4. WEATHER AND SNOWPACK CONDITIONS PRECEEDING MAJOR AVALANCHES IN THE SOUTHERN CHUGACH MOUNTAINS

4.1 Objectives

The objective of this study is to research and present data on the weather and snowpack conditions preceeding major avalanches in the area. This work was done by Mr. Dave Hamre of Alcan Snow Management Services. A summary of his research and our conclusions based on this research follow.

4.2 Data Required

The mapping problem consists in defining limits of avalanches that fit the definition of the red and blue zones given in section 1. For the Municipality, long-term avalanche and weather records, at least for the high altitudes where avalanches begin, are not generally available. Improvement of our knowledge of the design avalanche weather conditions can only be made by mapping unusually large avalanches and by correlating these events with the preceeding weather and snow conditions from remote country and high altitudes.

4.3 Avalanche Data Obtained

Three sources of avalanche data are available for analysis: (1) the Alyeska Ski Area, (2) the Alaska Railroad (ARR), and (3) the Department of Transportation (DOT). Alyeska records are available for 14 winters beginning in October, 1968. These data are shown in Table 4-1 where an "avalanche activity index" has been computed for each month. This index is derived by assigning a weighting factor for avalanches observed at the ski area classified according to the U.S. Forest Service system (Perla and Martinelli, 1976). The Alyeska avalanche index is defined in Table 4-2. The system defined in Table 4-2 descriminates months with frequent large (class 4 and 5) avalanches from months with frequent but small slides. Five months in the past 14 winters (Apr., 1974; Apr., 1976; Feb., 1977; Feb., 1978; Mar., 1979), are considered "exceptional" avalanche producers because index totals exceed the mean by 2 standard deviations or more.

The Alaska Railroad records extend from 1951 to 1981 and are available for 53% of the December to May months. The ARR records compute avalanche volumes per unit of track width covered and are a good measure of the total avalanche volume discharged during any monthly period. If this record is studied and the Alyeska criterion for "exceptional" avalanche month is applied, we find 4 exceptional winters in the past 30 years (Jan., 1958; Feb., 1952; Feb., 1978; and Mr., 1979). During the 14-year period when both Alyeska and ARR data are available (1968-1982), only one month (March, 1979) was exceptional according to both sets of data.

Department of Transportation data are not quantitative, but, as noted in the introduction, exceptional avalanche activity occurred along the Seward Highway during March, 1979. Furthermore, as shown in section 5.3, March, 1979 also produced 8 avalanches that nearly reached, reached, or damaged structures in the Municipality.

TABLE 4-1

Alyeska avalanche activity index by month

	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Dec.-April Total
68-69	-	0	24	0	171	39	55	289
69-70	-	0	31	54	49	57	126	317
70-71	8	0	26	31	152	101	141	451
71-72	12	0	100	0	118	69	101	388
72-73	22	32	143	137	56	115	240	691
73-74	46	48	78	10	241	111	294	734
74-75	-	-	102	109	147	59	215	631
75-76	-	-	160	206	31	137	285	819
76-77	-	-	157	193	298	0	161	809
77-78	-	-	46	134	314	36	49	579
78-79	-	29	117	95	8	353	77	650
79-80	-	37	61	156	87	196	103	603
80-81	-	0	36	237	112	226	12	667
81-82	-	53	145	6	14	67	173	405
Avg.	22	19	88	97	128	111	145	573

4-year monthly statistics

monthly mean (Dec.-Apr.): 114
monthly standard dev. : 82
mean + 1 std. dev. : 196
mean + 2 std. dev. : 278

TABLE 4-2

Alyeska Avalanche Activity Index

U.S. Forest Service Classification	Alyeska Ski Area Weighting Factor
Class 1	1
Class 2	2
Class 3	3
Class 4	5
Class 5	10

