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IMPLEMENTING THE AGS LANDSLIDE RISK MANAGEMENT GUIDELINES IN A MUNICIPAL PLANNING SCHEME - A CASE STUDY IN THE COLAC OTWAY SHIRE, VICTORIA.

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ABSTRACT

The Colac Otway Shire in south west Victoria are in the process of amending their Planning Scheme to include landslide risk assessment for new developments in landslide prone areas. The amendment is primarily intended to limit the Shire's liability and will require consultants to assess risk using the Australian Geomechanics guidelines on landslide risk management. However data limitations, particularly the paucity of historical information on landslide events, have precluded landslide hazard mapping for all types of landslides and their likelihood of occurrence, at the site-scale required for planning controls. The solution adopted was to extend the Erosion Management Overlay to cover all areas of the Shire in which landslides are credible, and the implementation of a documented process to determine when a landslide risk assessment for any development is required. The process includes reference to existing information stored on a GIS database, a checklist for use in an initial site visit by the Shire, specific requirements for consultant's reports, and information checking and mediation processes for the Shire. The limited landslide risk management experience of the Shire planners and some small and medium-scale consulting companies has highlighted a local desire for a more prescriptive code.

1. INTRODUCTION

A review of landslide risk management for the Colac Otway Shire in south west Victoria has recently been completed by the authors. The two-year study focused on municipal planning controls for new developments, managed under the Shire's Planning Scheme and concluded that the past planning procedures did not reflect the current thinking on landslide risk assessment and failed to adequately limit the Shire's liability. In addressing this shortcoming, the Shire has adopted the Australian Geomechanics Society (AGS) guidelines on landslide risk management, which were published in March 2000 (AGS, 2000). From March 2002, any new development in the area of the Shire mapped as susceptible to landslides requires a risk assessment in accordance with the AGS guidelines.

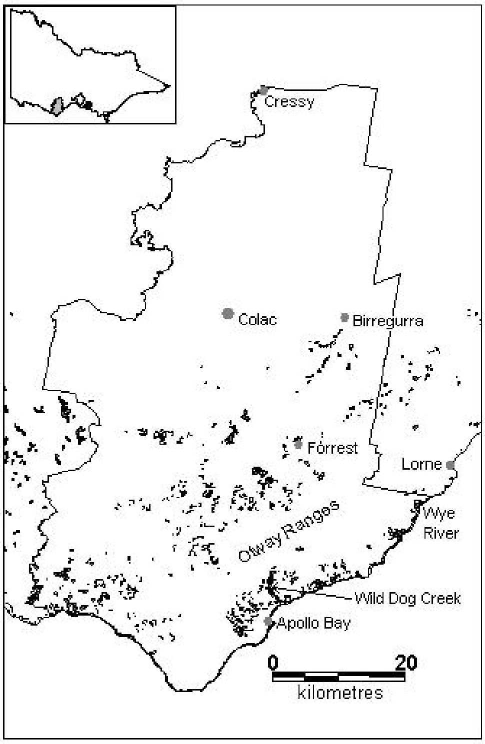

Figure 1. Landslide distribution in the Colac Otway Shire.

1.1 COLAC OTWAY SHIRE

The Colac Otway Shire covers over 3,400 km^2 in south west Victoria. Centred on the City of Colac. (Figure 1) the northern half of the Shire comprises the Western Victorian Volcanic Plains, and the Otway Ranges and foothills of the Victorian Southern Uplands dominate the southern portion. The average annual rainfall varies from approximately 550 millimetres on the northern plain to over 1900 millimetres on the crest of the Otway Range. Maximum rainfall occurs in late winter and early spring, with the greatest single day total of 167.4 millimetres at Apollo Bay. Primary industries, especially dairy farming and timber harvesting are the dominant land-uses. The past decade has seen an increase in tourism, especially associated with the Great Ocean Road along the spectacular coastline.

Over 900 landslides have been mapped in various studies within the Colac Otway Shire and it is estimated that thousands more, of varying sizes, exist (Figure 1 & Table 1). Landslides vary in area from a few square metres to over 60 hectares and in volume from a few cubic metres to over ten million cubic metres. They are triggered by prolonged and/or intense rainfall, elevated pore-water pressures, man-made changes to the landscape and rare earthquake events. The vast majority of landslides occur in two rock types, *viz*: the Cretaceous age Otway Group rocks and the Neogene Gellibrand Marl.

