AUSTRALIAN BACKCOUNTRY AVALANCHE AND MOUNTAIN RISK REVIEW

Prepared for:
Mountain Sports Collective
Bright, Victoria, AUSTRALIA

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Executive Summary

Winter backcountry use in Australian alpine regions is increasing. While more skiers, riders and climbers are enjoying the backcountry, there is an increased risk of injuries and fatalities as they, often unknowingly, expose themselves to alpine hazards. This leaves government agencies, rescue groups, ski areas and ski community groups exposed to increased risk without appropriate mitigation.

The Mountain Sports Collective (MSC) was established in 2015, and has achieved a remarkable increase in awareness of alpine hazards by backcountry users in its organisation.

However, to reduce risk to the MSC and to increase the quality and effectiveness of MSC's public communications, we recommend that a formal alpine hazard forecasting service be established. The service would produce forecasts using best practices in line with other alpine countries such as Canada and New Zealand. The service would be delivered by a team of professional avalanche forecasters and observers, with qualifications and experience in public forecasting. The service would be funded by contributions from affected government agencies, ski areas and backcountry users.

Australia is at a turning point in the delivery of public safety messaging for alpine hazards. Public demand for an alpine hazard forecasting service is evident. There are motivated and capable individuals who could develop the proposed program to produce high-quality public safety products and services that address community needs.

The next key steps to delivering this service include:

- Assign a responsible government agency. Most winter backcountry use in Victoria is in National or State Parks (public land), or within ski area leases outside the ski area boundaries. Given that it is members of the public (either backcountry user or rescue personnel) who are exposed to the alpine hazard, it is not appropriate for private groups to issue public forecasts, and a responsible government agency should be assigned.
- Obtain sufficient funding. Our estimate for the minimum size forecasting service, appropriate to the risk level, and in line with similar services internationally, is on the order of A$150,000 annually. This would cover costs for the forecasting team, professional training and development, management, administration, outreach and communications. Software, hardware and equipment would need to be purchased upfront. Funding could be a mix of public and private contributions.
- Develop sufficient training and experience in public forecasting of existing avalanche professionals. The current level of local training and experience is suitable for collecting observations, but not in line with international best practice for producing forecasts. As such, no forecasts or advisories should be published until there is supervision from a forecaster with Canadian or New Zealand Avalanche Operations II certification (or equivalent), with experience in public forecasting. This includes forecasting for the backcountry surrounding the ski areas, unless the ski areas are willing to accept the risk.

This report was developed at the request of Mountain Sports Collective (MSC) to review their activities for the Winter 2019 season (Section 4) and to develop recommendations for a Victorian Alpine Forecasting Program to address the increased risk to backcountry users and rescuers (Section 5). It is based on discussions and feedback from MSC members and stakeholders, and a set of documents provided during discovery.

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1 Background

Australia has a relatively small, but increasing winter alpine risk problem. The Mountain Sports Collective (MSC) notes on their website that the 2014 Winter showed an alarming increase in avalanche incidents across the range, with five parties requiring rescue, including two fatal accidents. In addition to avalanche incidents, backcountry users are also exposed to the risk of falls down icy slopes and freezing temperatures. MSC also notes that conditions are dangerous and difficult for alpine rescuers, with each rescue requiring more than 30 people to be further exposed to alpine hazards.

MSC formed following the 2014 Winter, after an avalanche killed two people, with the goal to reduce incidents of people being involved, injured or killed in the Australian Backcountry during winter recreation. They created a network of backcountry users, and published observations of avalanche, weather and snowpack conditions on their website. In 2017 they started publishing avalanche danger ratings and backcountry route maps.

Since 2015, MSC and their partners have achieved a remarkable increase in public awareness of Australian backcountry alpine hazards. This is demonstrated by the number of website views (200-300/week, increasing to 600/week during weather events), comments on social media in response to MSC posts and increasing attendance at events and avalanche training courses. It is clear that there is both an increase in backcountry usage during the winter, as well as increasing public interest in obtaining information and skills to manage backcountry alpine risk.

Despite this success, with the increasing number of local and international backcountry users in the Victorian backcountry, further mitigation is still required to reduce the risk and bring practices in line with international best practices.

Many alpine countries in the world have either a fully funded government service that provides avalanche hazard advisories to the public, or one that is funded by a combination of public and private sector funding. This includes smaller regions with relatively small alpine hazard problems such as Scotland, Quebec (Canada), Sweden and Norway. In Australia, as at May 2019, no responsible government agency has been assigned for backcountry alpine risk, and no public funding has been provided for advisories.

There are a number of government agencies who could take the role as responsible agency, including Parks Victoria and Emergency Management Victoria. Establishing an appropriate advisory service could decrease risk to backcountry users and rescuers, and attract more people to the Parks.

In order for MSC to provide effective backcountry advice to the public, we recommend that their methods be developed in line with international best practices, and that a responsible government agency needs to be assigned.

2 Scope and intent

Mountain Sports Collective (MSC) approached Dynamic Avalanche Consulting Ltd. (Dynamic) seeking:

A. A review of their program in advance of the 2019 Winter Season, and support to advocate for a partially publicly funded, public alpine hazard advisory program.
B. Mentorship and training of their local professional and recreational contributors.
C. A forecaster for the 2019 Winter season, who holds Canadian Avalanche Operations Level II or equivalent and has experience in the Australian alpine backcountry.

This report is provided to address Part A. The scope is to:

1. Review the current MSC Program and initiatives for Victoria
2. Provide recommendations for MSC Victorian initiatives for the 2019 Winter.
3. Provide recommendations for establishing a public alpine hazard advisory program.

This report presents three key sections. The first is to provide background on the Australian alpine terrain, weather, snowpack and alpine hazard characteristics, as well as known avalanche events (Section 3). The second is to provide short-term recommendations to help MSC prepare for the 2019 Winter season (Section 4). The third is to provide recommendations to help MSC advocate for a partially publicly funded, long-term public alpine hazard advisory program (Section 5). The report focuses just on the Victoria region.

3 Australian alpine hazards

This section presents a summary of the avalanche and alpine hazards and details of current winter backcountry risk management in Australia.

3.1 Definitions

This report contains a set of terms, specific to avalanche and alpine hazard and risk management, which are defined below.

Avalanche
An avalanche is a mass of snow and ice moving down a slope. Avalanches vary in size and can be described by their destructive potential, ranging from relatively harmless to people (Size 1), through being able to bury, injure or kill a person (Size 2), to being able to destroy a village (Size 5)[1]. In Australia, the most common size avalanches would be size 1 and size 2, with the occasional Size 3. No size 4 or 5 avalanches have been reported in Australia, and are unlikely given the scale of the terrain.

Alpine hazards
In many alpine countries, avalanches are the major backcountry hazard, and thus many advisory programs focus only on this single hazard. In Australia, however, other alpine hazards can be more likely and dangerous to backcountry users, and are thus important to include in any winter hazard advisory. From discussions with local ski patrollers and backcountry users, the primary alpine hazards include the following, which are also listed on the MSC website:

- Icy slopes, leading to loss of footing and sliding down the slope at speed
- Poor visibility, leading to disorientation
- Exposure, leading to hypothermia

Hazard, danger and risk
These terms are often used interchangeably and sometimes incorrectly. For this report, we use the following definitions:

- *Hazard.* A situation or thing that has the potential to harm a person[2]. Hazard (or danger) is independent of the element at risk (e.g. the backcountry skier). Since MSC has no control or knowledge of the exposure or vulnerability of people to the avalanche hazard, they therefore cannot forecast or report the avalanche risk, only the avalanche hazard. Avalanche hazard is a function of likelihood (i.e. probability) of an avalanche and destructive size[3].
- *Danger.* Synonymous with hazard.

[1] McClung & Schaerer (1981)
[2] Safe work Australia (2018)
[3] According to the Conceptual Model of Avalanche Hazard (CMAH) described by Statham et al (2018)

- *Risk*. The effect of uncertainty on objectives[4]. In this report, avalanche or alpine risk is a function of the alpine hazard, the vulnerability and exposure of the backcountry user(s).
- *Stability.* The chance of an avalanche not occurring when force is applied to the snowpack (e.g. a slope is skied). This term is often mistakenly used in place of danger.

Additional risk management definitions.
The following definitions are defined in ISO (2018).

- *Event.* An occurrence or change of a particular set of circumstances. In this case, an event could be a person becoming involved in an avalanche or losing grip on a large icy slope that results in a fall.
- *Likelihood.* The chance of something happening. In this case, this refers to the chance of an avalanche or alpine hazard occurring.
- *Consequence.* The outcome of an event, which can be certain or uncertain, direct or indirect. It can also escalate through cascading or cumulative effects. In this case, the consequence could be death, injury, cost for rescue or legal action.
- *Control.* Measure that maintains and/or modifies risk. In this case, controls could include increased awareness of backcountry users, an alpine hazard reporting or forecasting program, or a highly trained and experienced rescue team. It could also include public avalanche safety training and rescue equipment, both of which reduce vulnerability and thus risk.
- *Treatment.* Measure that is expected to maintain and/or modify risk, but is not yet implemented.

Backcountry
In this report, we refer to the backcountry as unpatrolled terrain outside of ski area boundaries, which has not been controlled (using explosives, ski cutting or passive measures) for avalanches or other alpine hazards.

Conceptual Model of Avalanche Hazard (CMAH)[5]
This is a model developed in Canada, and adopted in North America and New Zealand to manage avalanche risk. It is a structured, systematic and consistent workflow based on the routines of experienced avalanche forecasters. It is built around the concept of an avalanche problem, and is applicable to all types and sizes of avalanche forecasting operations.

Avalanche problem
An avalanche problem is a particular type of active snowpack instability. For example, the key avalanche problems in Australia are storm slab, wind slab, wet slab, wet loose and cornice. Each problem has a set of characteristics and management strategies. Following the CMAH, each problem can be expressed in terms of location, likelihood and size[6].

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[4] According to the International Standard for Risk Management ISO 31000 (ISO, 2018)
[5] For the most recent model see Statham et al (2018)
[6] For photos see: https://www.avalanche.ca/tutorial/avalanche-formation/avalanche-problem-types

3.2 Victorian alpine terrain, weather and snowpack characteristics

The Victorian Alps are part of the mountainous region in southeastern Australia known as the Australian Alps. The highest peaks in the Australian Alps are just above 2000 m, and Victoria's highest point is Mt Bogong (1986 m). The mountains are typically flat on top, with crags and escarpments rolling over to very steep, densely vegetated ridgelines and deeply-incised gullies. Alpine vegetation (shrubs and grass) starts at about 1800 m, with snow gums and grassland in the sub-alpine and wet forest and rainforest below.

