using wind direction-dependent pattern maps from the model as objective aids. Isohyets on these pattern maps were calibrated using forecast values of wind speed, moisture depth, duration and areal coverage, and cloud temperature. Skill scores for 24 hour quantitative precipitation amounts ranged from 0.55 to 0.67.

8.2 Conclusions

From this study a number of conclusions can be drawn and these are listed below.

1. It has been demonstrated that it is feasible to assess the average magnitude and the inter-season variation of topographic effects on winter season precipitation in the mountainous section of Colorado using only routinely available upper air information, a fine mesh topographic grid, and a simple orographic precipitation model.

2. Computations of model volume precipitation over various watersheds in the study area show strong positive correlation to observed spring and summer runoff. This has led to the substantial potential for providing input to hydrologic process models for streamflow forecasting, especially for watersheds of greater than 150 square miles. This input could consist of computed areal and temporal distributions of winter precipitation using only routinely available upper air data as soon as it is collected.

3. The employment of model wind-direction dependent pattern maps of precipitation as objective aids to quantitative precipitation forecasting in mountainous areas is quite useful and should be continued.

and compared to observed spring and summer runoff from watersheds of varying size. Correlation coefficients between seasonally-summed model watershed precipitation and observed runoff range mainly between 0.75 and 0.94. On a daily basis large discrepancies between model and observation sometimes exist, but model frequency distribution of daily precipitation totals appears realistic.

A 13 year model mean precipitation map was found to agree quite well in mountainous areas with an isohyetal map constructed by ESSA of the U.S. Department of Commerce using precipitation and snow-course data with empirical correlation to topographic features. The model underestimated broad valley precipitation in most cases.

Test quantitative precipitation forecasts (QPF's) were made (and communicated daily to the U. S. Forest Service) from November, 1975, to March, 1976, using wind direction-dependent model pattern maps as objective aids. Isohyets on these pattern maps were calibrated using forecast wind speed, moisture depth, duration, cloud coverage, and cloud temperature. Skill scores for 24 hour QPF's ranged from 0.26 to 0.67.

The derived method has utility (a) in assessing the average magnitude and the inter-season variation of topographic effects on winter precipitation in western Colorado and (b) as an objective aid for quantitative precipitation forecasting. It has substantial potential utility as input to hydrologic process models for streamflow forecasting. The basic approach should be transferable to other topographically complex areas which are dominated by stratiform precipitation.

Jenn Owen Shen
Department of Atmospheric Science
Colorado State University
Fort Collins, Colorado 80523
Summer, 1977

4. The basic model should be transferable to other mountainous areas which are not dominated by convective precipitation. Parameter re-calibration would be required depending on such things as latitude, altitude, terrain scale-size and micro-physical characteristics of the moist air masses.

5. Historical orographic precipitation computations using real upper air information as model input require correctors for humidity sensor lag if meaningful model results are to be obtained.

8.3 Model Utilization Suggestions

Model patterns of precipitation are sufficiently realistic to suggest several immediately useful applications. Some of these are briefly discussed below.

First of all, the skill scores attained from the 1975-76 winter of test quantitative precipitation forecasting (QPF) are sufficiently high to warrant the construction and use of model pattern maps for QPF also in other topographically complex areas as well as the continued use of the method for Colorado.

A second endeavor which would likely yield useful results would involve the interfacing of this orographic precipitation model to models of hydrologic processes and blowing snow to obtain runoff estimates. Snowcourses and precipitation gauge data for adjusting the model volume watershed precipitation should be incorporated in the method, while then using the adjusted precipitation model output to define the areal relative distribution of precipitation over the watershed. Adaptation of the blowing snow model by Schmidt (1972) for use with interpolated winds aloft

data is recommended as a technique for estimating sublimative water losses from blowing snow in the alpine zone.

The combined usage of the orographic precipitation model and a blowing snow model naturally suggests the incorporation of the resulting output into an avalanche dynamics model currently being developed by the U.S. Forest Service. Related to this, but more empirical in nature would be a climatological study of the model-indicated frequency of conditions conducive to avalanche occurrence utilizing model precipitation and upper air wind information.

Historical upper air information concerning previous record point snowfalls could be input to the model for the construction of maps of "project snowstorms", an exercise which should be useful for structural planning purposes.

The gridded arrays of model output for each wind direction would be immediately useful for identifying widely separated points having a high degree of correlation between their precipitation values over a wide range of wind directions. Such information could be utilized for selection of precipitation measurement sites for use as weather modification target and control areas. The technique could also be employed to strategically locate gauges in a hydrometeorological network to maximize the information gained from a minimum number of gauges.

With adequate spatial and temporal resolution of upper air soundings, model output would be a quite useful data set for direct use as a covariate (equivalent to a control area precipitation station) for reducing the unexplained variance in weather modification target area precipitation and thus minimizing the required duration of the experiment for obtaining meaningful results.

Finally, the rather dramatic visual and quantitative depiction of terrain shadowing effects in model output suggests that qualitative insight into the possible downwind effects of weather modification might be gained from a series of model sensitivity tests employing spatially variable precipitation efficiency values.

