LAWYERS CREEK – MANAGING AVALANCHE RISK IN THE OMINECA MOUNTAINS OF BRITISH COLUMBIA, CANADA. INTERNATIONAL SNOW SCIENCE WORKSHOP 2026, WHISTLER, CANADA

Mark Vesely[1]*, and Greg Johnson[1]

1 Point Avalanche Control, Nelson, BC, Canada

ABSTRACT: The Omineca Mountains are made up of a series of remote ranges located in north central British Columbia, Canada. Due to their remote nature, published avalanche climate data is limited for these ranges. In the winter of 2021-22, 6 Point Avalanche Control managed avalanche risk for an exploration project in this region. This operational program observed avalanche climate data from 3 different areas including notable experiences in managing a road through 2 high elevation passes. This paper summarizes completed work, avalanche climate observations, and provides a reference for future practice in the Omineca Mountains.

KEYWORDS: Omineca Mountains, Operations, Avalanche Climate

1. INTRODUCTION

The Omineca Mountains are made up of a series of remote ranges located in north central B.C. Canada. In the winter of 2021-22, 6 Point Avalanche Control provided avalanche risk management services for a mineral exploration project located in this region. Road access to the project followed the Omineca Resources Access Road to the historical Cheni mine site. The project required avalanche hazard monitoring and controls for 3 areas along this route. These sites were known as Osilinka, Johanson and Lawyers, respectively, for this project. Collectively, these areas provided data from the southeastern, central, and northwestern regions of the Omineca Mountains.

The severities of avalanche hazards managed varied in the 3 areas observed. Osilinka and Johanson included road sections on valley floors exposed to avalanche path runouts, while Lawyers included road sections ascending to alpine elevations, exposing roads to lower start zones and tracks. In total, this project included monitoring 70 avalanche paths exposing ~25 km of road length. The monitoring period spanned from September 20th to June 1st and observed 161 avalanches that intersected roads.

The remote nature of this program demanded a high degree of self-reliance for data acquisition and mitigation work. Strategies included field-based observations, forecasting, hand charging, helicopter control, and the use of a portable avalauncher gun. This paper presents data from completed work and offers perspective on the avalanche climate in the Omineca Mountains for general interest or future practice.

2. BACKGROUND

The Omineca Mountains include traditional territories of the Dakelh and Tse'khene First Nations. Historical resource interests in the region are linked to forestry and mineral exploration. Gold was first discovered in the region in the 1860s, with mining development continuing from the 1980s to the present day. Road access to this area is supported by a resource access road constructed in the 1980's. The Omineca Resource Access Road (ORAR) spans the Omineca's south to north and provides access to the historical Baker, Cheni (Lawyers) and Kemess mine sites. There is a history of avalanche risk management by historical users of the ORAR for the Osilinka and Johanson areas.

The Baker Mine (active during the early 1980's) included development of exploration roads throughout its claim area. A notable road was a high elevation route that connected Baker to the Lawyers mine site properties via 2 high elevation passes. These are known as Tigers Crotch and Tigers Notch and are at elevations of 1,784 m and 1,847 m, respectively. The Lawyer's deposit was mined between 1988 and 1992. During this time, the Cheni (Lawyers) mine developed a lower elevation access route to its site that followed the Jellicoe, Lawyers, and Attorney Creek valleys. This all-season road was decommissioned

* Corresponding author address:
Mark Vesely
Point Avalanche Control, Nelson, BC, Canada
email: mark.vesely@6pointeng.com

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when the Cheni mine closed, necessitating future access to the Lawyers site via the Tigers Pass route. This route was part of 6PAC's program for the 2021 / 22 winter and was noted as a unique endeavor, as it had not observed management over a full winter season before.

