AVALANCHE FORECASTING AT STEVENS PASS
PART II
SKI AREA RATING FOR AVALANCHE POTENTIAL

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In 1994 we started a new program for avalanche control purposes at the Stevens Pass ski area. We have given the U.S. avalanche danger scale nine weather and snowpack variables to coincide with the description of each categories, and turning it into our Avalanche potential scale for avalanche control. The nine weather and snowpack variables are: Settlement, 24 HR snowfall, 12 HR snowfall, Temperature-Trends, Winds, Intensity, Density, Layering structure, and Natural activity.

Taking this information from our study plots and telemetry sites we plug theses into our graph and come up with an Avalanche Potential forecast to assist in our avalanche control missions.

Example: AVALANCHE POTENTIAL GRAPH

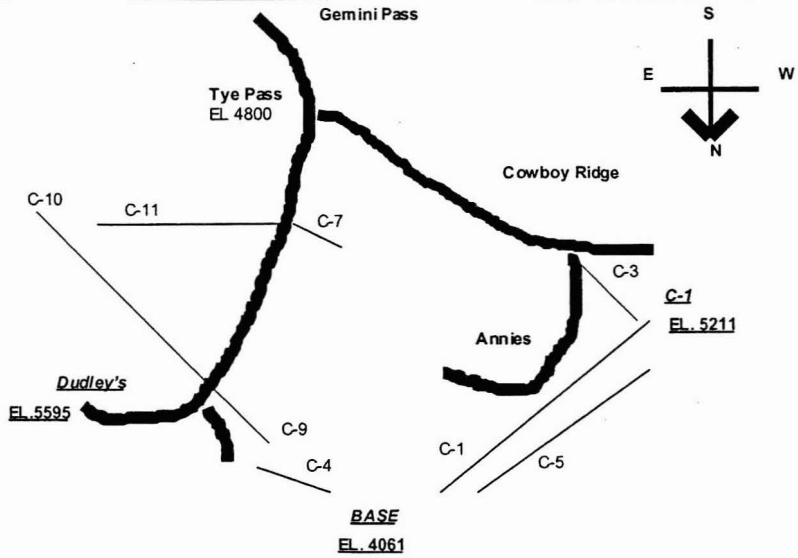
	LOW	MOD	CONSIDERABLE	HIGH	EXTREME
Settlement	20%	10%	5%	0%	
24 Hour	7-10"	11-15"	16-25"	26-30"	30+
12 Hour	0-6"	7-10"	11-15"	16-25"	25+
Temp-Trend	26o	26-30o	30-31o	32-36o	Rain on Snow
Winds	0-10	12-18	20-30	30-50	50+
Intensity	.08	.10th	.11-18	.20hr	.30-.40 hr
Density	5%	6-10%	11-18%	20%	Rain
Layering	LOW	MOD	CONSIDERABLE	HIGH	EXTREME
Natural Activity	LOW	MOD	CONSIDERABLE	HIGH	EXTREME

In the following example, the avalanche potential category most consistently represented is MODERATE: 1-6-98

PARAMETERS	AVALANCHE POTENTIAL
1) Settlement	Low
2) 24 Hour	Considerable
3) 12 Hour	Moderate
4) Temp-Trend	Moderate
5) Winds	Low
6) Intensity	Moderate
7) Density	Considerable
8) Layering	Moderate
9) Natural Activity	Low

INFORMATION GIVEN TO CONTROL PERSONNEL ON AN OVERHEAD

Date: _____ Time: _____ Forecaster: _____



C-7 WIND

W-DIR_____

W-MAX_____

W-AVG_____

C-1 WIND

W-DIR _____

W-MAX_____

W-AVG._____

C-1

24 HR_____

12 HR_____

STORM_____

DENSITY_____

WATER_____

INTENSITY_____

TOTAL_____

BASE

24 HR_____

12 HR _____

STORM_____

DENSITY_____

WATER_____

INTENSITY _____

TOTAL_____

C-7 TEMP

H_____

L_____

CURRENT _____

C-1 TEMP

H_____

L_____

CURRENT_____

BASE TEMP

H_____

L_____

CURRENT_____

SETTLEMENT_____

AVALANCHE FORECAST:

WEATHER FORECAST:

34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2

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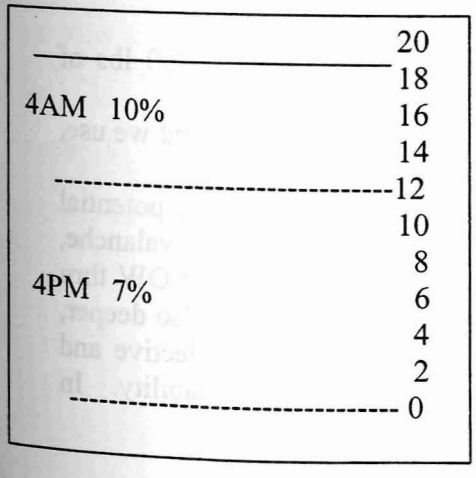
Spending more and more time in our study plots over the years we have tried to see what relates to what we might find out on the hill. What kind of information is important and applicable to avalanche potential?

For the past two seasons we have taken three of our weather and snowpack variables and studied them more in-depth. They are Wind, Temperature-trends, and Layering structure.