While results from this simple approach to the orographic precipitation problem are encouraging and point to its immediate utility for certain purposes, limitations inherent in both the model simplicity and in the input data should be kept in mind. Based on this study and those of several other investigators referenced herein, accuracy limits even with adequate input data for computing precipitation over periods of 6 hours or less should be near a value of 0.7 for the correlation coefficient between model and measurement. Summation of these short period computations over 24-hour periods might attain a correlation coefficient of approximately 0.8. Seasonal summations can be expected to attain peak correlation of near or just slightly above 0.9.

Accuracy beyond that stated above will likely require (1) consideration of three-dimensional effects on airflow, (2) markedly improved knowledge of precipitation efficiency, (3) improved parameterization of meso-scale banded precipitation phenomena, and (4) better temporal and spatial resolution of upper air moisture profiles.

8.4 Recommendations for Further Research

Continued pursuit of the problem of seasonal orographic precipitation estimation is recommended along the lines discussed in this study. In particular the implications from Section 7.4.3 suggest an attempt to quantify effects from (a) terrain funneling, (b) ridges aligned with the wind, or (c) isolated peaks might be profitable. Objective precipitation

corrections for these effects might logically be sought by comparing the fields of either horizontal perturbation velocity or vertical motion obtained from a three-dimensional flow model to those from the current computation scheme.

The regression relationships obtained between total precipitation and observed runoff should be tested for stability for several subsequent years. In particular tests should be made using data from any available extremely dry or wet years.

Also, it would be instructive to test the approach for other areas including topographically complex coastal locations by application again.

Much more effort should be expended to understand the nature of and quantify precipitation efficiency.

An attempt should be made to fine tune the model to even finer resolution topography. This should include testing the model topographic grids with resolutions of one kilometer and 2.5 km. The trajectory subroutine of the model should be retained for this research. Empirical fine-grain solutions could then be sought by developing correction factors for current model output by comparing model and actual station elevations and precipitation. These correction factors might then be useful over a limited area to estimate precipitation on the sub-grid scale.

Finally, the model should be coupled with an appropriate water balance box model such that the moisture budget over the box volume quantity precipitation minus evaporation rate and orographic model is utilized to locally deliberate the precipitation. Extensive usage of interpolated upper air temperature, wind, and humidity data should be made in this study not only for model corrections but also

to test the utility of these interrelated data for developing relations to indicate periods of high mountain evaporation through both blowing snow sublimation and from the stationary snow cover. Insight into the areal and temporal distribution of evaporation should be one outcome of this research.

The extreme short period variability of relative humidity profiles observed in this study suggests the need for additional research into the causes for such with end goals of (a) arriving at improved ways of considering the effects of mesoscale banded structures (including convection bands) and (b) a determination of the minimum sampling frequency of upper air moisture fields required to significantly improve precipitation estimates.

U. S. SKI ASSOCIATION - ALASKA DIVISION

RESOLUTION

STATE-WIDE AVALANCHE WARNING SERVICE IN ALASKA

WHERE AS:

The U. S. Ski Association-Alaska Division, a non-profit organization for the promotion and development of Alpine and Nordic skiing and comprising of 750 members, is vitally concerned for the safety of both their members and non-members participating in these sports, and

WHERE AS:

Snow avalanche hazards in Alaska have resulted in the highest number of avalanche fatalities in the Nation since 1970, and

WHERE AS:

More than 500 human habitable structures are directly exposed to avalanches in addition to 180 avalanche paths crossing public highways and railroads and thousands of avalanche paths within heavily used developed and undeveloped public recreation areas, and

WHERE AS:

the establishment of a State-wide avalanche network is needed in order to alert our State citizens to changing snow conditions and to inform outdoor use of related avalanche danger, and

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WHERE AS:

the establishment of a State wide avalanche network is needed in order to alert our State citizens to changing snow conditions and to inform outdoor use of related avalanche danger, and

WHERE AS:

such a network could provide important supplemental benefits for flooding and fire weather forecasting, and mountain weather forecasting for mountain climbers, and thus resulting in a year-round life and property saving service to all our citizens.

THEREFORE BE IT RESOLVED:

the U. S. Ski Association - Alaska Division urges the State of Alaska Legislature to provide financing for a cooperative State-wide Avalanche Warning Service in Alaska, and

BE IT FURTHER RESOLVED

that such a service should involve State and Federal Agencies, Municipalities and private enterprises for the purposes of a jointly financed and operated Alaska Avalanche Warning Service.

ADOPTED BY, the U. S. Ski Association - Alaska Division at their annual meeting on 12 May 1979.

_____

SAM HAYES
President - USSA - Alaska Division

Climber Killed By Avalanche In Alaska Range

A Japanese mountain climber was the victim Wednesday of the first climbing fatality of the season in the Alaska Range, but his death was not reported until Friday when his partner reached a landing strip on the southeast fork of the Kahiltna Glacier.

Dead is Masamitsu Urayama, 29.

Yutaka Shinohara, 40, is the partner who survived. He was taken to Providence Hospital and has been released.

Both were members of Shizuoka Climbing Club of Japan.

McKinley Park rangers said today they did not know what city in Japan the men are from.

An avalanche caught the climbers as they were descending the west ridge of Mount Hunter, which is just south of Mount McKinley in Denali National Monument.

The two had just completed a difficult route on the north face of the 14,573-foot peak, said Bob Gerhard, spokesman for the National Park Service.