3. AREA OVERVIEW

The Omineca Mountains are in north central B.C. Their proximity to other mountain ranges and reference cities in the province are shown in Figure 1. The Omineca's are located west of the Williston Reservoir. Primary drainages include Finlay, Ingenika, Mesilinka, Osilinka, Omineca and Nation Rivers. These all drain into Williston. The Lawyer's project was in the northern Omineca Mountains in the Samuel Black Range. Along the project's access route, 3 avalanche areas have been noted. The Osilinka (between KM 28 and 29 on the Osilinka FSR), Johanson (between KM 78 and 93 on the Tenakihi FSR and Lawyers (roads within ~15 KM of the Lawyers Camp).

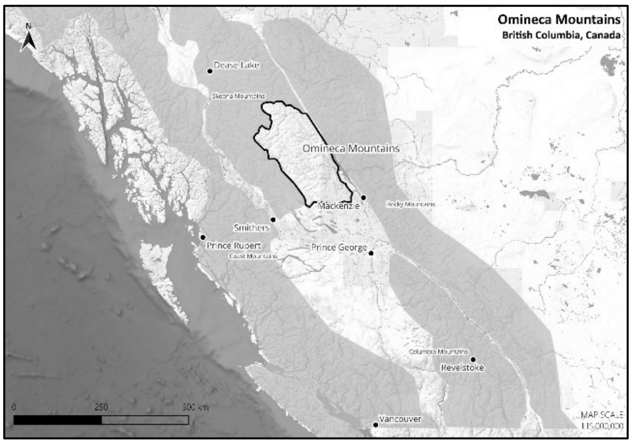


Figure 1. Omineca Mountains

Figure 2 provides reference for the project location and avalanche areas. Avalanche paths are represented by grey shaded polygons on inset maps to provide reference for the scales of avalanche areas.

