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EXPERIENCES COMMUNICATING LANDSLIDE RISK TO NON-TECHNICAL STAKEHOLDERS

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ABSTRACT

The language used by practitioners to communicate the concepts and results of a landslide risk assessments can be misunderstood by the end-user of such information. The authors draw on their experiences of how risk assessment outcomes, using language outlined in references such as the Australian Geomechanics Society Practice Note Guidelines for Landslide Risk Management (AGS 2007c), can be perceived differently by clients.

We explore the definitions and language used by practitioners and clients, and how they can perceive the meaning of the same words differently. Whilst technical practitioners deal in likelihoods, consequences, probability and uncertainty, non-technical end users may understand and perceive risk assessment outcomes to be more precise or definitive than the geoprofessional may intend.

Our aim is to identify issues and misconceptions in the risk assessment process and suggest some clarity to enable better communication of uncertainty and the true meaning of what is a challenging and at times unknowable predictive process. The authors hope the findings and views in this paper can be used to supplement the requirements of AGS (2007c) so that our clients can make informed decisions, and stakeholders have a better appreciation of landslide risks.

1 INTRODUCTION

Clients require landslide risk assessments to make management decisions regarding assets on or near slopes, and often to communicate such decisions to stakeholders. To do this, geotechnical engineers and engineering geologists (geoprofessionals) report landslide risk assessments (LRA) in a very structured manner – we help define the problem, analyse hazards, likelihoods, and consequences to estimate a risk, provide guidance regarding tolerability, and suggest management options. The AGS (2007c) Practice Note guidelines require LRA reports to document the data gathered, the logic applied, and conclusion reached in a defensible manner. Indeed, the guidelines go on to say that full documentation of these results provides evidence of completion, provides transparency in the light of uncertainty, enables the assessment to be re-examined or extended at a later date, and enables the assessment to be defended against critical review. As professionals working in an industry where litigation and insurance claims are unfortunately all too common, there is merit in us striving to meet these requirements.

In achieving our aim to create logical, transparent, and defendable professional reports, we use language and conventions that have narrow or specific technical definitions and meaning. There should be little room for alternate technical interpretations of our work, and a well-written report should be clearly understood by our peers. But commonly our clients and key stakeholders are not fluent in the language of landslide risk. The number of people impacted by landslides in Australia is relatively low when compared to notable other natural hazards such as bushfire and flood. Limited societal and client exposure to, and experience with, landslides has likely meant the community perceptions of risk associated with landslides is not as mature as with bushfire and flood hazards. Many clients may only have a very basic concept of what a landslide is. So, whilst we strive to produce well-written and technically accurate landslide risk reports, perhaps we're letting down the most important stakeholder in the task we're undertaking. Clients need to decide if the assessed risk is tolerable, what to do about it, and how to communicate their decision to stakeholders. The authors have experienced that landslide risk reports often don't provide the information to allow clients to achieve this.

This paper explores different aspects of communication from geoprofessionals to clients and stakeholders, including observations by the authors, and suggests approaches that could result in improved outcomes.

2 RISK TERMINOLOGY

2.1 PROBABILITY

Probability can be defined as a measure of the uncertainty about whether a particular event (e.g. a landslide or a particular level of landslide-related damage) will occur in the future. Probability is quantitatively expressed as a number between 0 and 1, with 0 indicating an impossible outcome and 1 indicating that a particular outcome is certain (Lee and Jones, 2023).

The outcome of a quantitative landslide risk assessment, conducted in accordance with the AGS (2007c) guidelines, will be an annual probability of loss of life of an individual. Whilst this is often paraphrased as a "risk to life" due to a landslide hazard, it remains a prediction of a possible (or the sum of many possible) outcomes. However, following the framework for landslide risk management described in the AGS (2007c) guidelines will not result in a certain or absolute outcome – it will not tell us when the next landslide will occur, how large it will be, or the consequences to property and life. Instead, the annual probability provides a best estimate of an outcome based on the judgement of the geoprofessional, with due consideration of the available evidence. There is uncertainty in the process of assessing the probability of loss of life, often a significant amount of uncertainty. Whilst we, as geoprofessionals, may have an appreciation of this uncertainty, how do clients and stakeholders interpret and use the probabilistic outcomes of a landslide risk assessment?

