GES

GEO-ENVIRONMENTAL SOLUTIONS

LANDSLIDE RISK ASSESSMENT

PROJECT:

Proposed New Units

Site Address:

70 Beach Road
Kingston Beach,
TAS
7050

CLIENT:

Glanville Architects

DATE:

26/06/2024

DOCUMENT CONTROL

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FIGURES

TABLES

1 INTRODUCTION

Geo-Environmental Solutions Pty Ltd (GES) were contracted by Glanville Architects to provide a geotechnical assessment to assess a landslide risk for a proposed townhouse units at Kingston Beach, which lays within the Kingborough Interim Planning Scheme.

The proposed works are located at cadastral title (CT 197675/1) at 70 Beach Road Kingston Beach, TAS 7050 (Figure 1). GES are to undertake this geotechnical assessment relating to the proposed development in conjunction with the requirements of the Landslide Hazard Code, part of the Tasmanian Interim Planning Scheme. GES have written this report with reference to the Australian Geomechanics Guidelines (AGS 2007).

GES have undertaken this assessment using previous site observations and investigation, photographs and publicly available datasets in the construction of this report. Estimations are determined by approximation with regional information applied where appropriate to site specific information.

Figure 1 - Location of the site

2 OBJECTIVES

The objective of the site investigation is to:

- Conduct a landslide risk assessment of the proposed development excavations with reference to the Australian Geomechanics Society (AGS) *Landslide Risk Management (2007) guidelines'*.
- Identify which planning scheme codes need to be addressed in terms of landslip and identify the relevant performance criteria relevant to the project which need addressing;
- Conduct a site risk assessment for the proposed development ensuring relevant performance criteria are addressed.
- Where applicable, provide preliminary recommendations on earthworks to ensure safe slope management.

3 Site Details

3.1 Project Area Land Title

The land studied in this report is defined by the following title reference:

- CT – 197675/1

This parcel of land is referred to as the 'Site' and/or the 'Project Area' in this report.

3.2 Australian Building Code Board

This report presents a summary of the overall site risk to landslide hazards. This assessment has been conducted for the year 2073 which is representative of a 'normal' 50-year building design life category.

Per the Australian Building Code Board (ABCB 2015), when addressing building minimum design life:

> *'The design life of buildings should be taken as 'Normal" for all building importance categories unless otherwise stated.'*

As per Table 3-1, the building design life is 50 years for a normal building.

Table 3-1 Design life of building and plumbing installations and their components

Building Design Life Category	*Building Design Life (years)*	*Design life for components or sub systems readily accessible and economical to replace or repair (years)*	*Design life for components or sub systems with moderate ease of access but difficult or costly to replace or repair (years)*	*Design life for components or sub systems not accessible or not economical to replace or repair (years)*
Short	1 < dl < 15	5 or dl (if dl<5)	dl	dl
Normal	50	5	15	50
Long	100 or more	10	25	100

Note: Design Life (dl) in years

3.3 The Tasmanian Building Regulations 2016

Building in hazardous areas

As outlined in the Department of Justice web site:

http://www.justice.tas.gov.au/building/building-and-plumbing/building_in_hazardous

Hazardous areas include areas which are bushfire prone, comprise reactive soils or substances, or are subject to coastal erosion, coastal flooding, riverine flooding, and landslip.

Division 5 - - Landslip. Section 59. Landslip hazard areas

- For the purposes of the Act, land is a landslip hazard area if –
  - the land is shown on a planning scheme overlay map as being land that is within a landslip hazard area; and
  - the land is classified as land within a hazard band of a landslip hazard area.
- For the purposes of the definition of *hazardous area* in section 4(1) of the Act –
  - classification under a landslip determination as being land that is within a hazard band of a landslip hazard area is a prescribed attribute; and
  - a landslip hazard area is a hazardous area.

3.4 Interim Planning Scheme Landslide Overlay

Almost the entire site is within the low landslide overlay due the slopes of 11-20 degrees (Figure 2).

3.5 Site and Proposed Works

The project area is situated in Kingston Beach, approximately a 20-minute drive from Hobart City. The site is approximately 1901m2 in size and currently occupied with an existing residential dwelling.

The proposed works are going to be delivered in two stages. The stage one will include demolition of existing carport, construction of a new side deck and roof over extent of rear portion of existing building plus parking hardstands and driveway. The stage two will involve development of the three townhouse units. To be able to accommodate all units it will require fill and cut in the slope. The proposed units are going to be a 2 storey with double garage. The finished floor levels for the units are:

- Townhouse Unit One – Ground finished floor level – 17.70m AHD
- Townhouse Unit Two - Ground finished floor level – 20.10 m AHD
- Townhouse Unit Three – Ground finished floor level – 22.50m AHD.

All units will have a minimum of 25m2 of primary open space directly accessible from living space on each dwelling is provided on the deck areas. The concrete access driveway will be developed along the northwest boundary to access each unit.

Plans have been provided to GES from the Glanville Architects (Project: Gla – 2204, Dated: 06/11/2023). The plans are presented in Figure 3.