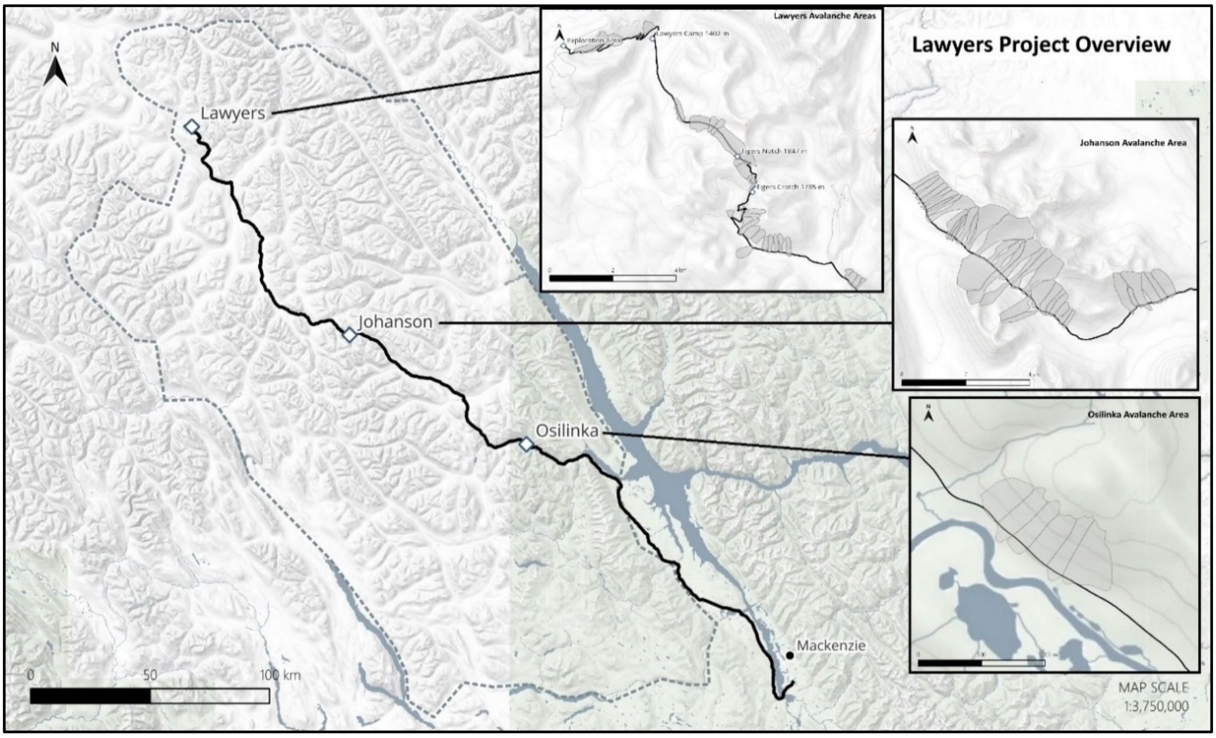


Figure 2. Lawyers Project Overview

4. OBSERVATIONS

4.1 *Weather and Snowfall*

The Lawyers project avalanche program was based at the Lawyers Camp during the winter of 2021 / 2022. Avalanche paths in the Lawyers area had daily observations and control efforts as conditions required. The Johanson and Osilinka areas were monitored remotely, with direct observation field visits conducted in accordance with observed storm systems and forecast hazards. In total, the program completed a 240-day record for the project. The primary study plot was near the Lawyers Camp, located at 57°20’4.06” N, 127°9’26.77” W, at 1400 m. Data including cloud cover, air temperatures, snowfall and winds are included for reference.

The general cloud cover and days with precipitation were representative of both forecast and observed conditions for Johanson and Osilinka. Of the 240 observed days, 45% of the season was mostly cloudy. 96 days observed no precipitation, while 144 days observed snowfall, rain or a combination of the two.

Figure 3 shows the air temperature and cloud cover distribution as observed from the Lawyers Plot. Several cold periods are notable, with December representing the coldest month. Minus 37°C was the seasonal low observed in late December and early January. Seasonal averages were noted as -0.4°C for daytime highs, -9.4°C for overnight lows and -4.8°C as a daily seasonal mean. Relatively cool temperatures were also observed throughout April, contributing to slow snowmelt rates in the spring. Again, these general conditions were representative of the Osilinka and Johanson areas.

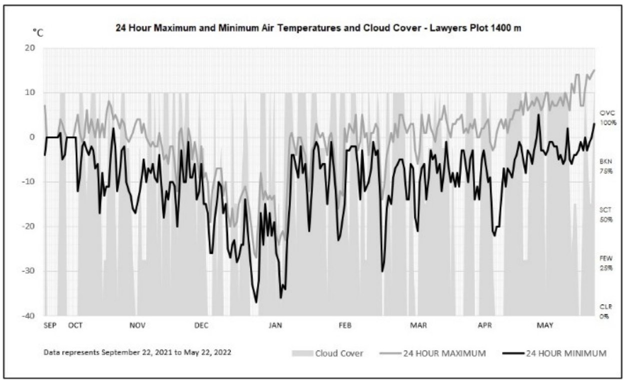


Figure 3. Air Temperature and Cloud Cover

Snowfall began at alpine elevations in mid-September. At the time the Lawyers plot began its records, alpine elevations already contained ~20 cm. The Lawyers Plot recorded 284 cm of snowfall, with a water equivalent of 250 mm, between Sept. 20th and May 28th. The snowpack's seasonal apex on April 12th had a bulk density of 280 kg/m³, correlating with a typical seasonal snowpack settlement of 66%. Of the 3 areas managed, Johanson observed the deepest snow depths, with a seasonal apex of 95cm at 1467 m. Comparatively, the Lawyers plot observed a seasonal apex of 89cm at 1400 m, and Osilinka observed 70cm at 1280m. 75% of the season’s snowfall occurred between November 1st to the end of February. November had the highest snowfall, accounting for 25% (70 cm). Storm amounts were modest, with 24-hour accumulations rarely exceeding 10 cm. Incremental loading during storm periods was observed to be ~20 cm over several days. Figure 4 shows 24-hour snowfall and settled snow depth distributions from the Lawyers plot.