Much of the alpine and subalpine environment is designated as protected areas by National Parks. In Victoria, these include Alpine National Park, Buffalo National Park and Baw Baw National Park. There are three main commercial ski areas within these national parks; Mount Hotham, Falls Creek and Mt Buller. There are also several smaller ski areas, including bases for cross-country skiing and tobogganing.

Weather is highly variable in the region. Winter conditions typically run from mid June until early September, with average temperatures typically ranging between -5°C to 5°C. Snowfall and depth are also highly variable, with average snow depth ranging from about 85 cm to 120 cm, and maximum snow depth ranging from 175 cm to 225 cm. Winds can be strong and blizzards are common, which can result in re-distribution of snow into wind slabs on lee (downwind) sides of ridges and scour on windward ridges. This can also produce cornices along ridge tops.

The potential effect of climate change on future weather, snowpack and avalanche conditions is not known; however, some studies suggest a decrease in average snow depth and a shortening of the winter season[7]. Many ski areas produce artificial snow to provide more certainty of ski conditions to visitors, but this does not affect backcountry areas.

Based on observations published by the MSC, the snowpack tends to comprise moist or wet new snow, melt forms and ice formations, which is characteristic of a Maritime snowpack climate[8]. In cold winters or areas with thin snow depth, basal facets can also occur, which de-stabilise the snowpack, and can contribute to higher avalanche hazard. The most common avalanche problem types reported include storm slab, wind slab, wet loose, wet slab and cornice.

The Bureau of Meteorology lists additional alpine hazards including blizzards, heavy snow and rain, strong wind, fog and low cloud and ice[9].

Avalanche history

The following table lists known events where a backcountry user has been caught in an avalanche (termed as an involvement) in the last ten years (2008-2018). The list is likely

[7] e.g. Sanchez-Bayo & Green (2012).
[8] For detail on Maritime snowpack climate see page 22 of The Avalanche Handbook (McClung & Schaerer, 2006)
[9] Bureau of Meteorology (2017)

incomplete because of a lack of reporting data. In a survey of Canadian backcountry users, Jamieson and Jones (2015) found that only approximately 10% of non-fatal avalanches are reported. In this case, there were 12 involvements reported, which could mean as many as 100-120 involvements occurred during this same period, 90% of which went unreported.

Table 1: Avalanche involvements reported since 2008.

Date yyyy-mm-dd	Area / path	Size	Trigger	Involvements	Fatality	Notes
2008-08-17	Mt Kosciusko National Park, near Blue Lake	2	Sa[10]	1	1	
2009-08-1?	Blue Lake	2	Sa	1	1	Ice climber, cornice
2011-08-24	Avalanche gully	0	Sa	1	1	Not clear if avalanche
2013-08-23	Thredbo	2	Sa	1	0	
2014-06-25	Mt Buller	1	~	1	1	
2014-06-29	Thredbo, out of bounds	1	Sa	1	0	
2014-07-10	Mt Bogong	2	Sa	2	2	
2017-08-01	Mt Bogong	1.5	~	~	~	
2017-08-08	Near Perisher	2	Sa	1	0	
2017-08-08	Mt Hotham summit out-of-bounds	~	Sa	2	0	
2017-08-08	Mt Hotham inbounds / Tardis run	1	Sa	1	0	
				12	6	

Avalanche fatalities in Australia are relatively low (6 fatalities over 10 years, or 0.6 fatalities per year on average) compared with other alpine regions such as Canada (14 fatalities per year in the last 20 years), the United States (28 fatalities per year in the last 20 years) and Europe (103 fatalities per year in the last 45 years). However, these other countries have far higher numbers of backcountry users. In Europe, 240,000 people are estimated to access the backcountry annually[11], as opposed to Australia's 500 people[12].

[10] Sa is an abbreviation for Skier Accidental, which is an avalanche that was unintentionally triggered by a person on skis, snowboard or foot.
[11] Winkler et al (2016)
[12] MSC estimate based on website views and forum activity

On reviewing the information available about each event in the above table, and reading through backcountry and snow forums, it appears that some of these events could have been avoided with better awareness, training and information. Should the number of backcountry users increase, and/or the alpine climate change to produce more powerful and inconsistent storms, there is an increasing likelihood that the number of involvements and fatalities will increase.

3.3 Stakeholders

The following section details the key stakeholders with an interest in Australian backcountry activities during winter.

Mountain Sports Collective (MSC)
MSC is a not-for-profit organisation formed in 2015 by professional and recreational backcountry users, with about 300 paying members each year. MSC works in partnership, and collects and shares observations, with ski areas, avalanche education providers and local winter sport recreationists. MSC is advocating for an alpine hazard advisory service with the stakeholders identified below. Website: http://mountainsportscollective.org/

Parks Victoria
Parks Victoria is a statutory authority, created by the Parks Victoria Act 2018. They are responsible for protection and conservation of 4 million hectares (about 18%) of Victoria. Their stakeholders include other government and non-government organisations and community groups such as the Department of Environment, Land, Water and Planning, catchment management authorities, private landowners, friends groups, volunteers, licensed tour operators, lessees, research institutes and the broader community. Parks Victoria identifies avalanches as a backcountry risk[13], however their major natural hazard concern is bushfire and flooding. Website: https://parkweb.vic.gov.au/

Emergency Management Victoria (EMV)
EMV leads and coordinates emergency preparedness, response and recovery in Victoria. They work closely with Victoria Police and with other government agencies, communities, and businesses. They run the Vic Emergency app, which is a centralised map-based warning service displaying incidents including floods, storms, fires, earthquakes, tsunami, beach closures and shark sightings. Since 2015, they have included a warning of “heightened” avalanche danger for when the danger rating is assessed as Considerable by the ski patrol directors at Mount Hotham and Falls Creek ski areas. Website: https://www.emergency.vic.gov.au

[13] https://parkweb.vic.gov.au/safety/be-safe-plan-ahead/safety-in-remote-parks/alpine-back-country-winter-safety

Victoria Police (Vic Pol)
Victoria Police serves 5.9 million Victorians. The relevant police service for the MSC forecasting area is Hume. Victoria Police is the control agency for search and rescue, where the Bush and Alpine Search and Rescue Squads provide specialist expertise in land search and rescue. Website (Victoria Police): https://www.police.vic.gov.au/. Website (Alpine Search and Rescue): https://www.alpinesar.org.au/about/

Victoria State Emergency Service (VIC SES)
VIC SES is a volunteer organisation that provides emergency workers during emergency search and rescue operations. They are the coordinating agency for emergency management of flood, storm, tsunami, earthquake and landslide. They have some planning and prevention, but the focus is on response.

Department of Environment, Land, Water and Planning (DELWP)
DELWP is an overarching State Government department responsible for “Victoria’s climate change, energy, environment, water, forests, planning, local government and emergency management functions”.

Sports and Recreation Victoria
A State Government department focused on sport and recreation for Victorians. They develop and maintain sporting infrastructure, support sport and recreation organisations advocate for improved health and wellbeing for Victorians. Sports and Recreation Victoria partners with statewide community sporting associations including Ski and Snowboard Australia, Orienteering Victoria and Sport Climbing Victoria. Website: https://sport.vic.gov.au/

Victorian Ski Areas
There are three major commercial ski areas in Victoria; Mt Hotham, Falls Creek and Mount Buller. There are three smaller areas, mostly used as cross-country or backcountry skiing bases, for beginners or for snow play: Mt Baw Baw, Mt Stirling and Lake Mountain. Websites: https://www.mthotham.com.au, https://www.fallscreek.com.au/, http://www.mtbuller.com.au, https://mountbawbaw.com.au, https://www.mtstirling.com.au/, https://www.lakemountainresort.com.au.

4 Recommendations for MSC Initiatives for Winter 2019

This section documents the current MSC initiatives, assesses risk to MSC and its stakeholders, and provides a set of recommendations to implement during the 2019 Winter. Recommendations for changes beyond 2019 are contained in Section 5.

4.1 Current MSC Initiatives

The MSC program has three core initiatives: Safety, Advocacy and Access. The following table shows the offerings within these initiatives.

Table 2: MSC Initiatives.

Initiative	Offering	Notes
Safety	Backcountry Travel Advisories	MSC provides 48-hour backcountry travel advisories covering three regions (North East Alpine, Central Alpine, Kosciusko) and six backcountry safety problems (storm slab, wet slab, wind slab, wet slide, persistent slab and rime/ice/hard snow). Started providing danger ratings in 2018. About 250 people per week view the site, rising to 600 during storm events. MSC publishes advisory archives. MSC also publishes an 'Extra Column' as part of the advisory, which details current observations and photos of events.
	Field Observations	MSC publishes about 70 observations collected each season by professionals from ski areas and local backcountry enthusiasts. The Field Observations are used to develop The Advisory. Started Observations in 2015.
	Training	MSC provides lists and contact details of safety training providers and guides in Australia. MSC does not provide training services.
	Awareness	MSC publicises events including backcountry festivals and races. MSC also shares avalanche information with members including "Tales of Whoa".
Advocacy	Raising funds	MSC coordinates various crowdfunding campaigns, merchandise sales and membership drives. For example, they are raising funds for an avalanche training centre (ATC) to practice rescue skills.
	Stakeholder coordination	MSC works with Mt Hotham Alpine Resort, Falls Creek Alpine Resort, Mount Buller Resort, Mt Stirling Resort, local mountain guides and avalanche education providers. Government stakeholders include Emergency Victoria, Victoria Police, and Sports and Recreation Victoria.
	Pro deals	MSC sells safety equipment, through pro deals with Everest and Ortovox.
Access	Backcountry Maps	MSC publishes a series of backcountry ski touring and mountaineering guides and topographic maps. Routes are named and graded.
	Intention log	MSC provides an online version of the Victoria Police intention form for Victorian users. MSC emails the nominated contact to relevant ski area patrol or police.

Through their program, MSC and their partners have achieved a remarkable increase in public awareness of Australian backcountry alpine hazard. This is demonstrated by the number of website views (200-300/week, increasing to 600/week during weather events), comments on social media in response to MSC posts and increasing attendance at events and avalanche training courses.

4.2 Risk assessment

While it has been a natural and useful step to incorporate Backcountry Travel Advisories and graded Backcountry Maps in 2018, MSC recognises that these offerings present increased risk and responsibility to their organisation. They are primarily concerned about increasing backcountry usage and avalanche involvements, and the need to develop a more formal alpine hazard reporting and forecasting program consistent with international best practices.

