 4-page CSIRO pamphlets (13 pages):
CSIRO Information sheet BTF 18. *Foundation Maintenance and Footing Performance*: *A Homeowner's Guide* (replaces Information Sheet 10/91; dated 2003)
CSIRO Building Technology File No. 19. *A builder's guide to preventing damage to dwellings. Part 1 – Site investigation and preparation* (February 2003)
CSIRO Building Technology File No. 22. *A builder's guide to preventing damage to dwellings. Part 2 – Sound construction methods* (August 2003)
Designers, builders and developers are encouraged to read these publications, and the other Attachments to this report.

Attachment 1

(2 pages)

Location, aerial photography and published geology

Sources: www.thelist.tas.gov.au, Google Earth and Mineral Resources Tasmania

Location

Deleted

Aerial photography

GN

0 500

Approx. metres (all maps)

Source for Geology: Calver, C. R., Latinovic, M., Forsyth, S. M., Clarke, M. J. and Ezzy, A. R. (2004). Map 2, *Hobart – Geology*. Tasmanian Landslide Hazard Series. Mineral Resources Tasmania.

Key to colours: Blues with white circles and dots = Permian-age sandstone and siltstone; Orange = Jurassic-age dolerite; All browns = Tertiary-age sedimentary rocks (in particular, near (address), Tcbd = conglomerate with pebble to boulder size clasts, mainly dolerite; Tssl = fine to medium grained sandstone, minor conglomerate

Published geology

Location detail

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GN

0 100

Approx. metres (all maps)

Google satellite image

Geology detail

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Attachment 2

(2 pages)

Existing and proposed house plans and elevations

Source: (deleted)

Existing site plan

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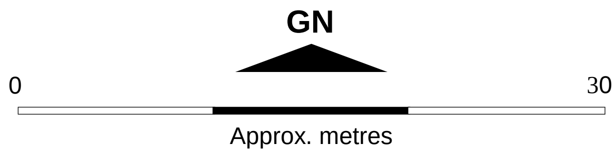
Proposed site plan



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WEST

EAST

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Attachment 3

(4 pages)

Tasmanian Landslide Hazard Maps in relation to the proposal

Notes

This Attachment shows the subject land in relation to four landslide hazard maps for area issued by Mineral Resources Tasmania. A portion of each map covering the property, and part of the Key to the map, are shown.

The maps are:

Map 1: Landslide Inventory and Geomorphology
Map 3: Potential Debris Flow Hazard
Map 4: Potential Rockfall Hazard
Map 5: Potential Deep Seated Landslide Hazard

Map 2 is the geological map of the area, part of which is reproduced in Attachment 2.

The following extract from the explanatory notes to Map 5 explains the purpose and limitations of the maps.

Deep Seated Landslide Hazard

Background, Aim and Purpose

Large tracts of land throughout Tasmania are subject to slope instability and about 60 houses have been destroyed by landslides since the 1950s. Fortunately only minimal loss of life has occurred in this time but such events are highly traumatic to those directly affected and the financial cost to individuals, organisations and the State runs into many millions of dollars. Recent disasters such as the Thredbo Landslide in New South Wales, serve to remind society of the potential for loss of life even from relatively small landslides. Fortunately, landslide damage can be avoided when ground conditions are properly understood before construction proceeds and, in already developed areas, this understanding can be used to mitigate the hazard through various measures.

Regional landslide hazard maps are produced to provide an insight into the natural hazards that may potentially affect the area concerned. Mineral Resources Tasmania, in partnership with the Hobart City Council has produced the first of a new landslide hazard map series in Tasmania, using Hobart as a pilot study area. The information provided is in the public domain and anyone is free to use it provided they read and understand the caveats for use.

Hazard and Risk

According to the joint Australian/New Zealand Standard (AS/NZS 4360:1999) risk is defined as the chance of something happening that will impact upon objectives. It is measured in terms of consequences and likelihood.

The definition of risk is often expressed by the following equation:

RISK = Hazard x Vulnerability x Elements at Risk

A hazard is defined as a source of potential harm or a situation with a potential to cause loss. A hazard, such as a landslide can be measured in terms of location, volume (or area), type, velocity and likelihood with time. Vulnerability refers to the susceptibility and resilience of structures, community and the environment to the hazard. The 'elements at risk' refers to the number of those structures, people, etc exposed to the hazard.

A hazard map attempts to portray the processes operating in an area, conveying all or some of the hazard parameters, generally in a qualitative to semi-quantitative manner. Because of the uncertainties involved, the translation of regional hazard maps into risk maps is challenging and seldom precise. An indication of the likely risk level is provided for each hazard at a regional scale but this will vary in detail. However, provided the limitations of the maps are understood, hazard maps can be used for many purposes in order to achieve the overall goal of safe and resilient communities.

Caveats for Use

The following caveats shall apply to the maps.

- The hazards identified are based on imperfect knowledge of ground conditions and models to represent our current understanding of the landslide process. As this knowledge improves our perception of the hazard and the depiction of the zones on the map may also change.
- These maps can be used as a guide (or flag) to the need for specific assessment in potential hazard areas.
- Planning decisions should not be made solely on the basis of the hazard zones delineated on the map.
- The scale limitations of the data should be considered at all times as exceeding this limit could lead to inaccurate decisions about the hazard.
- Specific assessment of landslide hazard and risk should be undertaken by suitably qualified and experienced practitioners in the fields of engineering geology and geotechnical engineering.
- Practitioners undertaking specific assessments should read the text and appendices attached to the maps and obtain a thorough understanding of the methodology and limitations of the maps.
- Areas where no hazard is shown can still have issues with slope instability.
- Anthropogenic influence on slopes cannot be predicted and the occurrence of slope instability resulting from the influence of human actions is specifically excluded from these maps.
- The identification and performance of cut and filled slopes have not been specifically considered in map production and their scale is such that they often cannot be resolved on the maps. The presence of such slopes should always be considered in specific assessments.

Map 1. Landslide Inventory and Geomorphology.
Mazengarb, C. (2004). Map 1, Hobart – Landslide Inventory and Geomorphology. Tasmanian Landslide Hazard Series. Mineral Resources Tasmania

Several small shallow landslides have been recorded on steep slopes in the vicinity of the subject land

Landslide Inventory and Geomorphology

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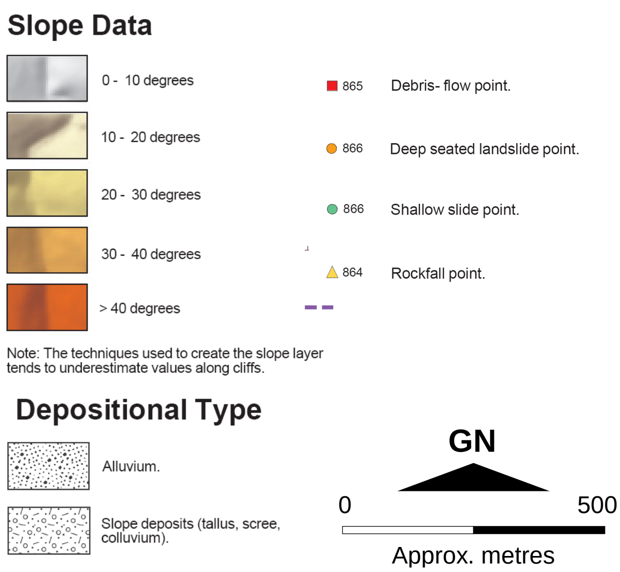

Map 3. Potential Debris Flow Hazard
Mazengarb, C. (2004). Map 3, Hobart – Potential Debris Flow Hazard. Tasmanian Landslide Hazard Series. Mineral Resources Tasmania

The subject land is not shown to be a source area for debris flows, but the nearby creeks are at risk of debris flow runout.

Potential Debris Flow Hazard

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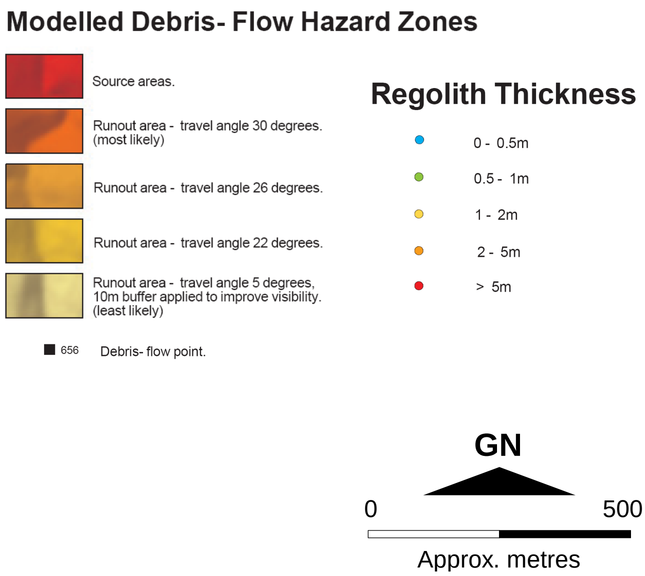

Map 4. Potential Rockfall Hazard

Mazengarb, C. (2004). Map 4, Hobart – Potential Rockfall Hazard. Tasmanian Landslide Hazard Series. Mineral Resources Tasmania

The coastal escarpment extending north and south of the subject land, and steep slopes in nearby unnamed creeks, are shown as potential source areas for rock falls.