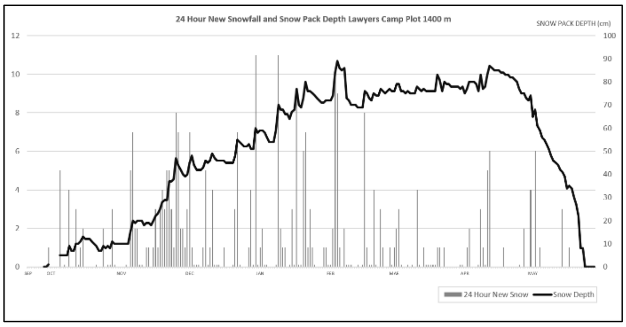


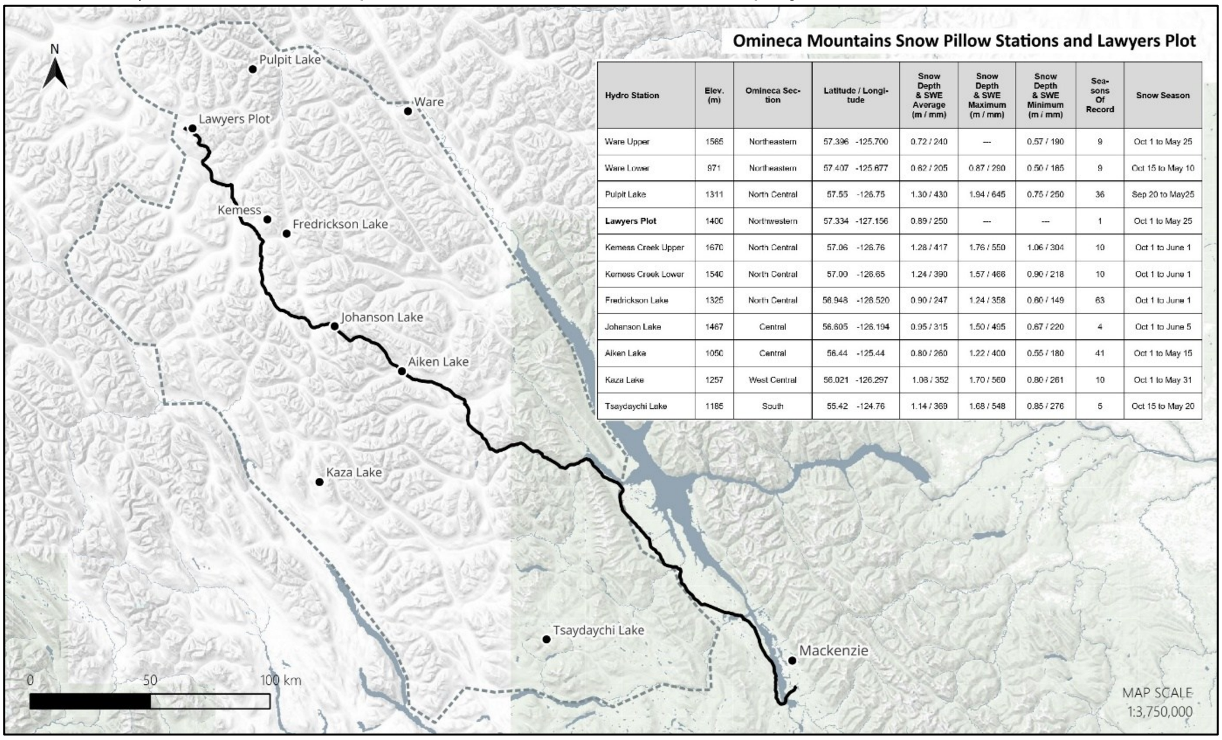
Figure 4. Lawyers Study Plot Snow Depth and SWE

Prevailing wind flows in the project area were observed to be from the Southwest. Variations in prevailing winds were linked to storm system tracking or alternate airmass intrusions (notably Arctic air outbreaks). The tendency for shifting westerly to easterly winds was noted as low-pressure system centers advanced south of the region. The months of November through February (shaded in the table) saw nearly 50% of their days with moderate winds from various directions. These values would typically correspond to wind speeds in the strong to extreme category at ridge-top work sites and through the high elevation passes. This was identified as a critical avalanche hazard factor in the Lawyers and Johanson areas.