This section identifies risks that affect MSC's objectives based on their current configuration and activities. The risk assessment will use the following matrix.

Table 3: Risk assessment matrix

	Negligible. Minor injury, no rescue required, no cost incurred	**Minor. Major injury, no fatality, small rescue operation required, minor cost incurred**	**Moderate. Multiple major injuries, no fatality, major rescue required, moderate cost incurred**	**Significant. Fatality, major rescue required, major cost incurred**	**Severe. Multiple fatalities, major rescue required, major cost incurred**
Almost certain	Low	Medium	High	Very High	Very High
Very likely	Low	Medium	High	High	Very High
Likely	Low	Medium	Medium	High	High
Possible	Low	Low	Medium	Medium	High
Unlikely	Low	Low	Low	Medium	Medium

MSC's objective is to reduce incidents of people being involved, injured or killed in the Australian backcountry during winter recreation. The following set of risks has been identified and assessed below based on international experience, the MSC website documents such as the coroner's report and discussions with MSC and stakeholders.

Table 4: Risk assessment based on MSC activities prior to Winter 2019.

#	Risk	Likelihood	Consequence	Rating
1	If backcountry use increases without appropriate alpine risk management, then more involvements, injuries and fatalities could occur	Almost certain	Significant	Very High
2	If MSC doesn't collect sufficient and consistent alpine hazard, weather and snowpack observations then they may produce inaccurate conditions reports or forecasts, which may inappropriately inform backcountry users' and workers' decisions	Very likely	Significant	High
3	If MSC observers and forecasters don't have sufficient training, then they may produce inaccurate conditions reports or forecasts, which may inappropriately inform backcountry users' and workers' decisions	Likely	Significant	High
4	If MSC doesn't use a robust reporting and forecasting processes, then they could suffer legal challenge from injured parties	Possible	Significant	Medium
5	If backcountry alpine risks are perceived to be mismanaged, then public and private support for winter backcountry use may reduce	Possible	Moderate	Medium
6	If "green runs" on MSC backcountry maps are misinterpreted by users to mean "safe alpine conditions", then MSC may be liable for events that occur in those areas	Unlikely	Significant	Medium

4.3 Recommendations

This section contains recommendations for MSC for Winter 2019, aimed at reducing the treated risk levels. It covers changes to observation and forecasting practices, and changes to communications on the website.

Recommendations for changes beyond 2019 are contained in Section 5.

Recommendation 4.1. Glossary
Provide glossary in the "About" page and ensure consistent terms are used across the site and printed material. The glossary should include the following terms: hazard, danger, stability, avalanche hazard/danger, alpine hazards, each avalanche and alpine problem type, backcountry, moderate/advanced/expert ski descent. The glossary could also link to other glossaries including Avalanche Canada glossary[14] and/or Utah avalanche Center encyclopedia[15]. Review all site and printed content to make sure terms are used consistently, especially hazard, danger and risk, alpine and avalanche hazard. Also, snow stability is sometimes used where it should read "avalanche danger". Snow stability is an outdated term, especially for the communication with the public. Avalanche danger (or avalanche hazard) is internationally used to communicate hazard levels.

Recommendation 4.2. MSC Scope
Provide a scope in the "About" page, to define what MSC is providing and what is not provided. For example, MSC is sharing observations of, and linking to weather data relevant to, avalanches, icy slopes and poor visibility, for people using the backcountry for alpine activities. It is not providing a go/no-go decision for backcountry users.

Recommendation 4.3. Website content
Consider splitting website into formal and informal content. Formal content would include the Backcountry Condition Reports and archives. Informal content would include "extra column" feeds, links to social media, informal trip reports, events, merchandise. For the formal component, consider presenting reports against a map of the region. There are many examples of this including Utah Avalanche Center[16], Avalanche Canada[17] and Colorado Avalanche Center[18], where the map is the first piece of information the user views. This may help to anchor people's understanding of where they are in the range, the terrain, and to better understand the commentary in the report.

Recommendation 4.4. Travel advisories / Forecasts
Do not provide advisories, forecasts or danger ratings for any area or region outside the ski area boundaries. As such, rename "Backcountry Travel Advisories" to "Backcountry Conditions Report" and remove or grey out the danger rating component. Remove any reference to "Advisory" or "Forecast" on the site. Separate the "extra column" from the forecast page.

In order to contribute to decision making for domestic and international backcountry users, the Conditions Reports should be consistent in quality, terms, syntax and timing. See Appendix B for a marked up copy of a past advisory using international standard language. Amend content in "How to interpret travel advisory" sub-page as per recommendations in Appendix B.

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[14] https://www.avalanche.ca/glossary
[15] https://avalanche.org/avalanche-encylopedia
[16] https://utahavalanchecenter.org/
[17] https://www.avalanche.ca/map
[18] https://avalanche.state.co.us/

Recommendation 4.5. Backcountry Maps
Change green to different colour because green may indicate "safe" to new users. Work towards adopting the Avalanche Terrain Exposure Scale (ATES)[19], perhaps with amendments for Australian conditions. If MSC chooses to do this, define a set of characteristics similar to the ATES technical model table shown in Appendix C. Add legend to map, rather than as separate paper. Amend legend to clear terms, syntax and remove comments about avalanche danger (as opposed to terrain) as per recommended text in Appendix C.

Recommendation 4.6. Intention logs
Remove from site. Refer users to Victoria Police to submit intention logs. Consider creating and providing a trip planning checklist[20].

Recommendation 4.7. Observations
Record professional observations in a searchable database, using NZ Guidelines & Recording Standards for Weather, Snowpack & Avalanche (NZMSC) or Observation Guidelines & Recording Standards for Weather, Snowpack and Avalanches (OGRS) (CAA, 2016a[21]) as the reporting standard. Seek daily observations from Mt Hotham, Falls Creek, Mt Buller and Mt Stirling ski patrol. Consider licencing the InfoEx, which has an international model used by the United States, Chile, Argentina, Iceland, Spain and Japan. There are also a number of other products including: Avanet, PowderCloud and the NZ InfoEx. Refer to Appendix D for subscription details for the InfoEx.

Continue encouraging recreational backcountry users to submit field observations, photos and comments. Encourage backcountry users to report involvements, even if there were no injuries or fatalities. Consider using existing software so that these observations can be searched over time and location for future forecasting and analysis. Observations from recreationists in other regions are supported by software and apps, including NZ[22], Canada[23], and the US[24].

Amend content in Observations Portal, including:

- Replace observation flowchart with avalanche problems descriptors in Appendix D. The flowchart is a good idea, but has some flaws that need revising before publishing.
- Replace the conceptual model download file with the new version[25].
- Change wording as per recommendations in Appendix D.

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[19] Statham et al (2006)
[20] A sample checklist from Avalanche Canada can be found at: https://avalancheca.cdn.prismic.io/avalancheca%2F31e28ed5-d71b-4f96-aa6e-2b36e4cc44a9_ast1_tripplanningform.pdf
[21] Available at www.avalanchecassociation.ca/store
[22] https://www.avalanche.net.nz/observation/submit
[23] https://www.avalanche.ca/mountain-information-network and obs submitted by guides, visible to the public: https://www.mountainconditions.com/
[24] https://avanet.avatech.com/
[25] The new version is available at: https://link.springer.com/article/10.1007/s11069-017-3070-5

Recommendation 4.8. Professional training
Current observations are collected by professionals with Canadian Avalanche or New Zealand Operations Level I certification or Avalanche Skills Training Level II. These qualifications are suitable for the collection of snowpack and avalanche observations to feed into a forecasting program. However, to meet international best practices, public avalanche forecasters should hold minimum Canadian (or New Zealand) Avalanche Operations Level II. It is also expected that they have currency in winter backcountry travel and specific training in public avalanche forecasting workflows and communications. No forecasts or advisories should be published until there is supervision from an Avalanche Operations II forecaster.

In order to achieve this, we recommend MSC advocate or seek funding for a training and mentoring program for AST providers, aspiring Level II's and potential forecasters. This could involve:

- Engaging an experienced forecasting professional (Level II or Level III with public forecasting experience) to run workshops and set up training plans in the winter.
- Establishing a mentoring program between Australian professionals and those in Canada, US or New Zealand who forecast using similar conceptual models and use similar training and awareness models for public communication.
- Supporting local professionals to take their Level II Operations in Canada during Australian summer, or in New Zealand during Australian winter.

Recommendation 4.9. Public training and awareness
Continue awareness efforts and links to training providers. Consider providing links on the website to online tutorials and training from other avalanche groups including:

- Avalanche Canada, Go Farther[26]
- Colorado Avalanche Information Center, Know Before you Go[27]
- Utah Avalanche Center, Education[28]

Recommendation 4.10. Advocacy
The advocacy, pro deals and fundraising should continue as planned by MSC.

Recommendation 4.11. Statewide warnings
As an interim measure until a responsible agency is assigned, EMV issues Statewide warnings when the danger rating reaches considerable as defined by the Ski Patrol Directors at Mount Hotham and Falls Creek. If warnings are not based on a robust forecasting process, backcountry users may receive inaccurate or incomplete information via MSC's website. We recommend that the warnings are critically reviewed, and are published with a statement about their source.

[26] https://www.avalanche.ca/education
[27] https://kbyg.org/
[28] https://utahavalanchecenter.org/education

4.4 Treated risk assessment

The following table shows the expected risk reduction (treated ratings) on the existing risk register after recommendations are implemented. Note that Risk 1 remains Very High. To reduce this risk to an acceptable level, a formal forecasting program would need to be established, as per recommendations in Section 5.