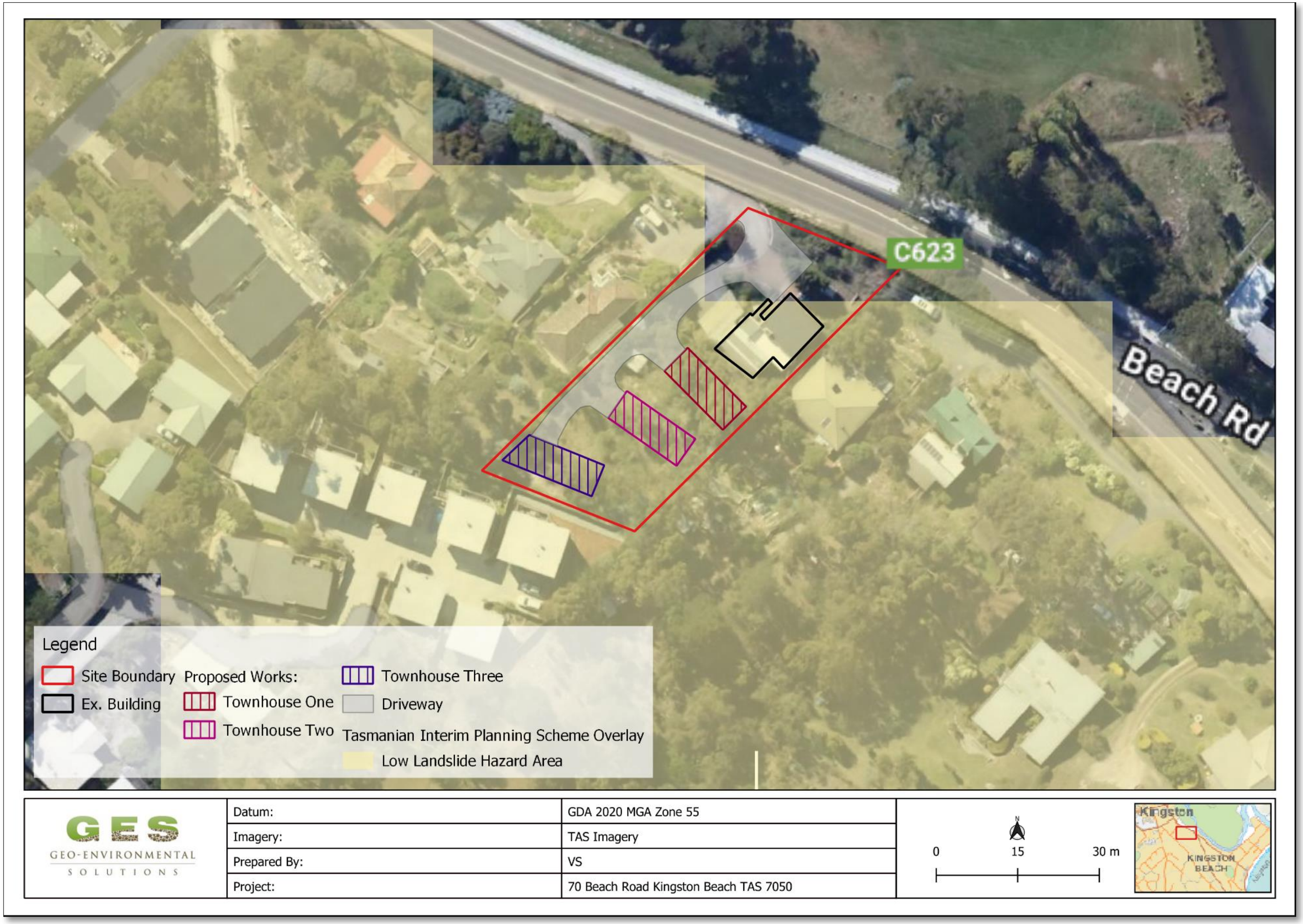

Figure 2 – Landslide Overlay near the Site (The List)

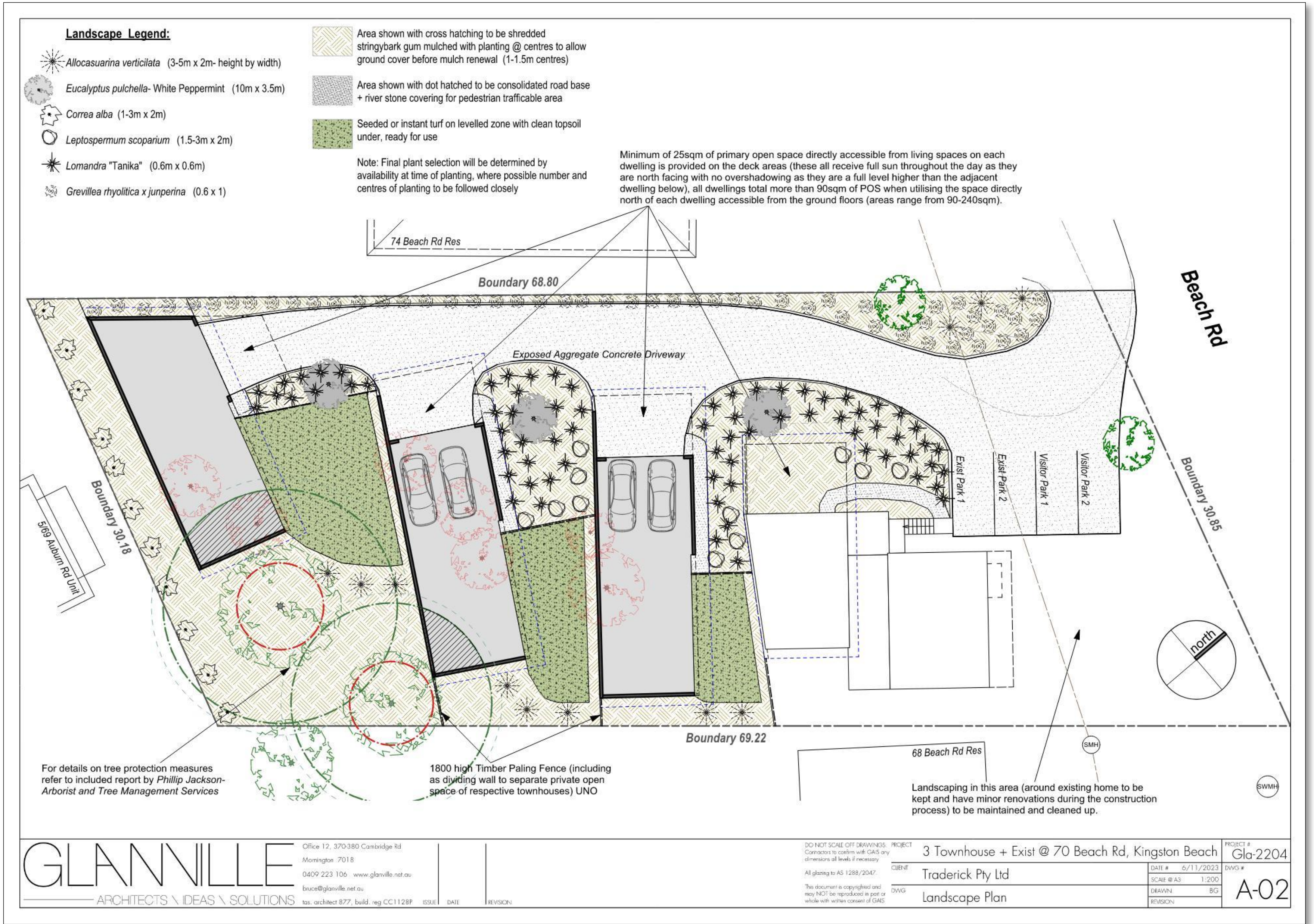

Figure 3 - Site Plan showing proposed works.