"This is probably the first fatality ever on Mount Hunter," Gerhard said.

Shinohara was flown to Talkeetna and then to Anchorage Friday for medical attention. He had an apparent knee injury, lacerations and bruises, Gerhard said.

The victim's family, the surviving climber and National Park Service personnel "will have to make the decision on retrieving the victim and then decide whether it will be possible, practical or desirable," Gerhard said.

Park Service personnel are not sure of the exact location of the body, he said.

THE PRECEDING PAGES WERE TREATED AS
A UNIT IN THE ORIGINAL FILE.

THE FOLLOWING PAGES WERE TREATED AS
A UNIT IN THE ORIGINAL FILE.

Alyeska RESORT

P.O. BOX 249 GIRDWOOD, ALASKA 99587

January 27, 1980

The Honorable Mike Miller, Chairman
House State Affairs Committee
Alaska State House of Representatives
Pouch V
Juneau, Alaska 99811

Dear Mike:

Bob Janes of the U. S. Forest Service in Juneau recently briefed me on the legislation pending before your committee regarding avalanche forecasting and control program funding. I certainly appreciate your active participation in getting such a program run on a professional basis statewide.

I had planned to testify last Monday via telecon before your committee from the Anchorage legislative office; however, the Seward Highway was closed due to avalanches, and I was unable to get through. As you have probably heard, the Highway was closed from Thursday, January 17 through Wednesday, January 23. Several cars were hit and a train derailed when it could not stop in time to avoid hitting one of the slides.

I have enclosed a letter and picture which I sent Commissioner Ward regarding the avalanches on the Seward Highway last spring. This slide cost the Highway Department over $60,000 to clean up. I am sure the cost of regular control work which would have brought down the snow before it had a chance to build up would have been far less costly.

Alyeska Resort is willing to participate in such a program to help in the scientific evaluation of avalanche hazards in this region. The resort itself has had an extensive control program for many years for the ski slopes and in recent years has spent approximately $75,000 per year to keep the slopes safe for skiers. Because the Department of Highways is not fully funded or prepared to undertake a regular control program, we have loaned them two of our four 105mm rifles.

Naturally, I feel this program is absolutely essential. It would be desirable for funding to be retroactive to this winter season and go through

1981; although, I feel the amount recommended is conservative especially if the program is to be successful on a statewide basis.

Bob Janes and I both agree that the agency of the State that would best be suited to be responsible for the program is the Department of Public Safety.

Mike, I appreciate your getting this going in the House. Although I do not know who will spearhead this program in the Senate, I have sent a copy of this letter to Senator Colletta who represents this district. He has been very helpful in getting a control program going and is well versed on the subject as it pertains to this area.

If I can be of further help, please let me know. I would be willing to come to Juneau and do whatever necessary to get the funding for this program approved.

Best regards,

Chris von Imhof
Vice President and General Manager

CVI/bbp
Attachments 2

Copy to Senator Mike Colletta
Mr. Bob Janes

GIRDWOOD
BOARD OF SUPERVISORS

P.O. BOX 249
GIRDWOOD, ALASKA 99587

PAT ARSHER
DANA BROCKWAY
HAROLD CASEY
SUVELL FAULKNER
CHRIS VON IMHOF, CHAIRMAN

MUNICIPALITY OF ANCHORAGE
GEORGE M. SULLIVAN, MAYOR

April 13, 1979

Mr. Robert Ward, Commissioner
Department of Transportation and
Public Facilities
Juneau, Alaska 99811

Mr. Robert Dorsey General Manager
Alaska Railroad
Pouch 7-2111
Anchorage, Alaska 99510

Gentlemen:

As a result of the recent major natural (uncontrolled) avalanches over the Seward Highway between March 23 and March 25, the Board of Supervisors felt an inquiry should be made into why it happened and what was done or not done to prevent the occurence.

We solicited reports from three avalanche experts who were directly involved in the follow up avalanche control. The experts are Tom Miller and Jim Hackett, Snow Rangers for the U. S. Forest Service; David Hamre, Avalanche Technician for Alyeska, the third most avalanche prone ski area in the country; and Doug Fessler, Chief Ranger, Chugach State Park. Their findings and recommendations are enclosed.

For decades the tremendous avalanche hazard between Bird and Girdwood has been acknowledged. Various experts over the years such as Norm Wilson of California and Art Judson of the U. S. Forest Service in Colorado, have been consistent in their recommendations that the area be controlled regularly.

Last year several natural avalanches covered the Seward Highway and concern was expressed at that time about safety of the highway given the sporadic control work done by the Department of Transportation. A meeting was held last February, and I felt the outcome would result in a coordinated preventative avalanche control program between the DOT and the Alaska Railroad. Apparently this did not happen.

Speaking as the General Manager of Alyeska Resort, we have been forced to become well-versed in all aspects of avalanche control techniques and consequently I feel qualified to recommend such a program be undertaken in earnest by the DOT and the Railroad before there is loss of life and property.

It is common opinion that it was only a matter of luck that no one was injured or killed in one of these natural releases. I know that three people narrowly escaped death - two from the Department of Highways in Girdwood and a Municipal inspector. It is providential that the highway was closed for construction (Potter South Project); however, the releases occurred within an hour of the road reopening.