Data Source	Location mapped	No. of landslides	Method used and data	Estimated Accuracy
Cooney, 1980	Shire area south of Colac	702	1946- 1950 Aerial photo interpretation, limited field checks, 1980	± 200 m
Wood, 1982	Area between Wild Dog Creek and Busty Road	35	Detailed field mapping, 1982	± 25 m
Rosengren, 1984	Shire of Otway, sites of geomorphological significance	82	Field mapping and aerial photo interpretation, 1984	± 100 m
Tickell, *et al*., 1991	Colac 1:50,000 geological map	72	Field mapping and aerial photo interpretation, 1986 – 1987	± 100 m
Edwards, *et al*., 1996	Colac 1:250,000 geological map	10	Compilation of existing maps, 1996	± 250 m
Previous geotechnical assessments	Development sites in existing planning control area	41	Field observation, 1986 – 1999	Located to property polygon
Dahlhaus & Miner, 2001. McVeigh, 2001	Colac Otway Shire, selected locations	15	Field mapping, 2000 - 2001	± 10 m
Total		**957**		

Table 1 Summary of existing landslide information in Colac Otway Shire

2. GEOLOGY

2.1 LOWER CRETACEOUS OTWAY GROUP

The Early Cretaceous Otway Group rocks that make up the majority of the southern portion of the Shire comprise volcaniclastic sandstones and shales that have been moderately strongly deformed. They are quickly and easily weathered and are regarded as the most landslide-prone of the geological units in southwest Victoria. Landslides occur in both the rock and soil materials, even where the rock is not significantly weathered (Wood, 1982). The Otway Group also exhibits the most voluminous slides of any geological unit.

2.2 TERTIARY SEDIMENTS

A variety of sediments were deposited in the mostly marine conditions that existed in the Otway Basin throughout the Tertiary Period, of which the Narrawaturk Marl and Gellibrand Marl are the most landslide-prone units. Landslides in the Gellibrand Marl have been extensively studied in the neighbouring Heytesbury region (Buenen, 1995; Miner, 1999), where they can occur on slope angles of only 6^o. These studies found that in some cases the weathering of the marl resulted in changes to the mineralogy and mechanical properties of the upper regolith. These changes, in conjunction with pedogenic development, can create low-strength layers at shallow depths, on which movement occurs (Dahlhaus & Miner, 1998). Within the Shire landslides up to 47 hectares in area on slopes of 5-15% (3^o–9^o) are recorded in the Gellibrand Marl (Tickell *et al.*, 1991)

3. LANDSLIDE HAZARD

3.1 PREVIOUS STUDIES

Of several studies of landslides in the Colac Otway Shire (Table 1) the work carried out by the Geological Survey of Victoria between 1979 and 1990 is the most relevant. This work was conducted initially for the Town and Country Planning Board (Cooney, 1980) and later the Department of Planning (Cooney, 1982b). The initial regional study mapped over 700 landslides by interpretation of aerial photographs (Cooney, 1980). While this study classified many of the larger landslides as dormant, it recognised that many of the active smaller slides occurred within the area of the larger slides, and noted a close association between currently active landslides and previous failures.

The initial broad-scale study was supplemented by a detailed field study of 35 landslides in the valley of Wild Dog Creek (Wood, 1982), regarded as one of the most landslide-prone areas of Victoria. These studies by the Geological Survey ultimately provided the basis of planning controls used by the Ministry for Planning and Environment and the Shire of Otway (Cooney, 1982b, MPE, 1986), and were inherited by the Colac Otway Shire following municipal amalgamation in the early 1990s.

3.2 HISTORICAL RECORD

Extensive research of the historical record confirmed the occurrence of numerous landslides in the Shire, however very few records of exact time and location of events were documented. Only three landslides have been well documented in the published literature:

Lake Elizabeth landslide

The Lake Elizabeth landslide, near Forrest, occurred on the 24th June 1952 following the wettest monthly rainfall on record (Currey, 1952; Cooney 1980; Dahlhaus, 1991). The landslide involved approximately six million cubic metres of rock, with a surface area of about 48 hectares. The slide formed a dam about 35 metres high and 400 metres wide that blocked the East Branch of the Barwon River, forming the 1.6 kilometre long Lake Elizabeth. On the 5th August 1953 the lake overflowed causing the top 26 metres of the landslide dam to fail and a wall of water and mud passed down the river, which overtopped the seven-metre (25 feet) high railway bridge at Barwon Downs, approximately 10 kilometres downstream. Significant damage was sustained to roads and bridges, and many farms were reported as financially ruined, as some had over 20 hectares of dairy pastures under silt. No personal injury was reported.

1952 landslide - Wild Dog Creek Road

A landslide triggered by heavy rainfall during June 1952 occurred at the junction of Wild Dog Creek and Busty Roads. The rock mass failed over a 390 metre section of the slope and the debris flow travelled another 410 metres downhill to block Wild Dog Creek. The dam resulted in some local flooding and deposition of an alluvial terrace. Drilling by Cooney (1982a) revealed that the 9 metre thick depositional fan at the Creek level had been deposited over several events.

1970 Windy Point Landslide

The Windy Point Rockslide on the Great Ocean Road south of Lorne, commenced with the removal of a relatively minor quantity of rock during road maintenance in late 1968. Several subsequent minor rock slides during 1970 and 1971 developed into the movement of up to 150,000 tonnes of sandstone, in large and small discrete blocks, moving down dip on the silty clay slip planes towards the road. The Great Ocean Road was closed between July and December 1971 while a cable anchoring system was designed and successfully installed (Neilson, 1970; Williams & Muir, 1972).