3.5.1 Development & Works Acceptable Solutions

Where applicable, the need for further performance criteria compliance is outlined in Appendix 1.

3.5.2 Landslide Hazard Code (LHC)

Given that the proposed development resides in the low Landslip Hazard Area and the existing excavation works are in excess of 100m^3 and there are no acceptable solutions for buildings and works, other than minor extensions, or major works in a low Landslip Hazard Area, the E3.7.1 P1 and E3.7.3 P1 performance criteria will need to be addressed.

3.5.3 Development Performance Criteria

The following performance criteria need to be addressed:

- *E3.7.1 P1*
- *E3.7.3 P1*

4 Site Mapping

4.1 Geological Mapping

The geological map for the site has been presented in Figure 4. Based on the MRT 1:25,000 Mineral Resources Tasmania (MRT) Geology of Tasmania (Map Sheet: Taroona), the site geology comprises of the following geological units:

- Lower Upper Parmeener Group (Map Unit – Pua): Generally unfossiliferous glaciomarine interbedded non-fissile and fissile siltstone and silty sandstone, with common bioturbation and lonestones, rare pebbly beds and fossiliferous beds; top beds of laminated grey to brown siltstone with thin beds (Abels Formation).

4.2 Site Geomorphology

The site is located to the northeast slopes associated with Boronia Hill which descend to Browns River. The natural slopes found throughout the site vary from gentle to moderately steep.

Slope angles and aspects are variable in the location of the proposed development but are typically between 3° and 20° to the east. The slope angles increase to 15-19° to the southwest of the site.

Regarding elevation, the site exhibits a range from approximately 26m AHD along the southwest boundary to dropping around 10m AHD along the northeast boundary. To provide a visual representation of the slope angles on-site, a slope angle map was generated utilizing QGIS software, utilizing the Kingborough 2022 LiDAR data. Refer to Figure 5 for a detailed depiction of the slope angles observed on the site.

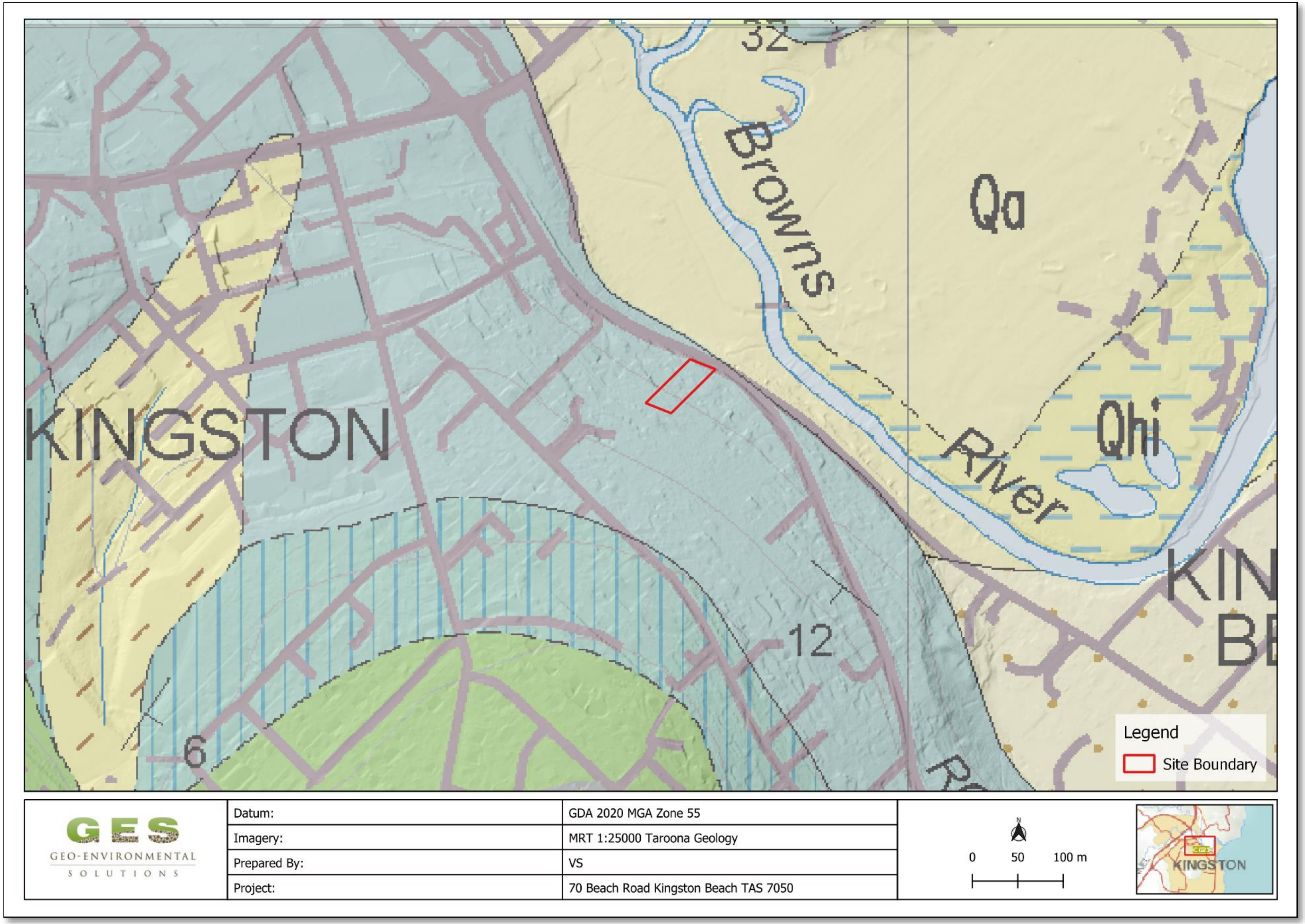

Figure 4 - Mapped Geology (Source: MRT 1:25,000)