Potential Rockfall Hazard

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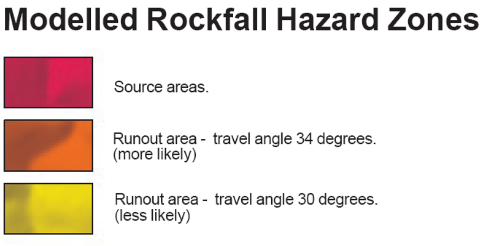

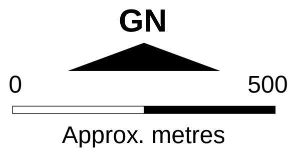

Map 5. Potential Deep Seated Landslide Hazard

Mazengarb, C. (2004). Map 5, Hobart – Potential Deep Seated Landslide Hazard. Tasmanian Landslide Hazard Series. Mineral Resources Tasmania

All of the Tertiary-age sedimentary rocks in the vicinity of and including the subject land are shown as exceeding the threshold angle for deep seated landsliding, or within the setback areas of such landsliding.

Potential Deep Seated Landslide Hazard

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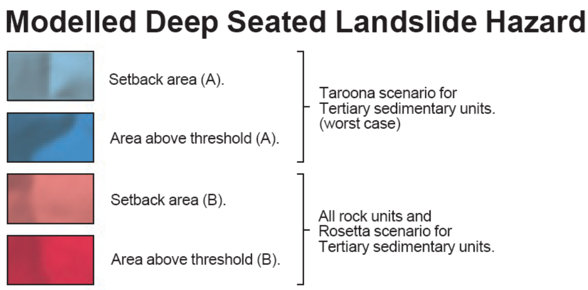

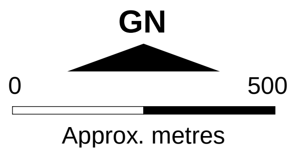

Attachment 4

(3 pages)

Satellite imagery, and plan and section sketches of (address)

Showing test pit locations (red rectangles), topography, drainage, existing house and surveyed cross section.
Source this page: Google Earth

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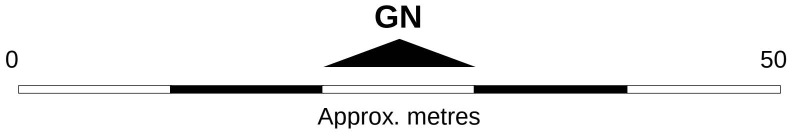
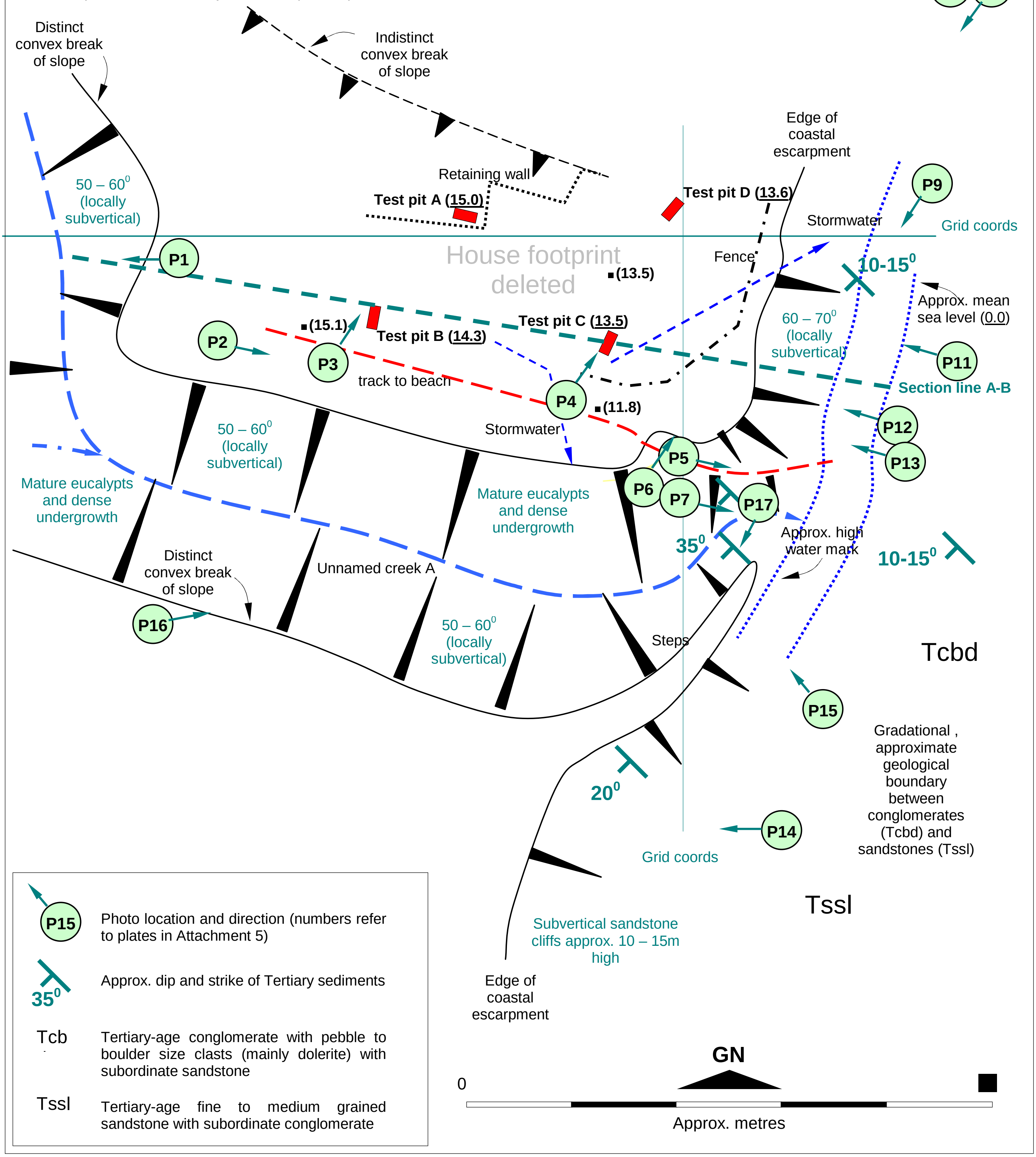