Figure 2. Landslide on Wild Dog Creek Road, 1979.

Anecdotal evidence and Observed landslides

Apart from the above three landslides, information is limited in consultant reports, poorly documented newspaper articles and Shire records, anecdotal evidence and casual observations. One active landslide, known as “the big slide” is situated on the eastern side of Wild Dog Creek approximately 5.3 km along Wild Dog Road from the Great Ocean Road. The unstable area extends over 16 hectares from Wild Dog Road to Busty Road and has been mapped into four zones, based on activity (P.J. Yttrup & Associates, 2001). Activity is triggered by heavy and/or prolonged rainfall. Debris flows and debris slides from the lower slopes of this large complex landslide have often closed the road during the past 50 years (Figure 2).

The Great Ocean Road has been subjected to damage from landslides since it was built during the 1930s. Within the Shire boundary landslide debris is seen in outcrop in many cuttings along the road. Many of these slides remain active, especially in the Wongarra area, where recent debris flows have impacted on the road. In October 2000 the road was covered by debris from two flows which occurred following heavy rain (Figure 3). These rapid, wet, debris flows were initiated in the body of an ancient landslide complex and travelled up to 100 metres to the road.

Rock falls are probably the most common form of landslide along the road, usually triggered by rain. However, at Brown's Creek, anecdotal history records that a dairy was destroyed by a debris flow in 1953. Apparently, the remains of the building were contained in the debris which closed the Great Ocean Road for a time.

Figure 3. Two adjacent landslides that impacted on the Great Ocean Road, October 2000.

3.3 HAZARD PREDICTION

Several previous studies (eg. Joyce & Evans, 1976; Cooney, 1980, 1982b; Wood 1982; Buenen, 1995) attempted to relate landslide activity in south west Victoria to the angle of slope. However, in this study a correlation of landslide occurrence with slope or aspect based on a high resolution (20 x 20 metre) digital terrain model could not be established or justified given the occurrence of sliding on low angled slopes. In addition, anecdotal information and limited observation provides convincing evidence that extreme rainfall is the dominant trigger for landslides in the Colac Otway Shire. However, the paucity of information on the dates of landslide events restricted the opportunity to use the rainfall record to estimate the magnitude of cumulative antecedent rainfall that is likely to trigger landslides, such as has been used elsewhere in Australia (Chowdhury & Flentje, 1998).

Data from previous studies and the historical record limited hazard prediction in that:

- More than 70% of mapped landslides are derived from one study (Cooney, 1980) although the information is given the highest credibility. The landslides were mapped using stereo interpretation of 1:16,000 scale aerial photographs flown between 1946 and 1950. However, only large-scale landslides or those showing strong morphology are able to be recognized and mapped using aerial photographs. Many landslides are obscured by thick forest and vegetation, resulting in a bias towards distribution of mapped landslides on private land compared to Crown Land. Location of these mapped landslides is only accurate to +/- 200 m due to plotting limitations, although some have been recognized in the field and more accurately located during this study. Very few landslides which occurred after 1950 (including the 1951-1953 wet period) were included in Cooney's study.

- Studies of the mapped landslides are spatially variable. The most detailed and accurate is the Wild Dog Creek Study of 35 landslides (Wood, 1982), which is limited to approximately 0.088% of the Shire, or 0.14% of the area considered susceptible to landslides. Similarly the landslides mapped on the Colac 1:50,000 geological map (Tickell, *et al*., 1991), covers approximately 17.7% of the Shire, and the Geological Heritage study (Rosengren, 1984) only maps specific sites.

- Apart from those of the Wild Dog Creek study, little information exists on the individual landslides that have been previously mapped. It is not known when they occurred, their style or state of current activity.

Given the paucity of information on landslides and the scale required for planning controls (i.e. site scale), the delineation of landslide hazard for all styles of landslides, including their likelihood of occurrence, was not practicable for the Shire. Hazard mapping requires a sufficient understanding of the interaction between of the preparatory factors and the triggering factors to derive the 'rules' for landslide potential at any place in the landscape. The economic and time investment required for site-scale delineation of hazard zones is substantial – possibly several million dollars and many years of data collection, as has been the case in Wollongong Shire (P.Flentje, *pers. comm*., 2001). This year the Shire has initiated a study for three towns (Wye River, Separation Creek and Kennett River) where the risk is perceived to be higher.

Similarly, the classification of landslide risk for each property in the Shire cannot be attained. Risk is the product of both likelihood and consequence, and the assessment of the level of risk posed to every conceivable development (buildings and works) by each possible style of landslide (slide, flow, creep, fall and topple) and associated consequences on every site in the Shire is not feasible.