Systematic preventative control work would have gotten the snow down as it accumulated before the accumulation was so heavy that the resulting slides covered the highway and railroad tracks. Besides alleviating the danger to life and property, a control program would have saved the considerable cost of clearing the snow off the highway. In addition, the huge climax slides cause heavy damage to the soil and therefore increase the likelihood of mud slides during rainy seasons which are also expensive to clean up.

The DOT does have a few dedicated employees with the basic knowledge of avalanches; however, either because of budget restrictions or other duties or lack of authority, they are not able to monitor the avalanche conditions on the highway consistently enough to provide reliable control. We are also concerned that the DOT does not have the necessary rifles, equipment, blind firing data, or commitment to do helicopter control work or whatever is necessary to keep the slides from reaching the highway.

Should a fatality occur as a result of an avalanche across the highway or railroad tracks, the DOT most certainly would be held responsible. Given the information already compiled on avalanche conditions, under most circumstances, it could not be considered an "Act of God."

We feel the taxpayers would not object to spending extra money to keep the Seward Highway safe for travel in the winter. We hope you will study these reports and are persuaded to budget for a more comprehensive avalanche control program for this coming year.

Speaking again as the General Manager of Alyeska Reosrt, one business that lost an estimated $70,000 over that weekend in March, the Resort stands ready to assist the DOT and the Railroad with manpower and artillery on a contractual basis.

The Board of Supervisors would like to ask the DOT and the Railroad how they intend to handle the avalanche problem on the Seward Highway for the 1979-80 winter season. By copy of this letter we would also like to request our State and Federal representatives to support the DOT with the necessary budgetary authorizations.

Sincerely yours,

Chris von Imhof
Chairman

CVI/bbp

Copy to Governor Jay Hammond
Mr. Mike Colletta, State Senator, District I
Mr. Ray H. Metcalf, State Representative, District II
Ms. Joyce Munson, State Representative, District II
Mr. Ted Stevens, U. S. Senator, Alaska
Mr. Mike Gravel, U. S. Senator, Alaska
Girdwood Board of Supervisors

INTER-OFFICE CORRESPONDENCE

Alaska Airlines

DATE 4/3/79

SUBJECT Avalanche problems on the Seward Highway

TO Chris Von Imhof

FROM David Hamre
Avalanche Technician

In response to your recent request to document the recent avalanche activity on the highway, and provide some recommendations for improving the control program, I have written a summary of weather and avalanche occurence here for the past month, a chronology of events on Bird Hill and other selected areas, a short summary of the methods used in two other transporation corridors, and a list of what I feel to be the most important areas that need attention in the D.O.T. control program. The list of recommendations could include numerous less important suggestions, but I have left these out in order to emphasize the importance of the six suggestions I made.

It is an unfortunate fact of life that problems are not often recognized until a major disaster occurs, hopefully my efforts here will help to persuade a far-sighted individual or group to act now, rather than react later when the effects of the current program become catastrophic, as they surely will.

Every year the amount of traffic on the Seward Highway increases, raising the chances of an accident. As has been the case in every other avalanche-threatened transporation corridor, economics will some day dict te that the avalanche problem here be dealt with on a far more active basis.

In spite of the lack of traffic on March 23rd, I still think we were very lucky that no one was caught in the avalanche activity. Let us both hope we don't have to rely on luck any more.

Alyeska RESORT INC.

4/3/79

WEATHER AND AVALANCHE SUMMARY ON MT. ALYESKA
prior to avalanche cycle of March 20-25 on Seward Highway

Weather - Late January- moderate depth and temperature snowpack
February 2- 5 inches of light new snow followed by 4 hrs of freezing drizzle.
February 3- Temperatures had been running in the high teens for lows and high twenties for highs for all of January making the snowpack somewhat uniform in temperature at 26-28°F. Then on Feb.3 a cold front came in dropping the temperature below 0°F. for several days, moderating to highs in the 4-7°F. and lows below 0°F. till mid-February.
February 4- Strong surface hoar formation above and depth hoar formation below the ice lens caused by the freezing drizzle on Feb. 2. Very steep temperature gradient between snowpack and air would normally form surface hoar, but ice on the surface of the snowpack is prohibiting necessary vapor transfer above, so vapor transfer is occuring just below ice lens.
February 6- Snow below ice lens now looking like begginning T.G., poorly sintered
February 9- T.G./ice lens layer of snowpack has now developed to the point that a notation is made in daily weather and snowpack summary that this layer could produce large avalanches when given a rapid load of new snow.
Mid-February- Highs moderating to mid-teens, lows around 5°F.
Late February- Highs moderating to mid-twentys, lows around 10°F.

