Planning Scheme Policy 15 – Landslide Hazard

15.1 Purpose

(1) The purpose of this policy is to –

(a) give guidance relating to the identification of potential slope instability areas;

(b) set out the requirements for preparation and submission of development applications, including technical reports, on land within designated Landslide Hazard Management Area;

(c) provide information relating to good engineering practices in regards to hillside development to assist applicants, engineers and planners in the design and application of appropriate type and form of developments that best reflects the capability of the land.

15.2 Applicability

(1) This policy applies to all development applications under the Planning Scheme on land within a designated Landslide Hazard Management Area in accordance with the Landslide Hazard Overlay Map.

15.3 What is a Landslide?

(1) A landslide is the movement of a mass of rock, debris or earth down a slope. They are the result of shear failure of the soil and/or rock materials that make up the hill slope and they are driven by gravity.

15.4 Formulating a Development Proposal

(1) Every year in Australia landslides damage many houses and cause millions of dollars of damage to the natural and built environment including buildings, roads, railways and pipelines. Historical records indicate some 50% of all landslides recorded are a result of alteration to slopes by human activity.

(2) The planning and design of future development comprising building or other works on sloping sites should consider the relevance of the slope instability to the type of development proposed and if required the implementation of effective and timely remedial measures. Specific geotechnical requirements will depend on the hazard rating category as discussed in Section 15.6.

(3) As a general rule:

(a) development is not encouraged in High or Very High Landslide Hazard Management Areas. Where it can be demonstrated that development can not be located outside of the High or Very High Landslide Hazard Management Areas the development is subject to rigorous analysis and restrictions apply. Good hillside practices must be adopted and for the majority of situations a risk assessment with respect to landsliding will be required, Remedial measures may be required to reduce or control the risk of slope instability to acceptable levels.

(b) development in Moderate Landslide Hazard Management Areas may only be considered where appropriate restrictions apply. Good hillside practices must be adopted. A risk assessment with respect to landsliding would be prudent.

(c) development is practicable in areas with a Low or Very Low Landslide Management Area without specific restrictions related to landslide hazard. Good hillside practices should be adopted.

(4) It is strongly recommended that applicants arrange a pre-lodgement meeting with Council to discuss the inherent landslide hazards of a site identified as within the Landslide Hazard Management Area prior to the lodgement of a development application.

15.5 Landslide Hazard Mapping

(1) A regional qualitative study to establish hazard ratings with respect to landslide potential has been carried out for the Redland City area as detailed on the Landslide Hazard Overlay Map. The assessment of the hazard ratings was carried out in accordance with *SPP1/03 Guidelines – Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* and is consistent with the procedures detailed in the paper entitled *"A Method of Zoning Landslide Hazards"* prepared by McGregor and Taylor.

(2) The implications of the hazard rating are given in Table 1. This serves as a tool for both planners and developers to determine the appropriate layouts, type and form of development that best reflects the capability of the land.

Table 1 – Implications of hazard classification

Hazard Rating	Description	Implications
VH (Very High)	The event is expected to occur	Extensive investigation, planning and implementation of treatment options essential to reduce risk to acceptable levels.
H (High)	The event will probable occur under adverse conditions	Detailed investigation, planning and implementation to treatment options essential to reduce risk to acceptable levels.
M (Moderate)	The event could occur under adverse conditions	May be acceptable provide treatment plan is implemented to maintain or reduce risk level.
L (Low)	The event might occur under very adverse conditions	Can be accepted. Treatment to maintain of reduce risk level should be defined.
VL (Very Low)	The event is conceivable but only under exceptional circumstances	Accepted. Managed by routine procedures.

(3) for individual sites within a designated Landslide Hazard Management Area, where slope instability is of concern, or areas that may impact on a Landslide Hazard Management Area as a result of the proposed development similar procedures can be applied for refinement of these hazard ratings, identification of unfavourable site conditions and control or manage such areas with regards to the proposed development.