4. LANDSLIDE RISK ASSESSMENT – OUTCOMES OF STUDY

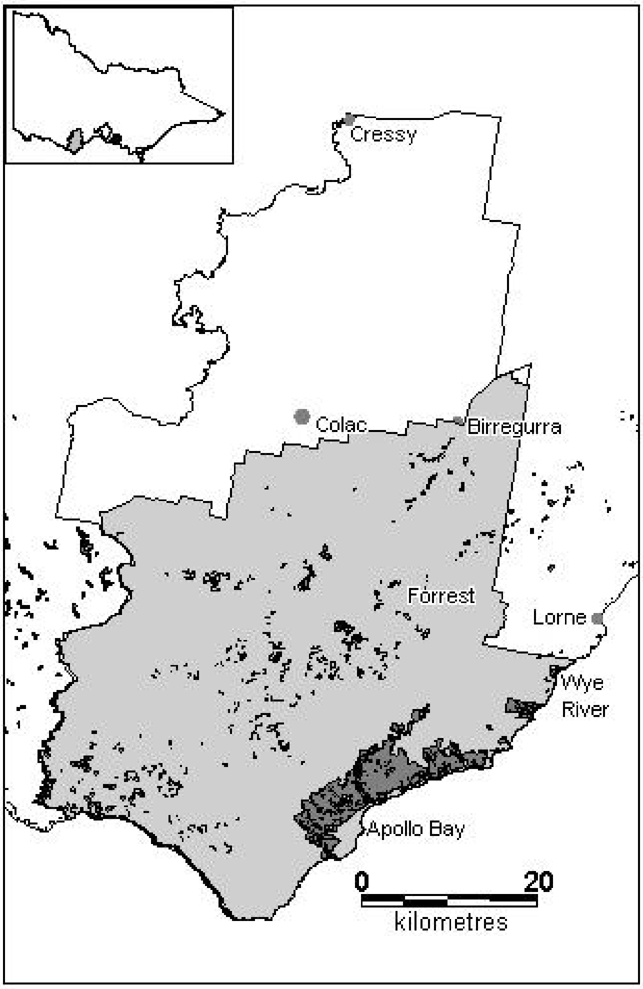

Figure 4. The extension (pale grey) to the Erosion Management Overlay covers the area of the Shire in which landslides are credible. The original 1982 landslide control area is shown in dark grey. The extension increases the area for landslide planning control from approximately $100km^2$ to over $2000km^2$.

An initial recommendation of this study was that the current Erosion Management Overlay (EMO) of the Colac Otway Shire Planning Scheme be extended to cover the areas of the Shire regarded as susceptible to landslides (Figure 4). The EMO does not represent a hazard map or zone, rather a planning overlay of all areas of the Colac Otway Shire in which landslides are credible. The Shire Council moved to extend the EMO in February 2002 and the process is currently being implemented.

The principal outcome of our study was to implement a process within the Planning Scheme to identify the proposed development sites within the overlay that required a detailed landslide risk assessment by a suitably qualified consultant. It was recognised that certain developments within the EMO overlay will have a very low risk of damage to property and loss of life through landslides and it is unreasonable to impose the additional expense and inconvenience of a landslide risk assessment on the developer. To resolve this matter, a process was recommended (Figure 5) that requires the Shire planners to extract existing landslide and geotechnical information from their GIS and then conduct a preliminary on-site assessment, to determine if the proposed buildings or works requires a Land Stability Assessment (LSA) report to be lodged with an Application for Planning Permit. The checklist procedure for the on-site assessments has been designed to be objective, formal, and transparent, and has been ratified by the Shire Council (Appendix 1). It is emphasised that the checklist procedure is not a landslide risk assessment, but provides a formal and accountable method for the Shire staff to eliminate very low risk developments (eg. the erection of a hay shed on flat land distant from steep slopes). Training the Shire staff in the proper use of the procedures has provided them with limited landscape recognition skills, and an evaluation and continuous improvement program has commenced to modify the procedures where required.

The majority of proposed developments within the EMO <u>will</u> require a landslide risk assessment, to be undertaken by a qualified and experienced professional, in accordance with the AGS (2000) guidelines. The Planning Schedule requires that the assessment be undertaken by a professionally qualified engineering geologist or geotechnical engineer with either (a) five years practical experience in slope stability assessment in the Colac Otway Shire or (b) ten years practical experience in slope stability assessment in areas other than Colac Otway Shire or (c) three years practical experience in slope stability assessment and a postgraduate qualification in a field related to slope stability studies. The landslide risk assessment report is required to state the risk for damage to property (qualitative or quantitative) and the risk of loss of life (quantitative), as well as recommendations whether the development should proceed and the risk treatment required.

The underlying intent in the recommended procedures for assessing Planning Permits has been to limit the Shire's liability, whilst providing a fully documented framework for the Shire, consultants and their clients to operate within.

