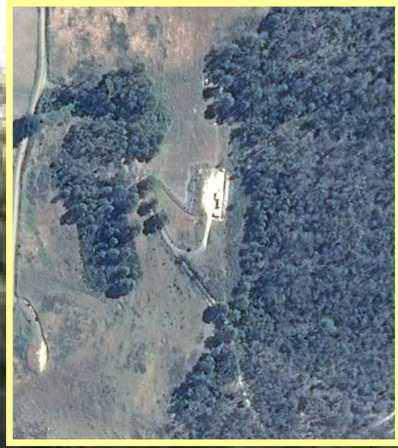

Proposed new house
110 Ayres Road
Ranelagh

Geotechnical Summary

In general accordance with AS1726 (1993) *Geotechnical Site Investigations*

Site (Soil test) Classification

In general accordance with AS2870 (2011) *Residential slabs and footings*

AND

Wind Load Classification

In general accordance with AS4055 (2006) *Wind loads for housing*

Municipality	**Huon Valley**
Client	**I and J Urquhart**
Location	**110 Ayres Road, Kettering**
Development	**New house**
Date of inspection	**6 May 2014**

Cover

Main photo

View looking southeast across the house site excavation prepared some three years ago by a previous owner. The proposed new house will be located in the flat area in the foreground, and at left, and will be raised one floor to allow parking underneath and level access via a deck or landing to the grassy slope behind. The undrained timber retaining wall supported by vertical steel posts has withstood several small superficial landslides on the oversteepened bank behind. Weathered and fractured Permian sandstone bedrock forms subvertical exposures immediately behind the wall. Bedrock is also exposed on the flat excavated ground in front of the wall.

The natural slope behind the wall is about 18 – 20^0, steepening upslope to 25^0, and then 30^0 and more in the timbered slope segment at upper left.

Inset image

January 2014 Google Earth satellite imagery of the house site (centre) and environs.

Refer to this report as

Cromer, W. C. (2014). *Geotechnical summary, site classification and wind classification, proposed new house at 110 Ayres Road, Ranelagh.* Unpublished report for I. and J. Urquhart by William C. Cromer Pty. Ltd., 19 May 2014; 33 pages

Important Notes

Valuable geotechnical information is contained in this report. The information may be useful to regulators and other geotechnical practitioners. Dissemination of such knowledge ought to be encouraged by practitioners and regulators.

Permission is hereby given by William C. Cromer as author, and the client, for an electronic copy of this report to be distributed to, or made available to, interested parties, but only if it is distributed or made available in full. No responsibility is otherwise taken for its contents.

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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 proposed new house at 110 Ayres Road, Ranelagh, are mostly in the Low – Moderate range (see Attachments 4, 5 and 6) and can be addressed by standard management techniques. High risk relates to uncontrolled fill on the house site pad. Others concern to slope instability. All can be managed at tolerably to acceptably low levels after development.

Recommendations are made to manage these issues in Section 4.6 of Attachment 4. Note also that a suitably experienced practitioner is required to inspect and certify all pier holes before piers are emplaced.

. Subject to these and recommendations, development of this site should proceed.

AS2870 Site Classification

In accordance with Australian Standard 2870 (2011) *Residential slabs and footings*, the area abcd in Attachment 2 to this report is classified as **Class P** (see Attachment 4). Designs for **Class S** footings are acceptable if the footings extend into, not onto, weathered sandstone bedrock.

Footings for Class P sites require certification by an engineer experienced in footing design. It is also recommended that a suitably experienced engineer or engineering geologist inspect and approve all holes for piered footings before footings are emplaced.

AS4055 Wind Classification

In accordance with Australian Standard 4055 (2006) *Wind loads for housing*, the following wind load classification is made for the proposed house site at 110 Ayres Road, Ranelagh:

Wind Region	**A**
Terrain Category classification	**TC2.5**
Topographic classification	**T2**
Shielding classification	**NS**
Wind classification	**N3**
Max. Design Gust Wind Speed	**32m/s** [Serviceability limit state ($V_{h, s}$)]
	50m/s [Ultimate limit state ($V_{h, u}$)]

W. C. Cromer

Principal
19 May 2014

This report is and must remain accompanied by the following Attachments

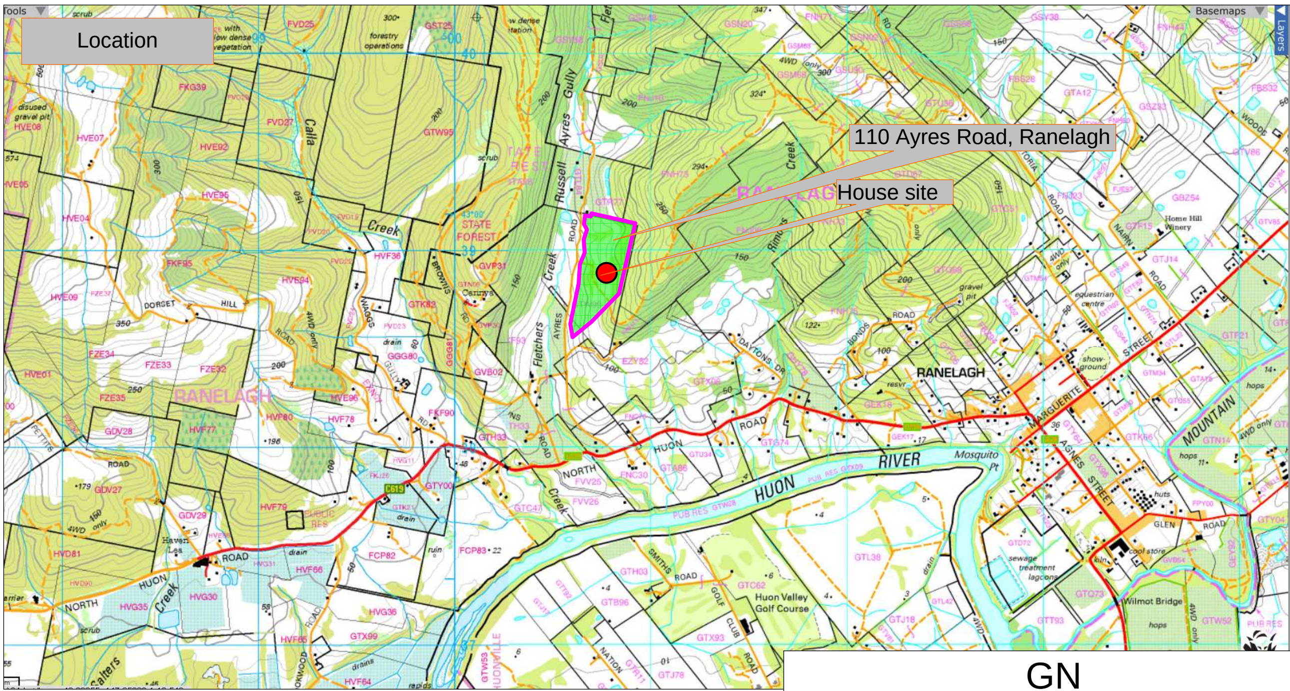
Attachment 1.	Location, aerial imagery, published geology and landslide hazard bands (2 pages)
Attachment 2.	Site sketch showing test pit locations and the area abcd to which the AS2870 site classification refers (2 pages)
Attachment 3.	Site and test pit photographs (10 pages)
Attachment 4.	Summary of test pits, interpretation of site geology; AS2870 site classification and Notes for Designers, Builders and Owners (4 pages)
Attachment 5	Landslide risk management and Certificate including Currency of PI insurance (8 pages)
Attachment 6.	Summary of geotechnical issues, risks and consequences to development site, 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)
	CSIRO Building Technology File No. 22. *A builder's guide to preventing damage to dwellings. Part 2 – Sound construction methods* (August 2003)
	Designers, builders, engineers and developers are encouraged to read the Attachments to this report.