2.2 HOW LIKELY IS IT?

Landslide risk, in the context of Australian industry practice, is typically the result of the probability of an event occurring and the consequence should that event occur. Qualitative terms for likelihood such as likely, possible, unlikely, high, moderate, low, are commonly used within society to imply how frequent a given event might occur. Acknowledging societal use and acceptance of such terms in everyday language, efforts are made to align these with specific quantified landslide recurrence intervals in guidelines such as AGS (2007c). While geoprofessionals might like to assume our clients read every word in our reports and are familiar with the quantified meaning of qualitative terms, clients will often focus on the Executive Summary and recommendations when making decisions. Terms describing landslide frequency might be included in these sections without the context of implied recurrence intervals.

In 2020 the online research group YouGov published the results of a survey looking at how Britons perceive probability (Smith, 2020) and it showed that perceptions of probability vary amongst individuals in the same society. More than 1,500 respondents were asked to rank a list of 'probability' descriptors between 0 and 10, where 0 is 'Completely certain not to happen' and 10 is 'Completely certain to happen'. Four of the descriptors in the YouGov survey are the same or similar to qualitative measures of likelihood terms in AGS (2007c), and the survey results for these descriptors are presented in Figure 1.

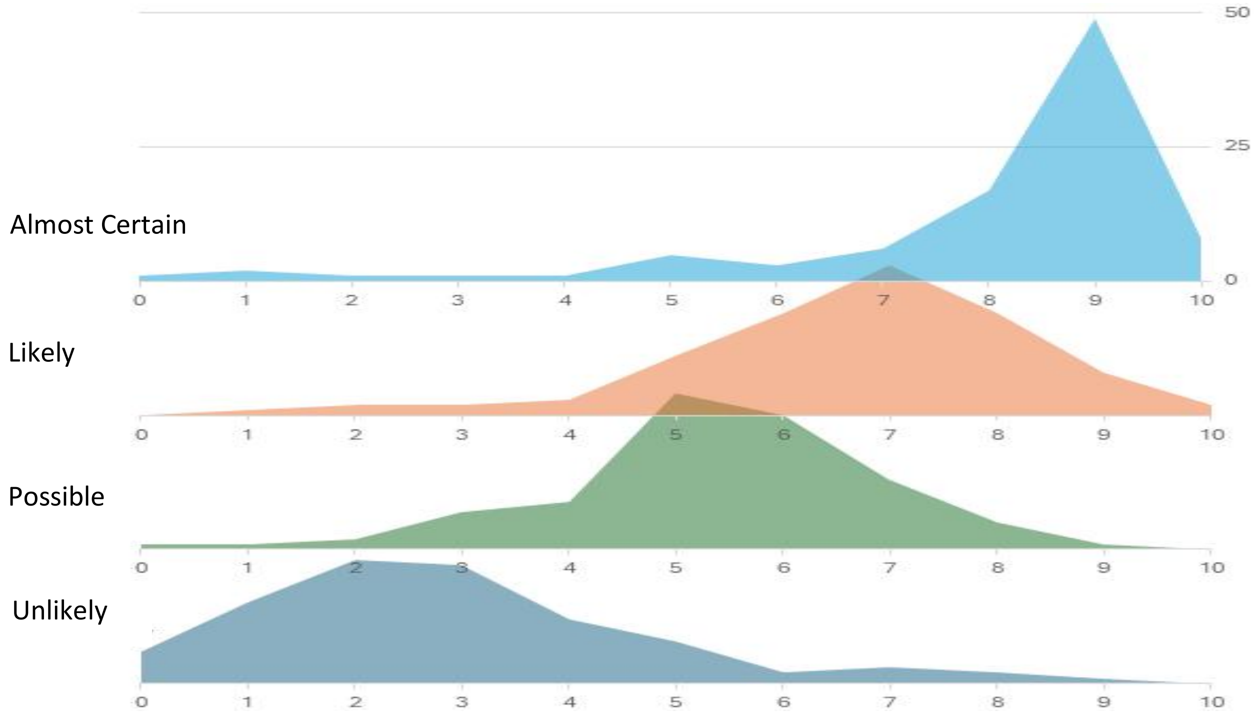

Figure 1: YouGov survey results showing proportion (%) of responses for qualitative likelihood terms

The most common interpretation for Almost Certain was 9 out of 10, but interestingly only 49% of respondents selected this. The consensus across the remaining three descriptors was less definite, with 7 out of 10 for Likely (only 28% of respondents associated 7 with Likely) 5 out of 10 for Possibly (29% of respondents associated 5 with Possible), and 2 out of 10 for Unlikely (23% of respondents associated 2 with Unlikely).