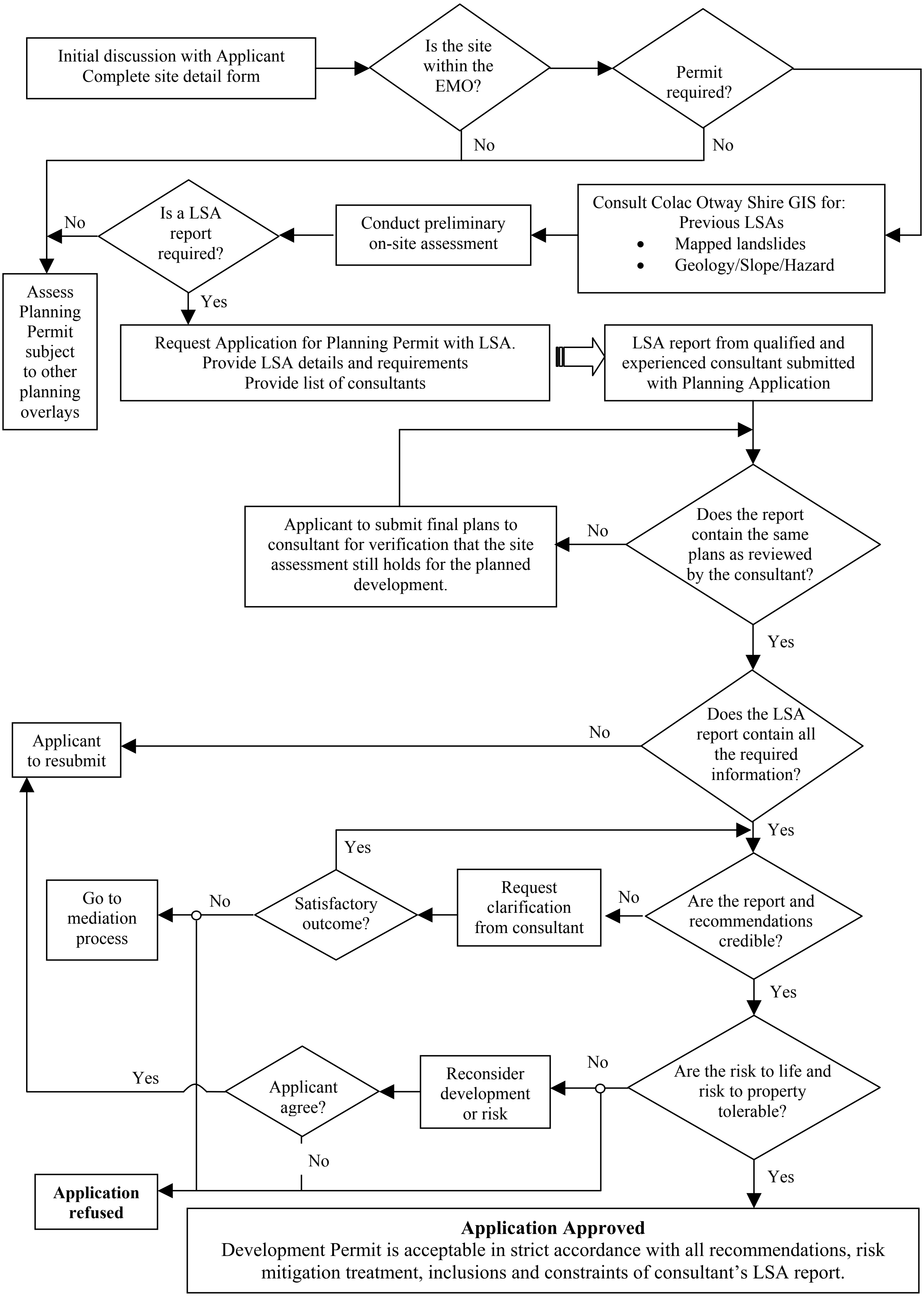

Figure 5. Recommended flowchart for assessing Planning Permit Applications within the EMO.

5. IMPLEMENTATION OF THE AGS GUIDELINES - ISSUES

Whilst the proposed changes to the EMO have yet to be formally incorporated into the Colac Otway Planning Scheme, the revised process has been implemented in the interim period, as the Shire is now in receipt of new information relating to landslide risk management and have acted to limit their liability. Implementing the use of the AGS guidelines is a key element of the proposed changes and it has highlighted a number of issues for the Colac Otway Shire (The Regulator), the consultants previously carrying out stability assessments (The Consultants) and the applicants and developers faced with changes to the previous planning scheme (The Client).

5.1 THE REGULATOR - THE COLAC OTWAY SHIRE

Although the Colac Otway Shire covers a large area, the extent of Public Land considerably reduces its revenue base. The provisions for landslide risk assessment were inherited from the former Shire of Otway following municipal amalgamation and few of the current planning staff have sufficient experience with landslide issues. The Shire does not employ a geotechnical engineer or engineering geologist to specifically deal with the landslide issue. As a result of these limited internal resources, the Shire is not equipped to handle the more flexible approach to landslide risk assessment as advocated and recommended in the AGS (2000) guidelines.