There was no precipitation from February 3 to March 3, then four storms followed in March as follows:
March 3- March 6 Storm#1 onto the T.G./ice layer
March 7- March11 Storm#2
March 13- March 17 Storm#3
March 18- March 23 Storm#4

Storm #	1500' elevation snowfall/Water equiv.	2,200' winds	3,000' snowfall/water equiv.
1	23"-2.25"	130[illegible]5m.p.h.	22"-2.68"
2	24"-2.55"	130[illegible]20m.p.h.	23"-3.85"
3	42"-3.64"	240[illegible]5m.p.h.	42"-4.73"
4	62"-6.22"	130[illegible]10m.p.h.	74"-8.85"
Totals	151"-14.66"		161"-20.11"

Avalanche- March 5-Significant avalanching starts at Alyeska with some natural releases and many paths reacting to control work- up to 2' fractures.
March 9- More loading causes slightly larger avalanching with average fracture depth around 2' and one fracture 3' deep. Inspection of the three foot fracture reveals that the snow had run on the T.G. crystals just below the ice lens caused by freezing drizzle.
March 13- Larger fractures appeared with good releases on almost all shots. Many areas of instability were cleaned out and most run-outs were far short of what they would have been had we allowed the snow to stay put for the next storm.
March 15-18 Lucas (D.O.T.) informed that there could be a serious instability on Bird Hill. Fracture size at Alyeska is dropping off in general, indicating that many places have avalanched off the T.G./ ice layer. Occasional large fractures to 5' are still

occuring indicating there is a probability that the unstable T.G./ice layer still exists in large pockets.
March 20-21 Many new snow avalanches but only occasional large releases from control.
March 22- Extreme loading from last storm has brought many remaining T.G./ice pockets to critical levels causing large natural releases in the backcountry, and onto the highway during the past 48 hrs. Several large releases occured on the 22nd on Alyeska, one of these went 2' below the T.G./ice layer into old T.G. 2 feet above ground. Fracture profile from North Face reveals 60" -86" depth with 13.75" of water content.

As early as February 9 we felt that we would see large avalanches on the T.G./ice layer so that when the precipitation arrived we made an attempt to do continuous control work in an effort to bring down the accumulating snow in small quantities. These efforts were reasonably succesful in keeping the size of the avalanches smaller than could have been expected had we allowed the hazard to build.

David Hamre, Avalanche Technician

Alyeska RESORT INC.

CHRONOLOGY OF AVALANCHE EVENTS ON BIRD HILL MARCH 20-28
and other selected areas

March 20 Natural avalanche at SP 15½ closes road all night. Road buried 300'x20'

March 21 Visual fire on SP19 and 20 produce one avalanche that crosses road in the morning burying road 80'x20'. Road crew cleans debris from avalanche of night before and control work, opening road approx. 10 A.M.
4 P.M. Intense storm causes natural release at 106 mile, first time since earthquake of 1964 that this avalanche had reached the road.
7 P.M. Natural release at 93 Mile closes road for night, two other natural releases occur shortly after.

March 22 6 A.M. Road crew goes to work clearing debris from avalanches of night before. Storm abating somewhat. Road open at noon. Blind fire on Whiskey in afternoon produces another avalanche that crosses highway. By evening the storm has let up considerably.

March 23 6 A.M Cloudy weather in early morning, D.O.T. gun crew decides to go to Hatcher Pass for control work.
8 A.M. Rapid clearup followed by warm breeze and sunshine.
1:15 P.M. First large natural release onto highway reported at Alyeska by skiers on hill. This avalanche was probably Bird Hill Left (SP9-12) burying road approx. 2,000'x20'. Triangulation of debris shows that the snow ran 550 yards into the inlet, giving an indication of the velocity involved.
1:17 P.M. Another major release goes well out into the inlet, this one probably Bird Hill Right (SP13 and 14)
1:18 Large natural avalanche hits highway near Whiskey
1:19 Tom Miller blocks traffic at Girdwood end.
1:20 Phone call from Alyeska to Bird catches Doug Fessler who stops traffic in Bird. Quick action in blocking the highway at both ends could well have saved some lives as several more large avalanches occured until approx.
2:30 P.M. Miller and Hamre had immediately suggested an aerial reconnaissance to determine if anyone had been in the avalanches. It is still not clear to them whether this was ever done.
3:00 P.M. Larry Daniels gets approval from Lucas or Morrow, D.O.T., to get a helicopter bombing mission together in an effort to make the road safe for highway crews to go to work clearing debris.
5:00 P.M. Helicopter bombing crew flies out to highway observing for people, cars, etc. before starting bombing mission. Observations show that approx. 40% of the release zones had avalanched naturally, leaving a tremendous amount of snow still to come down. Natural activity had already buried the road in about ten places, with about 1½ miles of debris averaging 10 ft. in depth. Control work is mandatory to insure safe conditions for road clearing operation. Helicopter lands on highway about ½mile beyond Bird Hill where D.O.T. control team has set up for firing. D.O.T. crew fires one round bringing a major avalanche out of SP8 and 9 that covers road approx. 400'x20'. The velocity of the avalanche when it hit the road was about 100 m.p.h. with a throw out of debris to 50 ft. high and a dust cloud to 200 ft. Several mature cottonwoods were seen flying through the air, with the debris coming to within 100 yards of the gun position. Lucas joins bombing team in helicopter while gun crew pulls back to safe position on Bird Point. Helicopter bombing commences at Girdwood end of Bird Ridge, and proceeds west to SP 6. The first mission uses 40 hand charges, placing approx. 32 effectively, and releasing another 4 major avalanches that went into the inlet and 10 that reached the road in addition to some smaller ones that did no reach the road. Aerial recon indicates that many of the chutes on the ridge had not released, particularly on the Girdwood end. Lucas decides to make up remaining explosives and make another pass. The second mission takes off at 6:30 and uses 6 charges, releasing one more

major avalanche and 5 smaller ones that stop just short of the road. Operations are suspended because of darkness.