Of further interest is the range of responses that respondents perceived such terms to mean. For example, looking at survey responses selected by more than about 10% of respondents, Likely could mean anything between 5 and 9 out of 10.

The wide spread of responses indicates differences in the way people perceive probabilities. The YouGov research concluded that perceptions of probability are varied and complex and finding a way to communicate such concepts in a way that everyone understands or accepts is difficult (Smith, 2020). Such a variation in responses has been observed by the authors of this paper in workshops and meetings discussing landslide risk.

2.3 RISK ASSESSMENT LANGUAGE

To be able to communicate the outcomes of a landslide risk assessment in a way that someone unfamiliar with the intricacies of AGS (2007c), the geoprofessional requires some knowledge of how such technical terms are being interpreted by the stakeholder and how aware the stakeholder might be of the risks being described.

The authors have experienced similar differences in how clients and stakeholders perceive the meaning of risk terminology and understanding quantitative risk. Table 1 lists some of the interpretations or implied meanings that have been encountered by the authors when communicating with clients and stakeholders.

3 SOCIETAL RISK AWARENESS AND PERCEPTION OF LANDSLIDES AND OTHER NATURAL HAZARDS

Different groups in a society have varying perceptions of risk in relation to natural hazards such as flooding, bushfires, and landslides. Clients engaging geoprofessionals for landslide risk assessments will also have various understandings and perceptions of landslide hazards.

The New Zealand Natural Hazards Commission (Toka Tū Ake EQC, 2023) observes that risk perception may ultimately be more important in affecting behaviour and choices than actual risk. They found that people may dismiss information that encourages action that is inconvenient to them. When communicating risk, it is important to ensure people do not underestimate risk, or think a risk is worse than it really is. But Toka Tū Ake EQC point out that simply providing more information does not necessarily lead to better communication.

Raaijmakers et al (2008) identified that conventional methods of risk analysis (with risk as a product of likelihood and consequences, which AGS (2007c) is founded upon) don't allow for a pluralistic approach that includes the various risk perceptions of stakeholders or lay people within a given social system. Work on flood risk in Spain considered societal risk perceptions in addition to conventional likelihood-consequence approach, and identified three broad categories of risk awareness:

1. Expert awareness or perception of risk assessment, with the least uncertainties about probabilities and consequences of the hazard.
2. Underestimation of probability of occurrence of the hazard or consequences of the hazard.
3. Ignorant of their risk exposure.

Clients and stakeholders can fall within any of the categories listed above.

Looking at these categories through a landslide risk lens, the first category would include the geoprofessional undertaking landslide risk assessments and well-informed stakeholders. An example of the second category might be a visitor to a beach that has unstable cliff warning signs, and who doesn't understand or misinterprets the information being presented. Using the same example, someone in the third category might be an international visitor who is unfamiliar with the hazard and unable to read the language of or interpret the importance of the messages on the sign. Experience provides a basis for these scenarios. A reduced effectiveness of signage that warns beach users of cliff hazards has been observed, rendering such management actions as sometimes being ineffective (Aucote et al 2012). Cui et al (2023) made similar observations, identifying that the level of risk awareness possessed by tourists and visitor is influenced by their familiarity with similar natural hazards. As such, 'warning' signage does little to address visitor ignorance of an unfamiliar hazard.

Alcántara-Ayala et al (2016) observed that when people have more experience with disasters, that experience shapes their perceptions to a greater extent. Conversely, when there is a lack of experience or it is considered as being remote, it is more likely judgements will be based on information obtained through the media, their own intuition, and immediate social networks.