As previously stated, the Shire's main focus during the review was to limit their liability and exposure to litigation. In their role as regulator, the Shire demanded a formal process to assess Planning Permit Applications for development in areas susceptible to landslides that was rigid, accountable, unambiguous, transparent, fully documented and legally and socially defensible. By implication, this indicated a preference to transfer liability to the consultant and the client where possible.

Without doubt, the endorsement of the AGS guidelines in the NSW Coroner's report on the Thredbo Landslide and their distribution to every local government authority in Australia were key factors in the adoption of the AGS guidelines by the Colac Otway Shire. The Shire planners and Shire Councillors view the AGS (2000) guidelines as the *de facto* National code of practice. Even though the Shire has expressed a difficulty in understanding parts of the guidelines, especially the quantification of risk of loss of life, their planning process requires that the consultants use this method because it is recommended by the AGS (guidelines), and the use of the guidelines is the key element in their defensible process.

5.2 THE CONSULTANTS

The experience of the Colac Otway Shire is that the larger multi-national consultants, who may be best qualified to handle the flexible approach of the AGS guidelines, are generally unwilling to do assessments for domestic residences because they are viewed as high risk, low return projects for one-off clients who may default on payment if the result is negative. Consequently there have been very few landslide risk assessments in the Shire by the larger consulting companies over the past decade.

The AGS guidelines acknowledge landslide risk assessment is a relatively new technique. In implementing the revised landslide risk management process, the Shire quickly discovered that most mid-range and smaller consulting companies did not have extensive experience in landslide risk assessment. It is also true that these same consultants do not have the time, resources or experience base to implement the flexible AGS approach for relatively low fee, high workload projects such as landslide risk assessments for domestic house sites, using the approach published by the AGS. Our experience of the implementation of the AGS guidelines is that many consultants new to risk assessment are generally poor at implementing the various methods and approaches for determining frequency, vulnerability, runout distances and consequence. Unfortunately, some consultants place less importance on identifying the potential types of hazards and potential consequences and are more importance on compliance with the stated requirements of the Shire.

In the absence of historical observations, an understanding of the geomorphological evolution of the region provides the best starting point for landslide recurrence data. As an example, the Plio-Pleistocene tectonic history of uplift in the Otway Ranges and the Quaternary sea level changes indicate that many landscapes are less than 3000 years old, including the largest coastal landslides (Dahlhaus & Miner, 2002). This knowledge can be further refined using regional rainfall records, experience, observations and site measurements to provide a reasonable estimate of frequency.

Whilst there may be a belief among some of the larger consultants that the AGS guidelines are too prescriptive, the experience in the Colac Otway Shire indicates many of the smaller consultants would welcome a more definitive standard or code. At the present both the Shire planners and the consultants servicing the Shire are comfortable with the qualitative method (AGS, 2000 - Appendix G) for calculating risk for damage to property. Both would also favour the adoption of a qualitative method of calculation for loss of life such as that suggested by DeAmbrosis (2000).

Although the guidelines provide a number of methods to calculate frequency, the majority of consultants in the Shire rely solely on the visual inspection and observational approach. The paucity of historical data highlights the urgent need for further research on landslide types and sizes, frequency or recurrence, runout distances of different styles of landslides, vulnerability and consequence in the region. Such extensive research programs are only feasible within the realms of universities, research organisations (eg. CSIRO, CRCs) or Shires with a higher revenue base which are serviced by experienced and qualified consultants

5.3 THE CLIENTS – PERMIT APPLICANTS

With the implementation of the AGS guidelines, the Shire reviewed a number of Applications for Planning Permits and requested further information on landslide risk. In these cases, the previous landslide assessments were deemed unacceptable on the basis that they contained insufficient detail to provide the Shire planners with the confidence to issue a Planning Permit, in light of the new guidelines. Whilst applicants accept that new guidelines have been implemented they resent incurring additional substantial costs for a process they do not understand. Consequently some applicants have not proceeded with development due to the additional costs of obtaining an AGS compliant report or costs associated with the revised risk treatment plan for their development. A few applicants have signalled their intent to challenge the Shire's decision at the planning tribunal although no cases have yet proceeded to arbitration. Despite a number of community consultative meetings held by the Shire to explain the changed planning procedures, some residents - even those in the most landslide prone coastal areas - are still disbelieving of the need for landslide risk assessment. Consequently, there is a suspicion among some of the residents and developers that the Shire is over-regulating development.