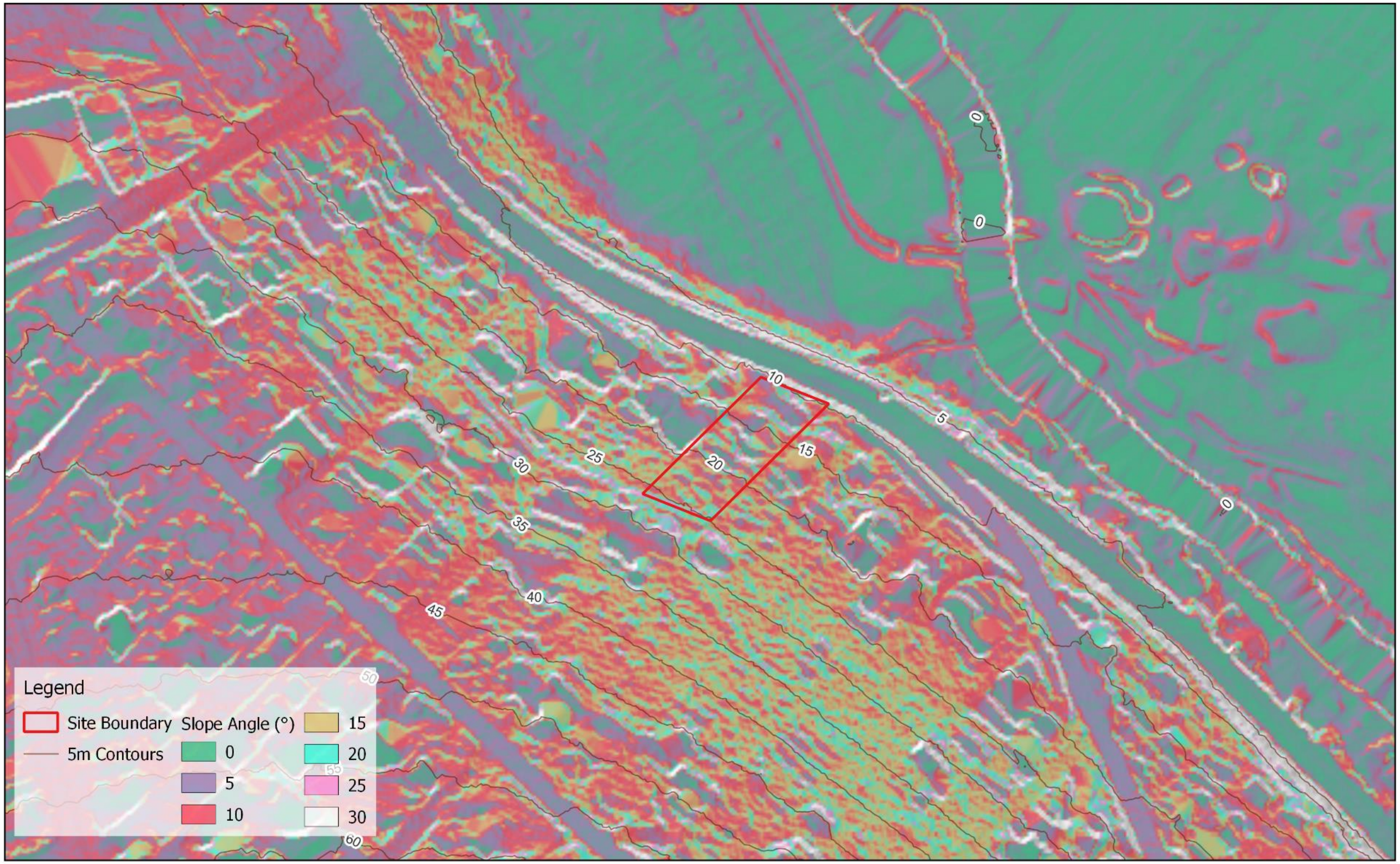

Figure 5 Slope angle model developed from Kingborough 2022 LiDAR data.

4.2 Site Investigation

A site investigation was conducted on 12/12/2023 by GES for the purpose of collecting data and observing the site for this report. Summary of soil profile within a proposed building envelope presented in Table 1. A number of test holes were conducted over the proposed building envelopes to identify the distribution of, and variation in soil materials. Soils on the site are developing from Permian sediments.

According to AS2870-2011 for construction the natural soil is classified as Class M - Moderately reactive clay or silt site, which may experience moderate ground movement from moisture changes. Some variation of subsoil depth and weathering of underlying rock is likely. It is recommended the foundations be placed on the underlying bedrock to minimize the potential for foundation movement.

Table 1 Soil Profiles

BH 1 & BH 2 Depth (m)	TP 3 Depth (m)	USCS	Description
0.00 – 0.40	0.00 – 0.50	SM	Silty SAND: grey, brown, slightly moist, loose,
0.40 – 0.80	0.50 – 1.10	CI	Silty CLAY: medium plasticity, grey, brown, slightly moist, stiff,
0.80 – 1.00	1.10 – 1.20	GC	Clayey GRAVEL: yellow, dry very dense, refusal

5 Landslide Hazard Analysis

5.1 Landslide Characteristics

Based on the slope characteristics including site geology, slope geometry and slope angles, and site observations, the following scenarios have been identified as potential slope failure mechanisms for the site:

- Scenario 1 – Shallow translational slide within shallow residual soils in cutting batters above the proposed units, caused by overstepping of natural soil slope with no allowance for drainage.
- Scenario 2 – Shallow Slide Failure below the proposed units

5.1.1 Frequency Analysis

Table 2 presents the frequency analysis for the identified slope failure mechanisms for proposed excavation on the site. Terminology used is in accordance with the Australian Geomechanics Society (AGS) guidelines for landslide risk management (2007a,b,c,d).