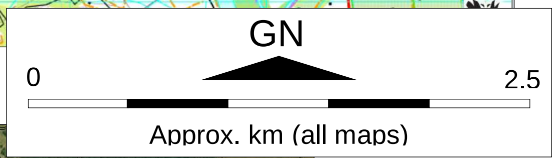
Attachment 1

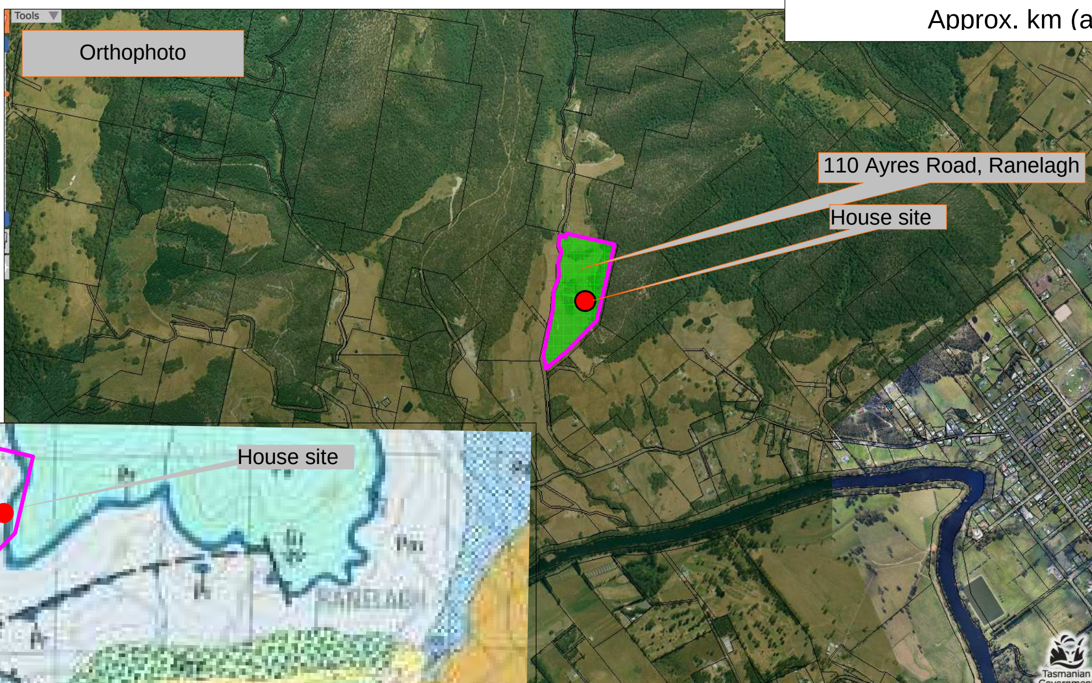
(2 pages)

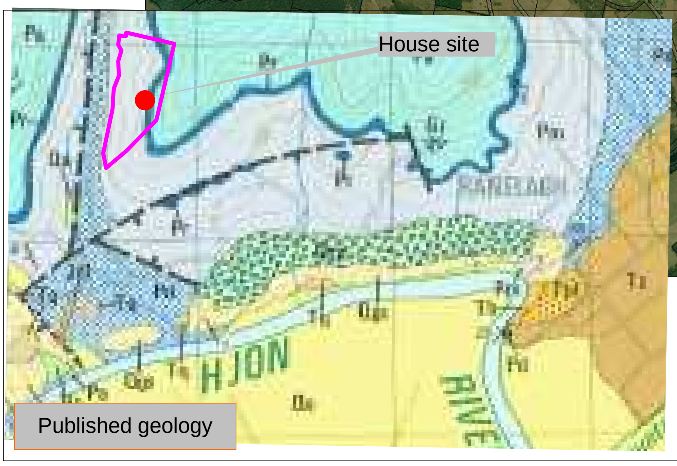
Location, aerial imagery, published geology and landslide hazard bands

Sources www.thelist.tas.gov.au, Mineral Resources Tasmania



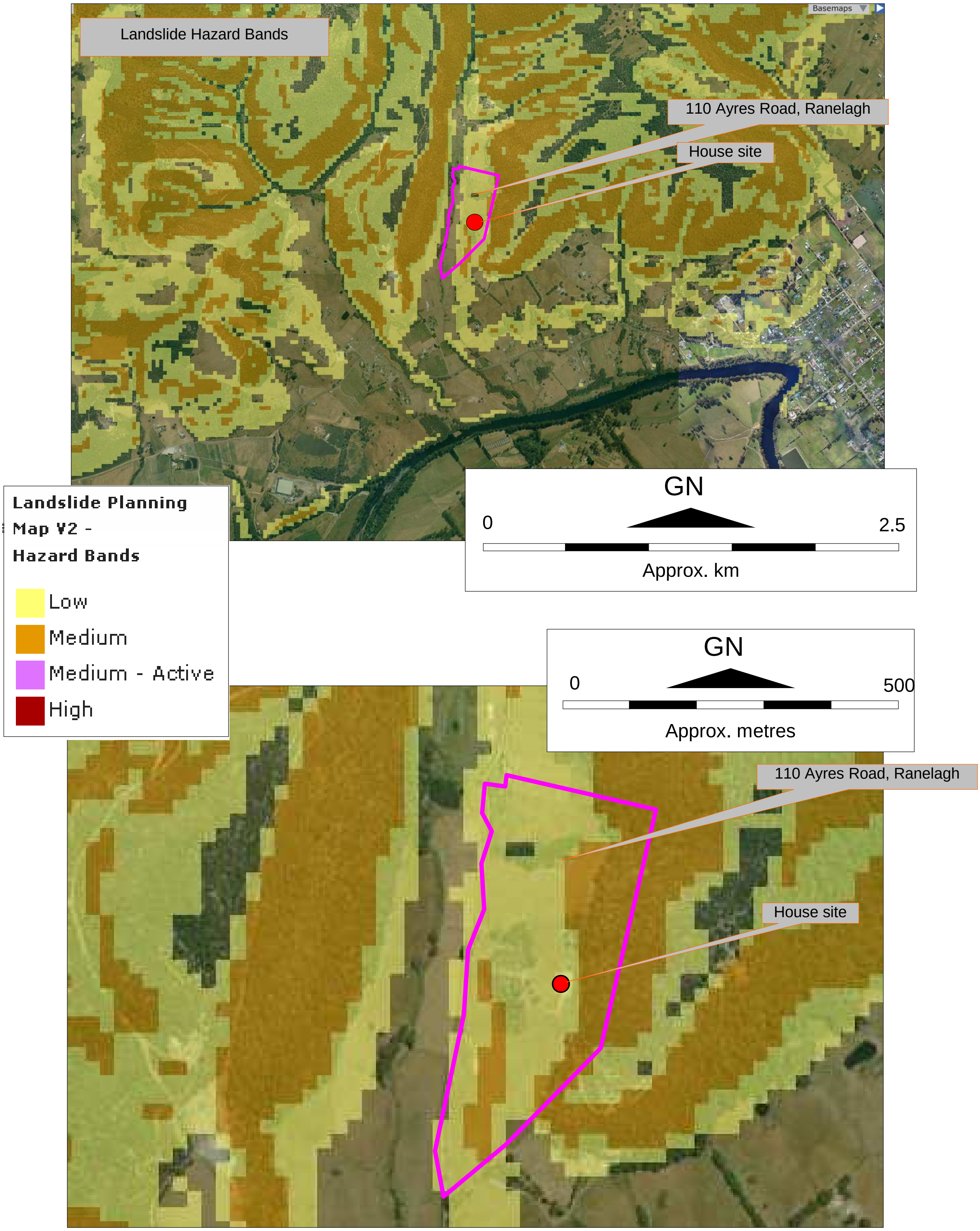






Source for geology
Farmer, N. (1981). Geological atlas 1:50,000 series. *Kingborough*. Tasmanian Department of Mines.

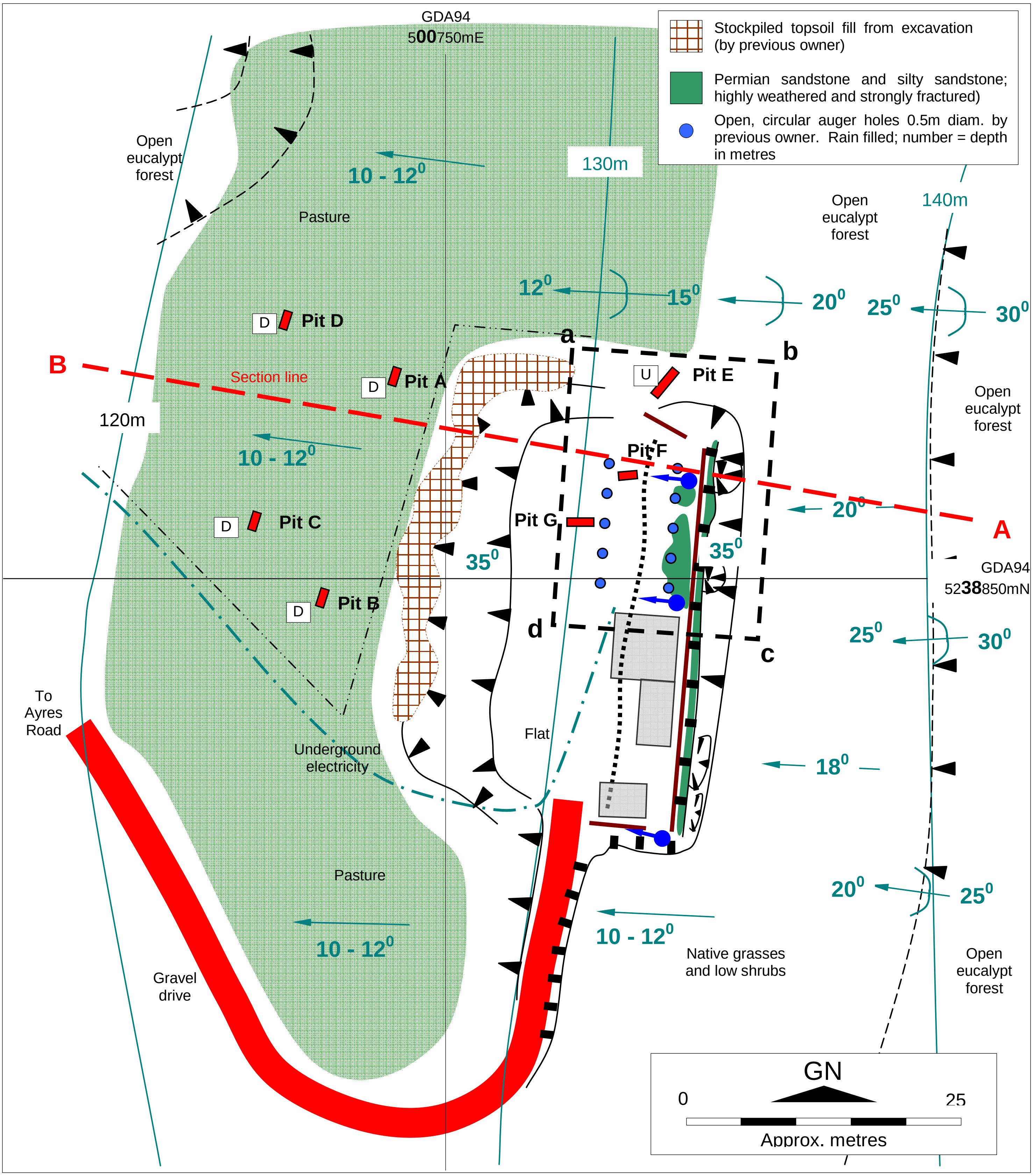
Key to colours: All shades of blue = Permian sedimentary rocks; brown = Tertiary sediments; Yellow = Quaternary alluvium