6. CONCLUSIONS

Whilst the introduction of landslide risk management concepts and guidelines for use by regulators, consultants and their clients is strongly supported, our experience suggests that each group has a different perception of the risk and different expectation of the guidelines. Our experience in implementing the AGS guidelines in the Colac Otway Shire suggests that the under-resourced regulator seeking to limit liability desires a prescriptive and definitive code of practice. This would include a standard qualitative risk matrix for both property and for life, which was specific for domestic or light industrial development with definitive guidelines on good and bad hillside building practice. Additionally, the Shire would welcome a clearer explanation of acceptable and tolerable risk and published National standard acceptance criteria. Although excellent guidance on landslide risk assessment has been published (eg. Fell, *et al.*, 2000) the small-scale consulting companies with limited risk management experience still seek explicit standard practices for quantitative assessment of risk. Furthermore, there is an urgent need for detailed information on good hillside development procedures, including building construction, wastewater and stormwater management. Ongoing education of the public, consultants and the regulators is strongly supported, as is the need for targeted landslide research and the dissemination of research findings.

Many municipalities around Australia will be in a similar situation to the Colac Otway Shire, with known hazards but insufficient data to produce hazard maps on site scale or accurately assess frequency, runout distances and assess vulnerability. Like the Colac Otway Shire, some will include the AGS guidelines as part of a rigid and defensible process within the regulatory framework of a Planning Scheme to limit their liability. Further development of the guidelines to take into account their use and user's expectations is welcomed.

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Appendix 1 Preliminary on-site assessment checklist (Colac Otway Shire)

IMPORTANT NOTE This checklist is to be used in conjunction with the GIS only as a guide in assessing the need for Land Stability Assessment report. The indicators are not absolute and if stability of the site is doubtful a LSA report is recommended. The use of this guide assumes a minimum level of skill and training of the user.

Items		Check	Response and Action								
Development	1	Will the proposed development have a degree of use or occupation by humans?	NA UNK		No		Yes				1
	2	Is the proposed development non-flexible, heavy construction?	NA UNK		No		Yes				2
	3	Does the development involve significant modification to the landscape, including cut and fill?	NA UNK		No				Yes		
Geology	4	Does the site lie within the geology of the Otway Group, Gellibrand Marl or Narrawaturk Marl?	NA UNK		No		Yes				4
	5	Does the site lie within the geology of the Hanson Plain Sand or Older Volcanics	NA UNK		No		Yes				5
Geomorphology	6	Are there any indications of possible landslides on the site or adjacent to it?	NA UNK		No				Yes		
	7	Does the site have distinct breaks in slope or benches?	NA UNK		No				Yes		
	8	Are the hillslopes of the site undulating or hummocky?	NA UNK		No				Yes		
	9	Are there terracettes or other signs of creep on the site?	NA UNK		No				Yes		
	10	Are there signs of tunnel erosion, such as sinkholes or collapse of soils on the site?	NA UNK		No				Yes		
	11	Are there any tension cracks in the ground surface of the site?	NA UNK		No				Yes		11
Adjacent Sites	12	Do adjacent sites show signs of slope instability as described above?	NA UNK		No				Yes		12
	13	Do adjacent sites have sensitive development close to boundaries?	NA UNK		No		Yes				13
	14	Do adjacent sites have non-retained cuts or fills close to boundaries?	NA UNK		No		Yes				14
	15	Are there steep slopes, different geology or landforms on adjacent sites that may pose a threat to this site?	NA UNK		No				Yes		15
	16	Will the proposed development threaten the stability of adjacent developments via cuts, fills or drainage?	NA UNK		No				Yes		16
Known Instability	17	Are there previously identified landslides on this site?	NA UNK		No				Yes		17
	18	Are there previously identified landslides on adjacent sites?	NA UNK		No		Yes				18
Slope	19	Does the site lie within the geology of Gellibrand Marl or Narrawaturk Marl <u>and</u> is the measured slope angle greater than 6° but less than 9°?	NA UNK		No		Yes				19
	20	Does the site lie within the geology of the Gellibrand Marl or Narrawaturk Marl <u>and</u> is the measured slope angle greater than 9°?	NA UNK		No				Yes		20
	21	Does the site lie within the geology the Otway Group <u>and</u> is the measured slope angle greater than 9° but less than 14°?	NA UNK		No		Yes				21
	22	Does the site lie within the geology of The Otway Group <u>and</u> is the measured slope angle greater than 14°?	NA UNK		No				Yes		22
	23	Does the site lie within the geology of the Moomowroong Sands or Wiridjil Gravels <u>and</u> is the measured slope angle greater than 14?	NA UNK		No		Yes				23
	24	Does the site lie within deposits of any other geological formation not mentioned above and is the measured slope angle greater than 9°?	NA UNK		No		Yes				24