Table 1. Lawyers Study Plot Wind Observations

Time Period	Primary Wind Direction (Days)								Avg. Wind Speed <(km/h)> (Days)		
	N	NE	E	SE	S	SW	W	NW	< 20	20-40	>40
September 21, 28 - 30, 2021	0	0	0	0	1	3	0	0	3	1	0
October 5 to 31, 2021	1	1	0	9	0	10	4	1	21	4	1
November 1 to 30, 2021	1	1	2	2	3	19	2	0	17	11	2
December 1 to 31, 2021	3	3	0	1	0	10	7	7	20	10	1
January 1 to 31, 2022	0	2	1	3	5	10	6	4	15	15	1
February 1 to 28, 2022	2	2	1	1	4	12	5	1	14	10	4
March 1 to 31, 2022	2	1	2	3	1	14	8	0	30	1	0
April 1 to 30, 2022	4	4	0	6	5	6	4	1	24	6	0
May 1 to 28. 2022	3	1	1	4	2	10	3	4	27	0	1
Seasonal Total Days	16	15	7	29	21	94	39	18	171	58	10
Percentage of Season	6	6	4	12	8	40	16	8	71	24	5

Extending conditions beyond data from the Lawyers Plot, the B.C. Provincial Snow Survey site has been referenced to provide perspective on the snow distribution climate for the Omineca Mountains. 10 sites were reviewed and are representative of various locations in the range. Figure 5 shows the station locations and relevant values for snow depth, water equivalency, seasons of record and approximate lengths of the snow season. The ORAR (black line) and approximate mountain range boundary (grey dashed line) are included for spatial reference of stations to the project.



Hydro Station	Elev. (m)	Omineca Section	Latitude / Longitude	Snow Depth & SWE Average (m / mm)	Snow Depth & SWE Maximum (m / mm)	Snow Depth & SWE Minimum (m / mm)	Seasons Of Record	Snow Season
Ware Upper	1565	Northeastern	57.396 -125.700	0.72 / 240	---	0.57 / 190	9	Oct 1 to May 25
Ware Lower	971	Northeastern	57.407 -125.677	0.62 / 205	0.87 / 290	0.50 / 165	9	Oct 15 to May 10
Pulpit Lake	1311	North Central	57.55 -126.75	1.30 / 430	1.94 / 645	0.75 / 250	36	Sep 20 to May25
Lawyers Plot	1400	Northwestern	57.334 -127.156	0.89 / 250	---	---	1	Oct 1 to May 25
Kemess Creek Upper	1670	North Central	57.06 -126.76	1.28 / 417	1.76 / 550	1.06 / 304	10	Oct 1 to June 1
Kemess Creek Lower	1540	North Central	57.00 -126.65	1.24 / 390	1.57 / 466	0.90 / 218	10	Oct 1 to June 1
Fredrickson Lake	1325	North Central	56.948 -126.520	0.90 / 247	1.24 / 358	0.60 / 149	63	Oct 1 to June 1
Johanson Lake	1467	Central	56.605 -126.194	0.95 / 315	1.50 / 495	0.67 / 220	4	Oct 1 to June 5
Aiken Lake	1050	Central	56.44 -125.44	0.80 / 260	1.22 / 400	0.55 / 180	41	Oct 1 to May 15
Kaza Lake	1257	West Central	56.021 -126.297	1.08 / 352	1.70 / 560	0.80 / 261	10	Oct 1 to May 31
Tsaydaychi Lake	1185	South	55.42 -124.76	1.14 / 369	1.68 / 548	0.85 / 276	5	Oct 15 to May 20

Figure 5. Omineca Mountains Snow Pillow Stations and Lawyers Plot

These data show that most areas in the Omineca Mountains average a seasonal peak snow depth of 1 meter (0.62 to 1.30 m) at low to mid elevations (970 to 1585 m). Lower elevation sites showed SWE averages near 300 mm with mid elevation areas closer to 400 mm. Extreme values showed a seasonal range of 1.75 m to 0.60 m (maximum / minimum) of seasonal apex snow depths.