March 24 6 A.M. Road crews go to work clearing avalanche debris from highway. Approx. 80% of the release zones had run yesterday leaving only a moderate hazard on Bird Ridge. Decision made by Lucas to shoot avalanche paths above Peterson Creek with Alyeska 75mm and use these observations to determine if more helicopter bombing is necessary on Bird Ridge. Bird Ridge has S.E. aspect and Peterson Cr. S.W. No results from test firing. Road crews work all day to clear avalanche debris. Helicopter bombing late in afternoon of ski slopes used by Far North Ski Guides Inc. releases a slab avalanche in Glacier Cr. with an 8 ft. fracture, and another in Winner Cr. with a 12 ft. fracure, both on southerly aspects.

March 25 6 A.M. Road crews again at work clearing debris from highway. By 2 P.M. using 16 pieces of machinery they have cleaned the road up to allow for a normal flow of traffic, and the road is once again opened. At 1 P.M. test firing is done on slopes adjacent to Bird Ridge with several large releases occuring. On the basis of these results Lucas decides to once agin helicopter bomb Bird Ridge in an effort to clean out all the remaining unstable pockets. Helicopter takes off at 3:30 P.M. to place 30 charges on the ridge. 29 charges are placed effectively producing one more large avalanche that crosses the highway, and several that stop just short. Road is closed from 3 P.M. to 6 P.M. for bombing and clearing debris.

By the end of the last Helicopter bombing mission approx. 90% of the hazard area that overhangs the 3.8 miles of highway from the west end of Bird Hill to the railroad crossing in Girdwood had released. The few chutes that did not release could well have been the ones that ran naturally early in the storm. Avalanche debris averaged 10 ft. in depth with a maximum of 40 ft. for a length of 2.2 miles of the 3.8 miles of highway in this section. SP 6 also released onto Bird Flats, bring down several 400 yr. old trees. There was a total of 35 avalanches on Bird Hill and 7 others on Bird Flat.

March 27 An earthquake measuring 2.9 on the Richter scale occured at 8:39 A.M. with an epicenter 12 miles S.E. of Girdwood. Numerous avalanches occured in California Cr. and Virgin Cr., one of which the fracture line was estimated to be two miles in length involving slopes of north, west, and south aspect, indicating that an unstable condition still exists in the snowpack.

March 28 Helicopter bombing for powerline problem areas releases another large avalanche with fracture depth of 6-8 ft.

March 29 Helicopter bombing for Railroad gets no results/

Alyeska RESORT INC.

4/3/79

AVALANCHES ---
MODEL FORECASTING AND CONTROL

Historically speaking, transportation corridors that are threatened by avalanches and show an increase in traffic every year find it economically necessary to establish a comprehensive control program to avoid property damage and loss of life. With the present control program on the Seward Highway, it is just a matter of time before there are severe losses of life and property. The problem is complex because of the interaction between politics and a natural phenomena, but there are several possible solutions that would greatly reduce the chances of an accident happening, and increase the reliability of the transportation corridor. For any solution to work, however, there must be a cooperative venture between the railroad and highway.

There are two transportation corridor control plans that we can look to as models for establishing a comprehensive solution to the problems here. The first and probably foremost is Rogers Pass in central British Columbia. There is no other pass available to transcontinental traffic for 400 miles north or south, so economics have fostered an awareness of the avalanche problem from the start. During construction numerous snowsheds were built in areas that frequently avalanche along both the highway and railroad. Weather data is fed to a main center from several mountaintop remotes and two other manned stations. Forecasting is done by a conventional method; when a storm reaches a critical level so that avalanches are expected on the road or rail, a gun crew is called in to fire on the places that are felt to be a problem. Blind fire data is kept and used when necessary on all shots. Crews are on call 24-hours a day, and shooting is done during the critical periods of instability, with temporary closures of an hour or so for control work to be done. Every attempt is made to control the avalanches while they are small, with the realization that the manpower and money for this is, in the long run, cheaper than large clean-up efforts after major avalanches and loss of the use of the transportation corridor. Natural avalanche occurances onto the highway or railroad is a very rare occurrence, as the intent of any control program is to reduce the odds of a natural avalanche occurring that will cause loss of life or property damage.

Another example of a highway control program is in Little Cottonwood Canyon, Utah. There are two major ski areas at the end of the nine mile road, with an average of 4,000 cars per day crossing underneath the 21 major avalanche paths. One hundred and ten avalanches cross the highway on an average year. As in Rogers Pass, storms are allowed to build up to an unstable condition short of naturally releasing, then the road is closed temporarily for firing from fixed mounts at three different locations. Firing is commonly done from all three mounts simultaneously. The intent again is to release the snow under controlled circumstances, with small enough avalanches to hopefully stop short of the road. Occasionally a large storm will occur with an instability deep in the pack that necessitates closing the road for a longer period of time. Forecasting is done utilizing conventional methods, with two mountaintop weather stations; and control work is done in the ski areas on similar slopes and aspects, providing basic input.

(continued)

Briefly, these are the methods used in two highly regarded transportation corridor control programs. Perhaps an examination of these compared to the Department of Transportation's program here could bring a revision in procedures to reduce the hazard to life and property.