Basemaps
Landslide Hazard Bands
110 Ayres Road, Ranelagh
House site
Landslide Planning Map V2 - Hazard Bands
Low
Medium
Medium - Active
High
GN
0
2.5
Approx. km
GN
0
500
Approx. metres
110 Ayres Road, Ranelagh
House site

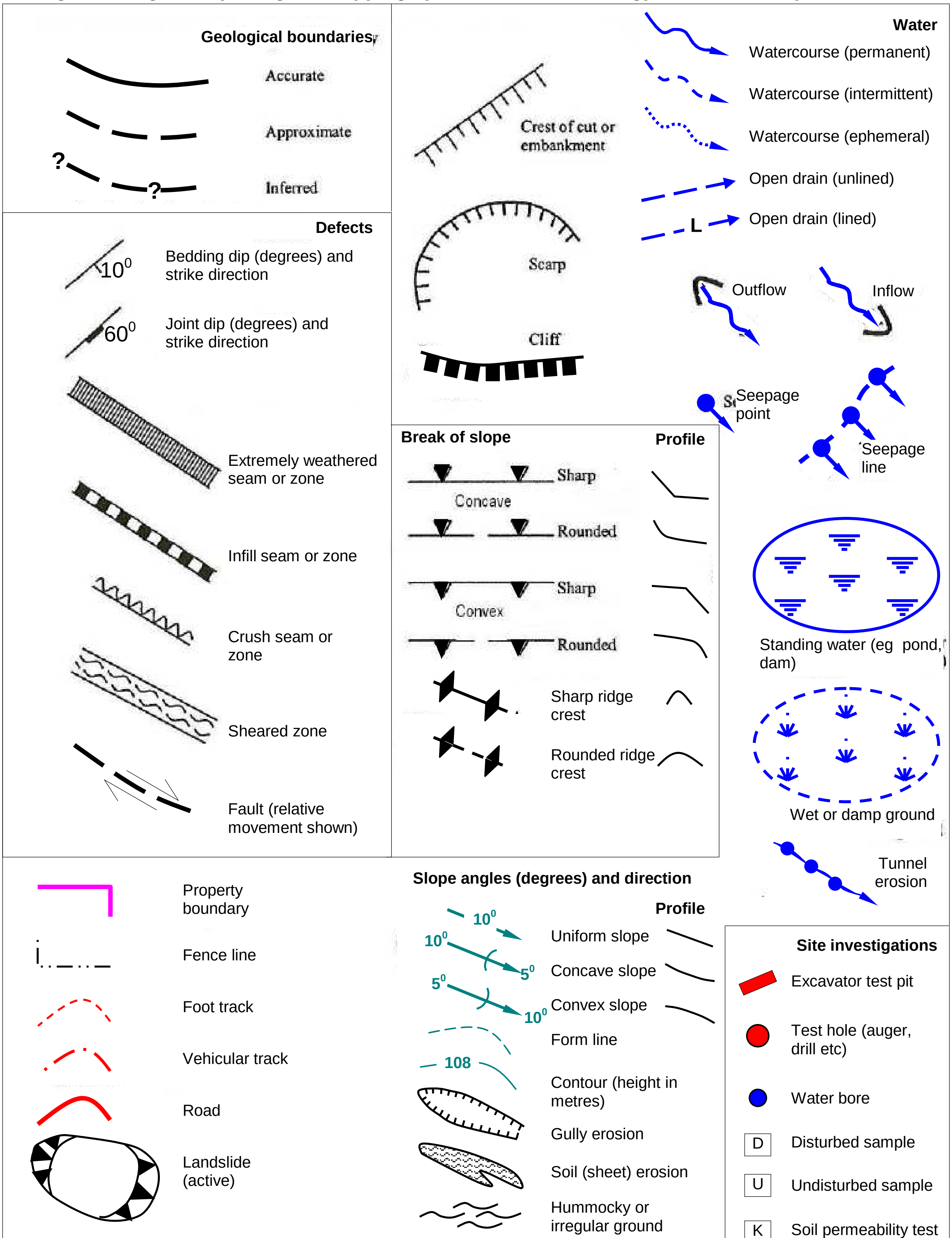
Attachment 2

(2 pages)

Site sketch showing test pit locations and the area abcd to which the AS2870 site classification refers



Geological and geomorphological mapping symbols and terminology used in this report



Source: Adapted from AGS (2007c) Appendix E, after *Guide to Slope Risk Analysis* Version 3.1 November 2001, Roads and Traffic Authority of New South Wales, and Gardiner, V. and Dackombe, R. V. (1983). *Geomorphological Field Manual*. Allen & Unwin

Attachment 3

(10 pages)

Site and test pit photographs (6 May 2014)

Plate 1 (above). View southeast and downslope towards the pad for the house (to be built at right of the existing buildings). The slopes in the foreground are 25 – 30^{0}.

Plate 2 (below). View north towards the house pad from the access drive. The low bank at right has been cut through an inferred small shallow translational landslide (activity unknown).

Plates 3 (above) and 4 (below). View north from the house pad. The shallow valley in the middle ground is inferred to be the run-out line (arrowed) of a medium sized shallow translational landslide (probably inactive) which originated on thin colluvial soils on 25 – 30^0 slopes.

Plate 5 (above). View south and cross-slope towards the pad for the house, showing the (presumably uncontrolled) fill from the excavation placed by a previous owner. The slopes in the foreground are flattening from 12 – 10^{0}.

Plate 6 (below). Panoramic (distorted) view west and upslope towards the house site. The access drive is at right.

Plates 7 (above) and 8 (left). Hillside slopes are in the 30 – 35^0. range above the house site, and comprise thin light coloured gravelly sandy silt soils on Permian age-bedrock. Bedrock or subcrop is common on the slopes.