Table 1: Examples of alternate interpretations to specific landslide-related language

Term	Landslide-related definition	Alternate, or non-technical, interpretation
Hazard	A condition with the potential for causing an undesirable consequence. The description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the probability of their occurrence within a given period of time[1].	A source of danger or harm, such as a snake, or a pothole in the road. Or sometimes, a natural hazard like flood, storms, tsunami earthquake. Not often considered with a sense of probability of likelihood of occurrence.
Risk	A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability x consequences. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form[1].	A hazard (without consideration of the consequence of occurrence). Or sometimes Likelihood (i.e. "what is the risk of a landslide occurring this year?"). Events that have probabilities of occurrence that are predictable and outcomes that can be estimated with some confidence[2].
Uncertainty	Result of imperfect knowledge concerning the present or future state of a system, event, situation or population under consideration. The level of uncertainty governs the confidence in predictions, inferences or conclusions[3]	Events where probabilities of occurrence are difficult to predict, and outcomes are challenging to quantify[2].
Tolerable risk	A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.[1]	If someone gets hurt but doesn't die.
Acceptable risk	A risk for which, for the purposes of life or work, we are prepared to accept as it is with no regard to its management. Society does not generally consider expenditure in further reducing such risks justifiable.[1]	Acceptable is when no one dies.
Possible	The event could occur under adverse conditions over the design life[1].	Although it might seem possible, if it hasn't happened in living memory, then it won't happen. "I would be very surprised if I saw that occur…"
10^{-4}	0.0001	What does that mean?
Rainfall ARI	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that the periods between exceedances are generally random[4].likelihood thru rainfall proxies are ARI and AEP…	A 1 in 100-year event only happens once every hundred years
Person most at risk	Individual risk will usually be the governing consideration for most residential developments, and the person most at risk generally has the greatest spatial temporal probability[1].	Isn't everyone at risk? Surely, we need to consider everyone exposed to the landslide?

[1.] AGS (2007c); [2.] Infrastructure Australia Assessment Framework (IA, 2021); [3.] Adapted from New Zealand Dam Safety Guidelines (NZSOLD, 2024), [4] Australian Water Information Dictionary online (BOM, 2025)

Information from the media regarding natural hazards can also affect the perception of the severity of an event. Although the media information may not accurately reflect the severity or frequency of natural hazards, it can change the way these events are perceived in a community (Alcántara-Ayala et al, 2016). Raaijmakers et al (2008) observe that risk awareness increases when

1. a society is confronted with a hazard; and
2. information and education about the hazard is widely available, and this information has implications for appropriate actions.

Awareness may lead to higher levels of worry, and as a consequence, higher preparedness. A better prepared society will then worry less about the risk it is prepared for, but over time reduced worry may lead to a decline in awareness of the risk. This is because individuals forget risks to which they or their communities have not been exposed to for a long period. Notwithstanding, worry is a valuable indicator in determining public preferences in the trade-off between risk and benefit. This means a high level of worry concerning a risk will lead to a greater societal basis for risk reducing measures (Raaijmakers et al, 2008).

Media-worthy landslides tend to be less common than other natural hazards in Australia, and as such the community is generally less aware of the impacts that landslide hazards can have. An intense rainfall event in Western Victoria triggered over 200 landslides in the Gariwerd (Grampians) National Park during January 2011. Surveys and interviews of residents, local businesses, and emergency response personnel captured the impacts on the community during the emergency and the recovery (Ollerenshaw et al, 2014). Feedback from the community, emergency services, and recovery services, all expressed that the nature and scale of the events – both of the flooding and of the landslides – were wholly unexpected and unprecedented and therefore difficult to prepare for and respond to. Although unexpected for the residents and emergency response organisations, there are good historic records of two similar landslide events in 1916 and 1934. The individuals responding to the surveys were not familiar with the history of the area, and it seems the broader community had forgotten risks to which they had not been exposed to for almost 80 years.

So how should a geoprofessional assist a client develop a considered appreciation of landslide risk, such that they can make informed decisions?

4 RISK AWARENESS AND UNCERTAINTY WHEN COMMUNICATING TO CLIENTS

The experience of the authors has been that when preparing landslide risk assessment reports for clients,

1. the executive summary and recommendations are often used to make decisions, and
2. elements of landslide risk reports are reproduced in stakeholder or community communications, often selectively and/or without an appreciation of the uncertainty associated with the outcome.

The reporting standards for a landslide risk assessment, as required by AGS (2007c), includes 15 elements that should be included (or an explanation provided as to why one of these elements is missing). Clearly the outcomes, assumptions, and limitations of these elements, and how each might contribute to the degree of uncertainty inherent in the findings and recommendations of a landslide risk assessment, cannot be succinctly summarised into an executive summary.