Table 5: Treated risk assessment

#	Risk	Rating	Treatment	Treated likelihood	Treated consequence	Treated rating
1	If backcountry use increases without appropriate alpine risk management, then more involvements, injuries and fatalities could occur	Very High	All recommendations	Very Likely	Severe	Very High
2	If MSC doesn't collect sufficient and consistent alpine hazard, weather and snowpack observations then they may produce inaccurate conditions reports or forecasts, which may inappropriately inform backcountry users' and workers' decisions	High	2.7 - improve observation density, frequency and reliability. 2.4 - remove forecasts until robust process in place	Unlikely	Significant	Med
3	If MSC observers and forecasters don't have sufficient training, then they may produce inaccurate conditions reports or forecasts, which may inappropriately inform backcountry users' and workers' decisions	High	2.8 - establish mentorship with Level II or III forecasters and/or employ Level II forecaster.	Possible	Moderate	Med
4	If MSC doesn't use a robust reporting and forecasting processes, then they could suffer legal challenge from injured parties	Med	2.4 - remove forecasts until robust process in place	Unlikely	Moderate	Low
5	If backcountry alpine risks are perceived to be mismanaged, then public and private support for winter backcountry use may reduce	Med	2.4 - remove forecasts. 2.1-2.3 - published cleaner MSC scope and content	Unlikely	Moderate	Low
6	If "green runs" on MSC backcountry maps are misinterpreted by users to mean "safe alpine conditions", then MSC may be liable for events that occur in those areas	Med	2.5 - remove green runs, add legend to map, adjust wording, define technical framework	Unlikely	Negligible	Low

5 Recommendations for a public alpine hazard forecasting program

This section presents recommendations for establishing and developing a forecasting program that appropriately mitigates the assessed risk to alpine backcountry users in Victoria.

The stakeholders we consulted with broadly agreed that an alpine hazard forecasting program would reduce the risk of involvements, injuries or fatalities in the backcountry, and subsequent exposure of rescue teams.

We support this view. A reliable, accurate forecast, together with increased awareness would contribute to more appropriate decision making of backcountry users.

There are several components required to produce reliable, accurate forecasts. These include:

1. Assignment of risk to the organisation best placed to mitigate it, i.e. a responsible government agency rather than a community organisation;
2. Reliable observation data collection and observer network;
3. Robust method and documentation of forecasting process;
4. Sufficient minimum training for forecasters (Level II) and observers (AST2/ Level I);
5. Sufficient funding

As at May 2019, each of these components requires development. Most notably, no responsible government agency has been determined, and no funding has been allocated. Although it appears that a decision will be made this year, we also present the actions MSC could take should there be no change to current status, or insufficient funding provided by the responsible government agency.

5.1 Proposed forecasting program

The objective of the forecasting program would be to reduce alpine hazard involvements, injuries and fatalities by providing consistent, professional alpine hazard advice for public backcountry users during winter.

Scope
We present the following program scope and costs as an appropriate size program to mitigate the assessed risk. It is not a gold standard, and excludes a number of desirable features. For precedent programs see Section 6.

The program would deliver the following:

1. Alpine hazard forecasts and advice for recreational backcountry users, based on observations of alpine hazards, weather, snowpack and terrain; and weather forecasts.
2. Support professional development of local avalanche professionals
3. Outreach

This would be separate from, but complement MSC activities, which would include:

1. Recreational membership
2. Awareness through social media, events, links to training
3. Fundraising, pro-deals and merchandise
4. Advocacy

Frameworks and Standards
The program would adopt the following frameworks and standards:

- The Conceptual Model of Avalanche Hazard[29] for avalanche hazard; and develop a similar method for icy slopes and whiteout.
- The North American Avalanche Danger (NAAD) Scale[30] for communicating avalanche hazard. The NAAD is a five-level danger rating, used in North and South America, New Zealand and Japan. There are English language training and communication materials developed for it in Canada, USA and New Zealand. Europe also presents a five-level rating, however its underlying structure and forecasting method is different.
- The Canadian Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches (OGRS)[31] or the NZ Guidelines & Recording Standards for Weather, Snowpack & Avalanche (NZMSC)[32].

[29] Statham et al (2018)
[30] Statham et al (2010)
[31] CAA (2016a)
[32] NZMSC (2017)

Forecast Areas and Methods

The forecast would target public recreational backcountry users, to provide a basis for trip planning, recognising that backcountry users make their own decisions and take responsibility for their own risk. It would cover avalanche, icy slopes, whiteout hazards for the two most highly used regions, as per the MSC wesbite.

1. North East Alpine (daily)
   Mt Feathertop, Mt Hotham, Mt Loch, Razorback, Mt McKay, Spion Kopje, Mt Bogong, Bogong High Plains, Mt Buffalo, Mt Fainter, Mt Jaitmathang, Falls Creek
2. Central Alpine (five times / week)
   Mt Buller, Mt Stirling, Mt Cobbler, Crosscut Saw, Mt Howitt, Mt Arbuckle, Mt Baw Baw

These regions could change with further analysis by the program team, and possibly include a set of smaller, specific zones rather than large regions, particularly for Central Alpine.

The forecasts would be supported by:

- Observations collected from field trips by forecasting program team members.
- A formal field observer network, where members submit reliable, daily observations of alpine hazard, weather, and snowpack.
- An informal observation platform, where recreationists submit observations, photos and comments during their backcountry trips – these data need to be separated from the formal field observer network to allow for evaluation of data quality.
- Weather data feeds from local stations.
- Terrain maps, assessed for each hazard using ATES or similar.
- A forecasting process and worksheet, which brings together all current observations to methodically develop and document all forecasts.
- Software to submit and maintain a database of observations in line with the above standards. This could be developed or licensed.

Observations

A reliable and accurate forecast typically requires a minimum density (in location and over time) of observations across an area, collected by reliable observers in representative and undisturbed locations. Areas or times of the season without sufficient observations are described as “data-sparse”, and communicated appropriately in the advisories.

The following map shows an approximation of the two regions. North East Alpine National Park (North East) is shown in blue and covers about 500 km^2. Central Alpine National Park (Central) is shown in purple covering about 300 km^2. The map excludes Mt Baw Baw and Mt Arbuckle, although they are included in the Central region currently.

Currently, daily observations in North East are collected by ski patrol of Mt Hotham and Falls Creek at the ski areas, and are marked in yellow. MSC also receives irregular observations by roving observers, who are off-duty ski patrollers, instructors of introductory avalanche courses, or local backcountry users. There are no regular observations from the Central region.

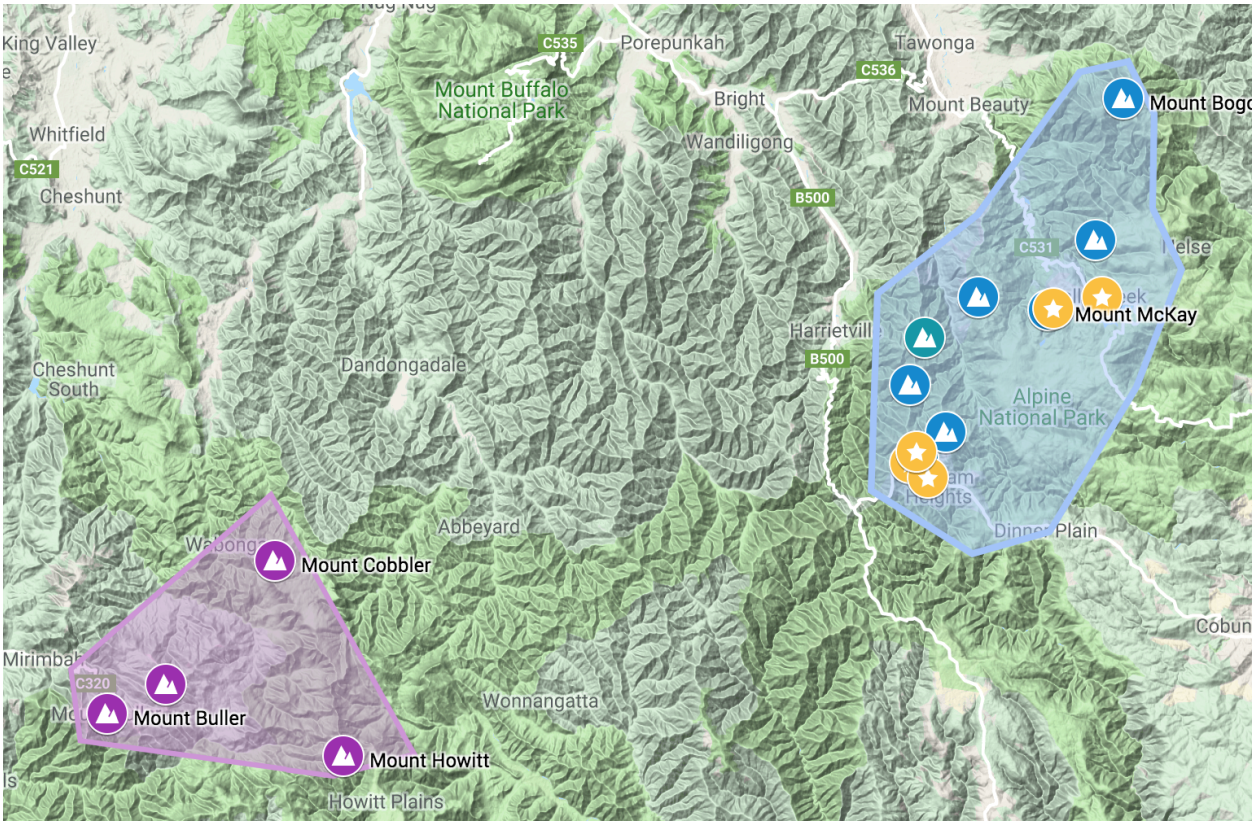

Figure 1: Extract from Google Map of approximate current MSC Forecast Regions. Excludes Mt Baw Baw, and Mt Arbuckle, which are further south. The Central region may be broken into a cluster of smaller zones. https://www.google.com/maps/d/viewer?mid=1JpGkEcsAl3Y89t4qFv2rl1EST-QJYsHx&ll=-37.112351510328956%2C147.11902407322634&z=10

There is no internationally accepted minimum number of observations required to publish a forecast; however, many programs will not publish forecasts for data-sparse regions or during early or late-season when there are insufficient observations. Instead, they publish conditions reports or focus their observations to specific locations. For an example see Storm & Helgeson (2014).

In order to collect sufficient reliable observations to produce a forecast in the two forecasting regions, we recommend:

- Establish an agreement with Mt Hotham, Falls Creek, Mt Buller, Mt Stirling and Mt Baw Baw ski patrol for daily weather, snowpack, avalanche and icy slope observations.[33]
- Establish protected (i.e restricted access) study plots at Mt Feathertop, Mt Bogong, Mt Cobbler, Mt Howitt, Mt Arbuckle, Mt Buffalo, Razorback and Mt Fainter, where observations can be collected as required.

[33] The agreement should be formalised through contracts between the forecasting program and observer organisations such as ski areas or training providers, where their professional staff provide observations for a fee. The contracts should ensure that the staff are paid and have capacity to collect and submit observations, at time and location requested by the forecasting program.

- Develop or license observation software for professionals to submit data and for forecasters to analyse such as the InfoEx.
- Keep developing an informal observer network by encouraging users to submit photos via instagram or a crowd-based observation portal such as Avanet or MountainHub. Integrate these into an historical map-based system, for forecasters to interrogate and analyse.