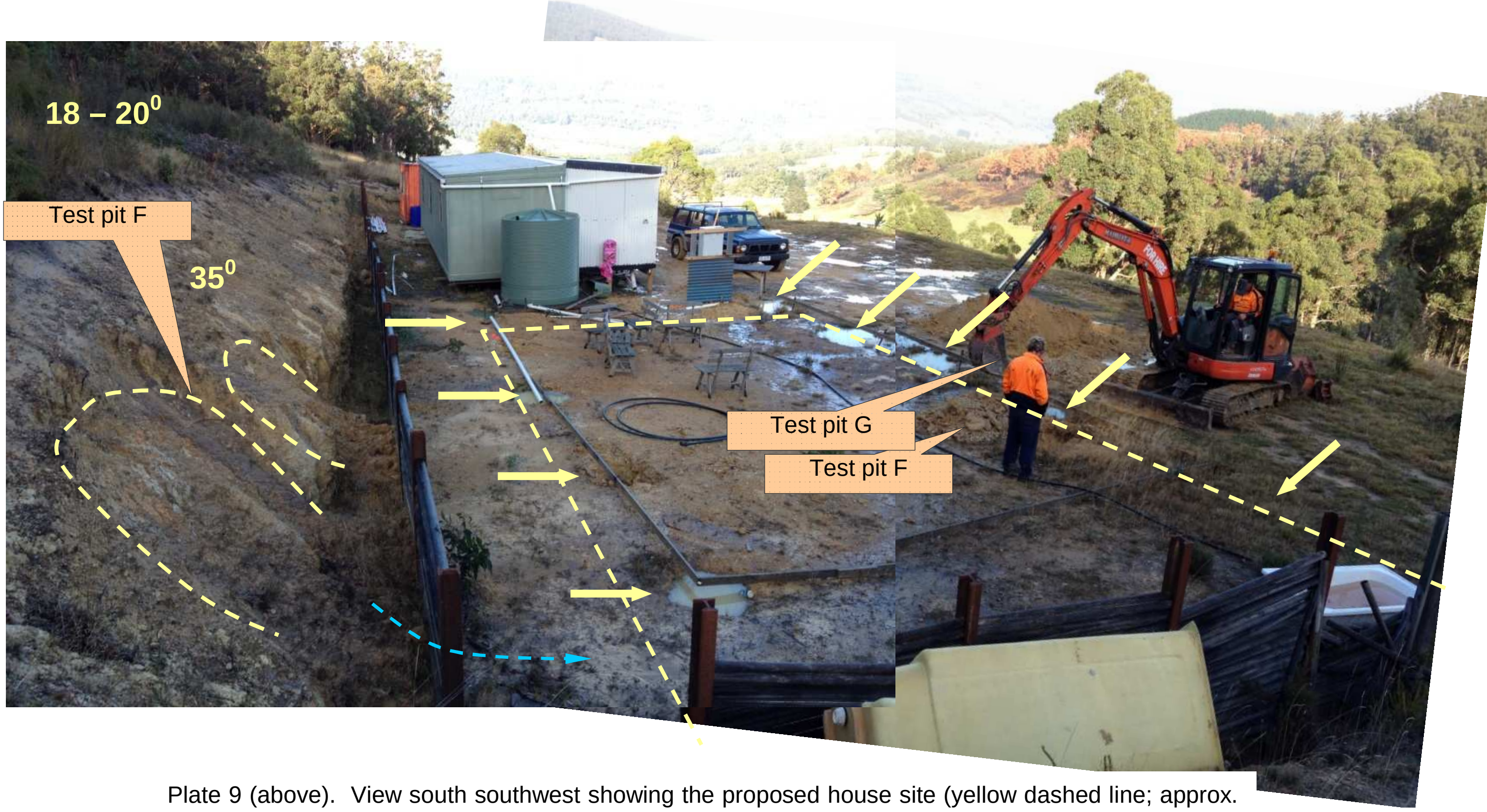


Plate 9 (above). View south southwest showing the proposed house site (yellow dashed line; approx. only), previously-dug auger holes for piers (arrowed), test pits F and G, the steel-posted and undrained timber retaining wall (blue dashed line shows water flow), the 350 batter slope behind, and two very small rotational landslides on the batter face.

Plate 10 (below). View northeast towards the proposed house site (yellow dashed line; approx.). The excavator is digging test pit G.

Plate 11 (above). View south at very small-scale rotational landsliding in colluvial soils at the southern end of the timber retaining wall.

Plate 12 (right). View south at the end of the timber retaining wall, showing the northern side of the small shallow translational landslide (activity unknown) identified in Plate 2. Colluvial soil has slid (slowly?) over similar materials. The staff is about 1.6m long.

Plate 13 (above). View north across the eastern side of the house excavation prepared by a previous owner. The staff is 2m long. The five arrowed pier holes, each about 0.5m in diameter and ranging from 0.3 to 0.5m deep, were excavated in highly weathered Permian sandstone bedrock (inset at left). Bedrock is exposed over most of the foreground in this photo.

In the following photos of test pit profiles, the staff is graduated in metre long yellow and white segments. The numbers are decimetres (tenths of a metre).


RANELAGH
6 MAY 2014
PIT F


RANELAGH
6 MAY 2014
PIT G
URQUHART
110 AYRES
ROAD
RANELAGH
6 MAY 2014
PIT G

Attachment 4

(4 pages including this page)

Summary of test pits, interpretation of site geology, AS2870 site classification and Notes for Designers, Builders and Owners

Table 4.1. Summary of test pit logs

Client URQUHART
Location 110 Ayres Road, Ranelagh
Date dug 06-May-2014

Test hole	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Depth dug (m)	1.5	1.4	1.5	0.6	2.3	1.1	2.2
Easting (GDA94)	500745	500739	500733	500735	500770	5007768	500763
Northing (GDA94)	5238870	5238847	5238856	5230874	5238868	5238860	5238855
Water inflow (depths in m)	None	None	None	None	None	None	None

Figures are depths to top and bottom of layer, in metres

No.	**Layer**	**Details**	**USCS**	**Interp.**	A	B	C	D	E	F	G
1	**Grav silty CLAY**	Includes clayey silt; variable (mainly orange cream) colour and thickness; low plasticity M; Fb	CL, GC	FILL						0 to 0.5	0 to 0.7
2	**Clayey SILT**	Grey brown; M; Fb	CL	A1 horizon	0 to 0.1	0 to 0.1	0 to 0.1	0 to 0.1	0 to 0.1		
3	**Sandy SILT**	Light grey; hardsetting; some fine andstone gravel; D, Fb	SM	A2 horizon	0.1 to 0.5	0.1 to 0.5	0.1 to 0.5	0.1 to 0.5	0.1 to 0.5		
4	**CLAY**	Includes silty clay grading to clayey sand; mottled orange and grey; mod to high plasticity decreasing with depth; weakly fractured; M<>PL; VSt	CH to CL, SC	B horizon	0.5 to 1.5 D0.6 EAR	0.5 to 1.4 D0.6 EAR	0.5 to 1.5 D0.6 EAR	0.5 to 0.6 D0.6 EAR	0.5 to 2.3 U50 0.7-1.0 EAR		
5	**Grav silty SAND**	Includes gravelly sand; orange; matrix nonplastic M; D	GW	Extremely weathered bedrock							
6	**SANDSTONE**	Orange and brown; strongly fractured; mainly highly weathered, with local joint infills of grey high plastifity clay; subhorizontal		Permian Abels Bay Formation (bedrock)						0.5 to 1.1 EAR	0.7 to 2.2 EAR

Notes and abbreviations

USCS = Unified Soil Classification System
Grey cells indicate a missing layer or layers in a test pit
D 0.1 = disturbed sample at 0.1m depth; U50 = undisturbed 50mm diameter drive tube sample at stated depth interval
SV 50 @ 1.2 = shear vane reading was 50kPa at 1.2m depth; PP = pocket penetrometer (figure is reading in kPa)

Excavability Equipment = 5.5t excavator, 0.45m bucket with 4 teeth; operator Neil Page
EAR = end as required; NR = no refusal; CR = close to refusal; R = refusal.

Weathering For rock only. F = fresh; SW = slightly weathered; MW = moderately weathered; HW = highly weathered;
EW = extremely weathered (ie soil properties; material can be remolded in the hand, with or without water)

Moisture D = dry; M = moist (M<=>PL = moisture less than, equal to or greater than Plastic Limit); W = wet.

Consistency Fb = Friable (crumbles to powder when scraped with thumbnail)
S = Soft (Easily penetrated by fist; 25 – 50kPa)
F = Firm (Easily penetrated by thumb; 50 – 100kPa)
St = Stiff (Indented with thumb; penetrated with difficulty; 100 – 200kPa)
VSt = Very stiff (Easily indented with thumbnail; 200 – 400kPa)
H = Hard (Indented by thumbnail with difficulty; >400kPa)

Rel density VL = Very loose (ravelling)
L = Loose (easy shovelling)
MD = Medium dense (hard shovelling)
D = Dense (picking)
VD = Very dense (hard picking)

4.1 Site geology

4.1.1 Published geology of the property

The geological map[1] of the area (Attachment 1) shows the property as wholly underlain by sub-horizontal Permian-age sandstones and minor siltstones.

4.1.2 My interpretation of the geology

Site inspection supports the published geology. The bedrock, where exposed, ranges from fresh to extemely weathered, and moderately to strongly fractured. At the house site, it is

[1] Farmer, N. (1981). Geological atlas 1:50,000 series. *Kingborough*. Tasmanian Department of Mines.

mainly highly to extremely weathered in test pits, the excavation at the rear of the house site, and in previously augerd pier holes.

4.2 Soils

4.2.1 Texture and thickness

Undisturbed soils are duplex profiles with light cloured sandy topsoils and brigher coloured clay subsoils, best shownby profiles in test pits A – D (Table 4.1). The clays are probably reactive[2].

Soils on slopes above and adjacent to the house site are mainly colluvial, light coloured gravelly silty sand over low plasticity claye gravelly sand subsoil (not shown in Table 4.1.