15.6 Requirements for Preparation/Submission of Development Applications

(1) In accordance with the Landslide Hazard Overlay Code site specific assessment is required when a premises is affected by land designated a Moderate, High or Very High Landslide Management Area.

(2) If an applicant can NOT show reasonable cause that their proposed development is located outside land designated as a Moderate, High or Very High Landslide Management Area, and does not contribute to slope instability if such areas, the applicant must achieve the intentions of the Section 15.6.1 to 15.6.3 for the appropriate Landslide Management Area. Reasonable cause will be subject to the approval of Redland City Council, and may require supporting documentation by a suitably experienced geotechnical professional.

(3) In many cases most of the above information on site conditions may be common logic, supplemented by adoption of good hillside practices, or can be obtained during a walk-over survey by a suitably experienced geotechnical professional. However, it may be necessary to supplement the site observations by subsurface investigations such as boreholes or test pits.

(4) In some cases Landslide Hazard Management Areas may vary across the site. If this occurs, the requirements for preparation and submission of a development application should adopt the

higher hazard rating. In order to justify a lower Landslide Hazard Management Area rating, the developer must demonstrate that the proposed development is located a safe distance away from the areas of higher rating and does not contribute to increase slope stability.

15.6.1 Development within a VERY HIGH Landslide Management Area

(1) The following identifies the level of professional input that should be incorporated in the assessment, planning and design of proposed developments to suitably identify, control and manage risks associated wit development on, or with the potential to impact on, land designated as a Very High Landslide Hazard Management Area:

(a) carry out a detailed geotechnical engineering report prepared by a suitably qualified geotechnical professional (RPEQ qualifications). At a minimum the geotechnical engineering report should comprise:
- (i) an extensive site investigation including subsurface investigation with groundwater measurements over at least one wet season;
- (ii) frequency of investigation locations should be no less than 1 location per 30m x 30m grid with an assessment of material strength by appropriate in-situ or laboratory testing. Investigations should establish a comprehensive geotechnical model over the whole site;
- (iii) installation of groundwater monitoring points with measurements over at least one typical wet season and comparison of groundwater levels to rainfall events should be made;
- (iv) a review of potential hazards; and
- (v) analysis of slope stability using a suitable model appropriate for the conditions.

(b) where analysis of slope stability (see above) indicates an unfavourable factor of safety, it is necessary to assess the risks to the community with regards to loss of life, injury and damage to infrastructure.

(c) undertake comprehensive siting for the development with regards to potential hazards, including restricting design of major structures and unfavourable earthworks in Very High Landslide hazard Management Areas where possible.

(d) Extensive design input is required from a qualified Practicing Engineering professional, including adoption of good hillside construction practices as provided in this policy.

(e) The design must be reviewed and certified by an experienced, suitably qualified geotechnical professional (RPEQ qualifications).

(f) Planning and implementation of a program of regular maintenance of slopes, cleaning of drainage course and monitoring of slope for signs of distress.

15.6.2 Development within a HIGH Landslide Management Area

(1) The following identifies the level of professional input that should be incorporated in the assessment, planning and design of proposed developments to suitably identify, control and manage risks associated with development on, or with the potential to impact on, land designated as a High Landslide Management Area:

(a) carry out a detailed geotechnical engineering report by an experienced qualified geotechnical professional. At a minimum the geotechnical engineering report should compromise:
- (i) a site investigation including subsurface investigation with groundwater measurements;
- (ii) frequency of investigation locations should adequately cover the site and slope in question to provide sufficient information to establish a comprehensive geotechnical model over the whole site, with assessment of material strength by appropriate in-situ laboratory testing;
- (iii) installation of groundwater monitoring points with measurements over at least one typical wet season and comparison of groundwater levels to rainfall events should be made;
- (iv) a review of potential hazards; and
- (v) analyse slope stability using a suitable model appropriate for the site conditions.

(b) Where analysis of slope stability (see below) indicates an unfavourable factor of safety, it is necessary to assess the risks to the community with regards to loss of life, injury and infrastructure.