While the noted values provide general snow depth distribution data, they are not necessarily representative of higher elevation conditions. Snow depth variations in the Lawyers area showed a 30-40% increase from sites below the treeline to alpine sites. This was observed at local snow course sites, where 0.80 m near 1400 m was compared with 1.50 m near 1700 m on the same dates in the Lawyers area. Snow profiles commonly observed snow depths of 1.5-2.5 m, with bulk densities near 350 kg/m³, at alpine elevations in the latter part of the winter season.

4.2 *Avalanche Hazard*

Avalanche hazard assessments included analyses and forecasts for all monitored areas over the 240-day period. To support these assessments, 74 snow profiles were completed, along with field observations at intervals deemed appropriate for each area. The high elevation passes in Lawyers were observed daily. The Johanson and Osilinka areas were observed during visits that coincided with storm periods, resulting in roughly weekly visits at Johanson and bi-weekly visits at Osilinka, respectively.

Avalanche Hazard was monitored and rated for alpine, treeline and below treeline elevation bands. The Omineca included valley floor elevations

Table 2. Elevation Band Avalanche Hazard Ratings

Elevation Band (Sept 21 to May 28)	Avalanche Hazard Ratings					
	No Hazard (Days)	Low (Days)	Moderate (Days)	Considerable (Days)	High (Days)	Extreme (Days)
Alpine (ALP) Above 1700 m	0	19	158	59	4	0
Treeline (TL) 1700 to 1500m	14	45	115	70	6	0
Below Treeline (BTL) Below 1500m	62	126	61	1	0	0
% Of Season (ALP)	0	8	65	25	2	0
% Of Season (TL)	5	18	48	29	3	0
% Of Season (BTL)	25	51	23.5	0.5	0	0

near 800 m to a treeline elevation of ~1700 m and alpine elevations extending to ~2400 m. Of note, no extreme avalanche hazard days were forecast or observed.

Significant l avalanche cycles were observed in late November, early December, late January and early February. While the Omineca Mountains did show a tendency toward cold temperatures, extreme temperature swings were observed, with swings greater than 15°C over 12 hours. Notably, the late November, January, and February apex hazard periods observed above-freezing temperatures reaching mid-elevations as part of destabilizing trends. The avalanche hazard distribution is shown in Figure 6 and indicates the seasonal apex hazard periods mentioned. The elevated hazard in late May was linked to the observed region's final spring avalanche cycle.

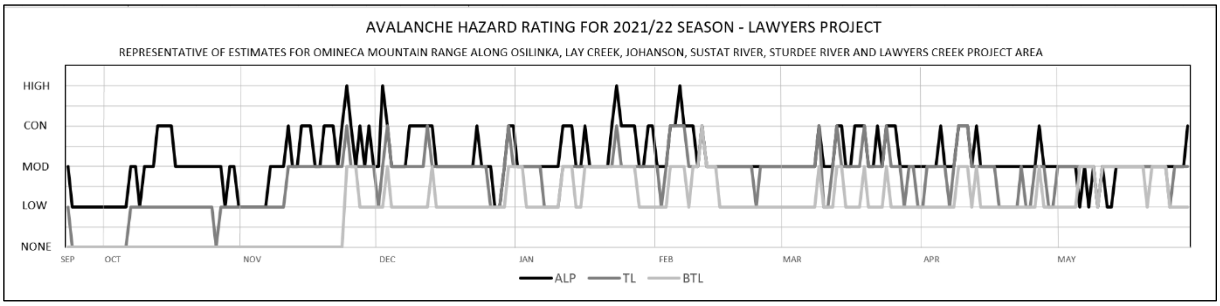


Figure 6. Seasonal Avalanche Hazard Time Series

To capture the avalanche climate, snow avalanche problems (expressed as snow avalanche characteristics) have been summarized from the program's assessment records. This provides perspective on which avalanche problems were most prevalent for the project season. Notably, all project areas showed primary seasonal climate tendencies supporting wind slab, persistent slab and cornice characterized hazards.