The following sections explore ways to assist clients to make binary decisions based on probabilistic (uncertain) outcomes, and how these decisions could be communicated to stakeholders.

4.1 EXPLAINING RISK AND UNCERTAINTY TO DECISION MAKERS

The inherent uncertainty in a risk assessment might be understood by a practitioner or informed client but is often not appreciated by less informed clients or stakeholders. Clients and decision-makers might seek binary answers (yes/no, safe/unsafe) from landslide risk assessments, and are looking for clear recommendations and advice on how to implement remedial measures. They might interpret terms like Risk and Uncertainty in terms of a business or project management, (Saunders, 2016), which as shown in Table 1 can be subtly, albeit sufficiently different to generate a misalignment of expectations regarding the degree of confidence a landslide risk assessment might be reporting.

Various definitions of risk and uncertainty exist in other industries, and as an example The Infrastructure Australia Assessment Framework (IA, 2021) defines risk and uncertainty in the following ways (terms underlined by authors, not IA).

- Risk is defined as events that have probabilities of occurrence that are predictable and outcomes that can be estimated with some confidence.
- Uncertainty is defined as events where probabilities of occurrence are difficult to predict, and outcomes are challenging to quantify.

AGS (2007c) openly acknowledges that the assessment of landslide frequencies is particularly difficult at frequencies in the order of 10^{-4} (1 in 10,000) or less, because methods involving the review of historic data are not applicable. As landslide frequency is a fundamental LRA input, the potential for confusion and misjudgement in decision making can be inherent on the understanding of what a client considers to be “risk”.

The United Kingdom governmental Guidelines on the Use of Scientific and Engineering Advice in Policy Making (DBIS, 2010) explores how scientific and engineering advice should be sought and applied to enhance the ability of government policy makers to make better informed decisions. The guidelines, prepared by the Government Chief Scientific Adviser, provide an insight into how governments consider and incorporate scientific and engineering advice in decision making. Amongst other advice, the guidelines acknowledge:

1. Evidence in public policy making contains varying levels of uncertainty that must be assessed, communicated and managed,
2. Experts should not be pressed to come to firm conclusions that cannot be justified by the evidence available,

3. As a result, levels of uncertainty should be explicitly identified and communicated directly in plain language to decision makers.

The authors consider these points very important, regardless of whether the client is a government authority, or a private entity. So how can the uncertainty inherent within landslide risk assessments be communicated and understood by a client in a way that still allows informed decisions to be made?

Lee (2015) notes that landslide risk assessments contain degrees of randomness (aleatory uncertainty, natural variability) and imperfect knowledge (epistemic uncertainty). Aleatory uncertainty is described as being a property of the system (that is, a property of nature) independent of the observer's knowledge of it or evidence for it. It cannot be reduced by further study, as it expresses the inherent variability of a phenomenon. Epistemic uncertainty is described as the level of understanding of a problem. In many situations, difficulties in estimating future landslide activity are due to a lack of knowledge about ground conditions, failure mechanisms and the circumstances that could lead to failure, rather than randomness. Knowledge uncertainties are due to things we could, in principle, know but do not in practice.

Methods for describing uncertainty associated with landslide risk assessments is the subject of a recent paper by Paul and Miner (2025), which introduces a range of methodologies to communicate an improved understanding of uncertainty. As different stakeholders will have different capabilities and/or knowledge regarding landslide risk assessments, three levels (or tiers) of communication style have been developed to assist communicating the uncertainty associated with landslide risk.

- Tier1 is where uncertainty is communicated through a qualitative descriptor based on an index rating, related to the state of knowledge of site conditions (*e.g., Risk of loss of life for the individual most at risk is* 1.7×10^{-4} *with MODERATE confidence. Risk estimation is based on observation and a degree of belief*).
- Tier 2 is where quantitative risk (probability) is communicated as a range centred on a best estimate with an upper and lower bound, whereby the broader the range means the greater the uncertainty *(e.g., Risk of loss of life for the individual most at risk ranges between* 2.6×10^{-5} *and* 1.1×10^{-3} *with best estimate of* 1.7×10^{-4}).
- Tier 3 is where quantitative risk (probability) is communicated as confidence limits derived from a log-normal distribution centred on a best estimate and relative to a nominated evaluation criterion. *(e.g., Based on an initial risk estimate of* 1.7×10^{-4}*, there is a 74% chance the risk is unacceptable relative to a nominated evaluation criterion*).