(c) Undertake appropriate siting for the development with regards to potential hazards, including restricting/reducing design of major structures and unfavourable earthworks in high landslide hazard areas where possible.

(d) Considerable design input from a qualified Practicing Engineering professional, including adoption of good hillside construction practices as provided in this policy.

(e) The design must comply with recommendations detailed on the geotechnical engineering report.

(f) Planning and implementation of a program of regular maintenance of slopes, cleaning of drainage courses and monitoring of slope for signs of distress.

15.6.3 Development within a MODERATE Landslide Management Area

(1) The following identifies the level of professional input that should be incorporated in the assessment, planning and design of proposed developments to suitably identify, control and manage risks associated with development on, or with the potential to impact on, land designated as a Moderate Landslide Hazard Management Area:

(a) Carry out a geotechnical engineering report by an experienced, qualified geotechnical professional. At a minimum the geotechnical engineering report should comprise:
   (i) site walkover survey with investigations as required establishing a geotechnical model over the whole site. This may require moderate subsurface investigation and/or testing to provide subsoil material properties;
   (ii) review potential hazards; and
   (iii) assessment pf slope stability using a suitable model appropriate for the site conditions.

(b) Consider the risks to the community with regards to injury or loss of life and damage to infrastructure and mitigate unacceptable risks.

(c) Design input from a qualified Practicing Engineering professional, including adoption of good hillside construction practices as provided in this policy.

(d) The design must comply with the recommendations detailed in the geotechnical engineering report.

15.7 Characteristics of Landslides

15.7.1 What types of landslides occur?

(1) Once a landslide is triggered, the material is transported in three forms;
   (a) by sliding along a failure surface;
   (b) by falling down a steep slope; and
   (c) by flowing as a suspended mass, usually in water for example a mudslide or debris flow.

(2) Landslides may be classified into the following main types:

Translational Sliders: where failure occurs on a planar surface or surfaces, usually natural defects in the material such as fissures, joints or bedding. Material within the slide can remain relatively undisturbed.

Creep Sliders: where failure occurs as a gradual downslope progression (often extremely slow rates) of slope material. The slide area may appear relatively undisturbed and identification of the slide is often reliant on surface features.

Rotational Sliders: where failure occurs through the material substance commonly on a concave surface. Material within the slide is considerably disturbed.

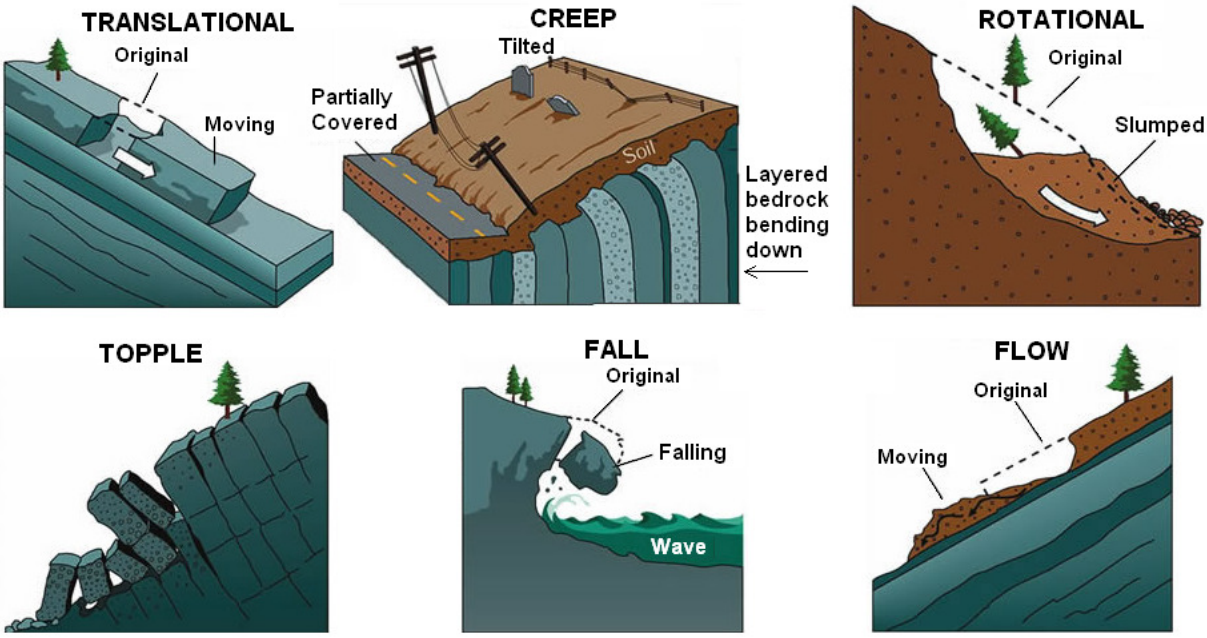
Topple: where failure occurs from the end over end motion of rocks on a down slope. Often resulting from closely spaced sub-vertical jointed rock outcrops.