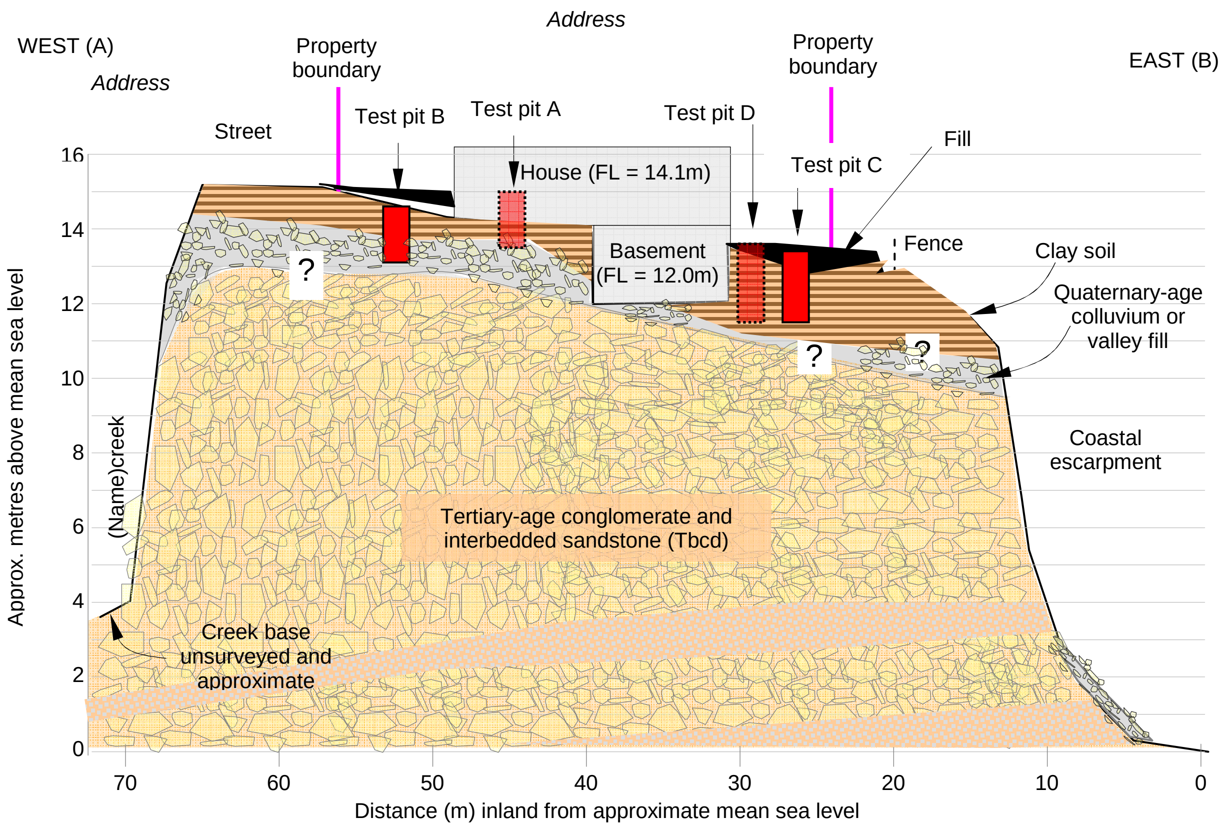
Sketch of the property and environs

Showing test pit locations, topography and drainage

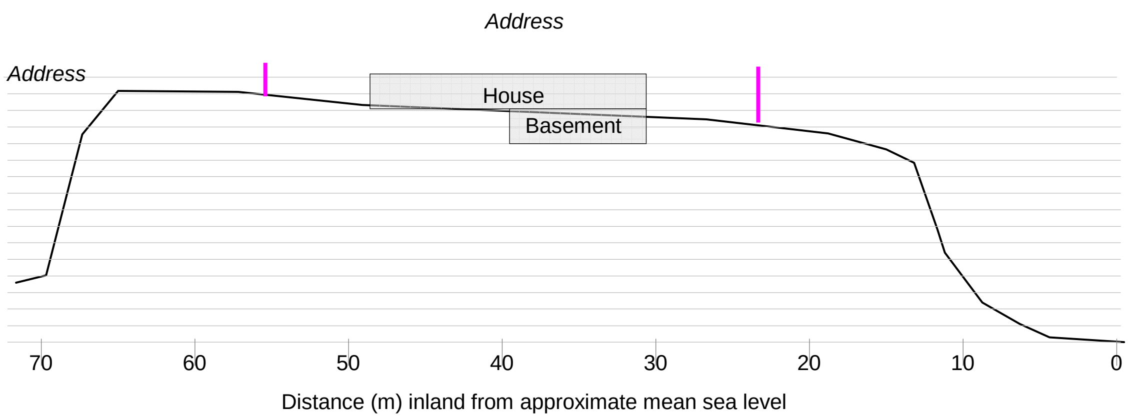
Bold underlined numbers are dumpy levelled elevations in metres above approximate mean sea level. Add approx. 0.6m to correspond to elevations by architects (deleted)



East-west interpretative geological cross section (V/H = 2.5)
Add approx. 0.6m to correspond to floor elevations by architects (name)



East-west cross section (natural scale)



Attachment 5

(11 pages)

Site and geological photographs

(See Attachment 4 for photo locations and directions)

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Plate 1 Deleted

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Plate 2 (above). View east from the lower end of (street) along the public access past (address). The land at right is on the edge of a 12 – 15m escarpment cut in Tertiary sediments by (name) creek in Plate 1.

Plate 3 (below). View northeast towards (address), showing locations of test pits A and B.

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Plate 4 (above). View north along the eastern side of (address), showing test pits C and D, and the approximate property boundary set back about 10m from the edge of the coastal escarpment.

Plate 5 (left). View east from (address) to the base of the coastal escarpment. The staff is graduated in black and red segments each one metre long. On the left are clayey gravels interpreted as Quaternary colluvium or valley fill which overlies Tertiary conglomerate and interbedded sandstone (Tcbd).

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Plate 6 (above). Detail of the weakly consolidated material interpreted as Quaternary colluvium or valley fill, exposed on the (deleted). The material is a near-clast supported conglomerate of 50% angular Permian sandstone and siltstone clasts to 0.1m, and subrounded dolerite clasts to 0.2m, in a moderate plasticity gravelly clay. The proportion of sedimentary to dolerite clasts is about 3:1. Shown here is mostly the former.

Plate 7 (below). Deleted

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Plate 8 (left). A view south of the foreshore below (address) (the fallen tree is at the bottom of the timber steps). The escarpment at right (12 – 15m high) comprises Tertiary conglomerate and interbedded sandstone (Tcbd).

Plate 9 (below). Detail of the foreshore below (address). The dead tree has toppled in the past several years. The staff is 5m high.

Plate 10. A view north, showing subvertical coastal cliffs up to about 18 – 20m high in Tertiary conglomerate (Tcbd). The staff is 5m high. Dolerite cobbles winnowed at sea level from the conglomerate litter the foreshore. At left is a veneer of landslide debris sourced from near the top of the cliff. Dolerite boulders (arrowed) occasionally topple from the cliff face. Instability along this coastal escarpment in Tcbd has been minor in the last 50 years.

Plate 11. A view west of the coastal escarpment up to 15m high in Tertiary conglomerate and interbedded sandstone (Tcbd) in front of (address). The staff is 5m high.

Plate 12 (above). Detail of the base of the coastal escarpment up to 15m high in front of (address). The staff is 1.3m high. Quaternary colluvium or valley fill overlies conglomerate and sandstone.

Plate 13 (below). Detail of Tertiary sandstone, and conglomerate (Tcbd) with spheroidally weathered dolerite clasts on the foreshore below (address).

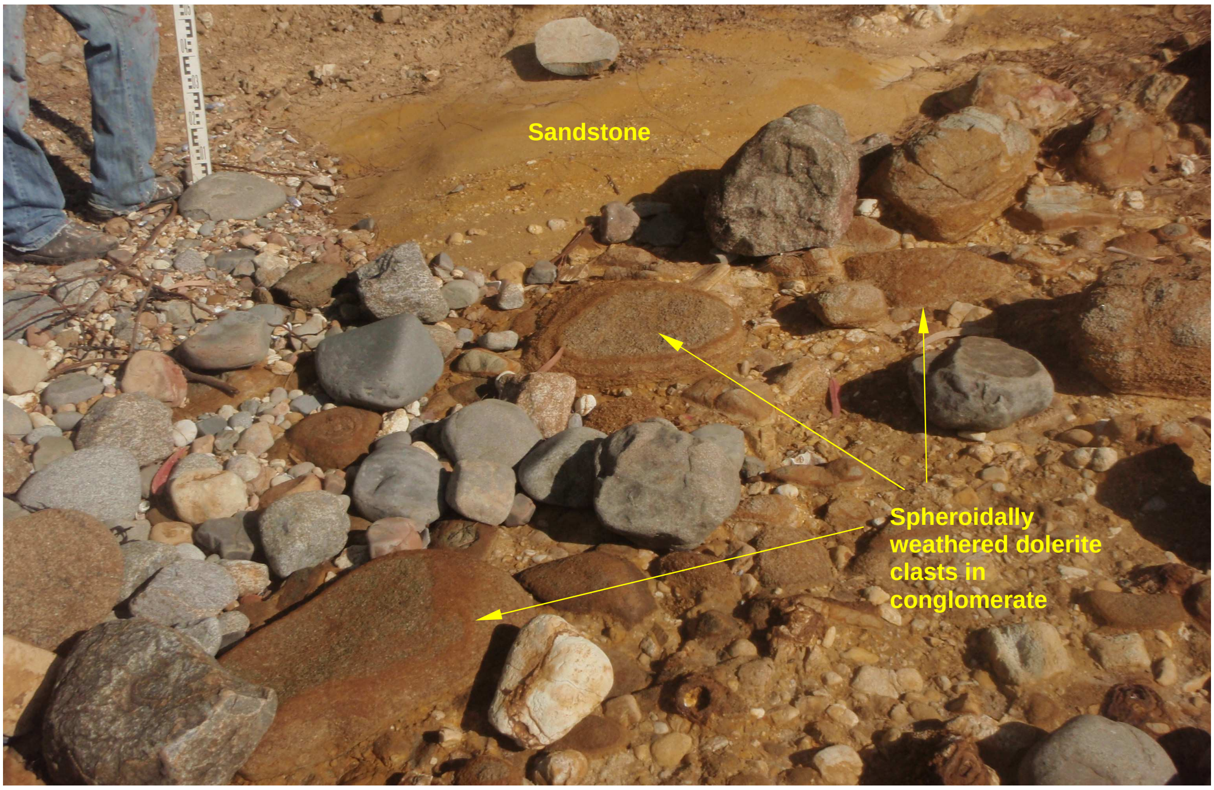

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Plate 14. Deleted

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Plate 15 (above). Deleted

Plate 16 (below). Deleted

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Plate 17. Deleted

Attachment 6

(13 pages including this page)