Table 3. Avalanche Hazard Characteristics

Time Period	Snow Avalanche Characteristics					
	No Hazard (Days)	Storm Snow (Days)	Wind Slab (Days)	Persistent Slab (Days)	Cornice (Days)	Wet Snow (Days)
September 21, 28 - 30, 2021	4	1	2	0	1	0
October 5 to 31, 2021	27	8	23	9	27	0
November 1 to 30, 2021	21	7	25	30	30	0
December 1 to 31, 2021	0	2	30	31	31	0
January 1 to 31, 2022	0	2	29	31	31	2
February 1 to 28, 2022	0	10	21	28	28	2
March 1 to 31, 2022	0	4	27	31	31	3
April 1 to 30, 2022	0	8	20	30	30	10
May 1 to 28. 2022	0	1	0	28	28	28
Totals	52	43	177	218	237	45
% Of Season as a Concern	22	18	74	91	99	19

Avalanche observations are primarily associated with the Lawyers area, as this was the region where daily records were kept. When observations of natural activity were observed from Johanson and Osilinka, their estimated time of occurrence was correlated in the records. Observations are summarized in Table 4 and represent natural activity per day. Of note, the project did observe 18 natural events depositing on roads. All these events were linked to the Lawyers' Avalanche Area.

Table 4. Natural Avalanche Observations (Days)

Time Period	No Observed Events (Days)	Few Natural Events (Days)	Several Natural Events (Days)	Numerous Natural Events (Days)	Natural Avalanches on Road (Number)
September 21, 28 - 30, 2021	3	1	0	0	0
October 5 to 31, 2021	13	7	4	0	0
November 1 to 30, 2021	22	6	2	2	3
December 1 to 31, 2021	13	12	3	1	7
January 1 to 31, 2022	17	10	4	0	0
February 1 to 28, 2022	14	6	4	4	0
March 1 to 31, 2022	18	8	4	1	4
April 1 to 30, 2022	17	9	4	0	3
May 1 to 28. 2022	16	4	2	0	1
Totals	133	63	27	10	18
Percentage of Season	56	27	12	5	

Controlled avalanches were a major part of 6PAC's mitigation strategies. In total, 101 control missions were completed over the project term. 487 avalanches were triggered, resulting in 150 avalanches depositing on roads. Table 5 shows the control missions, triggered avalanches, and road-intersection distributions for all managed areas. Of note, snow

Table 5. Avalanche Control Summaries

Avalanche Area	Control Missions	Avalanches Triggered	Avalanches Deposited on Roads
Lawyers	90	383	143
Johanson	9	90	4
Osilinka	2	14	3

clearing equipment triggered 18 avalanches during their work. These are not included in Table 5. None of these events resulted in machinery becoming stuck or operator injuries.

5. NOTABLE EXPERIENCES

5.1 Strategies

A notable experience from this project stems from the program's remote nature, resulting in the need for flexible, self-reliant and economical avalanche mitigation options. Given the project's scale and term, limited options existed for longer term strategies or higher investment systems. To support resource flow, access over the Tigers passes had to be highly reliable even when supporting aircraft were unavailable. One strategy employed to aid this requirement was using a truck bed mounted avalauncher gun for performing avalanche mitigation work. This strategy proved highly effective, allowing the program to open the passes every day during the project term. The avalauncher program was developed with standard parking areas and targeting support systems that included reference firing values and use of a physical based model for unique target acquisition.

Figure 7. Truck Mounted Avalauncher Gun

5.2 Winds

Winds proved to be a primary contributor to avalanche hazards in the Omineca Mountains. Even with relatively low storm snowfall amounts, wind redistributed snow was observed to support sizable avalanches.

In addition to supporting avalanche hazard formation, the generally thin snowpack combined with strong winds at mid and upper elevations would commonly negate or reduce hazards on windward features. A common pattern was the observation of avalanche paths becoming either active or dormant on the eastern or western sides of the Tigers passes, coinciding with observed storm patterns. Johanson also observed a highly wind-modified snow distribution pattern that tended to favor loading into paths in its southern section.