4.2.2 Shrink swell testing and soil reactivity

To assess the reactivity of the undisturbed subsoil materials, and to assist in site classification in accordance with AS2870, one undisturbed subsoil sample (Layer 4 in Table 4.1) from the site was tested[3] for shrink swell capability (the Shrink-Swell Index, I_{ss}). All other soil layers in Table 4.1 are regarded as non-reactive (ie I_{ss} = zero).

The test results were:

Pit E (0.7-1.0m) Silty CLAY: weakly mottled orange and grey; high plasticity

Initial moisture content	24%
Swelling strain	1.2%
Shrinkage strain	0.9%
Shrink swell index (I_{ss}) =	**0.8%**

This is a low I_{ss} value for clay. Assume the on-site variation in I_{ss} is 0.8 – 1.3%. When it is applied to the Layer 4 thicknesses in each test pit (where it is present) the following estimated ground surface movements result[4]:

Test pit A	Estimated ground surface movement in range 10 – 15mm (Class S)
Test pit B	Estimated ground surface movement in range 10 – 15mm (Class S)
Test pit C	Estimated ground surface movement in range 10 – 15mm (Class S)
Test pit D	Estimated ground surface movement in range 10 – 15mm (Class S)
Test pit E	Estimated ground surface movement in range 10 – 20mm (Class S)

4.2.3 Bearing capacities of materials

Shear vane testing of clayey layer 4 (Table 4.1) was done in test pit E, and of extremely weathered inferred bedrock (layer 6) in pit G. The former returned 220kPa at 0.7m, and 240kPa at 1.5m, for an estimated safe bearing capacity of about 400kPa, which is adequate for houses. The latter returned 240kPa at 0.9m, and 180kPa at 1.1m, for an estimated safe bearing capacity also of about 400kPa.

---

[2] Reactive clays increase or decrease in volume as their moisture content increases or decreases respectively. Such volume changes can transfer to vertically up or down ground surface movement, which may compromise the integrity of house footings unless the surface movement is anticipated and footings are designed to cope with them. This is the basis of Australian Standard 2870:2011 *Residential slabs and footings,* which classifies house sites and provides footing designs for the various classes.

[3] 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.

[4]

Notes

1 Regional suction base depth = 2m
2 Change in suction at surface = 1.5pF
3 Assumes layer will be completely dry and completely wet at surface during a 50 year period
4 AS2870 classifications

Class	Ground surface movement
A	0 – 10mm
S	10 – 20mm
M	20 – 40mm
H	40 – 70mm
E	>70mm

Groundwater
No groundwater was noted in any test pit. No springs were observed on the site..

Deeper, permanent groundwater is present beneath the property, but its occurrence will have no impact on the house, and vice versa.

Tunnel erosion and soil dispersion
No instances of tunnel erosion (suggestive of dispersive soils) were noted during site investigations.

Nevertheless, four samples (one each from test pits A, B, C and D) were tested for dispersion using a modification of the Emerson Aggregate Test. The technique is outlined in AS/NZS1547:2000 *On-site domestic-wastewater management*, Section 4.1D7.

During testing, all samples slaked but showed no or very minor dispersion. Remoulded samples did not disperse. Accordingly, Emerson Class numbers 4, 5 or 6 are indicated. It is inferred from these results than dispersive materials do not exist on the property and that tunnel erosion of Layer 1 and 2 clayey materials is potentially a low risk issue for development.

4.3 Fill

Fill has been placed as a (presumably) uncontrolled wedge of soil and weathered bedrock at the house site, where it forms an outer embankment several metres high. Topsoil from the excavation has been placed at the base of the embankment.

4.4 Landslide risk assessment

See Attachment 5.

4.5 AS2870 site classification

The proposed house site is classified **Class P** in accordance with Australian Standard 2870 (2011) *Residential slabs and footings* because of

(a) the observed and inferred presence of slope instability (refer to Attachment 5),

(b) the presence of adjacent fill up to at least 2m thick, but thinning from the lip of the embankment to locally along the eastern side of the house footprint, and

(c) the variable depth to bedrock, and its extremely variable degree of weathering.

Footings for Class P sites require certification by an engineer experienced in footing design. The builder should ensure that the engineer has (a) read this report, and (b) inspected and approved all holes for piered footings before footings are emplaced. A suitably experienced geotechnical engineer or engineering geologist could inspect the empty footings, provided he or she is familiar with this report.

If all footings are placed into (not onto) sandstone bedrock at various stages of weathering, the site classification is **Class S**. See Notes for designers, engineers and builders below.

Irrespective of the classification, the pier footings at this site shall be inspected by a suitable experienced engineer, geotechnical engineer or engineering geologist before piers are emplaced.

4.6 Notes for designers, engineers and builders

4.6.1 Variability of subsurface conditions'

Subsurface conditions encountered during construction which appear to differ significantly from those described here should be immediately brought to my attention.

4.6.2 House design
I have not viewed house plans but am informed by the client that the dwelling will be a single storey dwelling, raised on piers one storey above ground to allow (a) a clear area for car parking underneath and (b) a level or inclined constructed access from first floor level east to the hillside above the oversteepened slope.

The house should be constructed on lightweight materials, and preferably be in a modular, articulated form.

This design, with qualifications (see following paragraphs) suits the site. If a concrete slab house is proposed, the slab shall be supported by piers founded everywhere in bedrock.

4.6.3 House bracing and strengthening
To mitigate the potential consequences of small scale shallow landsliding at and above the site (Scenario 5 in Attachment 5), and beneath the house site (Scenario 4), the house piers should be adequately founded (see below) and braced to each other. Similar braces shall be extended into the battered slope, or the slope above the batter, or both, to offer further lateral support and mitigation of Scenario 3. A suitably experienced engineer shall certify the design.

4.6.4 Footings
I recommend all piers be extended into sandstone bedrock, at various stages of weathering. Along the eastern side of the house footprint, highly weathered but adequately competent bedrock is at or within about 0.3m of the excavated surface.

Along the western side of the footprint, and especially in a northerly direction towards pit E, expect variable depth to bedrock from about 1 – 1.5m near pit G, to over 2.3m at pit E. If bedrock is not encountered in the vicinity of Pit E, a pier depth of 2m in clayey materials will be acceptable.

4.6.5 Excavations and retaining wall
Minimise further cut and fill. To enhance upslope slope stability (Scenario 3 in Attachment 5), do not extend the existing excavation towards the northeastern corner of the house footprint. This retains the current earth support on the natural slope.

The existing retaining wall can be retained, at least in the medium term, because its steel posts and timbers are sound, and it is easily holding back the very small landslide material (1 – 3m^3) created behind it The wall may need upgrading and strengthening in future. However, before house construction starts, the existing open piers in front of it need to be backfilled with concrete.

4.6.6 Use of fill
No on-site materials should be used as fill to support infrastructure. .

4.6.7 Drainage
To prevent surface water moving across the house footprint, a shallow drain needs to be installed the full length of the existing retaining wall, and in front of it (at the rear is the norm, but there are access problems). Discharge from the drain needs to be directed to the south of the house site, but away from downslope on-site wastewater disposal areas.

4.7 Notes for owners and occupiers
Australian Geomechanics Society Geoguides
Al interested parties are advised to read the AGS Geoguides[5], and in particular, the examples provided for good and bad hillside construction methods. The latter are included here as Attachment 6.

[5] AGS (2007e). The Australian Geoguides for Slope Management and Maintenance. Australian Geomechanics Vol 42 No 1 March 2007

Attachment 5

(13 pages)

Landslide Risk Management (LRM)

This Attachment addresses slope stability (landslide) issues for the proposed development in accordance with Australian Geomechanics Society (AGS) *Landslide Risk Management* (2007)[6]. The process is depicted in Figure 5.1.