Table 2 Frequency analysis for landslide hazards 1 & 2

Scenario	Failure Mechanism	Unit Affected	Observed in the field	Potential Size	Potential Speed	Water Content	Likelihood
Scenario 1	Shallow translational slide - cut	Residual Soils	No	Small	Very slow to moderate	Wet/saturated	Possible
Scenario 2	Shallow slide failure within shallow residual soils below units	Residual Soils	No	Very small to small	Slow to rapid	Wet/	Possible

5.2 Risk Analysis

5.2.1 Risk to Property

Risk has been considered for the proposed development pre- and post-construction. Based upon the proposed excavation without suitable management of the site is considered **Moderate to Low** risk. Treated risk for Scenario 1 and Scenario 2 may reduce the risk to **Low** (Table 3).

Table 3 Consequence analysis for landslide hazards – Property

Scenario	Issue	Current Risks			Recommended Risk Treatment	Level of Risk post Treatment
		Likelihood of occurrence	Consequence to property	Level of Risk to Property		
Scenario 1	Shallow Translational Slide - Cut	Possible	Medium	Moderate	• Proposed townhouse units to have foundations extending into underling bedrock. • All earthworks should be conducted in accordance with AS3798-2007 and a sediment and erosion control plan should be implemented on the site during and after construction. • Cut slopes to the west of the development should be constructed using the following slope angles: ▪ Residual Soils - 1V: 2 H; and ▪ Rock - 1V: 1H. ▪ Alternatively, slopes can be retained using suitably designed retaining walls. • All cuttings should include a cut-off v-drain above the cutting and a graded toe drain immediately below the cutting face. • It is recommended cut batters surfaces to be protected from erosion using an erosion control blanket, top-dressed with topsoil, and revegetated to improve soil stability.	Low
Scenario 2	Shallow Slide Failure	Possible	Minor	Low	• Foundations of the proposed units should be extended on the rock and be adequately designed in accordance with good hillside construction practices as outlined in the Australian Geomechanics Society (AGS) Geoguide LR8.	Very Low

5.2.2 Risk to Life

Risk to life is considered acceptable given the treated likelihood and consequence of a shallow slide failure above the proposed structure and a shallow failure below the proposed works (Table 4). Societal risk has not been assessed as part of this report.

Table 4 Consequence analysis for landslide hazards – Life

Hazard	Scenario 1	Scenario 2
Factor	Shallow Translational Failure - Cut	Shallow Slide Failure
Likelihood	Unlikely	Unlikely
Indicative Annual Probability	0.001	0.0001
Probability of Spatial Impact	0.2	Unlikely to affect foundations. 0.01
Probability of Not Evacuating	Residual soils should exhibit signs of stress (tension cracking prior to failure), resulting in time for evacuation and/or remediation. 0.1	Residual soils should exhibit signs of stress (tension cracking prior to failure), resulting in time for evacuation and/or remediation. 0.08
Vulnerability	0.05	0.05
Risk Evaluation	Acceptable	Acceptable

Note 1: It has been assumed that each person has an equal probability of death for each of the hazards. This is a conservative estimate of the risk to life.

6 Conclusions and Recommendations

Based on the observations made during the site visit and the outcome of the investigation, landslide risk assessment, the following conclusions are made:

- Soils on the site are developing from Permian sediments with refusal approximately at 1 to 1.2mbsg.
- Foundations of the proposed dwellings should be extended on the rock and be adequately designed in accordance with good hillside construction practices as outlined in the Australian Geomechanics Society (AGS) Geoguide LR8.
- All earthworks should be conducted in accordance with AS3798-2007 and a sediment and erosion control plan should be implemented on the site during and after construction.
- Cutting batters to the west of the of the townhouses development should be constructed using the following slope angles:
  - Residual Soils - 1V: 2 H; and
  - Rock - 1V: 1H.
  - Alternatively, slopes can be retained using suitably designed retaining walls, free – draining walls.
- Aggregate toe drains have been included into the design along the base of all cuttings. A cut-off drain is recommended above the development to intercept surface water away from the proposed development and any cutting/retaining wall faces.
- It is recommended cut surfaces to be protected from erosion using an erosion control blanket.
- The proposed works will not cause or contribute to landslide on the site, adjoining land provided the recommendations are adhered to.
- It is concluded that the proposal is compliant with the landslide hazard code of the Kingborough Council Interim Planning Scheme 2015 (Code E3).

GES should be contacted immediately should conditions greatly differ to that which are stated in this report.

7 LIMITATIONS STATEMENT

This Assessment Report has been prepared in accordance with the scope of services between Geo-Environmental Solutions Pty. Ltd. (GES) and 'the Client'. To the best of GES's knowledge, the information presented herein represents the Client's requirements at the time of printing of the Report. However, the passage of time, manifestation of latent conditions or impacts of future events may result in findings differing from that discussed in this Report. In preparing this Report, GES has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations referenced herein. Except as otherwise stated in this Report, GES has not verified the accuracy or completeness of such data, surveys, analyses, designs, plans and other information.

8 REFERENCES

AGS (2007a). Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007

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Calver, C.R. and Latinovic, M. (compilers) 2002. Digital Geological Atlas 1:25 000 Scale Series. Sheet 5224. Taroona. Mineral Resources Tasmania.

Tasmanian Government, Director's Determination – Landslip Hazard Areas. Version 1.0 6 February 2020.