Test pit logs, geology and soils, and
AS2870 site and AS4055 wind classifications,

William C. Cromer Pty. Ltd. Environmental, engineering and groundwater geologists

Excavation log

Pit A

Sheet 1 of 1

Project [redacted] **Location** : [redacted]

Coordinates [redacted]

Datum GDA94

RL Approx. 15m above mean sea level

Dimensions (m)
Depth 1.5 Length 2 Width 0.7

Exposure type Test pit
Equipment 1.5xcavator; 0.5m bucket; 4 teeth
Operator [redacted]

Date dug [redacted]
Date logged

Logged by W. C. Cromer
Checked by W. C. Cromer

Depth (m)	Notes (Samples and tests)	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Hand penetrometer (kPa)	Structure, geology and interpretation
0 – 0.15		Gravel	Var	GRAVEL, silty CLAY: grey brown; variable plasticity	D	Fb-St		Imported fill
0.15 – 0.85	U50 (0.5)	Clay	CH	CLAY: mottled orange and grey brown; high plasticity; trace sand and gravel	M<PL	H; VSt	500; 350	Soil developed on Quaternary colluvium or valley fill
0.85 – 1.5		Gravel	GW	CONGLOMERATE: yellowish brown; >50% well graded angular Permian-age sandstone and siltstone class to 150mm in silt matrix; nonplastic; almost clast supported	D	VD		Weakly cemented Quaternary –age colluvium or valley fill
1.5				End as required at 1.5m in inferred Quaternary-age colluvium or valley fill				

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

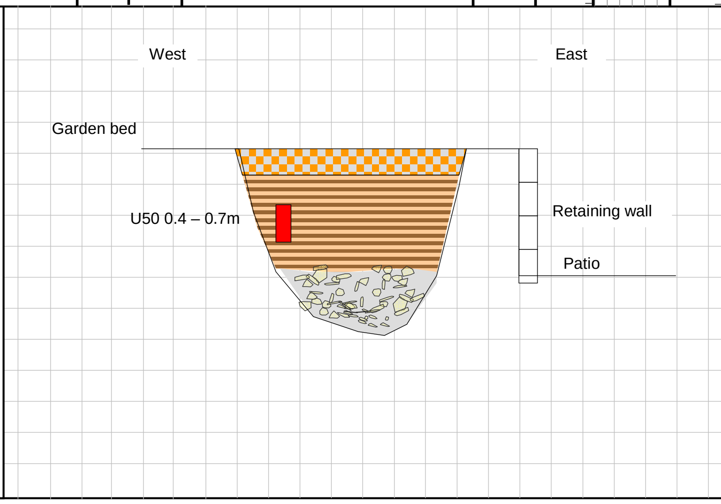
Penetration column: 1 2 3; Shear Vane (kPa); Dynamic cone penetrometer (Blows per 100mm) 2 4 6 8 10; Hand penetrometer scale 25 50 100 200 400

V and H scale 0.5 / 0.5 m

Moisture
D = Dry M = Moist W = Wet

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal



Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)


[redacted]
PIT A

William C. Cromer Pty. Ltd. Environmental, engineering and groundwater geologists

Excavation log

Pit B

Sheet 1 of 1

Project [redacted] **Location :** [redacted]

Coordinates 5[redacted]
Datum GDA94
RL Approx. 14.3m above mean sea level
Dimensions (m) Depth 1.4 Length 2 Width 0.7

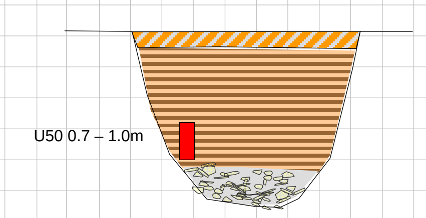
Exposure type Test pit
Equipment 1.5xcavator; 0.5m bucket; 4 teeth
Operator [redacted]

Date dug [redacted]
Date logged
Logged by W. C. Cromer
Checked by W. C. Cromer

Depth (m)	Notes (Samples and tests)	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Hand penetrometer (kPa)	Structure, geology and interpretation
0.0–0.1		CL	Clayey SILT grey brown; low plasticity	D	Fb-St		Imported fill
0.1–1.1	U50 (0.7–1.0)	CH	CLAY: mottled orange and grey brown; high plasticity; trace sand and gravel	M<PL	H	550, 450	Soil developed on Quaternary colluvium or valley fill
1.1–1.4		GW	CONGLOMERATE: yellowish brown; >50% well graded angular Permian-age sandstone and siltstone class to 150mm in silt matrix; nonplastic; almost clast supported	D	Fb - VD		Weakly cemented Quaternary –age colluvium or valley fill
			End as required at 1.4m in inferred Quaternary-age colluvium or valley fill				

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

V and H scale 0.5 / 0.5 m



Moisture
D = Dry M = Moist W = Wet

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
CLAY (CH, CL)
SAND (SP)
SILT (SM)
GRAVEL (GP, GW)
COBBLES (63-200mm)
BOULDERS (>200mm)
SHELLS
SHELL FRAGMENTS
ROOTS
FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)


[redacted]
PIT B


PEARCE
FLINDERS
ESPLANADE
TAROONA
KX41-3V

William C. Cromer Pty. Ltd. Environmental, engineering and groundwater geologists

Excavation log

Pit C
Sheet 1 of 1

Project [redacted] **Location** : [redacted]

Coordinates [redacted]
Datum GDA94
RL Approx. 13.5m above mean sea level
Dimensions (m)
Depth 1.9 Length 2 Width 0.7

Exposure type Test pit
Equipment 1.5xcavator; 0.5m bucket; 4 teeth
Operator [redacted]

Date dug [redacted]
Date logged [redacted]
Logged by W. C. Cromer
Checked by W. C. Cromer

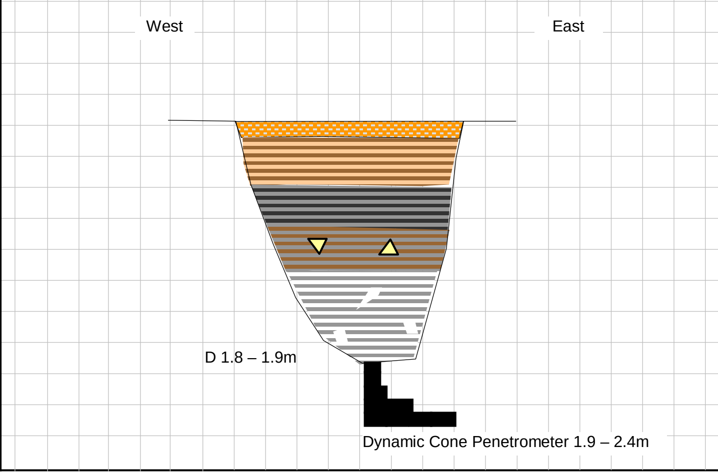
Notes (Samples and tests)	Depth (m)	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Density index	Hand penetrometer (kPa)	Structure, geology and interpretation
	0–0.1	SC	Clayey SAND; brown; nonplastic	D	D		FILL
	0.1–0.5	CL	Sandy CLAY: yellowish brown; moderate plasticity; many fine roots	M<PL	H	>400	
	0.5–0.8	CH CL	Silty CLAY: black; organic; high-mod plasticity; 10% white shell fragments	M<PL	VSt		Original disturbed topsoil with midden
	0.8–1.2	CH	CLAY: greyish brown; high plasticity; occasional sandstone clasts	M<PL	VSt		?Weakly cemented Quaternary –age colluvium or valley fill
D 1.8 – 1.9	1.2–1.9	CH	CLAY: grey with flecks and patches of cream/white travertine?; high plasticity; fractured, with occasional charcoal and rock fragments	D	Fb - VD	>500	
	1.9		End as required at 1.9m in inferred Quaternary-age colluvium or valley fill.				Dynamic Cone Penetrometer 1.9 – 2.4m

V and H scale 0.5
0.5 m

Moisture
D = Dry M = Moist W = Wet

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal



Graphic log key
CLAY (CH, CL)
SAND (SP)
SILT (SM)
GRAVEL (GP, GW)
COBBLES (63-200mm)
BOULDERS (>200mm)
SHELLS
SHELL FRAGMENTS
ROOTS
FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)