Falls: where movement is by free-falling or rolling of fragments on steep slopes with outcrops of closely jointed rock.

Flows: where, after failure along a planar or concave surface, the material is transformed into a viscous fluid consisting of soil and rock particles suspended in water.

Complex: where there is a combination of one or more of the above mechanisms.

Figure 1 – Commons types of landslides



The above figure is courtesy of the Geosciences Australia Web-site. (www.ga.gov.au)

(3) The rate of landslide movement varies from extremely slow (millimetres for centimetres per year) to a sudden and extremely rapid (metres per second) as with rock fall or debris flow. Sudden and rapid events are the most dangerous because the lack of warning, the speed at which they can travel down the slope and the force impact.

15.7.2 <u>What causes landsliding?</u>

(1) The stability of sloping ground is controlled by three main factors:
- (a) the angle of the ground surface;
- (b) the strength of the materials below the ground surface; and
- (c) the level of water within the slope.

(2) In Australia intense rainfall is by far the most common trigger of landslides.

Several factors combine to define the complex relationship between the physical environment and land instability, however two basic conclusions can be drawn into the likelihood of their occurrence. Firstly, it is likely that landslides will occur in areas where they have occurred in the past, and secondly they are likely to occur in areas exhibiting similar conditions to these areas.

(3) Landslides can be triggered by both natural causes or by human activity.

(a) Natural causes may include:
- (i) saturation of slope material from rainfall or seepage;
- (ii) undercutting of cliffs and banks by erosion;
- (iii) prying loose of rock masses from vegetating growth within joints; and
- (iv) vibrations caused by earthquakes.

(b) Human activities may include:
- (i) the modification of slopes by cut and fill activities associated with construction;
- (ii) interference with or changes to natural drainage;
- (iii) leaking pipes (water, sewer);
- (iv) changes to materials;
- (v) the removal of vegetation;
- (vi) mining activities; and
- (vii) vibrations from heavy traffic, blasting or excavation.

15.7.3 Identification of potential slope instability

(1) In comparison to many other countries, much of Australia is subject to minimal landslide activity. Generally we receive little rainfall and the landscape has minimal influence from the processes of uplift.

(2) There are however certain areas that are more commonly affected by landslides. Such areas typically comprise cliffs, steep colluvial deposits, or gentler slopes of unstable geology subjected to prolonged or intense rainfall events. Landslide prone areas commonly comprise:
- (a) coastal cliffs;
- (b) existing or old landslides;
- (c) any sloping ground in an area known to have a landslide problem;
- (d) areas at or on the base of slopes;
- (e) within or at the base of minor drainage hollows; and
- (f) and the base or top of cut and fill slopes.