Comparison Chart
Avalanche Control

Description	Rogers Pass	L.C. Canyon	Department of Transportation
Fixed Mounts for Gun Positions	Yes	Yes	Some
Blind Fire Data on all Shots	Yes	Yes	Blind Fire on SOME Shots
Capability to Shoot at Night	Yes	Yes	Onl w/Existing Blind Fire .ata
Instrumentation	Yes	Yes	Fu Is Pending
Qualified Forecaster w/only Responsibility Hwy. Control	Yes	Yes	Not Sole Responsibility
Study of Snow & Snow Pack in Release Zones	Yes	Yes	No
Emergency Rescue Procedures for Crew & Pub.ic	Yes	Yes	Speed of Rescue in Doubt
Closures before Natural Activity	Yes	Yes	Rarely

* * *

Dave Hamre, Avalanche Technician

DH:bjb

Alyeska RESORT INC.

4/3/79

RECOMMENDATIONS FOR D.O.T. AVALANCHE CONTROL PROGRAM

For any meaningful improvements to occur in the avalanche control program there must be a recognition amongst a wide diversity of people that there is a problem that could be solved before there is a serious accident. Had conditions of Friday, March 23rd been slightly later in reaching thier peak, there could have been a school bus full of children under the paths, or a truck with people and cargo, or a train with equipment bound for the north. The results would obviously be far more catastrophic. Following is a list of recommendations:

1. Appropriations specifically earmarked to deal with the avalanche problem on the Seward Highway and Alaska Railroad.

2. Hire a qualified avalanche technician with transportation experience to set up and run a comprehensive control program utilizing the funds hopefully appropriated for this purpose.

3. Fixed mounts installed to have the capability of blind firing all shots at any time of day or in any weather.

4. Instrumentation for weather monitoring at starting zone locations.

5. Rescue plans should be drafted and practiced.

6. Economics demand a unified approach by the D.O.T. and Alaska Railroad in the funding and operation of a control program. Cost of the original installation could be appropriated by the state, with operational costs to be split between the two agencys.

A very rough estimate of the amount of money necessary to set up a comprehensive control program, including the purchase of two howitzers, installation of two gun platforms, signing systems, manpower, and one more weather station would be around $100,000.

To run a comprehensive program with two people to do the forecasting and control plus 600 rounds of artillery per year and two full scale helicopter bombing missions when conditions warranted, will cost approx. $50,000/yr.

STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF PARKS

JAY S. HAMMOND, GOVERNOR

Terry A. McWilliams, Director

2601 Commercial Drive
Anchorage, Alaska 99501

April 2, 1979

RECEIVED

APR 4

ALYESKA RESORT, INC.

Chris Von Imhof, Chairman
Girdwood Board of Supervisors
P.O. Box 249
Girdwood, Ak 99587

Dear Chris,

Pursuant to your request for recommendations for increasing public safety in Avalanche Zones along the Seward Highway, I offer the following comments:

- A public safety problem does exist along the Bird Hill section of the Seward Hwy and elsewhere due to avalanches. (This is evident in the number of close calls to passerbys, destruction of power lines, guard rails, motor vehicles and railroad tracks, road closures and loss of business revenue. However, only one fatality and 5 injuries are known to have occured since 1952.

- It is not anticipated that this problem will disappear without initiation of a bonafide program of avalanche control in conjunction with snow pit studies and meterological data collection.

- The purpose of an avalanche control program is to trigger small avalanches on a regular basis under controlled situations in order to protect public safety, transportation and business interests.

- It is generally less expensive - and far safer - to deal with an avalanche problem through a comprehensive avalanche control program then to respond to road clean-up as a result of fate.

- DOT's present activity of periodically shooting down avalanches is not an avalanche program in the real sense of the meaning and it would seem that the State is leaving itself open to a significant amount of liability should someone be killed or injured along the Highway as a result of an avalanche in an area that is supposedly "controlled".

Perhaps those agencies delegated with joint management responsibilities for areas identified as being avalanche hazard areas should form a joint Task Force whose responsibility it would be to draw up and implement a comprehensive snow safety plan which would address the how, who, what, when and where of avalanche control, snow pit and meterological data collection, and road closure/rescue contingency plan.

Additionally, it would be wise for the DOT to hire an avalanche "expert" who's full time responsibility would be to implement and coordinate the program. Much of the actual control work could be done on a contractual basis for less than present costs. Public safety would be greatly enhanced and State liability would be greatly reduced. I hope these comments are of some use in helping to solve the problem. The problem is enormous but not out of reach.

Sincerely,

Doug Fesler, Chief Ranger
Chugach State Park

DSF:lmk

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Chugach National Forest
Pouch 6606
2221 E. Northern Lights Blvd
Anchorage, AK 99502

4 APR 1979

2340

Chris von Imhof
Board of Supervisors
Community of Girdwood
Girdwood, Ak. 99587

The following is an analysis of the Seward Highway Avalanche activity March 23-25, 1979 and recommendations to Department of Transportation, State of Alaska (DOT) pertaining to public safety, the avalanche phenomenon, and control procedures along the Seward Highway.

ANALYSIS

1. March 23, sunny, clear snowplumes observed on Bird Ridge. Approximately 1:00 p.m. Snow Ranger Miller received report from Alyeska Resort's Pro-patrol that two avalanches had just been observed crossing the highway below Bird Ridge.