Communication and Outreach
The program would communicate the alpine hazard forecast and advice through a website, and coordinate hazard warnings with the responsible government agency. The program would work to improve backcountry user awareness in collaboration with the responsible government agency and MSC, who has access to a good proportion of the target audience. The program should develop a social media outreach program in addition to the published forecasts and MSC audience to access more users. A media policy should be developed. In addition to online publication, the program should also develop improved trailhead and ski area boundary signage that provides information to backcountry users about the presence of hazards and where to obtain information.

Program Team, Qualifications and Training
The program team should include a forecaster and assistant forecaster for each region, and a network of observers. The program should be managed by a lead forecaster for Victoria, who would provide oversight, training, and deal with media and outreach.

The responsibilities and minimum qualifications for each role are shown in the following table.

Table 6: Team roles and responsibilities.

Role	Responsibilities	Minimum qualifications / experience
Lead Forecaster / Program Manager	• Overseeing forecast and observation service • Mentoring Forecasters and Observers • Liaising with government stakeholders • Coordinating season planning and training • Responding to media, professional and public inquiries • Presenting outreach events • Managing budgets and deliverables	Avalanche Operations II or equivalent, program management experience. Working towards Avalanche Operations III.
Forecaster	• Collecting, submitting, maintaining and analysing observations • Developing and publishing forecasts • Mentoring Assistant Forecasters and Observers • Attending outreach events	Avalanche Operations II or equivalent, and role in industry (e.g. ski patrol director or training provider). Working towards Avalanche Operations III.
Assistant Forecaster	• Collecting, submitting and maintaining observations • Developing and publishing forecasts under supervision of Forecaster • Mentoring Observers • Attending outreach events	Avalanche Operations I or equivalent and role in industry (e.g. ski patrol member or AST instructor). Working towards Avalanche Operations II.
Observer (paid)	• Collecting and submitting observations	Avalanche Operations I
Observer (unpaid)	• Collecting and submitting observations	Avalanche Skills Training II. Working towards Avalanche Operations I.

The region currently lacks qualified locals to deliver this model in the first year. For a pilot season, a qualified professional (Avalanche Operations II or III with public forecasting experience) could train and mentor some locals to achieve their Avalanche Operations II in Canada during Australian summer, or New Zealand during winter. In addition, a mentoring program could be established as described in Section 2, Recommendation 2.8.

To support development of the local professionals, the program would coordinate pre-season training and post-season debriefs.

Cost

The following table provides a high-level cost estimate for the first season for the North East and Central Regions. Each forecast position would be part time, part of the year as detailed in the assumptions. Observers would be paid per submission. Additional funding would be required for hardware and software, field equipment and travel costs, communication and outreach activities.

Table 7: Cost estimate (annual costs, including some initial capital costs).

Item	Assumptions	Cost / season*
Lead Forecaster / Program Manager	One lead forecaster / program manager from April to October, 3 days/week at $60/hr	$41,823
Forecasters	Two forecasters from May to September, 5 days per week for two hours at $40/hr	$20,944
Assistant Forecasters	Two assistant forecasters from May to September, 5 days per week for two hours at $35/hr	$14,661
Observers	Ad hoc allowance for 18 weeks of 3 observers per day	$8,910
Training	Pre-season training, Avalanche Operations course allowance, mentor allowance	$30,000
IT	Software, hardware	$10,000
Fieldwork	Equipment, travel allowance	$10,000
Communication and outreach	Events, website development, media	$10,000
		$146,338

Costs of establishing and maintaining forecasting programs depend on several factors including type of forecast, observation network, size of forecast area, number of backcountry users, size of outreach program, amount of fieldwork and software needs. The costs we present are in line or below similar regions such as Scotland (~A$220,000/year), forecasting regions in alpine States in the US such as Flathead Montana (~A$275,000/yr) and Gallatin (~A$365,000).

Funding

The ideal alpine hazard forecast program would be joint public-private funding. Contributions could come from:

- Responsible Government Agency (to be assigned, but will likely be one of Parks Victoria, Emergency Management Victoria, Victoria Police or other)
- Parks Victoria
- Emergency Management Victoria
- Sports and Recreation Victoria
- Ski areas including Mount Hotham Alpine Resort, Falls Creek Alpine Resort, Mt Buller Resort, Mt Stirling Resort
- MSC Membership and fundraising
- Alpine Shire Council and local businesses

5.2 Other scenarios

The section above presents a structure and scope for a forecasting program, which we believe is appropriate to our assessment of the level of risk to backcountry users in Victoria. In the first few years, we estimate annual costs to be about A$150,000 / year. Based on discussions at the May 20 meeting, we expect that this level of funding will not be achieved through public funding. The following table shows the most likely scenarios and recommended actions for MSC.

Table 8: MSC Recommended Actions

Scenario	Description	Action for MSC
1	No change	• Advocate for a responsible agency to be assigned. • Advocate for increased funding. • Publish conditions reports and observations but not forecasts incorporating recommendations from Section 4. Public danger ratings should not be published until a responsible agency is assigned. • Continue all other MSC activities as per recommendations in Section 4
2	Responsible agency assigned. Investment of **$20k / year** in avalanche forecasting program.	• Advocate for increased funding. • Advocate for Avalanche Operations Level II oversight and mentorship • Advocate for alpine hazard forecasts for the backcountry accessible from Mt Hotham and Falls Creek Fri, Sat, Sun, Wed • Advocate for conditions reports and observations but not forecasts for all other areas • Continue all other MSC activities as per recommendations in Section 4
3	Responsible agency assigned. Investment of **$75k / year** in avalanche forecasting program.	• Advocate for increased funding. • Advocate for Avalanche Operations Level II oversight and mentorship • Advocate for daily alpine hazard forecasts for the backcountry accessible from Mt Hotham and Falls Creek. • Publish conditions reports and observations but not forecasts for all other areas • Advocate for formal observer network, data collection and maintenance • Advocate for funding for mentoring and training local professionals to achieve Avalanche Operations I and II • Continue all other MSC activities as per recommendations in Section 4

6 Comparable programs

This table below contains information on programs in other alpine countries.

Table 9: Comparable programs

Region	Characteristics	Advantages / Disadvantages	This is a good example of...
New Zealand	Country-wide daily forecasts for 12 regions administered by New Zealand Mountain Safety Council (NZMSC), which provides safety information for all mountain hazards / public safety. Each region forecast is produced by a local paid avalanche forecaster who has an Avalanche Operations Level II and a professional role in the industry such as Ski patrol forecaster or Lead Guide. Forecasts based on InfoEx, public observations, forecaster's own observations and publicly sourced weather models. Forecasters are paid an extra 1-2 hours per day in addition to their regular job. Other costs include program manager who provides training and oversight and deals with media, computer hardware, software, training and outreach.	Relatively inexpensive - and used as the basis of recommendations in Section 5. The forecaster works in isolation from other forecasters, limiting the amount of critical review of the product. Not achievable for Victoria yet due to lack of qualified locals. Would require mentor/trainer for the first season.	A forecasting program model that is relatively cheap to run.
Quebec, Eastern Canada	Region where avalanches are unfamiliar to the local population, but present a real risk. Similar avalanche statistics to Australia, with about 10 fatalities per decade. In 2001, the Quebec Collaborative Avalanche Project was formed to provide training and avalanche awareness. See Deschenes (2004) for more information.	Good focus on outreach.	An area with a relatively small avalanche problem but relatively high number of engaged users.
Northern Rockies, Western Canada	Large region with few avalanche safety operations submitting field data. Avalanche Canada considered providing advice to areas of high use ("Hot spots") rather than a generic bulletin. Strong focus on outreach and education. See Storm & Helgeson (2014).	"Hot spots" can be confusing. Atypical forecasting methods. Requires roving observation team.	A data-sparse area, where the forecasting centre does not provide a danger rating.
Sweden	Daily forecasting service set up to mitigate avalanche involvements (37 fatalities since 2001). Started forecasting in 2016. Staff includes forecasters, area managers and field observers for each region and a meteorologist. Follows the Conceptual Model of Avalanche Hazard, an adjusted North American Danger Scale for Sweden, Canadian CAA ITP course program and OGRS. See Wikberg (2016) for more information.	Scalable model. Relies on professional level, sufficient density of observations for accurate forecasts.	A forecasting program set up recently (<3 years)

Norway	Forecasting service provided by Norwegian Avalanche Warning Service Program for 25 regions, two to three times per week. Large country, vast area of steep mountains. Staff includes two field observers per region and forecasters. See Engeset et al (2018) for more information, in particular changes they made after surveying forecast readers.	Scalable model. Relies on professional level, sufficient density of observations for accurate forecasts.	A large forecasting program set up recently (<6 years)
Avalanche Canada	Centralised, office-based remote forecasting run for 12 regions (one conditions report, one hot zone), by forecasters with depth of industry or academic experience and Level II. Forecasts use conceptual model of avalanche hazard supported by specialist software, based on large amount of data from InfoEx, field teams, public reporting, forums, as well as weather station feeds from ski and highways operations, and specialist weather models provided by Meteorological Service of Canada. Ongoing media and social media messaging. The team comprises 3-4 forecasters per day, with 2-3 people per field team. Each forecaster covers 4 regions / day. Other operating costs include snowmobiles, trucks, outreach events, office space, IT equipment, software and app development, and other positions: management, admin, media & social media, youth outreach, finance, education, fundraising. IT equipment, software and app development, research. Operating costs in millions funded publicly and privately.	High quality forecasts, outreach and training. Expensive. Relies on professional level observations for accurate forecasts.	A centralised, remote forecasting program with very large regions and an extensive professional observer network
Scotland	Daily avalanche reports for five regions. Winter mountain activity is usually on foot (walking, mountaineering, ice climbing) rather than ski touring. Forecasts developed by teams doing field observations. Funded ~A$220,000/year. See Diggins (2009) and SAIS (2018) for more information.	n/a	An area with relatively small avalanche problem but a very high number of users
South Coast & Sea to Sky Forecasting Regions, Canada	Whistler Blackcomb and the small ski areas (Cypress, Grouse and Seymour) to the north of Vancouver used to provide forecasts for their local backcountry. They are all now included in Avalanche Canada forecast regions. Whistler Blackcomb had sufficient capability and observations to do this, while the forecasting teams at Cypress, Grouse and Seymour built capability working with Avalanche Canada over a number of years.		Areas where the ski areas provided forecasts for their local backcountry