APPENDIX 1 – Acceptable Solutions

Standard	Code	Acceptable Solution		Performance Criteria
Use	E3.6.1 Hazardous Use	A1	Hazardous use relates to an alteration or intensification of an approved use.	P1
		A2	No acceptable solution.	P2
	E3.6.2 Vulnerable Use	A1	Vulnerable use is for visitor accommodation.	A1
		A2	No acceptable solution.	A2
Development	E3.7.1 Buildings and Works, other than Minor Extensions	A1	No Acceptable solution	P1
	E3.7.2 Minor Extensions	A1	Buildings and works for minor extensions must comply with the following: (a) be in a Medium Landslide Hazard Area.	P1
	E3.7.3 Major Works	A1	No acceptable solution.	P1
Subdivision	E3.8.1 Subdivision	A1	No Acceptable solution	P1
		A2	Subdivision is not prohibited by the relevant zone standards.	P2

APPENDIX 2 – Qualitative Risk Assessment Tables

Likelihood & Consequence Index

QUALITATIVE MEASURES OF LIKELIHOOD

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

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

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

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

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

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

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

Qualitative Risk Matrix

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.

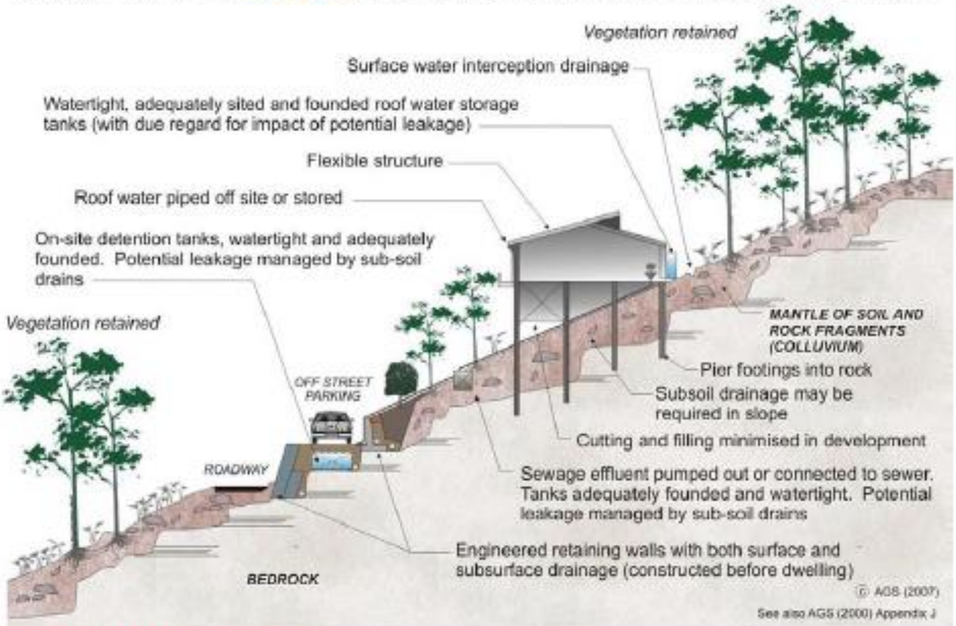
APPENDIX 3 - Australian Geomechanics Society (AGS) Landslide Risk

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

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

EXAMPLES OF GOOD HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES GOOD?

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

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

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

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

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

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

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

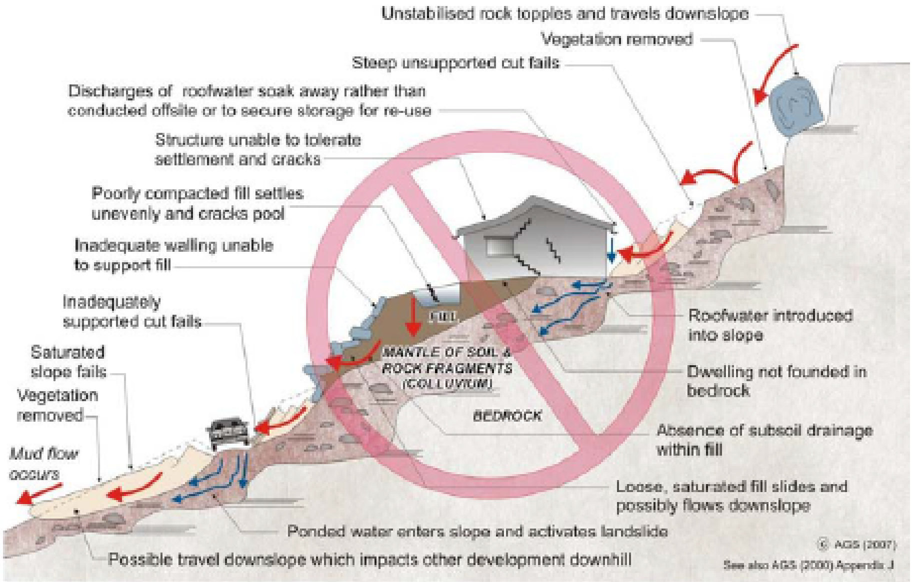
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing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