[redacted]
PIT C

William C. Cromer Pty. Ltd. Environmental, engineering and groundwater geologists

Excavation log

Pit D

Sheet 1 of 1

Project [redacted] **Location** : [redacted]

Coordinates [redacted]

Datum GDA94

RL Approx. 13.6m above mean sea level

Dimensions (m)
Depth 2.2 Length 2 Width 0.7

Exposure type Test pit

Equipment 1.5xcavator; 0.5m bucket; 4 teeth

Operator [redacted]

Date dug [redacted]

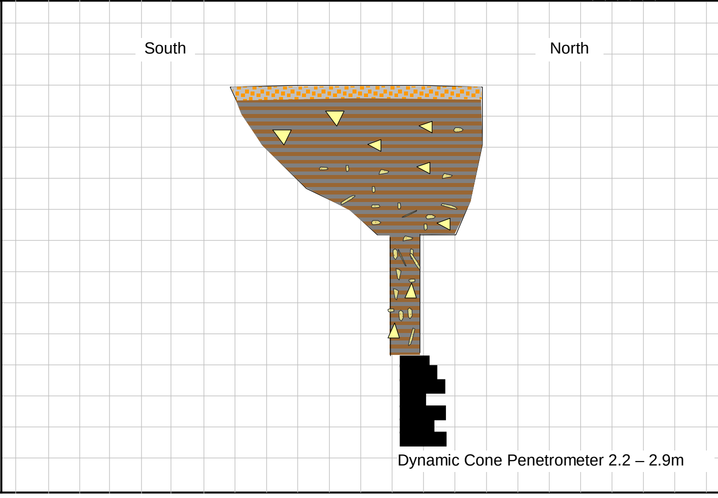
Date logged [redacted]

Logged by W. C. Cromer

Checked by W. C. Cromer

Penetration (1 2 3)	Water	Notes (Samples and tests)	metres (RL / Depth)	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Density index	Strength: Hand penetrometer (kPa) (25 50 100 200 400)	Strength: Shear Vane (kPa)	Strength: Dynamic cone penetrom (Blows per 100mm) (2 4 6 8 10)	Structure, geology and interpretation
		Excavator (0–1.2m)	0.0		SC	Clayey SAND; brown; nonplastic	D	D				FILL
		U50 (approx. 0.5–0.9m)	0.5		CH	CLAY: greyish brown; high plasticity; some sand and occasional sandstone clasts increasing to 10-20% below about 1.2m	M<PL	H	>400			Soil developed on Quaternary colluvium or valley fill
			1.0						>500			Quaternary – age colluvium or valley fill
		Hand auger (1.2–2.2m)	1.5						>500			
			2.0									
			2.5			Hand auger terminated at 2.2m in inferred Quaternary-age colluvium or valley fill						Dynamic Cone Penetrometer 2.2 – 2.9m
			3.0									
			3.5									

V and H scale 0.5 | 0.5 m



Moisture
D = Dry M = Moist W = Wet

Water
- Water level
- Water inflow
- Water outflow

GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS, SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)


PIT D

Bedrock geology

Published geology

The published geological map (Attachment 1) shows the property and surrounding area as being wholly underlain by sedimentary rocks of Tertiary age. The key features of the geological map in this area are:

- A west to south-west dipping conglomerate and subordinate sandstone unit (symbol Tcbd in Attachment 1), which forms dominant subvertical sea cliffs up to about 15m high. This unit and the sea cliffs extend north for about a kilometre, from the unnamed creek next to (address), almost to (name) Point (Plates 8 and 10, Attachment 5). The yellowish-orange rock comprises roughly equal proportions of angular Permian-age sandstone and siltstone clasts, and larger (up to one metre) spheroidally weathered dolerite clasts, in a sand-silt matrix. It is relatively well consolidated and cemented, and an even more resistant series of conglomerate beds crops out near mean sea level as (name) (see the Google Earth image in Attachment 1, and Plate 7 in Attachment 5), extending some 50m southeasterly into the (name) River. The resistant beds trend inland in a northwesterly direction beneath (addresses).

- A similarly west to southwest dipping unit of sandstone with subordinate conglomerate (symbol Tssl) which overlies Tcbd also forms sea cliffs (Plate 14, Attachment 5) which extend some 150m south from (name) creek. Along the beach leading to (address), Tssl dips beneath fractured Tertiary clays (with freshwater fossils) and the coastal escarpment disappears. It is replaced by a complicated series of clays and boulder beds and younger colluvial materials marking the northern boundary of the (name) a large, slow moving but active landslide within the larger (name)[3].

- The boundary between Tcbd and Tssl is described in the geological map as gradational. It trends inland in a northwesterly direction almost to the (name), where it both rock units are overlain by younger clays and boulder beds. The course of the unnamed creek flowing through (addresses) roughly corresponds to the boundary, and appears to have cut a deep channel through mostly the more readily eroded sandstone unit (Tssl).

Observed geology

Tertiary sedimentary rocks

Surface inspection generally supports the published geology (see the photographs in Attachment 4). The conglomerate Tcbd crops out at and near sea level below (address), and extends up the cliff line to about 10m above mean sea level, where it is obscured by vegetation and younger materials. It is also exposed on the northern bank of (name) creek.

Tcbd was not observed in any of the four excavator test pits[4] dug on (address). However, it is inferred that the conglomerate underlies all of the existing and proposed house sites, and probably most of property.

Quaternary? colluvium

Material interpreted as Quaternary-age colluvium[5] or valley fill crops out on the northern side of (address), and overlies conglomerate near sea level at (location) (Plates 5, 6 and 12 in Attachment 5). Test pits A and B exposed the colluvium? (see the test pit logs, this Attachment) which comprises a weakly cemented (but very dense) almost clast-supported

[3] For detailed reports on (name), see (references)

[4] See the four engineering log sheets for the test pits in this Attachment. A small 1.5t excavator with a depth limit of around 2.2m was required because of restricted access to the seaward side of the house. A larger machine might have intersected Tcbd although pit D was extended by dynamic cone penetrometer to 2.9m with no indication of the rock unit.

[5] The material is unlikely to be Tcbd since it is only weakly cemented and dolerite clasts are absent.

yellowish-brown conglomerate or breccia (GW) with more than 50% angular Permian-age sandstone and siltstone clasts to 0.15m diameter, in a nonplastic silt matrix.

The colluvium is inferred to cover the whole of (address), and to overlie Tcbd (see the interpreted cross section in Attachment 4). The attitude of the boundary between it and Tcbd is unknown.

Uncontrolled fill

Small amounts of uncontrolled fill are present on the property, where it comprises clayey silt, silty clay and local gravel imported to the site for landscaping, etc. Generally it did not exceed about 0.2m in pits A, B and D, but was 0.5m thick in pit C.

Soils

Texture and thickness

Soil developed on Quaternary-age colluvium on the property is variable in colour, thickness and texture.

In pits A and B it comprised a uniform, high plasticity, mottled orange and grey clay (CH) with traces of sand and gravel. Thickness ranged from 0.7 – 0.9m.

In pit C, the original topsoil beneath 0.5m of fill is a dark-coloured, disturbed silty clay (CH) 0.3m thick with shell fragments (a midden). The underlying materials were 0.4m of greyish brown clay (CH) over 0.7m of grey clay (CH) flecked with cream travertine patches and a trace of charcoal. Both clays had occasional sandstone clasts. The combined 1.1m (at least) of clay may be a residual soil profile but is more likely to represent a colluvial deposit, of presumably Quaternary age, but younger than the colluvium described above and lacking the high proportion of sandstone and siltstone clasts. A dynamic cone penetrometer test suggests that the clay extends to about 2.2m but material strength appears to increase markedly around 2.2 – 2.4m

In pit D, beneath 0.1m of fill, a greyish brown high plasticity clay (CH) with occasional sandstone clasts extended to at least 2.2m. As shown on the engineering log for this pit (this Attachment), this clay is possibly of colluvial origin (like the clay in pit C). A dynamic cone penetrometer profile suggests that clay extends to about 2.9m with no significant increase in material strength.

Reactivity

Dark-coloured, high plasticity clays on Tertiary sediments in the (name) area are known to be reactive.

To assess soil reactivity, and to assist site classification in accordance with AS2870 – 1996 *Residential slabs and footings – Construction*, an undisturbed (drive tube) clay sample was collected from each of test pits A, B and D and tested[6] to estimate its Shrink-Swell Index (I_{ss}). Test results are summarised in Table 6.1, which also shows estimated ground surface movements at each pit, and the corresponding AS2870 classification. I_{ss} values range from 1.6 – 4.6%, with estimated natural ground surface movements in the range 30 – 90mm at test across pits A, B and D because of the differing soil thicknesses and I_{ss} values.