(3) In the natural environment the progressive development of hill slopes by weathering and erosion involves a gradual incision of the stream beds into higher ground and results in the formation of slope surfaces that are essentially uniform, convex or planar. The occurrence of natural landslides on these slopes produces an irregular profile, often concave, accompanied by features reflecting the disturbance that has taken place. In the case of recent landslides these features are usually sharp and distinct. With time, the effects of weathering and erosion modify these features which become indistinct but usually can be recognised by close observation. Individually the features may not be related to landsliding but the presence of several features at one location indicates that some mass movement of material may have occurred.

(a) Features that indicate existing natural slope instability include:
- (i) irregular surfaces: areas of hummocky ground and depressions indicating disturbed material;
- (ii) benches: anomalous flat areas in uniform sloping areas;
- (iii) scars: areas where vegetation has been stripped during slope movement;
- (iv) scarps: linear features showing the location of vertical displacement of the ground surface;
- (v) cracks: linear features showing lateral displacement of the ground surface;
- (vi) debris mounds: deposits of loose soil and rock on or at the base of slopes;
- (vii) disturbed vegetation: tilted trees; and
- (viii) seepage: presence of springs and sense vegetation regrowth.

(b) Features that indicate that some lateral mass movement of material may have occurred in areas that have been developed include:
- (i) cracking or tilting of walls and retaining structures;
- (ii) cracking or slumping of embankment slopes;
- (iii) cracking and fall of material from excavated slopes;
- (iv) broken/fractured water pipes and underground facilities;
- (v) tilted powerlines, retaining walls and fences (or offset); and
- (vi) sunken or cracked road surfaces.

15.8 Implementing Good Hillside Practices

15.8.1 What guidelines apply to development applications?

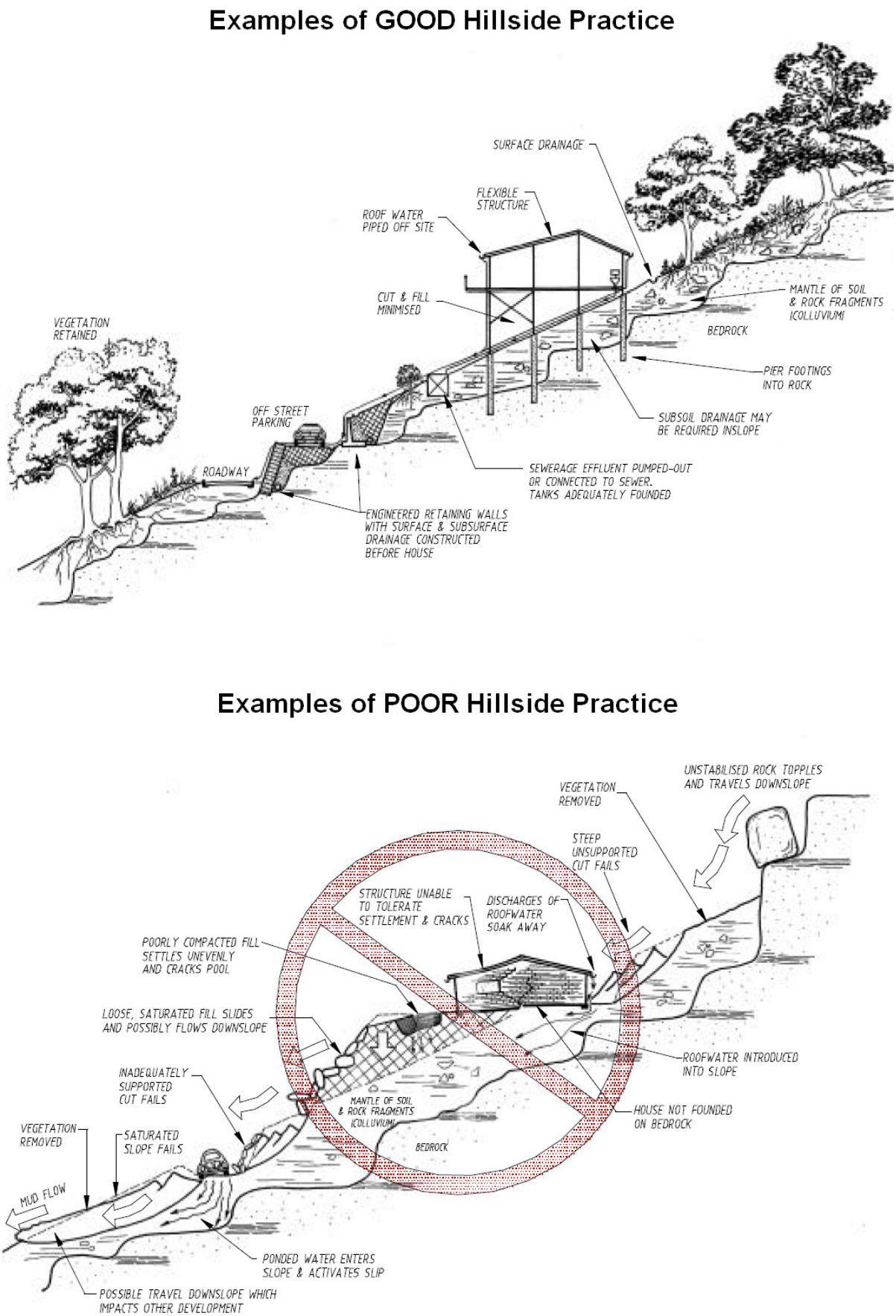
(1) Examples of Good and Poor Hillside Engineering Practice are given in Table 1 and Figure 2 below.