2. Miller and Alyeska's Avalanche Technician Dave Hamre act to close the highway. (Miller on south end, and Hamre by phone to Park Ranger D. Fesler on north end)

3. Miller finds one barricade and sign already established on south end so proceeded to first avalanche where he finds the Girdwood Trooper.

4. Trooper states that one loader and operator in route to start clearing the slides from south end. Miller pointed out that in his opinion road should be closed to all personnel and area below Bird Road should be vacated immediately - due to the high probability of additional natural released avalanches occurring.

5. The trooper radios D.O.T. personnel and advises of the recommendation. D.O.T. concurred.

6. Several additional avalanches released naturally and ran to and across the road during the next two hours.

7. Hamre - Miller recommended that the Seward Highway between Bird Point and Girdwood be flown to look for any victims or trapped vehicles and that stranded D.O.T. personnel be flown out.

8. Approximately 4:00 p.m. Miller, Hamre, Alyeska Mountain Manager L. Daniels flew by helicopter with explosives ready for bombing operation to location of D.O.T. gun 105 mm truck and crew, and landed 100 yds. North of gun to observe artillery results and discuss bombing operation with D.O.T.

9. D.O.T. fires one 105 round to the ridge crest above and released a large class 4-5 avalanche that crossed the highway a few yds. in front of the gun truck and crew. The slide continued down and spilled into Turnagain Arm.

10. The crew was lucky the avalanche did not propagate back-up the ridge or the crew would have been buried.

11. The helicopter bombing operation produced several additional avalanches across the highway approximated 50 charges were thrown.

12. March 24, Sat., clear, sunny, winds observed from N.W. along Turnagain Arm.

13. D.O.T. begin highway clearing project from north and south ends of avalanche debris with D.O.T. and leased equipment.

14. Miller - Hamre advise D.O.T. that they felt the snowpack conditions were still unstable on Bird Ridge due to deep snow instability. They advised of possible natural avalanche releases south of Girdwood. Miller and Hamre recommended use of U.S.F.S. and Alyeska's 75 mm for test shots at Peterson Creek slide area. D.O.T. concurred and the shots were scheduled for 2:00 p.m.

15. Five rounds were fired with negative results. Miller and Chris von Imhof recommended to move to Kern Creek slide area for more test shots. D.O.T. turned down recommendation.

16. Just prior to the test shooting at Peterson, Snow Ranger Jim Hackett discussed with D.O.T. on the north end of the slides that he felt, due to the deep snow instability that additional hazard still existed on Bird Ridge.

17. March 25, Sunday, clear, sunny.
Miller, Hackett recommend to D.O.T. that the 75 mm be used for more shots on Bird Ridge.

18. Miller - Hackett felt strongly that unstable conditions still existed Bird Ridge and that until all large snowfields had released that the potential of more avalanches reaching and crossing the highway was high. D.O.T. concurred and test shots were fired at 2:00 p.m.

19. Three large avalanches reaching the valley floor resulted from six shots.

20. Miller, Hackett, and Hamre recommended additional helicopter bombing that afternoon.

21. Highway clearing was completed and the road opened to the public at approximately 2-3 p.m.

22. Helicopter bombing was postponed due to railroad activities during late afternoon, exposing them to potential run-out zones.

23. Monday, March 25,1979.
Helicopter bombing performed on Bird Ridge at approximately 2:00 p.m. Several large avalanches occurred.

24. One avalanche deposited five piles of debris on the highway. One pile approximately 50 ft. wide and 20 ft. high, and the other 30 ft. wide, 20 ft. high. Both large enough to bury several vehicles.

Recommendation to D.O.T.

1. Consult experienced individuals and firms in highway and transportation corridor avalanche control and forcasting programs. (Rogers Pass, British Columbia which is considered the leading program in North America dealing with avalanche hazard)

2. Hire an experienced, qualified avalanche technician to constantly monitor snow stability and direct an avalanche control program.

3. Install meteorological instrumentation at necessary locations at ridge top elevations along the Seward Highway. This data received being a major imput for stability evaluations.

4. Set up control program of initiating slides prior to the time when they become critical and natural release in large volumes.

   a. Blind fire from fixed gun positions during and after storms.

   b. Helicopter bomb when weather permits.

5. Document an intensified Snow Safety Plan that outlines the procedures that state personnel shall follow to maximize state employee and public safety during snow avalanche occurrences.

6. Initiate a plan to relocate the highway from the runout zones where possible. Where not possible consider defense mechanisms, snow sheds, etc. Many of these considerations have been outlined by an avalanche study report prepared by the State of Alaska, Department of Highways Planning & Research Section completed in 1963.

7. In conclusion, considering the avalanche potential along the Seward Highway, that we, the State of Alaska, the community of Girdwood, residents of the Kenai Peninsula, and employees of the Alaska Railroad, have been very very lucky in the past. This is especially true during last week's Bird Ridge avalanche activity. In our opinion the avalanche problem along the Seward Highway is complex. Extensive effort, technology, and dollars must be spent in order that the safety of the traveling public is assurred.

Tom S. Miller

TOM S. MILLER
Head Snow Ranger
Chugach National Forest

J.E. Hackett

J.E. HACKETT
Snow Ranger
Chugach National Forest

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