[6] Although William C. Cromer Pty. Ltd. is not NATA registered, testing was performed essentially in accordance with AS1289.7.1.1-1998. Methods of testing soils for engineering purposes. Method 7.1.1. Soil reactivity tests – Determination of the shrinkage index of a soil – Shrink-swell index. *Standards Australia*. From the Shrink-Swell index, the maximum ground surface movement can be estimated, and hence the site classification.

Table 6.1. Summary of shrink swell tests

Test pit	Sample depth (m)	Material tested	Bedrock geology	Initial moisture content (%)	Swelling strain (%)	Shrinkage strain (%)	Shrink swell index (Iss, %)	Est. ground surface movement (mm)	Corres ponding AS2870 site class	Suggested AS2870 site class**
A	0.4-0.7	CLAY (CH)	Soil on Quaternary? colluvium	17	1.0	2.5	**1.6**	30	M	P
B	0.7-1.0	CLAY (CH)	Soil on Quaternary? colluvium	29	8.7	4.0	**4.6**	90	E	P
D	0.5-0.8	CLAY (CH)	Soil on Quaternary? colluvium	15	3.1	1.5	**1.7**	45	H	P

**House footprint is recommended Class P because of variability of est. ground surface movements, and thickness and nature of soil

Dispersion
No obvious signs of tunnel erosion were noted during site investigations. No samples were dispersion-tested for Emerson Class numbers.

AS2870 site classification

Because of the range of ground surface movements indicated in Table 6.1, and potential slope instability issues discussed in Attachment 7, the property is classified **Class P** in terms of AS2870 – 1996 *Residential slabs and footings – Construction*.

Footings for Class P sites require certification by an engineer experienced in footing design.

AS4055 wind classification

In accordance with Australian Standard 4055 (2006) *Wind loads for housing*, the following wind load classification applies to the property:

Wind Region	**A**
Terrain Category classification	**TC2**
Topographic classification	**T3**
Shielding classification	**PS**
Wind classification	**N3**
Max. Design Gust Wind Speed	**32m/s** ($V_{h,s}$); **50m/s** ($V_{h,u}$)

Bearing capacity of materials

Fill
Clayey fill is uncontrolled and has inadequate bearing capacity for houses.

Soil and Quaternary? colluvial deposits
At the time of investigation the clayey soil profile was drier than perhaps is usual. This is reflected in the relatively high strength consistencies and results from the pocket penetrometer[7] which in all pits was never less than 350kPa and mostly more than 400 – 500kPa.

Approximate relationships between clay consistency and penetration resistance are shown in Table 6.2.

[7] The pocket penetrometer reads about twice the unconfined compressive strength

Tertiary conglomerate
The conglomerate, which is expected at relatively shallow depth over the site, is expected to have relatively high strength and more than adequate bearing capacity for the proposed house.

Table 6.2 Some suggested correlations between consistency of clay and penetration resistance

Consistency	Field Test	Undrained Shear Strength c_u Torvane (kPa)	Unconfined Compressive Strength q_u Pocket Penetrometer (kPa) **	Dynamic Cone Penetrometer blows/100 mm *	CPT Resistance MPa
Very soft	Easily penetrated >40 mm by thumb. Exudes between thumb and fingers when squeezed in hand.	<12	<25	<1	<0.2
Soft	Easily penetrated 10 mm by thumb. Moulded by light finger pressure	12 - 25	25 - 50	1	0.2 - 0.4
Firm	Impression by thumb with moderate effort. Moulded by strong finger pressure	25 - 50	50 - 100	1-2	0.4 - 0.8
Stiff	Slight impression by thumb cannot be moulded with finger.	50 - 100	100 - 200	2 -4	0.8 - 1.5
Very Stiff	Very tough. Readily indented by thumbnail.	100 - 200	200 - 400	4 - 8	1.5 - 3.0
Hard	Brittle. Indented with difficulty by thumbnail.	>200	>400	>8	>3.0

* Very approximate only, better to rely on soil sample field test

** Note pocket penetrometer reads twice the unconfined compressive strength (q_u)

Attachment 7

(9 pages)

Qualitative slope stability assessment,
and Notes for Designers, Builders and Landowners

Qualitative slope stability assessment

Published evidence and inferences

The Mineral Resources Landslide Hazard maps in Attachment 3 show in the vicinity of (address):

- several small shallow landslides on the coastal escarpment and the steep slopes of (name) creek (location numbers 856, 857, 858, 859 and 860),
- (name) creek is at potential risk of debris flow runout but the house site is at a lower risk because of its elevation (about 14m above mean sea level),
- potential rock fall hazards along the coastal escarpment and the steeper slopes of the unnamed creeks to the west, and
- the property and neighbouring ones are potentially at risk of deep seated landsliding

Location numbers 856 – 860 are also shown on the landslide map on the Mineral Resources Tasmania website[8] which is reproduced here as Figure 5.1 (green circles added for clarity).

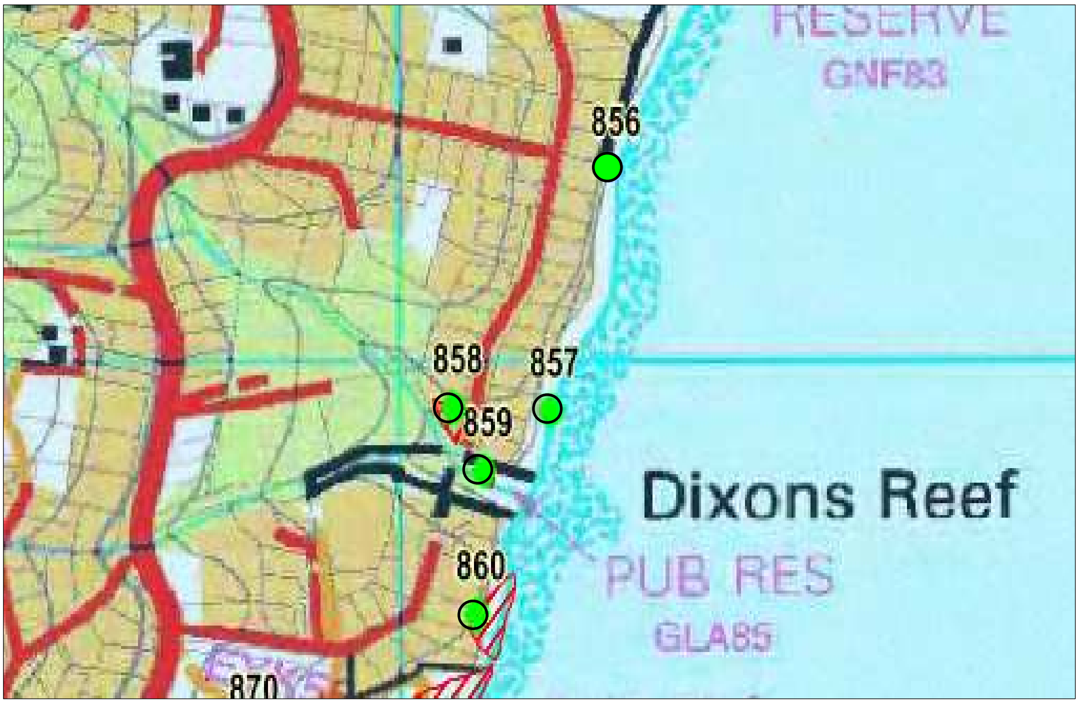


Figure 7.1. The Mineral Resources Tasmania landslide map near (address)

The website information associated with the numbers is as follows.

Landslides 856 and 857 refer to small un-mapped landslides mentioned by Cromer and Leaman (1976)[9].

Landslides 858 and 859 refer to recent or active landslides on the northern bank of the un-named creek with steep slopes over 20^0. #858 is shown as a relatively large feature but is not

[8] http://www.mrt.tas.gov.au/Viewer/Exposure/E3?REQUEST=Entry&PRJ=Geohazards_Public&DELETE_DEFAULT=Y&SID=34665639&MODE=mrt&reload=1

[9] Cromer, W. C. and Leaman, D. E. (1976). *Marine erosion at Taroona*. Unpublished report Dept. Mines Tasm. 1976/68. November 1976.

discussed in Latinovic *et al* (2000)[10]. The slopes at 859 are obscured by thick low growth (similar to Plate 16 in Attachment 5) and it is not possible to confirm whether or not the landslide exists. Landslide 859 includes land owned and occupied by (name) since the early 1970s, and the feature probably does not exist. Instead, the gradual break and flattening of slope in the general vicinity (including (address)), which extends southwest across (name) creek I interpret not as a landslide but as a narrow flood plain formed perhaps during the Last Interglacial when sea level was between 10 and 20m higher than present.