Utah Avalanche Center and other centers in USA.	Utah Avalanche Centre budget for 2018 was about A$1.4M for multiple forecast centres for about 8 regions across the State[34]. Funding comprised roughly a third from federal/state/county governments and two thirds private sponsorship. Almost half of funds were spent on education (i.e. services like teaching courses, seminars/workshops, etc.). Possibly a good model for MSC, but the split could vary depending on support levels from government. Other centres with similar structures and funding models but smaller programs include: Flathead Montana (~A$275,000/yr) and Gallatin (~A$365,000).		Public forecasting programs with split public-private income

[34] https://utahavalanchecenter.org/sites/default/files/archive/annual-reports/uac/AnnualReport2018-19.pdf

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Appendix A - Stakeholders

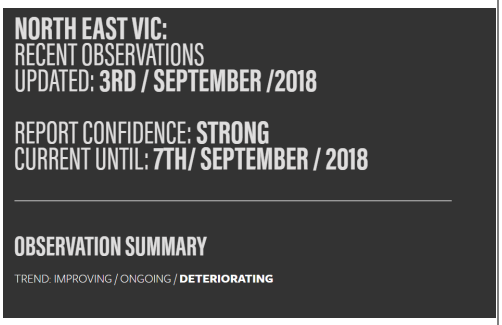
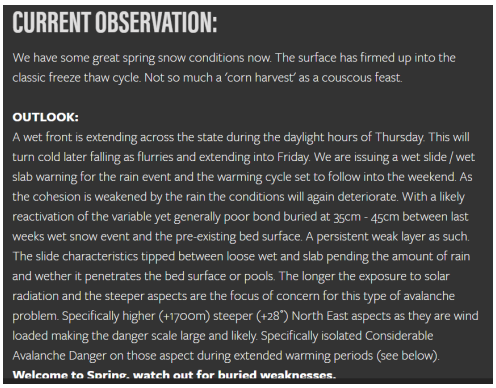
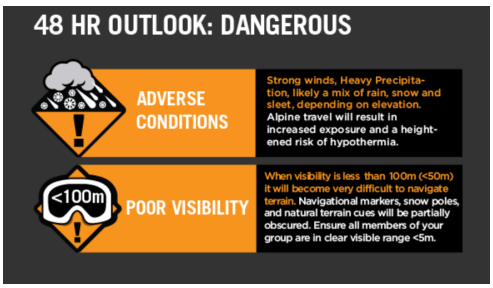
The report has been developed based on conversations with the following stakeholders.

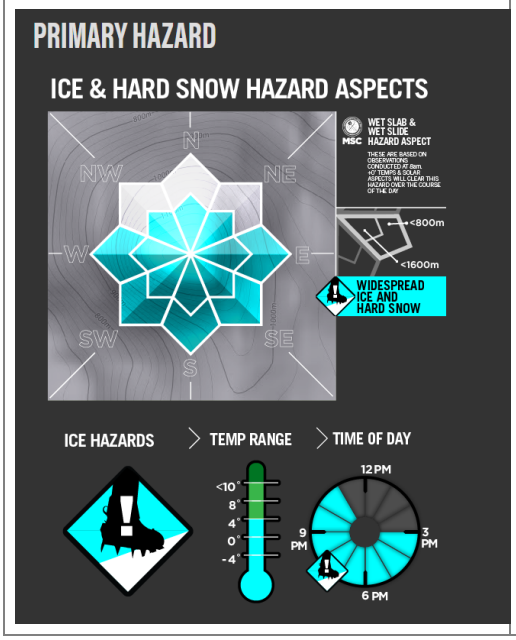
Name	Organisation	Position	Engagement type
Simon Murray	MSC	Director	Detailed discussion
Bill Barker	Mt Hotham Alpine Resort	Ski Patrol Director	Brief discussion, attended May 20 meeting
Matt O'Keeffe	Falls Creek Alpine Resort	Ski Patrol Director	Brief discussion, attended May 20 meeting
Dave McComb	Mt Stirling Resorts	Ski Patrol Director	Brief discussion, attended May 20 meeting
Dave Herring	Alpine Access Australia	Instructor	
Luka Szczepanik	Alpine Access Australia	Instructor	Detailed discussion, attended May 20 meeting
Pauline Williams	Victoria Police	Emergency Management Inspector, Hume	Brief discussion, chaired May 20 meeting
Craig Hore	Parks Victoria	Ranger in charge, fire and emergency operations	Brief discussion, attended May 20 meeting
Keith O'Brien	State Emergency Service	North East Region Manager	Brief discussion, attended May 20 meeting

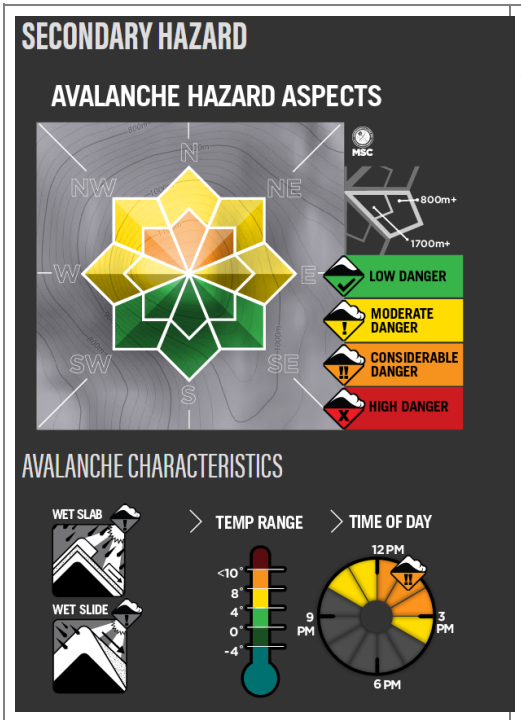
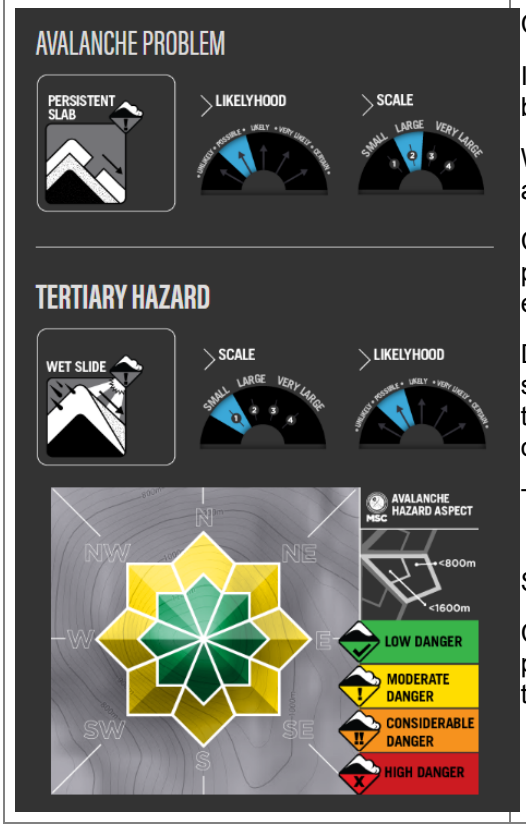
Appendix B - Advisories

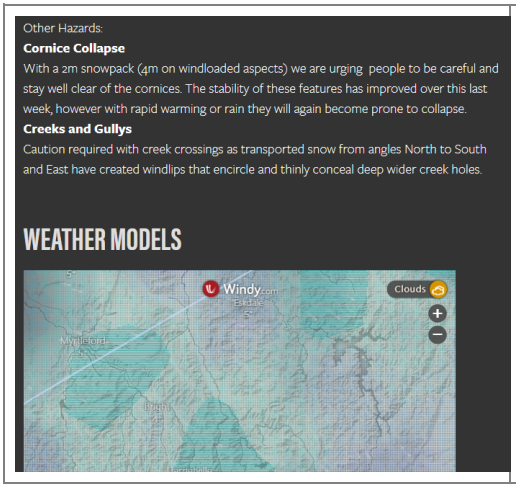
Sample report – markup

The following comments are a review of a sample forecast for 3rd September, 2018 for the North East Region, found at: http://mountainsportscollective.org/north-east-vic-exjs9

Forecast element	Comments
	Overall, the graphics and look of the information is great. This title is clear. Consider adding a zoomable map to help people identify where they are and which advisory they should read. Could consider changing report confidence options to 'low/moderate/high' (and adding a justifying statement) for international consistency. However, there's a good argument for not using words that could be confused with the avalanche danger scale ratings. What are the options other than "Strong"?
	Minimise jargon and technical-sounding descriptions. e.g. Change "cohesion is weakened" to "snowpack is weakened". Practice simple sentences with subject-verb-object structure. e.g. Change "With a likely reactivation of the variable yet generally poor bond buried at 35cm-45cm between…" to: "A poor bond down 35-45 cm is likely to be reactivated by the rain." Try to shorten sentences and proof-read to make them more concise. e.g. Change "The slide characteristics tipped…" to "Both Wet Loose and Wet Slab avalanches are possible, depending how deeply the rain penetrates the snowpack." Remove all reference to danger ratings. Change to discussion of conditions. e.g. Touchy avalanche conditions may develop, especially on high, steep, wind-loaded slopes." Change Wet Slide to Wet Loose (for consistency with international avalanche problems) Nice final sentence. It provides a concise summary.
	What are the other options other than "Dangerous"?

	Change ‘Stability Summary’ and ‘Snow Stability’ to Avalanche Danger Remove or grey out all reference to avalanche danger ratings Use all 5 parts of the avalanche danger scale (i.e. include Extreme), which is an international norm. The graphic is great. However, consider excluding slope angle as danger ratings naturally cover all the terrain, including low angled parts. If you are limiting Moderate danger to slopes greater than 25 degrees, what is the danger on lower angled slopes? It becomes unclear. Recognising avalanche terrain should fall on the user and is part of how they can manage their travel under different danger rating scenarios.
	Time of day clock: What about the morning hours? Suggest changing to a text description like NZ has. e.g. All day/ Morning/ Afternoon or reimagining the clock.