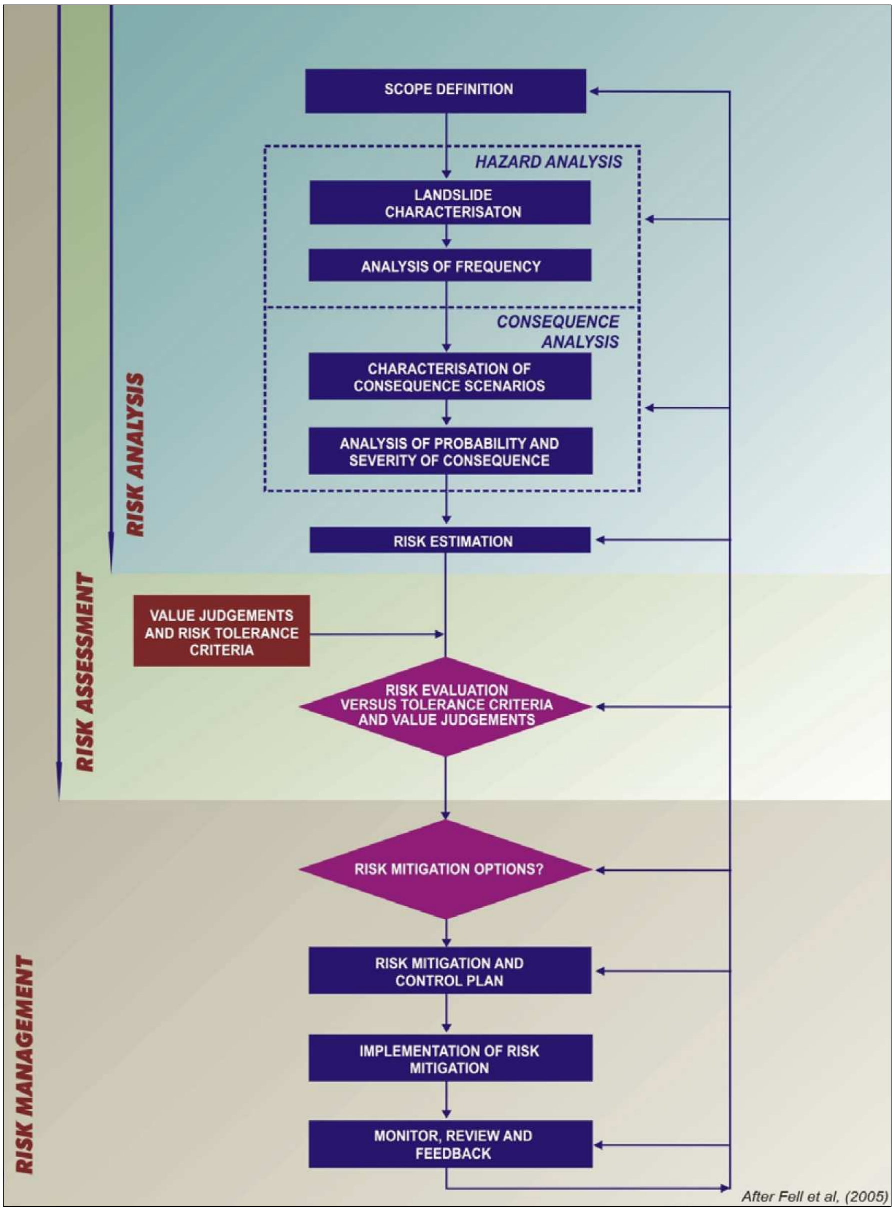


Figure 5.1. Framework for Landslide Risk Management
Source: Reproduced without amendment from AGS (2007a). Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007

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[6] The five AGS documents are:
AGS (2007a). Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007
AGS (2007b). Commentary on Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007
AGS (2007c). Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007
AGS (2007d). Commentary on Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007
AGS (2007e). The Australian Geoguides for Slope Management and Maintenance. Australian Geomechanics Vol 42 No 1 March 2007

5.1 Preliminary

5.1.1 Desktop review of slope instability

Published evidence

See Attachment 1 of this report.

The house site and surrounds are in the Low Landslide Hazard band, but a Medium band exists quite close on the steeper ground to the east.

I an unaware of any published reports relating to slope stability issues in the neighbourhood of the proposed development, or of recognised slope instability issues affecting residential development in the general district.

Field evidence

The following are relevant:

- Slope angles are in the 10 – 12^0 range on a slope segment below the house, but are in the 25 – 30^0 range east and west of the site. Intermediate ranges exist on the slopes immediately east of the house site.

- The steep sloes west of the house appear to have a very thin and variable colluvial soil cover, with many subcrops of sandstone bedrock. Probably, some of the sol cover has moved downslope towards the house site.

- The excavation by a previous owner for the house site has created slopes of around 30 – 35^0 in an oversteepened cut to the east, and an uncontrolled fill embankment to the west (Attachment 2). Very small scale rotational landsliding has occurred on the oversteepened cut, and the failed material has been adequately retained by a 1.8m high wall.

- The cutting at the southern end of the house site has exposed a shallow translational landslide involving colluvial materials.

- The short, narrow and shallow valley about 50mor so north of the house site appears to be a landslide feature, but probably quite old and inactive because no downslope run-out material is evident.

5.1.2 Site investigations

Addressed in the body of this report, and in Attachments.

5.1.3 Site plan

See Attachment 2 for a geotechnical and geomorphological fact map of the house site and environs. See also Figure 5.1 (this Attachment).

5.1.4 Conceptual hydrogeological cross section at natural scale

See Figure 5.3 in this Attachment.

5.2 Hazard Analysis

5.2.1 Landslide characterisation

Refer to Figure 5.1 and Table 5.1 (this Attachment) for a description of the main forms of landslide movement.

Figure 5.2 schematically shows several potential forms (scenarios) of landslide movement in relation to the proposed development, under current and post development conditions. The post development conditions relate to landslide risk management measures recommended here for house construction.

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

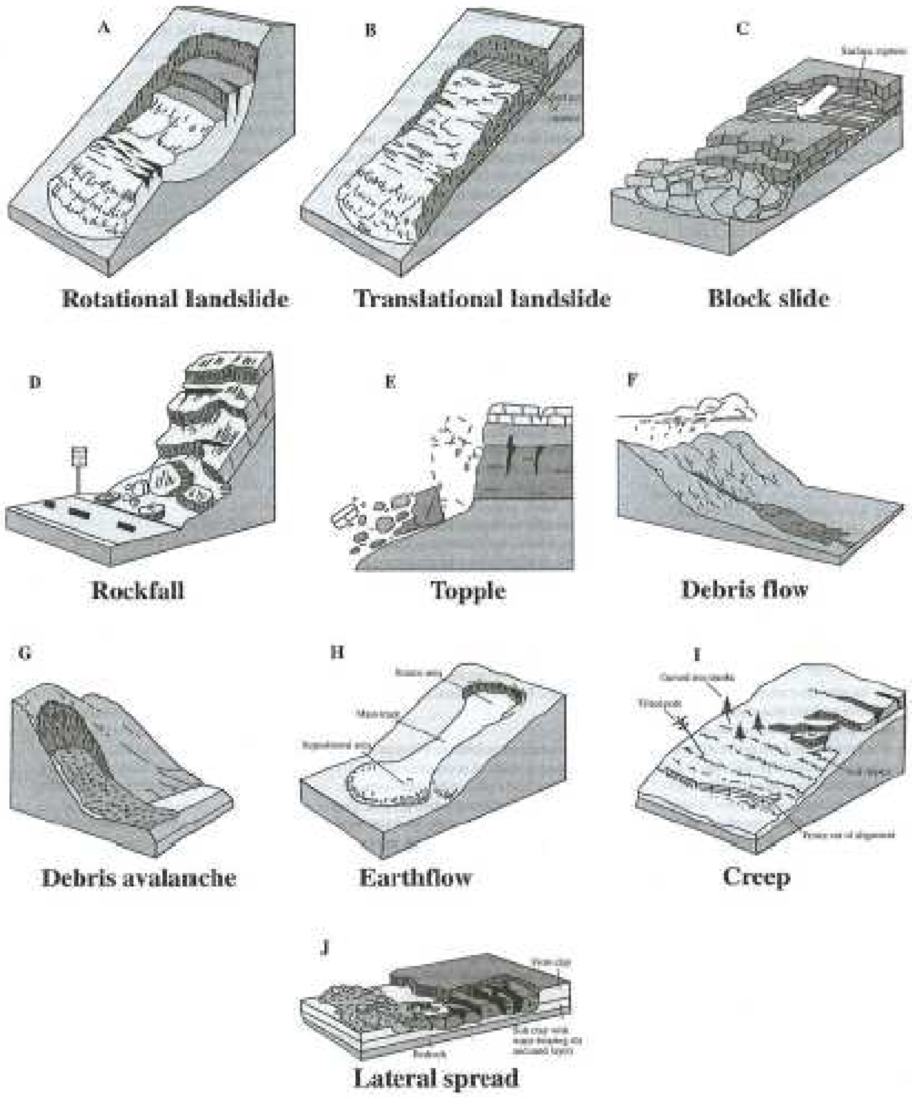

Figure B1: These schematics illustrate the major types of landslide movement.
(From US Geological Survey Fact Sheet 2004-3072, July 2004, with kind permission for reproduction.)

The nomenclature of a landslide can become more elaborate as more information about the movement becomes available. To build up the complete identification of the movement, descriptors are added in front of the two-term classification using a preferred sequence of terms. The suggested sequence provides a progressive narrowing of the focus of the descriptors, first by time and then by spatial location, beginning with a view of the whole landslide, continuing with parts of the movement and finally defining the materials involved. The recommended sequence, as shown in Table B2, describes activity (including state, distribution and style) followed by descriptions of all movements (including rate, water content, material and type). Definitions of the terms in Table B2 are given in Cruden & Varnes (1996).

Figure 5.1 **Main types of landslide movement**
Source: From Appendix B of AGS (2007c). Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007

5.2.2 Frequency analysis

Table 5.2 (this Attachment) lists the potential occurrence and subjective likelihood of slope instability for the proposed development, under current and post development conditions.