Drainage	25	Does the site have deeply dissected drainage courses?	NA UNK		No		Yes				25
	26	Is the site likely to receive significant surface water runoff from other sites upslope?	NA UNK		No		Yes				26
	27	Does the site have dams, lakes, ponds, swamps, bogs, seeps or soaks?	NA UNK		No		Yes				27
	28	Does the site receive drainage from un-engineered road culverts or spoon drains?	NA UNK		No		Yes				28
	29	Will any aspect of the development significantly modify the existing site drainage?	NA UNK		No		Yes				29
Erosion	30	Are there any severe forms of erosion including tunnels or gullies on the site?	NA UNK		No				Yes		30
	31	Do any existing cuts and fills show signs of erosion including loss of vegetative cover?	NA UNK		No		Yes				31
	32	Are there deposits of silts or clays at the base of existing cuts fills or retaining walls?	NA UNK		No		Yes				32
	33	Do access tracks show erosion, scouring or signs of uncontrolled runoff?	NA UNK		No		Yes				33
Access	34	Is (are) there existing access track(s) on the site?	No	Go to Q. 39			Yes				34
	35	Do existing access roads have Shire approval?	NA UNK		No		Yes				35
	36	Do existing cuts and fills on the access exceed 1.0 m height or depth, or appear to be un-engineered?	NA UNK		No		Yes				36
	37	Does the existing parking bay appear to be suitably engineered designed?	NA UNK		Yes				No		37
	38	Are there signs of distress or movement in the existing access road or parking bay?	NA UNK		No				Yes		38
Site Cuts and Fills	39	Is (are) there existing cut(s) and/or fill areas on the site?	No	Go to Q. 49			Yes				39
	40	For a slope with an angle less than 14°, are there any existing unsupported cuts or fills that exceed 1.0 metre in height or depth?	NA UNK		No	2	Yes				40
	41	For a slope with an angle greater than or equal to 14°, are there any existing unsupported cuts or fills that exceed 1.0 metre in height or depth?	NA UNK		No				Yes		41
	42	Are batter angles steeper than 1 Vertical to 2 Horizontal (1V:2H or 26° or 50%) for any existing cut or fill in soil materials?	NA UNK		No		Yes				42
	43	Are batter angles steeper than 1 Vertical to 1 Horizontal (1V:1H or 45° or 100%) for any existing cut in rock?	NA UNK		No		Yes				43
	44	Are any exposed weathered rock faces unsupported?	NA UNK		No		Yes				44
	45	Do existing cuts and fills have adequate surface or subsurface drainage?	NA UNK		Yes		No				45
	46	Was the vegetation removed before any filling was placed?	NA UNK		Yes		No				46
	47	Have suitable fill materials been used and have they been properly compacted?	NA UNK		Yes		No				47
	48	Do any existing cuts and fills show seepage?	NA UNK		No		Yes				48
Retaining Walls	49	Is (are) there existing retaining wall(s) on the site?	No	Go to Q. 54			Yes				49
	50	Are timber retaining walls used for any purpose other than minor landscaping?	NA UNK		No		Yes				50
	51	Do existing retaining walls appear to be un-engineered?	NA UNK		No		Yes				51
	52	Do existing retaining walls show signs of distress or excessive movement?	NA UNK		No				Yes		52
	53	Do existing retaining walls have adequate drainage above and below the wall?	NA UNK		Yes		No				53
Groundwater	54	Are there discharge areas such as springs, seeps, bogs, swamps or constantly wet areas on the site?	NA UNK		No		Yes				54
	55	Are there bores intersecting a shallow watertable on the site?	NA UNK		No		Yes				55

Rock	56	Do any exposed cuts have rock strata that are dipping out of the slope?	NA UNK		No		Yes				56
	57	Do any exposed rock faces show open joints or loose boulders?	NA UNK		No				Yes		
Soil Profile	58	Do exposed faces or existing excavations show soil profiles exceeding 1.5 metres?	NA UNK		No		Yes				58
	59	Do exposed faces or existing excavations show a mixture of soil and rock, which may be landslide debris or colluvium?	NA UNK		No				Yes		
	60	Does the soil profile show inconsistent colouring or interbedded layers of differing materials?	NA UNK		No		Yes				60
	61	Does the exposed profile show imported materials or fill?	NA UNK		No		Yes				61
Vegetation	62	Has the natural vegetation been substantially cleared from the site?	NA UNK		No		Yes				62
	63	Does the proposed development involve significant clearing of the site?	NA UNK		No		Yes				63
	64	Are any of the plants species on site indicators of waterlogging (eg. spiny rush, swamp gums)?	NA UNK		No		Yes				64
	65	Is revegetation work required?	NA UNK		No		Yes				65
	66	Do existing trees and shrubs show signs of slope instability, such as tilting or bent trunks?	NA UNK		No				Yes		
	67	Does any existing vegetation show signs of isolated dieback or distress?	NA UNK		No		Yes				67
	68	Will the removal of any vegetation cause increased erosion and degradation to the adjacent areas?	NA UNK		No		Yes				68
Effluent disposal	69	Does the geology or stability of the site suggest that septic system absorption trenches are unsuitable?	NA UNK		No		Yes				69
	70	Are there any signs of increased waterlogging, nutrients or impact from effluent from adjacent sites?	NA UNK		No		Yes				70

Other Comments observations and site sketch

Assessment by:				Date:	
Inquiry No:		Planning Permit Application No:		Planning Permit No:	