	Change Wet Slide to Wet Loose Take out danger ratings Change time of day clock
	Change Likelyood to Likelihood Inconsistent to have persistent slab as an avalanche problem, but no associated compass rose/ temp/ time of day info. Wet Slide appears already in the advisory, so doesn't need to appear as a tertiary hazard here. Clean up the format so it is consistent. Each avalanche problem should contain the same accompanying information e.g. compass rose, likelihood, size, temp, time of day Does the scale only go to size 4 because the terrain won't support a size 5? Size 4 and 5 should be included in the scale to be consistent with international norms, but perhaps greyed out if they are not possible in the Australian backcountry. The term scale could be changed to "size" for consistency Likelihood and Scale icons are in reverse positions here. Standardise the layout. Could consider adding terrain and travel advice under each problem. In Canada there is a series of drop-down statements the forecaster can use for this (editing these is also possible).

	Change gullys to gullies Change 'angles North to South and East' to 'wind-transported snow from north through to south-east' (or 'from variable winds'). Or change to "Caution required with creek crossings. Wind transported snow has created wind lips in many areas…"

Travel Advisory Site – recommended changes

These recommendations are based on the content at the following site on May 29, 2019: http://mountainsportscollective.org/index#/new-page/

Under How to Interpret…

- Static snapshots of these dynamic phenomena" (change from this)

Under weather warnings:

- "You will find two warnings…". This is confusing, as four weather conditions descriptions follow, only one of which is labelled a 'warning'. Change to "Travel during Adverse Conditions and Blizzard Warning conditions is not recommended".
- "Generally Favourable": change low precipitation to "light", change "fair travel conditions prevail" to "fair travel conditions are expected", remove sentence about deteriorating rapidly as this seems like it belongs in changeable conditions, not favourable conditions, and is confusing.
- Under "Changeable Conditions": Change "clarity" to "clear weather". Correct the spelling of "visibilty".
- Under "Blizzard", and "White Out": Include a sentence "Backcountry travel not advised".

Under On Mountain Observations:

- Grammar: Consider swapping the word 'prevails' for 'exists'. Remove full stop after Hard Packed Icy Snow. Ridgelines doesn't need a capital.
- The paragraph about snow blindness has a few spelling and grammatical errors. Moreover, it seems overly wordy and detailed compared to other parts of the website. Suggest editing to the first and last two sentences. Extra info on snow blindness could be provided as a link.

Under Snow Stability:

Consider removing this section until danger ratings are issued again, or noting that you won't be providing danger ratings for public use until a government agency is assigned. It currently has a few errors and the following changes need to be made before it is re-published:

- Replace "Snow Stability" with "Avalanche Danger". Apply this change across the site.
- Refer to North American Pubic Avalanche Danger Scale and change first instance of High Danger to Extreme Danger
- High Danger – change to "Natural Avalanches likely. Human triggered avalanches very likely." . Refer to North American Public Avalanche Danger Scale. https://www.avalanche.ca/tutorial/pre-trip-planning/check-the-bulletin/avalanche-danger
- Not Assessed – re-word advice to be clearer. e.g. Assume danger is Considerable. Could link to the Dangerator (https://www.avalanche.ca/dangerator), although this needs a critical review first to see if it's appropriate in Australia.
- If Spring conditions are common, consider adding a Spring Conditions icon such as: https://www.avalanche.ca/pages/static-page/spring-conditions

Appendix C - Backcountry maps

ATES Technical Model from Statham et al (2006)

	1 – Simple	2 - Challenging	3 - Complex
Slope angle	Angles generally < 30°	***Mostly low angle, isolated slopes >35°***	***Variable with large % >35°***
Slope shape	Uniform	Some convexities	Convoluted
Forest density	Primarily treed with some forest openings	Mixed trees and open terrain	Large expanses of open terrain. Isolated tree bands
Terrain traps	Minimal, some creek slopes or cutbanks	Some depressions, gullies and/or overhead avalanche terrain	***Many depressions, gullies, cliffs, hidden slopes above gullies, cornices***
Avalanche frequency (events:years)	1:30 ≥ size 2	1:1 for < size 2 ***1:3 for ≥ size 2***	1:1 < size 3 ***1:1 ≥ size 3***
Start zone density	Limited open terrain	Some open terrain. Isolated avalanche paths leading to valley bottom	Large expanses of open terrain. Multiple avalanche paths leading to valley bottom
Runout zone characteristics	Solitary, well defined areas, smooth transitions, spread deposits	Abrupt transitions or depressions with deep deposits	Multiple converging runout zones, confined deposition area, steep tracks overhead
Interaction with avalanche paths	Runout zones only	Single path or paths with separation	***Numerous and overlapping paths***
Route options	Numerous, terrain allows multiple choices	A selection of choices of varying exposure, options to avoid avalanche paths	***Limited chances to reduce exposure, avoidance not possible***
Exposure time	None, or limited exposure crossing runouts only	***Isolated exposure to start zones and tracks***	***Frequent exposure to start zones and tracks***
Glaciation	None	***Generally smooth with isolated bands of crevasses***	***Broken or steep sections of crevasses, icefalls or serac exposure***

Backcountry legend – recommended text

Travel in the backcountry at your own risk. Routes are approximate. Hazards including avalanches and icy or variable surfaces may be encountered at any time on any route.

Moderate Ski Descent
Warning: This is a Backcountry* terrain rating.

This descent requires moderate ability, based on an equivalent ski resort 'Black' terrain rating. Skier must be able to safely respond to varied surface conditions. Assessment of conditions, particularly avalanche danger and/or the prevalence of hard ice is important for safe skiing on this terrain.

Low Fall Consequences.

Avalanche terrain may be encountered.

Advanced Ski Descent

Warning: This is a Backcountry* terrain rating.

This descent requires advanced ability, based on considerable backcountry experience. Skiing responsively to sudden changes in pitch and surface conditions is critical to life and limb. Experience and judgement around sluff management and sound responses to unexpected 'on the move' terrain outcomes is expected. Assessment of conditions, particularly avalanche danger and/or the prevalence of hard ice is important for safe skiing. This should be matched with a preparedness for a long steep hike up and out to relative safety.
Serious, potentially fatal, fall consequences
.
Known avalanche terrain

Expert Ski Descent
Warning: this is a Backcountry* terrain rating.

This descent requires expert ability, based on extensive backcountry experience. Skiing responsively to sudden changes in pitch and surface conditions is critical to life and limb. Confident jump turn technique required. Expert judgement around sluff management and sound responses to unexpected 'on the move' terrain outcomes is mandatory. A fall from a cliff or impact with trees in this terrain could be fatal. Assessment of conditions, particularly avalanche danger and/or the prevalence of hard ice is important for safe skiing.
Likely fatal fall consequences.
Known avalanche terrain

* Backcountry: Uncontrolled, unpatrolled terrain outside of ski area boundaries.

Appendix D – Observations

Observation briefing site – recommended changes

These recommendations are based on the content at the following site on May 29, 2019: http://mountainsportscollective.org/patrol-hq#/new-page-5/

Conceptual model is old (linked to on observations portal page). New version here: https://link.springer.com/article/10.1007/s11069-017-3070-5. The change is likelihood of avalanche rather than likelihood of triggering.

ECT instructions – should read isolate below the depth of the weakness

Wet Loose: "In the case of a wet slab, if you don't get propagation on the extended column, but consistent easy CT score, the problem is a Wet Slide (loose wet) hazard". This sentence is a bit confusing as it refers to wet slabs at the start and loose wet at the end. Loose wet (now called wet loose) and wet slabs are not the same problem and should not be used interchangeably. Also, it's a questionable assumption, as compression tests are not good indicators of loose wet or wet slab likelihood, as wet snow tends to bond in compression i.e. the snow "glues" together at the interface as you bang on the shovel. There is no perfect snowpack test for loose wet or wet slab conditions. The old shovel shear test can provide some information but is subjective.

Change stability tests to snowpack tests

Storm slab: "stability hazard" change to avalanche problem

Wet slab – The "water pooling test" looks like a potentially useful and interesting test, but is there anything published on this? If not, then someone should submit and present to the next International Snow Science Workshop. It's a bit fraught using non-standard test results to create a public hazard advisory, even if they are anecdotally helpful.

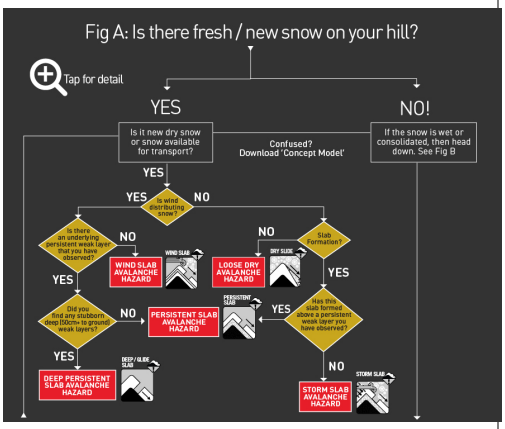
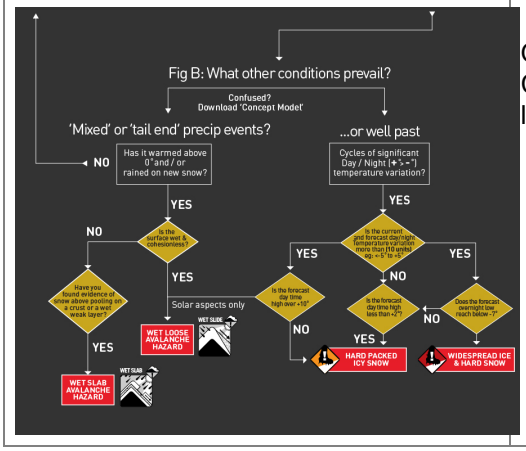
Step 1: shear quality should be sudden, resistant, non-planar break (not fast, resistant, stubborn)

Persistent slab: change comment about bridging sufficient to prevent human triggering to: initiation and propagation characteristics. Sometimes increased bridging (e.g. an increase in stiffness due to added wind slab development) can increase the likelihood of human triggering, not decrease it.

Observation workflow – recommended changes

These recommendations are based on the content at the following site on May 29, 2019: http://mountainsportscollective.org/patrol-hq#/new-page-5/.

The flowchart is a good idea, but has some flaws that need revising before publishing as per comments below. Replace with the table from Statham et al (2018) until revised.

Element	Recommendations
	Change all 'hazards' to 'problems'. e.g. Wind slab problem (or just take out 'avalanche hazard' all together) Problem with slab formation > "has this slab formed above a persistent weak layer" = persistent slab. Not necessarily. A wind slab forming over a persistent form at or near the surface would probably be classified as a wind slab until days had passed and it was still persisting. 'Did you find any stubborn deep (50 cm +) layers..' Remove the word stubborn. Also, deep persistent slabs are more about the nature of the interface than the depth of burial. (if PWL formed on surface, it's considered a persistent slab. If it formed in the snowpack (e.g. facets), it's considered a deep persistent slab. In both cases, they have to prove their persistence and may not be classified as such immediately during or following a storm.
	Query having absolute temperature values to define problems. Change the avalanche problem icons to match the titles 'wet loose' and 'wet slab'.