5.3 Consequence analysis and qualitative risk to property estimation – current situation

Table 5.3 (this Attachment) is a consequence analysis and risk to property assessment for the pre-development scenarios (#1, 2, 3, 4, 5, 6) shown in Figure 5.2 and listed in Table 5.2.

Consequences for the scenarios range from minor to major, and the attendant risks are in the Very low to Moderate range.

Table 5.1 Main types of landslide movement

Source: From Appendix B of AGS (2007c). Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007

TYPE OF MOVEMENT		TYPE OF MATERIAL		
		BEDROCK	ENGINEERING SOILS	
			Predominantly Coarse	Predominantly Fine
FALLS		Rock fall	Debris fall	Earth fall
TOPPLES		Rock topple	Debris topple	Earth topple
SLIDES	ROTATIONAL TRANSLATIONAL	Rock slide	Debris slide	Earth slide
LATERAL SPREADS		Rock spread	Debris spread	Earth spread
FLOWS		Rock flow (Deep creep)	Debris flow (Soil creep)	Earth flow
COMPLEX		Combination of two or more principle types of movement		

Table 5.2 Landslide characterisation in relation to the current proposal

	Field Evidence	Potential or observed size	Potential speed	Water content	Current likelihood	Likelihood after development	Scenarios in Figure 5.2
Falls							
Rock fall	None	Small	Extremely rapid	Dry	Barely credible	Possible	
Debris fall	None	Small	Extremely rapid	Dry	Barely credible	Possible	
Earth fall	None	Small	Extremely rapid	Dry	Barely credible	Possible	
Topples							
Rock topple	None	Small	Extremely rapid	Dry	Barely credible	Possible	
Debris topple	None	Small	Extremely rapid	Dry	Barely credible	Possible	
Earth topple	None	Small	Extremely rapid	Dry	Barely credible	Possible	
Rotational or translational landslide							
Rock slide	None	Small	Slow	Dry to moist	Barely credible	Barely credible	1
Debris slide	None	Small to large	Slow	Moist to wet	Rare	Rare	2
Earth slide	Yes	Small to very small	Slow to rapid	Moist to wet	Almost certain to Unlikely	Almost certain to Unlikely	3 – 6
Lateral spread							
Rock spread	None	Small	Slow	Dry to moist	Barely credible	Barely credible	
Debris spread	None	Small to medium	Slow	Moist to wet	Rare	Rare	
Earth spread	None	Small to medium	Slow	Moist to wet	Rare	Rare	
Flows							
Rock flow	None	Small to medium	Rapid	Dry to moist	Rare	Rare	
Debris flow	None	Small to large	Very rapid	Moist to wet	Rare	Rare	
Earth flow	None	Small to large	Very rapid	Moist to wet	Rare	Rare	
Complex	None	Small to large	Slow to rapid	Dry to moist	Rare	Rare	

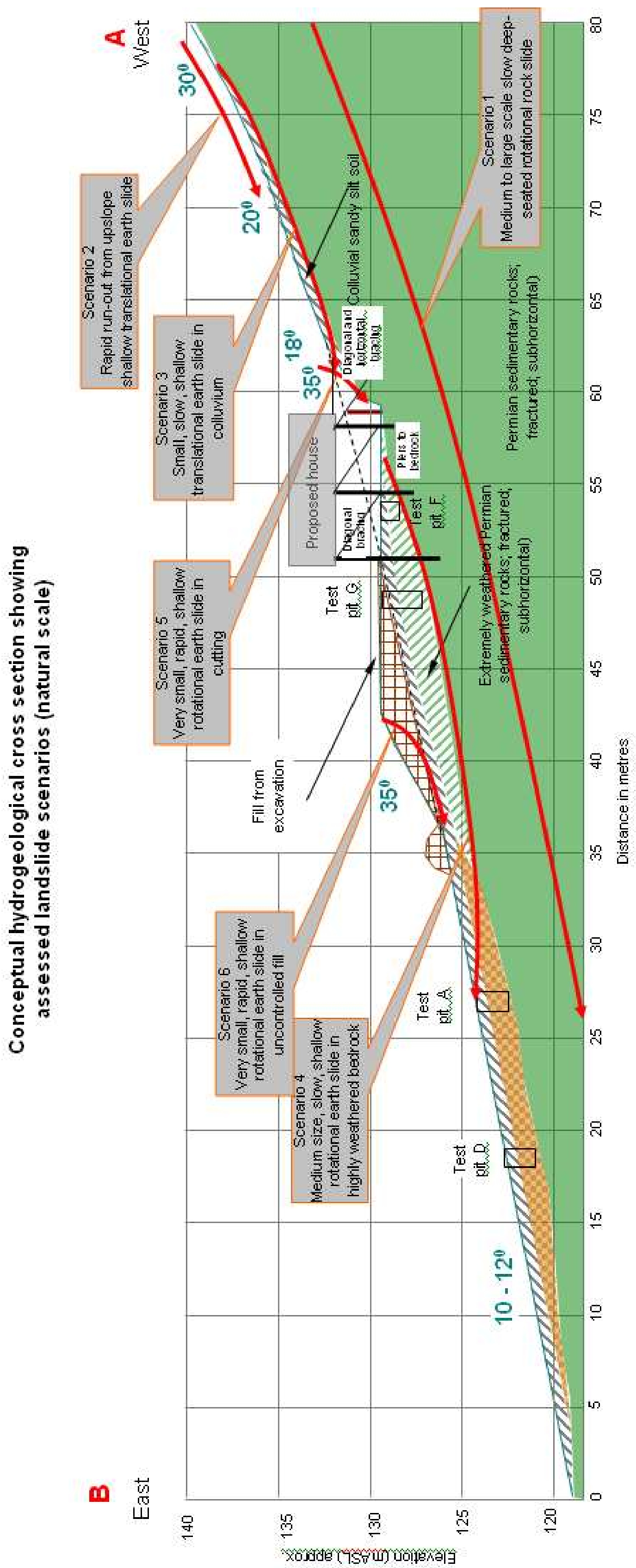

Figure 5.2 **Interpreted cross section through proposed house site (natural scale), showing landslide scenarios 1 – 6 addressed in this Attachment.**
See Attachment 4 for location of the section line.

Table 5.3 **Qualitative consequences and risks to property for landslide scenarios for the proposed development under current conditions**

	Scenarios in Figure 5.2	Current likelihood	Consequences to property	Risk to property
Falls				
Rock fall		Barely credible	Minor	Very low
Debris fall		Barely credible	Minor	Very low
Earth fall		Barely credible	Minor	Very low
Topples				
Rock topple		Barely credible	Minor	Very low
Debris topple		Barely credible	Minor	Very low
Earth topple		Barely credible	Minor	Very low
Rotational or translational landslide				
Rock slide	1	Barely credible	Major	Very low
Debris slide		Barely credible	Minor	Very low
Earth slide	2	Rare	Major	Low
	3	Possible	Medium	Moderate
	4	Unlikely	Medium to Major	Low to Moderate
	5	Almost certain	Insignificant	Low
	6	Likely	Minor	Moderate
Lateral spread				
Rock spread		Barely credible	Major	Very low
Debris spread		Rare	Major	Low
Earth spread		Rare	Major	Low
Flows				
Rock flow		Rare	Major	Low
Debris flow		Rare	Major	Low
Earth flow		Rare	Major	Low
Complex		Rare	Major	Low

Table 5.4 **Qualitative consequences and risks to property for landslide scenarios for the proposed development (after development**

	Scenarios in Figure 5.2	Likelihood after development	Consequences to property	Risk to property
Falls				
Rock fall		Barely credible	Minor	Very low
Debris fall		Barely credible	Minor	Very low
Earth fall		Barely credible	Minor	Very low
Topples				
Rock topple		Barely credible	Minor	Very low
Debris topple		Barely credible	Minor	Very low
Earth topple		Barely credible	Minor	Very low
Rotational or translational landslide				
Rock slide	1	Barely credible	Major	Very low
Debris slide		Barely credible	Minor	Very low
Earth slide	2	Rare	Major	Low
	3	Possible	Medium	Moderate
	4	Unlikely	Medium	Low
	5	Almost certain	Insignificant	Low
	6	Possible	Minor	Low
Lateral spread				
Rock spread		Barely credible	Major	Very low
Debris spread		Rare	Major	Low
Earth spread		Rare	Major	Low
Flows				
Rock flow		Rare	Major	Low
Debris flow		Rare	Major	Low
Earth flow		Rare	Major	Low
Complex		Rare	Major	Low

5.4 Consequence analysis and qualitative risk to property estimation – after development

Table 5.4 (this Attachment) is a consequence analysis and risk to property assessment for the pre-development scenarios (#1, 2, 3, 4, 5, 6) shown in Figure 5.2 and listed in Table 5.4.