The policy maker is generally responsible for increasing risk awareness, so how can geoprofessionals assist in providing sound advice to promote improved awareness across society? In the aftermath of the worldwide COVID-19 pandemic, Intemann (2021) considered the role of scientific communication in facilitating (or undermining) public trust in science and science-based policy recommendations. Whilst no set rules were identified that will always result in responsible or effective communication that facilitates trust for everyone, the following recommendations were made.

1. Have a clear sense of who your audience is and what they care about in relation to decision-making.
2. Strive to present information that is not only accurate but relevant to the kinds of decisions those audiences want to make.
3. Develop targeted, audience-specific messaging in cases where there are populations who have different circumstances, needs, and interests.
4. Explain – as clearly and concisely as possible – why the evidence for the findings being presented is epistemically reliable or competent.
5. Try to present evidence, findings, or recommendations in ways that acknowledge or speak to a diversity of values or serve a diversity of public interests.
6. Remind audiences how science works (or set expectations for what might change).
7. Articulate benefits and risks in a balanced manner.

Aspects of a LRA report, if clearly presented, can help the policy maker communicate decisions to stakeholders. A well-developed landslide inventory, for example, might assist the client gain an appreciation of landslide risks that stakeholders may not be aware of or that society has forgotten about.

4.2 SUPPORTING CLIENTS COMMUNICATING LANDSLIDE RISK CONCEPTS WITH STAKEHOLDERS

Technical risk information can be challenging to communicate in a way that will resonate and be meaningful for communities. Language barriers and subjective perceptions of risk can exacerbate this challenge. When the client of a LRA is a policy maker, reports prepared in accordance with AGS (2007c) provide a logical, transparent, and defendable basis for the client to implement policy. What these reports don't necessarily do is help the policy maker with raising awareness of landslide risk within the community. Fischhoff et al (2011) note that risk communication is required in situations when people need good information to make sound choices, and it differs from public affairs (or public relations) communication by its commitment to accuracy and its avoidance of spin. They go on to recommend communications must be evidence-based and consistent with the science, avoiding things known not to work or ignoring known problems. Communications should also be reviewed and evaluated, because even the best science cannot guarantee results.

The USGS Landslide Handbook (Highland et al, 2008) provides landslide-specific risk communication guidance, identifying that for communication of hazard information to be useful, the nontechnical user must be able to

1. Perceive likelihood, location, and severity of the hazard so that the end-users become aware of the danger,
2. Convey the risk to others, and
3. By using the information, be able to directly to deduce a threat and know where and how to evacuate.

Research into development of flood and other natural hazard risk communications can also provide guidance that may be of relevance when considering landslide hazards. In a study looking at developing flood risk communication strategies in Europe, Bradford et al (2012) observed that scientists and the public at large perceive risk in very different ways. Exploring the role of public perception in developing flood risk communication strategies, the study made recommendations that may have parallels when improving landslide risk awareness, depending on the type(s) of landslide and hazards at risk. The recommendations highlighted:

1. The need for clear tailored information regarding preparedness, mitigation and evacuation,
2. Benefits in capturing personal accounts from victims and use this in future communications, and
3. That communications should not evoke fear amongst vulnerable communities.

Whilst the first recommendation is similar to the likelihood-consequence-risk framework of the USGS Landslide Handbook, the second and third recommendations aim to improve the risk awareness of stakeholders, drawing similar conclusions to the work of Raaijmakers et al (2008).

The Natural Hazard Risk Communications Toolbox (Aukland Council, 2014) is a useful reference that provides simple explanations of a range of natural hazard risk terminologies and provides suggestions for how to communicate these concepts. The toolbox was developed to increase understanding of basic hazard and risk concepts, by providing consistent content for communication materials used within council and externally to stakeholders, politicians and the community. The toolbox contains written and visual materials to describe frequently used local natural hazard risk management concepts, including case studies from the Auckland area (where possible). It provides one set of definitions, with the aim to create a consistent and integrated approach to communicating natural hazard risk management.

In the immediate response to the worldwide COVID-19 pandemic, Goldstein (2020) found that tailoring effective scientific communications requires perspective-taking, insight, humility, and knowledge of the target audiences. USGS Landslide Handbook, AGS (2007c), and to a lesser degree the Aukland Natural Hazard Risk Communication Toolbox perhaps don’t address this level of engagement with landslide-affected communities as acutely as the perspective-taking insight described by Goldstein.