Extract of avalanche problems from Statham et al (2018)

Table 4 Types of avalanche problems

Name	Description[1]	Formation	Persistence	Typical Physical Characteristics					Typical Risk Mitigation
				Weak Layer Type[2]	Weak Layer Location	Slab Hardness[3]	Propagation Potential	Relative Size Potential[4]	
Dry Loose Avalanche Problem	Cohesionless dry snow starting from a point. Also called a sluff or point release.	Surface layers of new snow crystals that lack cohesion, or surface layers of faceted snow grains that lose cohesion.	Generally lasts hours to days when associated with new snow, and longer when associated with facets.	~	~	~	Downslope entrainment	R1-2	Avoid terrain traps where avalanche debris can concentrate, exposure above cliffs where small avalanches have consequence, and steep terrain overhead where sluffs can start.
Wet Loose Avalanche Problem	Cohesionless wet snow starting from a point. Also called a sluff or point release.	Snow becomes wet and cohesionless from melting or liquid precipitation.	Persistence correlates with warm air temperatures, wet snow or rain, and/or solar radiation.	~	~	~	Downslope entrainment	R1-3	Avoid gullies or other confined terrain features when water from melting or precipitation is moving through the snowpack.
Storm Slab Avalanche Problem	Cohesive slab of soft new snow. Also called a direct-action avalanche.	Cohesive slab of new snow creates short-term instability within the storm snow or at the old snow interface.	Peaks during periods of intense precipitation and tends to stabilize within hours or days following.	DF, PP	In new snow or at new/old snow interface	Very soft to medium (F-1F)	Path	R1-5	Avoid avalanche terrain during periods of intense precipitation, and for the first 24-36 hours following. Assess for crack propagation potential in all avalanche terrain during and in the days following a storm.
Wind Slab Avalanche Problem	Cohesive slab of locally deep, wind-deposited snow.	Wind transport of falling snow or soft surface snow. Wind action breaks snow crystals into smaller particles and packs them into a cohesive slab overlying a non-persistent weak layer.	Peaks during periods of intense wind loading, and tends to stabilize within several days following. Cold air temperatures can extend the persistence.	DF, PP	Upper snowpack	Soft to very hard (4F-K)	Terrain feature to path	R1-4	Identify wind-drifted snow by observing sudden changes in snow surface texture and hardness. Wind erodes snow on the upwind side of an obstacle, and deposits it on the downwind side. They are most common on the lee side of ridge tops or gullies and are most unstable when they first form and shortly after.
Persistent Slab Avalanche Problem	Cohesive slab of old and/or new snow that is poorly bonded to a persistent weak layer and does not strengthen, or strengthens slowly over time. Structure is conducive to failure initiation and crack propagation.	Weak layer forms on the snow surface and is buried by new snow. The overlying slab builds incrementally over several storm cycles until reaching critical threshold for release.	Often builds slowly and then activates within a short period of time. Can persist for weeks or months but generally disappears within six weeks.	SH, FC, FC/CR combo	Mid to upper snowpack	Soft to hard (4F-P)	Path to adjacent paths	R2-4	Complex problem that is difficult to assess, predict and manage. Typically located on specific aspects or elevation bands but sometimes widespread. Identification and tracking of weak layer distribution and crack propagation propensity is key, along with a wide margin for error and conservative terrain choices.
Deep Persistent Slab Avalanche Problem	Thick, hard cohesive slab of old snow overlying an early-season persistent weak layer located in the lower snowpack or near the ground. Structure is conducive to failure initiation and crack propagation. Typically characterized by low likelihood and large destructive size.	Weak layer metamorphoses within the snowpack forming facets adjacent to an early-season ice crust, depth hoar at the base of the snowpack, or facets at the snow-glacier ice interface. The overlying slab builds incrementally over many storm cycles until reaching critical threshold for release.	Develops early in the winter and is characterized by periods of activity followed by periods of dormancy, then activity again. This on/off pattern can persist for the entire season until the snowpack has melted.	DH, FC, FC/CR combo	Basal or near-basal	Medium to very hard (1F-K)	Path to adjacent paths	R3-5	The most difficult avalanche problem to assess, predict and manage due to a high degree of uncertainty. Low probability/high consequence avalanches. Triggering is common from shallow, weak snowpack areas, with long crack propagations and remote triggering typical. Weak layer tracking and wide margins for error are essential, with seasonal avoidance of specific avalanche terrain often necessary.
Wet Slab Avalanche Problem	Cohesive slab of moist to wet snow that results in dense debris with no powder cloud.	Slab or weak layer is affected by liquid water which decreases cohesion. Crack propagation occurs before a total loss of cohesion produces a Wet Loose Avalanche Problem.	Peaks during periods of rainfall or extended warm air temperatures. Persists until either the snowpack refreezes or turns to slush.	Various but often FC or DH	Any level	Soft to hard wet grains (4F-P)	Path	R2-5	Rainfall, strong solar radiation, and/or extended periods of above-freezing air temperatures can melt and destabilize the snowpack immediately. Timing is key regarding slope aspect and elevation, and overnight re-freezing of the snow surface can stabilize the snowpack.
Glide Slab Avalanche Problem	Entire snowpack glides downslope then cracks, then continues to glide downslope until it releases a full-depth avalanche.	Entire snowpack glides along smooth ground such as grass or rock slab. Glide crack opens, slab deforms slowly downslope until avalanche release results from a failure at the lower boundary of the slab.	Can appear at any time in the winter and persists for the remainder of the winter. Avalanche activity is almost impossible to predict.	WG, FC	Ground	Medium to very hard (1F-K)	Path	R3-5	Usually localized, visible and easy to recognize, the presence of a glide crack does not indicate imminent release. Predicting a glide slab is almost impossible, so avoid slopes with glide cracks and overhead exposure to glide slabs.
Cornice Avalanche Problem	Overhanging mass of dense, wind-deposited snow jutting out over a drop-off in the terrain.	Wind transport of falling snow or soft surface snow develops a horizontal, overhanging build out of dense snow on the leeward side of sharp terrain breaks.	Persists all winter on ridge crests, and tends to collapse spontaneously during periods of warming, or following intense wind loading events.	~	~	~	Path	R1-5	Avoid overhead exposure to cornices whenever possible, particularly during storms or periods of warmth and/or rain. Cornices are heavy and can trigger slabs on the slopes below. Use great care on ridge crests to stay on solid ground, well away from the root of the cornice.

[1]Haegeli et al. 2010; [2]Fierz et al. 2009 (p 4); [3]Fierz et al. 2009 (p 6); [4]AAA 2016 (p 54)

InfoEx Subscription information

Provided by Stuart Smith, CAA, May 2019.

Schedule A: Subscription Fees

The Subscriber agrees to identify and classify its Operational Node and then pay the Subscription Fee for the applicable Operational Node as outlined below:

Identification and Classification of Operational Nodes

An **operational node** is a distinct snow avalanche hazard assessment, forecasting and risk management program, that may be independently owned and operated, or may be part of a larger operation (e.g. a single company that operates programs in a variety of locations).

Subscribers must purchase a separate subscription of the appropriate class for each operational node, however the InfoEx subscription agreement for an operation can encompass multiple nodes. Each operational node must be identified by the subscriber and assigned a classification according to the following categories. Each node is subject to a Subscription Fee based on its category (see table in "Subscription Fees" section below).

Please contact the CAA if clarification is required.

Class A Node

Small avalanche program; for example:

- Small mechanized backcountry skiing operation, normally only a single group on any given day.
- Non-mechanized backcountry lodge, normally only one group on any given day.
- Independent guide who occasionally employs or contracts other guides or assistant guides to assist on trips or programs.
- Small ski area with a minor avalanche control program, e.g. small base area, only a few lifts, and a few avalanche paths).
- Small industrial/highway site with few assets at risk and/or intermittent risk (e.g. low traffic volumes on a road with few avalanche paths).

Class B Node

Medium size avalanche program, for example:

- Medium sized mechanized backcountry skiing operation, normally more than one group; and several guides working on any given day.
- Non-mechanized backcountry lodge operation with more than one base (e.g. cabin or hut), normally more than one group in the field concurrently.
- Guiding company or mountain school often operating concurrent trips or programs.
- Medium size ski area with significant control program, e.g. large single base area with numerous lifts and numerous avalanche paths requiring regular control work.
- Medium size industrial/highway site with many assets at intermittent risk and/or significant assets at constant risk (e.g. 24/7 traffic on a road with many avalanche paths that require constant monitoring and regular control operations or fixed structures in avalanche paths).

Class C Node

Large avalanche program, for example:

- Large mechanized skiing organization with numerous machines operating from a single base and many guides working on any given day.
- Large ski area with multiple base areas, many lifts on multiple mountains, and a major control program involving many avalanche paths requiring regular control operations.
- Large industrial/highway site: significant multiple assets at constant risk (e.g. moderate to high volume traffic exposed to many avalanche paths 24/7 and fixed structures in avalanche paths.
- Large, mixed operations: e.g. a major highway program and a public avalanche forecasting program operated by the same agency.

Class I Node

Individual subscription. Only one person is granted access to InfoEx. This access is not extended to employees or assistants of the Subscriber. Subscriber must be an avalanche professional who is actively engaged in snow avalanche hazard assessment, forecasting, and risk management. For example:

- Independent guide who works alone and never hires or contracts another guide to carry out or assist with trips or programs.
- Avalanche Professional who works alone and never hires or contracts other staff to carry out or assist with avalanche work.

Subscription Fees

The following table defines fees for the subscription for the applicable class of operational note:

Class	Fee
Class A	$CDN 780 ($US 596)
Class B	$CDN 1670 ($US 1276)
Class C	$CDN 4200 ($US 3210)
Class I	$CDN 375 ($US 287)

Subscription fees cover a twelve (12) month period and the rates above are for season 2018-2019. Rates are set and payable in Canadian Dollars, and the US dollar rates given are an approximation based on the exchange rate on 17th August 2018.

The above amounts are exclusive of any applicable taxes, and such taxes shall be paid by the Subscriber concurrently with the applicable fee.

The CAA may amend or change the Classification of Operational Nodes and the Subscription Fees from time to time, provided that the CAA provides fifteen (15) days written notice of any such change to the Subscriber.