Figure 8. Windy Conditions in Tigers Notch

5.3 Persistent Slab Patterns

Persistent slab weaknesses were observed to be a consistent snowpack characteristic across all project areas. Release patterns were observed to vary with elevated hazard periods, random control work prompts, and, in a few cases, snow removal equipment triggering. It was common to have snowpack tests indicating sensitivity to failure, but no activity was observed. The early December apex hazard period saw a ~75 cm-thick, established, hard, persistent slab over basal facets (formed by cycling winds to date and strong temperature-gradient metamorphosis) with a bulk density of ~350 kg/m³.

Figure 9. Late May Persistent Slab

The one consistency observed in the snowpacks' basal weakness (depth hoar at the ground) was a single event release pattern. Once a start zone responded it did not release again on the monitored basal persistent interface or remaining depth hoar. All monitored features took their respective turns at release, with many seasonal holdouts releasing at ground level during the final spring cycle in late May.

One area that demonstrated this non-repeating release pattern was Osilinka. This area was monitored until a suitable slab was deemed to have developed over the depth hoar basal pack, and then successfully controlled in early February, with a snow depth near 70cm in the feature's start zones. This work proved to be the only seasonal effort required for the site. Narratives from local logging operators noted that the feature typically performs once, with an apex cycle per season, to the road level. If left unmanaged, this would typically be observed during a mid-season warming event or in the spring.

6. CONCLUSIONS

This paper presents observations from avalanche risk management work completed during the winter of 2021/2022 and provides perspective on snowpack, avalanche, and operational conditions encountered in the Omineca Mountains.

Observations from the 2021/2022 winter were consistent with a continental snowpack characterized by relatively shallow snow depths, prolonged cold periods, and persistent weak layers. These conditions supported strong temperature gradient metamorphism and the development of basal depth hoar. Long-term provincial snow survey data indicate that relatively shallow low- and mid-elevation snowpacks are characteristic of much of the region. Although observations from additional winters would be required to establish the frequency of persistent avalanche problems, persistent weaknesses were an important and recurring feature of the snowpack during the season observed.

Wind was another defining influence on avalanche conditions. Wind redistributed snow, contributing to the formation of large cornices and thick wind slabs over persistent weaknesses. At alpine elevations, wind loaded slabs approaching 1 m in thickness and densities of approximately 300 to 400 kg/m^3 were observed as early as November over basal depth hoar. An important consideration for practitioners is therefore not to underestimate the potential for large destructive avalanches from mid- and upper elevation start zones simply because snow depths at lower elevations are relatively modest.

Over shorter time scales, wind also supported rapid changes in avalanche hazard with little or no new snowfall. Changes in wind direction associated with passing storm systems produced loading on multiple aspects during individual storm periods. Conversely, strong winds could scour or substantially reduce snow cover on exposed terrain, decreasing avalanche potential on some features while increasing loading elsewhere. Direct observations of snow distribution at higher elevations were therefore an important forecasting tool, helping maintain reliable access through the high elevation passes.

The combined influence of persistent weaknesses and wind redistribution was a recurring theme throughout the 2021/2022 season. Persistent weaknesses increased the potential for larger avalanches during major seasonal cycles, while storm- and wind-slab problems produced more frequent, smaller events, particularly at higher elevations. Differences in avalanche activity between Lawyers, Johanson, and Osilinka also demonstrated the importance of local elevation, terrain, and wind exposure when applying regional weather observations to individual avalanche areas.

A concluding point from the project concerns remoteness and operational self-reliance. Given the limited availability of outside assistance, work in the Omineca Mountains required a high degree of preparedness, flexible mitigation systems, and conservative exposure management. The consequences of equipment failures, weather delays, or incidents can be substantially greater where emergency response and replacement resources are distant, limited or non-existent. Well maintained and appropriately stocked vehicles, redundant avalanche control options, reliable communications, and conservative approaches to worker exposure were therefore important components of the program. These operational considerations were as important to successful avalanche risk management as understanding the snowpack and avalanche conditions themselves.

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