Landslide 860 gets a brief but specific mention on page 20 of Latinovic *et al* (2001). It occurred perhaps 12 years or so ago and involved failure of Tssl sandstone along a steeply east dipping and slightly curved joint surface, probably lubricated by excess water from rain and (reportedly) stormwater. It involved at least 100m^3 of rock and soil, and has blocked foreshore access.

Recent field evidence
Relatively recent field evidence of instability is as follows.

Shallow landslides of soil/colluvium
In the past few years, instances of small-scale landsliding of soil and/or colluvium from the lip of the escarpment have been relatively common after heavy or prolonged rain, and much less common in the absence of rain. Most failures are less than a metre or so wide, and involve probably less than a cubic metre of material.

Rock falls
Rock falls (most likely of spheroidally weathered dolerite boulders) are inevitable but are not very common. For example, Plate 10 in Attachment 5 shows only one or two toppled boulders up to about 0.5m^3.

Potential slope instability scenarios
Based on the foregoing, Figure 7.2 shows seven potential slope instability scenarios (“issues”) affecting residential development of (name). Note that scenarios 6 and 7 are essentially the same, and are treated together. The red lines in Figure 7.1 are schematic only, and are intended to represent classes of scenarios, not necessarily actual failure surfaces.

In Table 7.1, the likelihood of each scenario occurring is estimated, based on existing evidence of slope instability in the area. Consequences are subjectively attached to each issue, and the resulting risk level assessed. Where appropriate, ways to treat (manage) the risk are suggested.

Scenarios 1 and 2 are rated as Almost certain, but with Insignificant consequences to property and Low risks. Scenario 3 is rated as Unlikely, with Medium consequences, and Moderate risk. Scenarios 5, 6 and 7 are rated Unlikely, with Major consequences and Moderate risks.

Moderate risks are generally regarded as Acceptable or Tolerable.

Risks associated with a range of other geotechnical issues are canvassed in Attachment 8.

[10] Latinovic, M., Waite, A., Calver, C. R. and Forsyth, S. M. (2001). An investigation of land instability in the Taroona area. *Tasmanian Geological Survey Record 2001/01. Mineral Resources Tasmania*

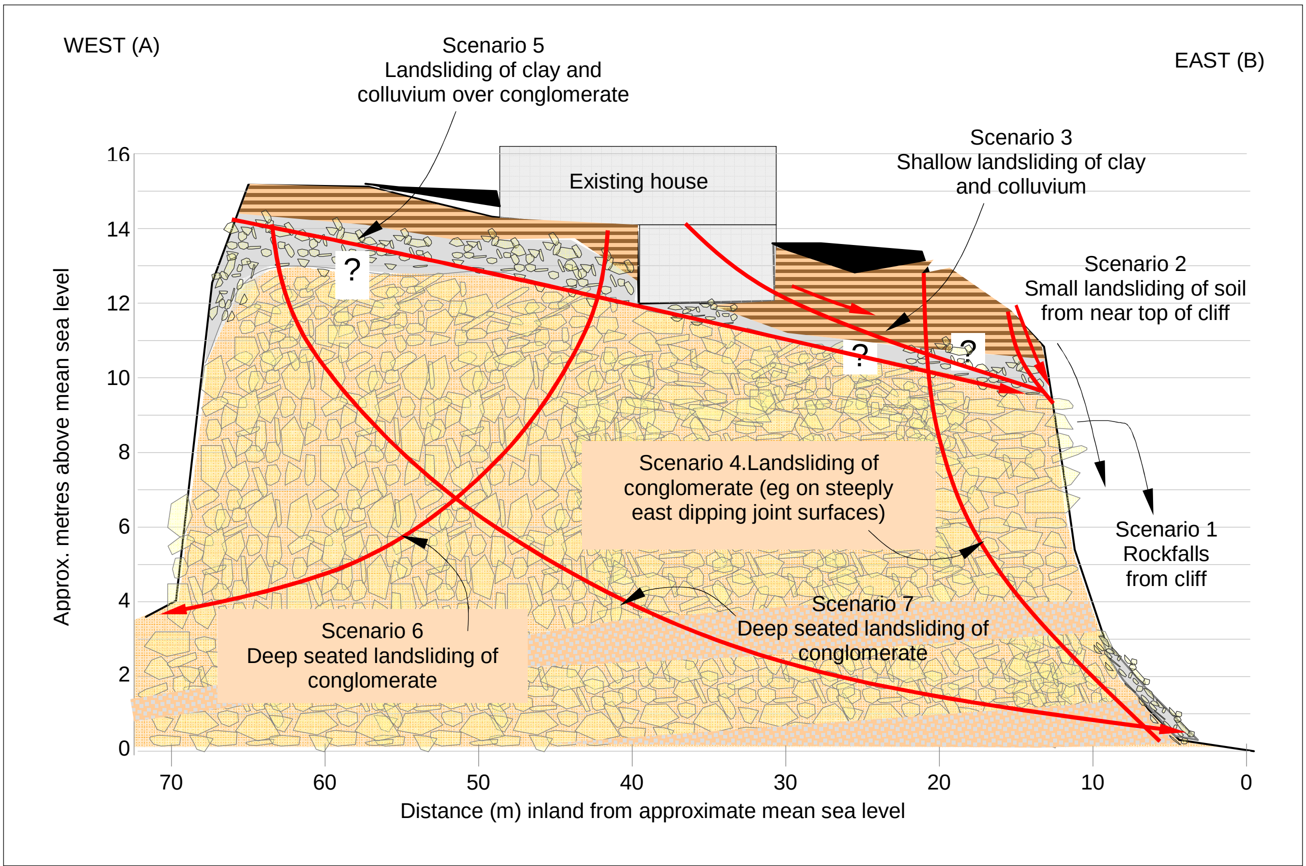


Figure 7.2. East-west interpretative cross section showing potential slope instability scenarios (V/H = 2.5)
Add approx. 0.6m to correspond to floor elevations by architects (name)

Table 7.1 Summary of potential slope instability issues, consequences and risks to (name), and suggested risk treatment practices

	Issue	Likelihood of occurrence	Consequences to property	Level of risk to property	Risk treatment
1	Scenario 1	Almost certain	Insignificant	Low	Pipe stormwater away from escarpment, or down escarpment to sea level.
2	Scenario 2	Almost certain	Insignificant	Low	As for issue 1
3	Scenario 3	Unlikely	Major	Moderate	As for issue 1. Extend house footings into (not on) conglomerate (Tcbd)
4	Scenario 4	Possible	Medium	Moderate	As for issue 3.
5	Scenario 5	Unlikely	Major	Moderate	As for issue 3. Removal of some of the material for a basement level will reduce risk.
6	Scenarios 6 and 7	Unlikely	Major	Moderate	No action required

Notes for designers and builders

Footings

It is strongly recommended that footings for the new house be piered into the Tertiary conglomerate (Tcbd). The depth to Tcbd is uncertain, and an excavator larger than 1.5t could be used prior to final design to investigate this issue.

Cut and fill

A cut of some 2 – 2.5m is proposed to create a lower floor, at a level similar to the current garage. It is expected that the excavation will be entirely in clay and Quaternary colluvium, with little or no orange-yellow, higher strength Tertiary conglomerate. The walls of the cut will probably be temporarily free-standing even if vertical, but future failure is certain if they are not supported by drained, engineered walls. Drainage from behind the walls must be directed in solid pipework off-site and away from the escarpment (or over the escarpment to sea level in solid pipe).

Drainage

All upslope surface runoff shall be adequately controlled and diverted around the house. Roof runoff may be collected in tanks for later use, but any overflow must be piped to sea level.

Wastewater management'

It is noted that the current house has two septic tanks. The discharge from one is directed to ground surface at the lip of the escarpment; discharge from the other possibly seeps south or southeast to the top of the embankment above the un-named creek.

It is noted that both tanks will be disconnected, and all wastewater from the new house will be pumped off-site to Council reticulation.

Variability of subsurface conditions'

Expect variability in subsurface conditions. The main variation will probably be in the thickness of clay overlying Quaternary colluvium.

<u>Subsurface conditions encountered during any development which appear to differ significantly from those described here should be immediately brought to my attention.</u>

Preventing damage to buildings

In conjunction with the generalised suggestions in the present report, the designer and builder are referred to the CSIRO Bulletins BTF19 and 22 in Attachment 9.

Notes for future owners and occupiers

Information bulletins

Future owners and occupiers are referred to the CSIRO Bulletin BTF18 in Attachment 9 of this report.