There has been a steady increase in community engagement across broader natural hazard and climate change risks during the past decade or so (LTAR, 2023). A Delphi survey of specialists across a range of areas including planning, strategic policy, emergency preparedness, community development, and climate risk research identified the following nine issues that experience has shown to exacerbate the challenges of community engagement in a natural hazard and climate change risk.

1. The high-stakes nature of the conversations, often evoking emotions such as anger, denial, fear, and distrust.
2. Uncertainties, which can lead to a lack of commitment to address the issue.
3. The highly technical content, and the challenges in explaining technical aspect of the risk.
4. The spatial and temporal variability of hazard risk, which are neither static nor predictable.
5. Different individual risk capacities and appetites between (and within) communities.
6. Lack of clarity about who owns and pays for the risk hinders the engagement process.
7. Identifying and coordinating people with necessary expertise and skills to collaborate as a team.
8. Engagement underutilisation by decision makers, who avoid seeking community feedback in risk situations.
9. Capability and capacity challenges to ensure engagements are supported by good risk engagement expertise and leadership skills.

The specialists surveyed by LTAR (2023) provided the following advice for practitioners engaging in community conversations with stakeholders, which align closely with the themes of perspective-taking, insight, humility, and knowledge of the target audiences explored by Goldstein (2020).

- Being open, honest, and genuine about listening to feedback
- Work with other practitioners and learn from them

- Talk to someone who has done it before, particularly if you're new to working in a given community
- Localise your processes, and demonstrate how science applies to local impacts.
- Know how to deal with grief when engaging with people affected by hazards.
- Tools tested with communities are the best, provided they are suited to the situation and community context.
- Use a set of principles but tailor to your process to the local context and setting.

5 LANDSLIDE RISK MANAGEMENT IN PRACTICE

5.1 CASE STUDY 1: AGS LRM GEOGUIDES

To help a stakeholder assess the acceptability of landslide risk, the Geoguides (AGS 2007e), an accompaniment to the main AGS LRM technical guidelines (AGS, 2007a,b,c,d), are written in less technical, plain English. To help improve people's intuitions about the magnitude of risks rather than provide insight regarding risk acceptability, Geoguide LR7 includes quantitative risk estimates for a variety of more common hazards, expressed as the annual probability of death.

Risk perception research suggests, however, that these sorts of comparisons may not be very satisfactory even for this purpose (Slovac, 1987). Perceptions and attitudes towards risk are determined by a variety of quantitative and qualitative characteristics, not only by the sort of unidimensional statistics used in tables such as the one presented in Geoguide LR7 and reproduced in Table 2, below. Instead, difficulties in understanding probabilistic processes, biased media coverage, misleading personal experiences, and the anxieties generated by life's gambles contribute to the denial of uncertainty, misjudging risks (sometimes overestimated and sometimes underestimated), and judgments of fact to be held with unwarranted confidence. Strong personal views ("*I wouldn't want to be in a plane crash, so I'll drive because I'm a safe driver*") are often resistant to change because they influence the way that subsequent information is interpreted, even when new facts, such as those in Table 2, are presented.

Table 2: Examples of alternate interpretations to specific landslide-related language

Risk (deaths per participant per year)	**Activity/Event Leading to Death** (NSW data unless noted)
1:1,000 (1 death per 1,000 participants per year)	Deep sea fishing (UK)
1:1,000 to 1:10,000	Motor cycling, horse riding, ultra-light flying (Canada)
1:23,000	Motor vehicle use
1:30,000	Fall
1:70,000	Drowning
1:180,000	Fire/burn
1:660,000	Choking on food
1:1,000,000	Scheduled airlines (Canada)
1:2,300,000	Train travel
1:32,000,000	Lightning strike

5.2 CASE STUDY 2: SIGNAGE STUDY AT BARWON HEADS, VICTORIA AUSTRALIA

Early in 2006 a study was conducted to find out the general public's beliefs concerning the dangers of falling rocks from cliff faces at Barwon heads, Victoria, Australia. The study was conducted to develop improved ways to discourage people from entering dangerous rockfall areas.