Table 1 – Guidelines for hillside construction practice

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminant bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto 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.	

Extract from "Landslide Risk Management Concepts and Guidelines", Australian Geomechanics Society Journal, Volume 37 No. 2, May 2002, p43.

Figure 2 – Illustration of good and poor hillside practices



Extract from "Landslide Risk Management Concepts and Guidelines", Australian Geomechanics Society Journal, Volume 32 No. 2, May 2002, P44.

15.8.2 What guidelines apply to road design over sloping ground

(1) Roads on side slopes usually are formed by a combination of cut and fill operations. The design must incorporate effective drainage, and should incorporate good practices:

(2) The road cut slope design should incorporate:

(a) The adoption of batter slopes appropriate to the engineering properties of the different materials exposed in the cut face. As a general rule batters in soil should be 2H:1V, in poor rock 1H:1V and in good rock 0.5H to 1V.

(b) Where cuttings in rock are proposed, road alignments should be planned as not to coincide with major jointing orientations of the rock.

(c) The higher cut faces should include the provision of benches at vertical intervals of not greater than 10m. These benches are required to catch fallen material, to control drainage and to provide access for maintenance of the cut face.

(d) The provision of formed surface drains at the top of the cut slope, on the benches and at the toe of the cut slope.

(e) The provision of slope protection, slope treatment or slope support in areas of potential concern. Slope protection against erosion may utilise a cover of topsoil and grass. On steeper slops treatment of erodible and closely joined rock is commonly by a cover mesh and shotcrete with rock bolts providing treatment of areas with adversely oriented joining. In areas of greater concern slope support can be provided by an engineered retaining wall. The design of the wall depends on the site conditions and cut dimensions but could include gabion crib, masonry and reinforced concrete wall designs.

(3) The road fill embankment design should incorporate:

(a) The removal of all unsuitable material including trees, vegetation and topsoil from embankment foundation.

(b) The preparation of the embankment foundation by the formation of terraces across the slope. These terraces should be at least 2m wide with a maximum height of 0.6m.

(c) The installation of drainage, if required, in the foundation. This drainage may involve trench drains in areas of local seepage or a drainage blanket in an area that is generally wet.