WINDS- Being on the crest of the Cascades,and on a pass, we see only a few times a season winds coming from one steady direction. General prevailing winds are from the west. These winds can swing from SE, SW, NE, and NW, with an easterly flow through the pass. In general, we find that for critical wind speeds that have a spread between the average WS and maximum WS of 15-20 MPH or more, we downgrade by one on the potential forecast.When ever the spread is high enough the gusty or maximum tends to pocket the snow instead of forming large, even slab in an avalanche path. Also, the high, gusty winds tend to come from different directions,further pocketing the snow. On the 24HR telemetry read out we look for WS and WDs that have WS of less than a 15 MPH spread between the average and maximum, for estimating loading potential.

LAYERING STRUCTURE- By looking at the 12 HR and 24 HR interval stakes in the study plots, we can pick out the layering structure of the new snow. We also have a storm stake for additional information about older layers during a storm cycle. What we find on the interval stakes can be comparable to what we find out on the hill. You can shine a flashlight through the interval stakes and see the density changes, a function of temperature, wind, intensity and settlement. Tilting the board and tapping enables you to look for shear planes. In general,concerning new snow layers, we find if the depth of the weak layer equals or exceeds the depth of the slab we down grade by one. It seems the slab in this situation is not under enough tension to propagate failure over a large area, the slab seems to be sitting on a larger cushion that can accept more stress. If more than one layer is evident on the stake, it seems more stress is needed to initiate slides in the total new snow. If the snow on the stake has a consistent density throughout the total new snow and it tends to react as one, the rating is HIGH for the layering structure category. We also follow the layering structure in storm cycles in the older layers in our study plots, and apply this information to what is going on out on the hill.

Example: 12-15-99



In the following example the depth of the weak layer exceeds the depth of the slab. The avalanche potential forecast was for CONSIDERABLE, which means, we were approaching the point of natural activity. Explosive and skier release avalanches were likely but only in the top 6-8" of snow. A clean shear was evident at 12". We felt there was a good bond across the previous 24HR snow layer. Little wind was present but there was a temperature trend that went from 22o to 31o in the last half of the snow fall period. On control 6-8" soft slabs were released.

TEMPERATURE-TREND- Temperature is one of the most important factors I look at for avalanche potential. The temperature-trend over a 12 HR and 24 HR period gives us an idea of the layering structure, settlement and bondability. We can see rapid changes in temperature over short periods of time. Observing temperature over time, we seem to notice a difference in snow structure, snow formation, bond and density. If the temperature is 26o or less the avalanche potential rating for temperature is LOW. 26o seems to be a good cut off point for temperature related snow. If the temperature is below 26o we tend to see lower density snow and less riming. When the temperature is above 26o we see higher densities and more riming occurring. In temperatures of 30-31o we see a difference in the new snow approaching the point of natural activity. Because of the inversions we can see at Stevens Pass it is good to have a temperature profile over elevation and distance due to east or west flow. Because of the inversions it does on occasion snow between 32 and 36oF. Looking at a temperature profile it is interesting to pick out the layering structure on the interval stakes. Even in the absence of wind, temperature plays a big role in slab formation.

In using these kinds of programs for avalanche control purposes, I have noticed several things. Giving as much information to our avalanche control people about snowpack and weather conditions, prior to avalanche control, as well as following these throughout the season, we find people learn more quickly and we developed a person going out on an avalanche control route that can make better forecasting decisions on their route. Knowing the avalanche control route intimately, slope angles, aspects, path histories, elevation differences, and how they can react under various conditions, then applying our nine weather and snowpack variables,gives a team member a road map. It helps to tell you where you need to go on your route,and what paths you might want to look at.

All nine of these weather and snowpack variables work together in upgrading or down grading avalanche potential. I don't think you can take just one factor and assess avalanche potential, they all need to go together. The avalanche potential graph shown here is specific to our area. I think it would work in other areas with more or less weather and snowpack factors that are specific to your area but in order for this particular graph to work there needs to be an uneven amount of factors. The variation within these factors needs to be wide enough to accept a variety of conditions.

In the mid 80s there were 115 avalanche paths mapped at Stevens Pass. 182 lbs of explosives were used on the average on a control mission.

In the late 80s thru early 90s 230 avalanche paths were mapped. 450 lbs of explosives were used on a full control mission on the average.

Now, mid 90s through current, we have 230 avalanche paths mapped and we use, on the average, 150 lbs of explosives on a full control mission.

We tend to use more explosives on LOW and MODERATE avalanche potential days than on CONSIDERABLE thru HIGH days. Looking through avalanche, weather and snowpack data it seems avalanches are harder to initiate on LOW thru MODERATE days because of cooling trends and high gusty wind events, also deeper, denser slab is evident in some situations were ski cutting might be ineffective and dangerous, more explosives are used in these situations to test snow stability. In

CONSIDERABLE thru HIGH days the snow seems to be more sensitive and easier to release also in HIGH situations natural activity is likely.

Explosives are only one of the tools we use to assess avalanche potential along with ski cutting, rutschblocks,weather and snowpack observations.

In Most situations we look at and assess the snow conditions in three ways. One, we go to our study plots and look at various snow parameters. Two, we look at the telemetry data and compare. Three, we go out in the field and apply this information and see what the avalanche potential is and how comparable it is to our measurements.