Results from the study (Aucote et al, 2010; Aucote et al, 2012) suggest that the warning signs used at the site were not sufficiently detailed to provide all participants with enough information to make informed decisions about safe behaviours. Interestingly, 40% of respondents thought signs were erected merely to stop the responsible authority getting sued.

Figure 2 presents a detailed interpretation of the perceived messaging of the Australian standard sign depicting an unstable cliff rock fall hazard. The land manager had a perceived duty-of-care to display this signage in order to inform the public about potential hazards after it had been recommended as part of an earlier landslide risk assessment.

Table 1. Five interpretations of the warning signs and the percentage of participants who endorsed them.

Interpretation of signage	%
Do not go too close to the cliff face	39.5
Do not climb the cliff face	23.6
Do not stand under/next to cliff face	13.2
Do not climb and Do not stand under/next to cliff face	18.4
General warning to be careful – could not state what "careful" entailed	5.3

Figure 2: Interpretation of the perceived messaging of the unstable cliffs sign (from Aurecote et al, 2012)

As a result of further ongoing risk assessments and a recent detailed signage audit, the following improvements have now been incorporated into the revised signage:

- Internationally recognised hazard pictograph (exclamation mark) and large font warning.
- Photos of the site showing area people will be exposed to the hazards
- Written description of what the hazard is (together with rockfall pictograph)
- Clear description that safe access along beach not possible at certain times (high tide)
- QR code for latest tidal information

Examples of the revised signage are shown in Figure 3.

Figure 3: New signage to inform the public of unstable cliff hazards

6 CONCLUDING REMARKS

The authors have shared some of their experiences and outlined challenges in communicating concepts of probability, risk and uncertainty to clients who may have varying degrees of understanding, knowledge, and perception of landslide hazards. A key outcome for us is to highlight the need to better communicate what we as geoprofessionals are undertaking within the restrictions of our professional duties and requirements, while at the same time providing our clients with outcomes they can use to make informed decisions. Often these two focuses don't align. How societal risk perceptions and associated community messaging of other natural hazards is framed and broadcast offers insight to how landslide risk communication might be improved.

To start bridging this communication gap, we believe that the geoprofessional should consider the following suggestions when working through a landslide risk assessment for a client.

At the start of the project:

- Spend more time at proposal or Request for Quote stage explaining what can be achieved and what limitations and inherent uncertainty exists.
- Listen to what the client is asking for. Often this is different to how the scope in a Request for Quote written (because of misalignments in risk assessment language, or unrealistic expectations regarding what a LRA report will provide). Make sure the scope is clarified prior to commencing the project.
- Clarify with the client that LRA does not lead to a binary outcome. Aleatory uncertainty and epistemic uncertainty cannot always be reduced to negligible levels.
- Inform the client of what a LRA report typically contains (what will be provided) so they have an understanding of what the outcomes might mean for them and their decision-making processes.
- Adequately communicate to the client that LRA reports are not necessarily a statement of how stable a slope is, but rather an estimate of possible future landslides, which in most cases has been based on limited information (when compared to engineering reports from other disciplines).

When reporting LRA findings for the client

- Spend more time at proposal or Request for Quote stage explaining what can be achieved and what limitations and inherent uncertainty exists.
- Appreciate how the client understands concepts such as uncertainty and probability.
- Understand how the client or Stakeholder intends to use the findings of a LRA report, and present the report in a way that the client can use.
- Draw attention to the consequences of landslide events. Consider using terms such as 'dangerous' landslide events. When communicating to a non-technical audience, consider using terms such as 'dangerous' in lieu of 'risk' as this communicates a harmful outcome that 'risk' might not.
- Include a glossary to help address misalignment in understanding of risk terms.
- Include, where possible, some form of quantification when using qualitative terms (possible, likely, etc) in Executive Summaries. This needs to be balanced with a clear statement regarding the uncertainty underlying the findings and recommendations of a LRA.

When discussing LRA outcomes with the client

- Ensure the client has the tools to be able to communicate the findings of a LRA report to upper management, decision makers, and/or policy makers. A well-written Executive Summary that includes a statement regarding the uncertainty underlying the findings, together with supporting evidence (such as a landslide inventory) should help with this communication.

The Authors agree there is still much work to do unpacking societal perceptions of landslide risk and how we, as geoprofessionals, can best contribute to this broader discussion. However, we believe highlighting the communication gap is an appropriate starting point for further advancement in effective risk assessment and management for all stakeholders.

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