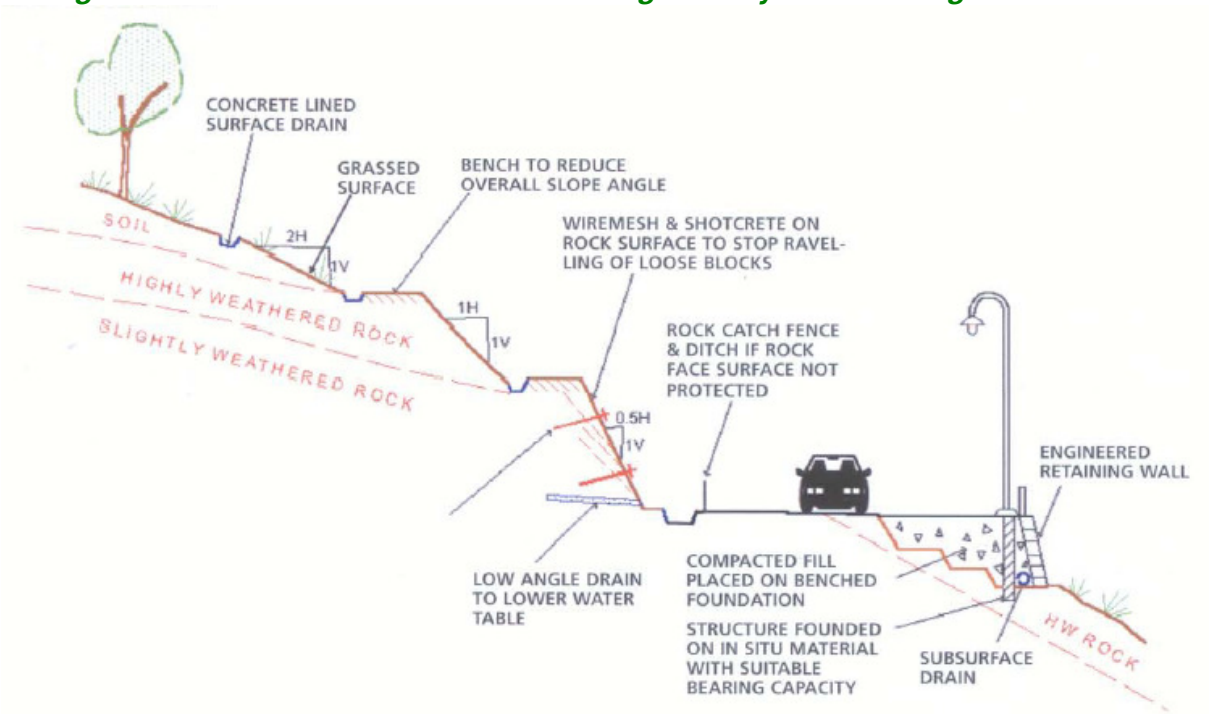
(d) The embankment fill should be placed in an engineered manner. Placement of earth fill should be in layers – each not thicker than 300mm and compacted by roller to not less than 95% relative to Standard Compaction.

(e) The design of compacted earth fill slopes in soil should be no steeper than 1.5H:1V, and may often be lower subject to retained height, soil strength and maintenance considerations. Surface protection should be my grass or rock.

(f) The provision of drainage at the crest and toe of the embankment as formed drains leading to an identified disposal area.

(4) Examples of how to maintain slope stability for road design is illustrated in Figure 3.

Figure 3 – Possible methods of maintaining stability in road design



15.9 References

- Queensland Government, State Planning Policy 1/03 “Mitigating the Adverse Impacts of Flood, Bushfire and Landslide” (SPP1/03), May 2003.
- Queensland Government, State Planning Policy 1/03 Guideline “Mitigating the Adverse Impacts of Flood, Bushfire and Landslide” (SPP1/03), June 2003.
- Australian Geomechanics Society Sub-Committee on Landslide Risk Management, “Landslide Risk Management Concepts and Guidelines”, Australian Geomechanics Journal, Volume 37 No, 2, May 2002.
- McGregor and Taylor “A Method of Zoning Landslide Hazards”, Australian Geomechanics Journal, Volume 36 No. 3. Sept 2001.