Attachment 8

(4 pages)

Summary of geotechnical issues, risks and consequences to the property, and suggested risk treatment practices (1 page)
Terminology used in geotechnical risk assessment (1 page), and
Examples of good and poor hillside engineering practices (2 pages)

Table 8.1 Summary of geotechnical issues, risks and consequences to development site, and suggested risk treatment practices

		A	B	C	D
	Issue	**Likelihood of occurrence**	**Consequences to property**	**Level of risk to property**	**Risk treatment**
1	**Surface soil erosion**	Unlikely	Minor	Low	Control stormwater. Refer to the following examples of good and poor engineering hillside practice. Pipe all stormwater in above ground pipes down escarpment to sea level.
2	**Tunnel erosion**	Unlikely	Minor	Low	As for hazard 1
3	**Soil creep**	Likely	Medium	High	As for issue 1
4	**Shallow-seated landslide (involving, for example, soil, boulder beds, talus, colluvium, etc)**	Almost certain to Unlikely	Insignificant to Major	Low to Moderate	See Table 7.1
5	**Deep-seated landslide (involving, for example, boulder beds, talus, colluvium, bedrock etc)**	Unlikely	Major	Moderate	See Table 7.1. No action required
6	**Foundation movement due to reactive soils**	Almost certain	Medium	High	Avoid reactive clay as founding material or design footings to cope. Recommend extending all footings beneath clay soils/colluvium to Tertiary conglomerate (Tcbd)
7	**Low strength materials (eg uncontrolled fill, soft soils)**	Locally certain, otherwise Rare	Medium	Locally High, otherwise Low	As for issue 6
8	**Vegetation removal**	Unlikely	Minor	Low	Revegetation encouraged. Avoid planting large trees within 10m of house. Maintain mature trees on embankment.
9	**Flooding or waterlogging**	Flooding Rare Waterlogging Possible	Flooding Medium Waterlogging Medium	Flooding Medium Waterlogging Medium	As for issue 1. Ensure basement walls are drained.
10	**Riverbank collapse**				See Table 7.1.
11	**On-site wastewater disposal**	Not applicable. Council sewer is available			
12	**Site contamination from previous activities**	Unlikely	Minor	Low	Visual examination during excavations for site development
13	**Earthquake risk**	Almost certain (magnitude <5); Likely (magnitude>5)	Insignificant to Minor	Low to Moderate	Generally accept risk. A similar risk or range of risks exists throughout Tasmania.
14	**Sea level rise**	Possible to Likely	Insignificant	Low	No specific action required

Notes
1. The assessments in Columns A, B and C are unavoidably subjective to varying degrees.
2. See the next page for an explanation of the terms used in this table.
3. Further reading: Australian Geomechanics Society Subcommittee (2007). Landslide Risk Management. Aust. Geomechanics 42(1) March 2007

Terminology used in geotechnical risk assessment (1 page)

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: – 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) For 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.

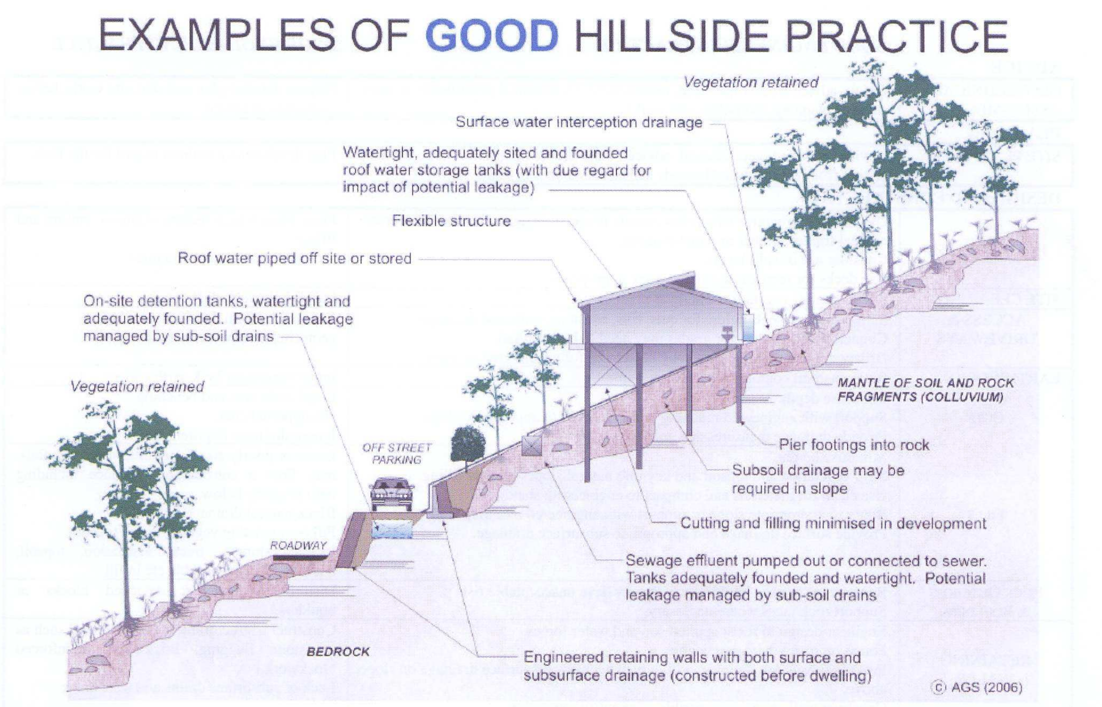
RISK LEVEL IMPLICATIONS

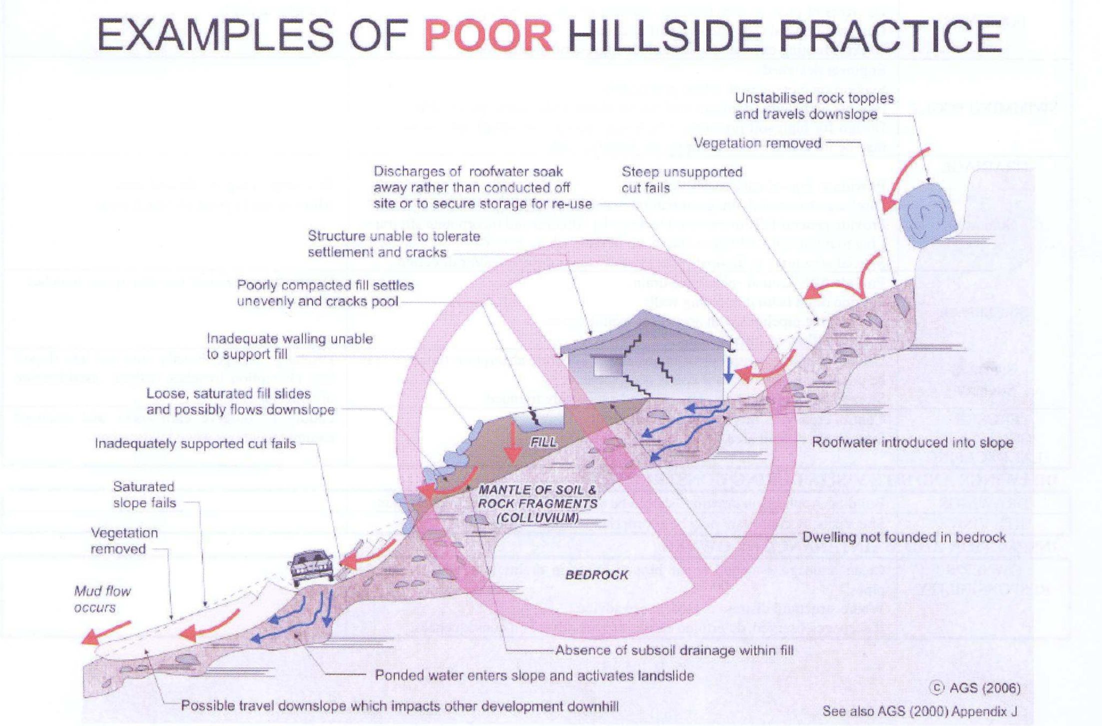
Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
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.

Examples of good and poor hillside engineering practices

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007





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APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner 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.	Indiscriminatory 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 property 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 rock 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 rock 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 general 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 on 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 roof runoff 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 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 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 see advice. If seepage observed, determine causes or seek advice on consequences.	

Attachment 9

(13 pages including this page)

Three 4-page CSIRO pamphlets

CSIRO Information sheet BTF 18. *Foundation Maintenance and Footing Performance*: *A Homeowner's Guide* (replaces Information Sheet 10/91; dated 2003)

CSIRO Building Technology File No. 19. *A builder's guide to preventing damage to dwellings. Part 1 – Site investigation and preparation* (February 2003)

CSIRO Building Technology File No. 22. *A builder's guide to preventing damage to dwellings. Part 2 – Sound construction methods* (August 2003)

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