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

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

EXAMPLES OF POOR HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

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

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

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

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

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

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

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

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

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

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

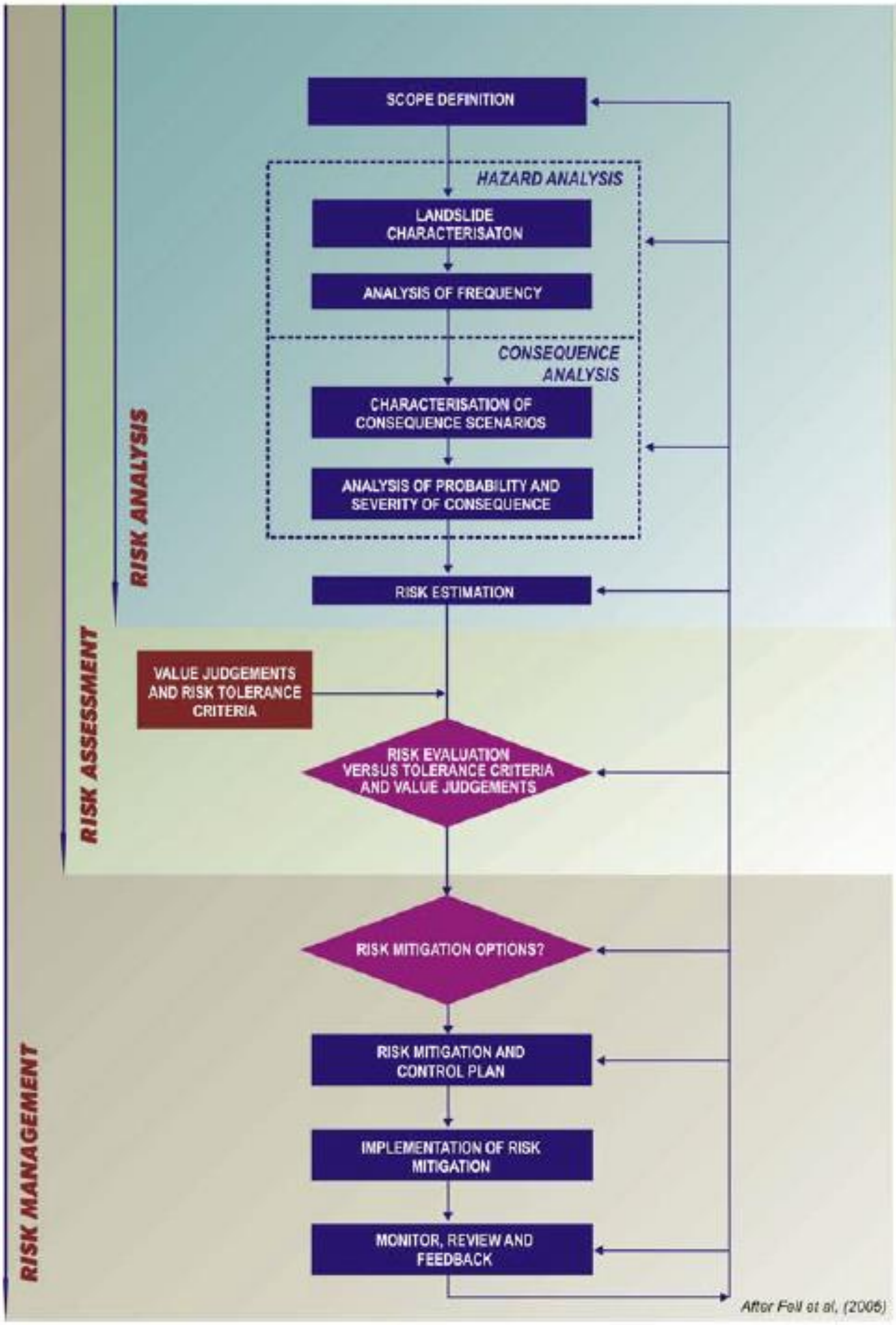
The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to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

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

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.	

FRAMEWORK FOR LANDSLIDE RISK MANAGEMENT



APPENDIX B - LANDSLIDE TERMINOLOGY

The following provides a summary of landslide terminology which should (for uniformity of practice) be adopted when classifying and describing a landslide. It has been based on Cruden & Varnes (1996) and the reader is recommended to refer to the original documents for a more detailed discussion, other terminology and further examples of landslide types and processes.

Landslide
The term *landslide* denotes "the movement of a mass of rock, debris or earth down a slope". The phenomena described as landslides are not limited to either the "land" or to "sliding", and usage of the word has implied a much more extensive meaning than its component parts suggest. Ground subsidence and collapse are excluded.

Classification of Landslides
Landslide classification is based on Varnes (1978) system which has two terms: the first term describes the material type and the second term describes the type of movement.

The material types are ***Rock***, ***Earth*** and ***Debris***, being classified as follows:-

The material is either rock or soil.

Rock: is "a hard or firm mass that was intact and in its natural place before the initiation of movement."
Soil: is "an aggregate of solid particles, generally of minerals and rocks, that either was transported or was formed by the weathering of rock in place. Gases or liquids filling the pores of the soil form part of the soil."
Earth: "describes material in which 80% or more of the particles are smaller than 2 mm, the upper limit of sand sized particles."
Debris: "contains a significant proportion of coarse material; 20% to 80% of the particles are larger than 2 mm and the remainder are less than 2 mm."

The terms used should describe the displaced material in the landslide before it was displaced.