Risks for scenarios #1, 2, 3 and 5 are unchanged, with risks remaining at Very Low, Low, Moderate and Low respectively (ie no reasonable risk mitigation measures can be taken to address these scenarios.

Risks for scenarios #4 and 6 after development have been reduced from Moderate to Low (highlighted in red in Table 5.4.) by house construction methods, and the probability of reducing water infiltration into the uncontrolled fill near the house site.

5.5 Qualitative risk to life estimation– current situation

It is subjectively estimated that current slope instability scenarios present acceptable risks to life. No quantitative risk to life has been attempted.

5.6 Suggested risk mitigation plan

See Notes for Designers, Engineers and Builders in Section 4.6 of Attachment 4.

5.7 Certificate of currency for Professional Indemnity Insurance

A copy of the certificate of currency for PI insurance for William C Cromer Pty Ltd is included here as Figure 5.3.

Figure 5.3 **Certificate of currency for PI insurance for William C Cromer Pty Ltd**

Certificate Of Currency

Liberty International Underwriters

This Certificate confirms that the undermentioned Policy is effective on the date of issue and in accordance with the details shown:

Class of Insurance	Professional Indemnity Insurance	
Policy Number	MI-BN-SPC-03-110365	
Named Insured	WILLIAM C. CROMER PTY. LTD.	
Policy Period	From:	31 August 2013 at 4:00pm local standard time
	To:	31 August 2014 at 4:00pm local standard time
Limit of Liability	$1,000,000	
Excess	$10,000	
Policy Wording	LIU AUS OQS PI Construction Consultants Policy Wording (03-11)	
Retroactive Date	31 August 2004	
Authorised by Liberty	LIBERTY MUTUAL INSURANCE COMPANY A.B.N. 61 086 083 605	
Date Of Issue	31 August 2013	

This Certificate:
- Is issued as a matter of information only and confers no rights upon the holder
- Does not amend, extend or alter the coverage afforded by the policy listed
- Is only a summary of the cover provided
- Reference must be made to the current policy wording for full details
- Is current at the date of issue only

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Liberty International Underwriters is a trading name of Liberty Mutual Insurance Company (ABN 61 086 083 605). Incorporated in Massachusetts, U.S.A.
(The liability of members is limited)

Attachment 6

(4 pages)

Summary of geotechnical issues, risks and consequences to house site, 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 6.1 Summary of geotechnical issues, risks and consequences to house site, and suggested risk treatment practices

	Issue	Likelihood of occurrence	Consequences to property	Level of risk to property	Risk treatment
1	Surface soil erosion	Possible	Minor	Low	Control upslope surface runoff and roof runoff. Ensure adequate drainage at retaining walls. Do not install upslope cutoff drain above house.
2	Tunnel erosion	Unlikely	Minor	Low	As for issue 1
3	Soil creep	Unlikely	Minor	Low	As for issue 1
4	Shallow-seated landslide (involving, for example, soil, boulder beds, talus, colluvium, etc)	Unlikely to Almost certain	Insignificant to Medium	Low to Moderate	See Attachments 4 and 5 this report
5	Deep-seated landslide (involving, eg boulder beds, talus, colluvium, bedrock etc)	Barely credible	Major	Very low	No action required
6	Foundation movement due to reactive or unstable soils	Possible	Medium	Moderate	Design footings in accordance with the AS2870 site classification and related comments in Attachment 4 of this report
7	Low strength materials (eg uncontrolled fill, soft soils)	Almost certain near house site	Medium (Minor at house site)	High	As for issue 6
8	Vegetation removal	Unlikely	Minor	Low	Avoid planting large trees close to buildings
9	Flooding or waterlogging	Waterlogging possible	Minor	Moderate	As for issue 1.
10	Riverbank collapse	Not applicable			No action required
11	On-site wastewater disposal	Certain	Minor	Low	Manage wastewater in accordance with separate report by William C Cromer Pty Ltd
12	Site contamination from previous activities	Unlikely	Minor	Low	Visual inspection during site construction, and cover or clean up as required.
13	Earthquake risk	Almost certain (magnitude <5); Likely (magnitude>5)	Insignificant to Minor	Low to Moderate	Generally accept risk. A similar range of risks exists throughout Tasmania.
14	Sea level rise	Not applicable			No action required
15	Storm surge	Not applicable			As above
16	Shoreline recession	Not applicable			As above

1. The assessments are unavoidably subjective to varying degrees.
2. See 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, pp 1 – 219.

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

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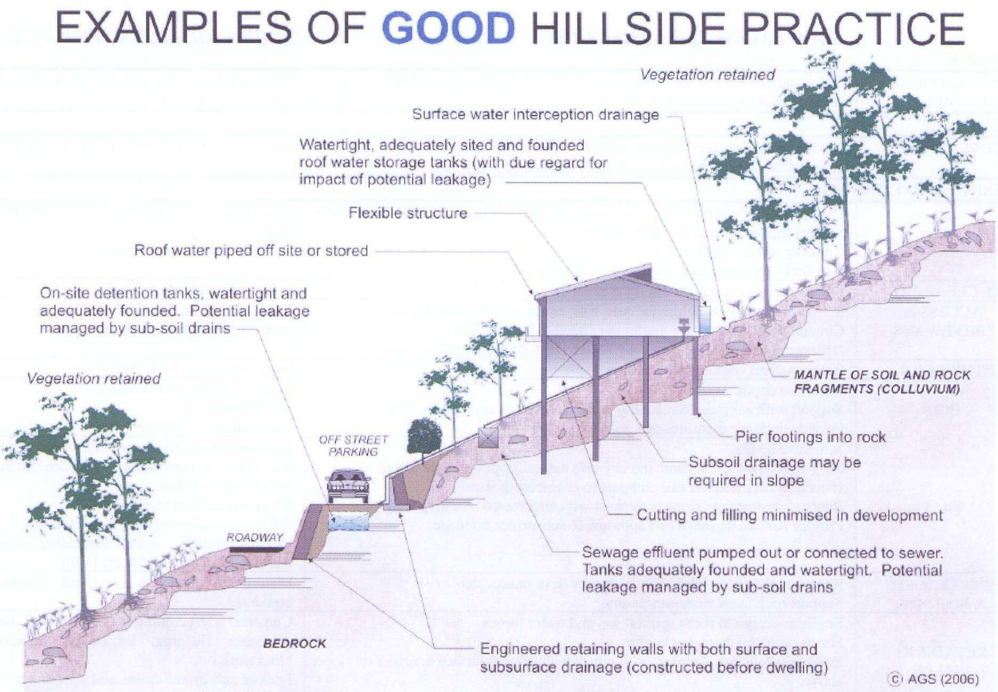

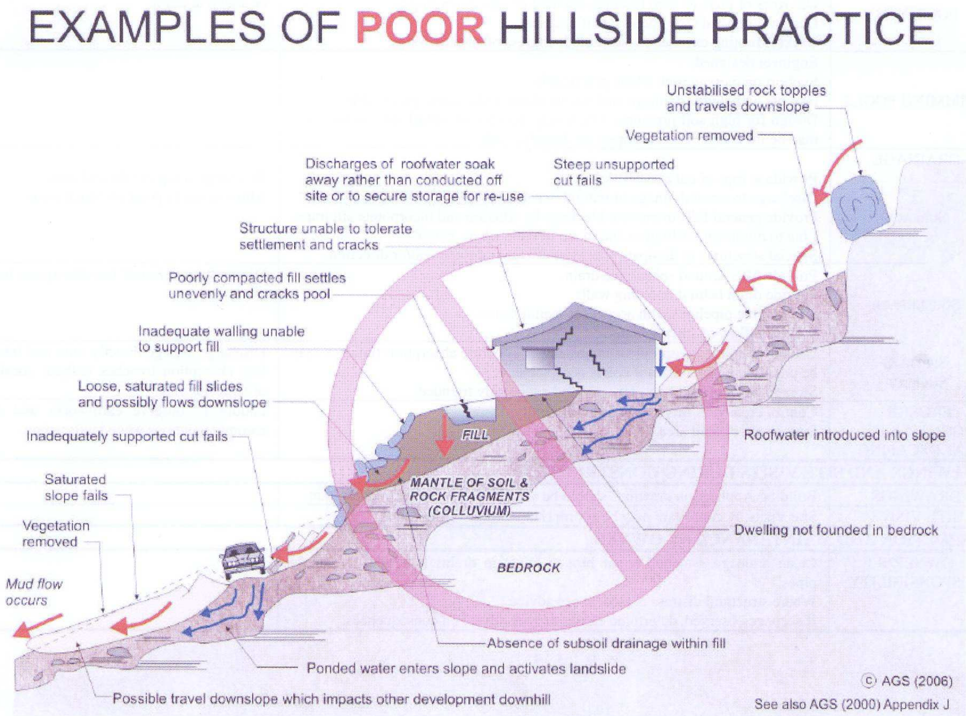

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	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.	

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