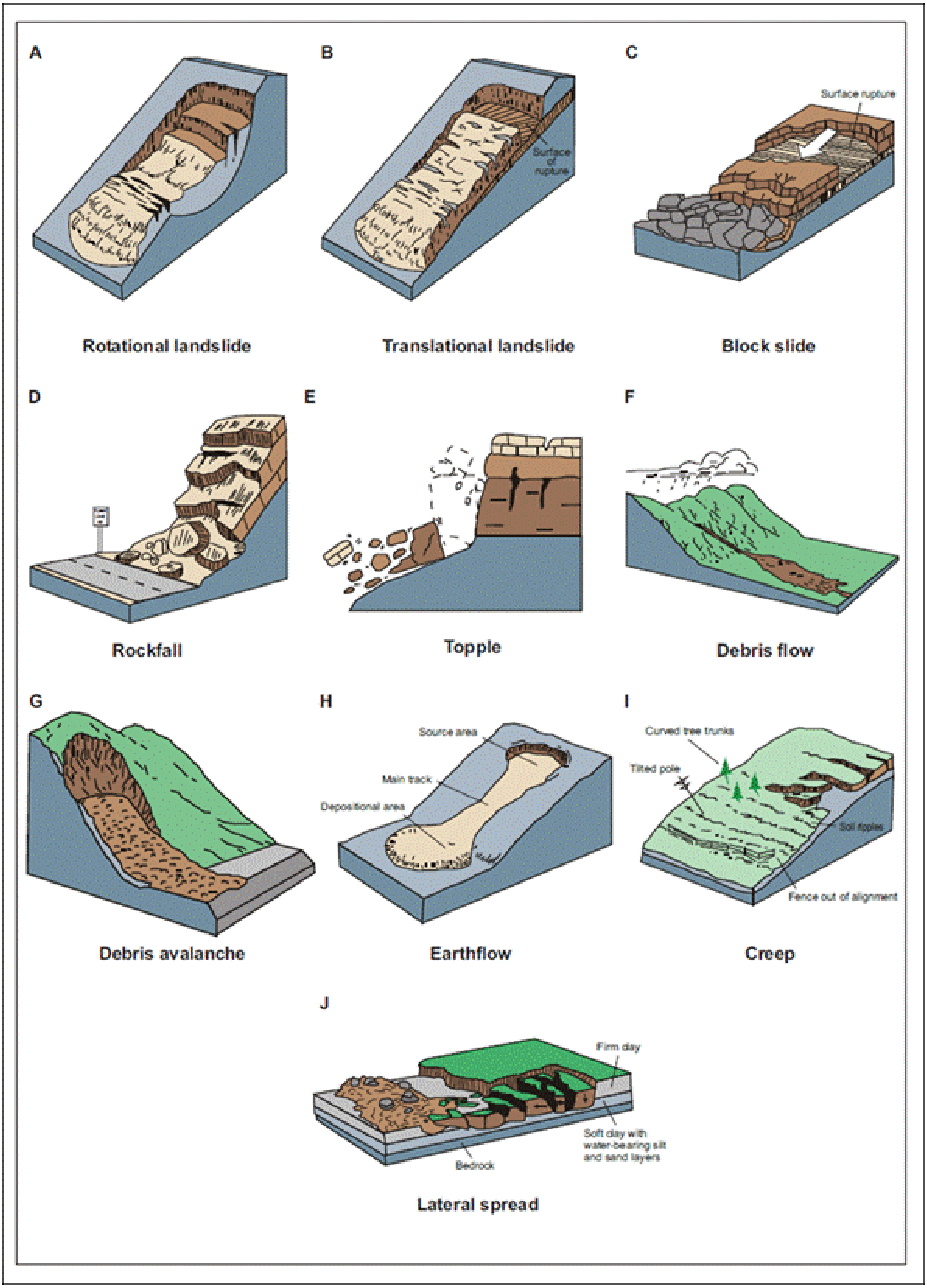
The types of movement describe how the landslide movement is distributed through the displaced mass. The five kinematically distinct types of movement are described in the sequence ***fall***, ***topple***, ***slide***, ***spread*** and ***flow***.

The following table shows how the two terms are combined to give the landslide type:

Table B1: Major types of landslides. Abbreviated version of Varnes' classification of slope movements (Varnes, 1978).

<table>
<tr><th colspan="2" rowspan="3">TYPE OF MOVEMENT</th><th colspan="3">TYPE OF MATERIAL</th></tr>
<tr><th rowspan="2">BEDROCK</th><th colspan="2">ENGINEERING SOILS</th></tr>
<tr><th>Predominantly Coarse</th><th>Predominantly Fine</th></tr>
<tr><td colspan="2">FALLS</td><td>Rock fall</td><td>Debris fall</td><td>Earth fall</td></tr>
<tr><td colspan="2">TOPPLES</td><td>Rock topple</td><td>Debris topple</td><td>Earth topple</td></tr>
<tr><td rowspan="2">SLIDES</td><td>ROTATIONAL</td><td rowspan="2">Rock slide</td><td rowspan="2">Debris slide</td><td rowspan="2">Earth slide</td></tr>
<tr><td>TRANSLATIONAL</td></tr>
<tr><td colspan="2">LATERAL SPREADS</td><td>Rock spread</td><td>Debris spread</td><td>Earth spread</td></tr>
<tr><td colspan="2">FLOWS</td><td>Rock flow
(Deep creep)</td><td colspan="2">Debris flow   Earth flow
(Soil creep)</td></tr>
<tr><td colspan="2">COMPLEX</td><td colspan="3">Combination of two or more principle types of movement</td></tr>
</table>

Figure B1 gives schematics to illustrate the major types of landslide movement. Further information and photographs of landslides are available on the USGS website at http://landslides.usgs.gov.


A
Rotational landslide
B
Surface of rupture
Translational landslide
C
Surface rupture
Block slide
D
Rockfall
E
Topple
F
Debris flow
G
Debris avalanche
H
Source area
Main track
Depositional area
Earthflow
I
Curved tree trunks
Tilted pole
Soil ripples
Fence out of alignment
Creep
J
Firm clay
Soft clay with water-bearing silt and sand layers
Bedrock
Lateral spread

APPENDIX 4 - Qualitative Risk Assessment

Performance Criteria E3.7.1 P1 Buildings and works must satisfy all of the following:	Relevance	Management Options	Managed (treated) Risk Assessment			Further Assessment Required
			Consequence	Likelihood	Risk	
(a) no part of the buildings and works is in a High Landslide Hazard Area;	N/A					
(b) the landslide risk associated with the buildings and works is either: (i) acceptable risk (means a risk society is prepared to accept as it is. That is; without management or treatment); or (ii) capable of feasible and effective treatment through hazard management measures, so as to be tolerable risk. The residual tolerable risk may be assessed using either qualitative or qualitative methods in the landslide risk assessment either: (a) if using the AGS qualitative risk assessment method apply the "As Low As Reasonably Possible (ALARP)" principle with the residual tolerable risk level no higher than a "moderate" risk level under the AGS 2007(c) risk method; or (b) if using the AGS quantitative risk assessment method then the tolerable loss of life for the person most at risk as suggested by the AGS 2007(c) to be: (i) if existing slope / existing development: 10-4 / annum; (ii) if new constructed slope / new development / existing landslide: 10-5 / annum.	Capable of feasible and effective treatment through hazard management measures	Refer to Recommendations	Minor	Unlikely	Low	N/A

Performance Criteria E3.7.3 P1 Major works must satisfy all of the following (same as 3.7.1P3):	Relevance	Management Options	Managed (treated) Risk Assessment			Further Assessment Required
			Consequence	Likelihood	Risk	
(a) no part of the works is in a High Landslide Hazard Area; (b)the landslide risk associated with the works is either: (i) acceptable risk; or (ii)capable of feasible and effective treatment through hazard management measures, so as to be tolerable risk.	Capable of feasible and effective treatment through hazard management measures	Refer to Recommendations	Minor	Unlikely	Low	N/A