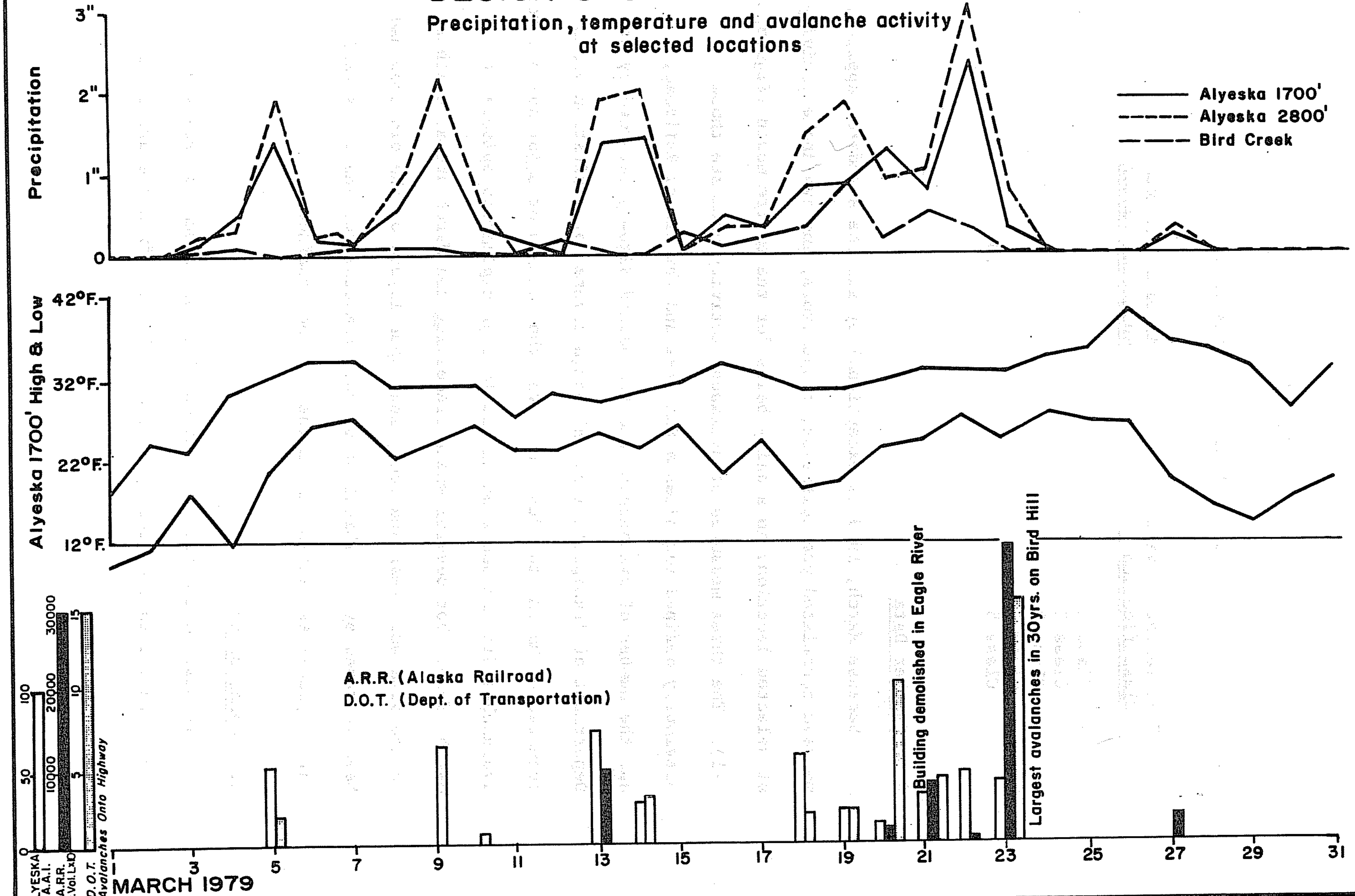
4.4 Weather Data

Because March, 1979 is exceptional by all the standards applied, we have correlated precipitation, temperature, and avalanche activity at selected locations on a daily basis for the entire month (Figure 4-1). The three measures of avalanche activity used are those previously defined for Alyeska Ski area and the Alaska Railroad, and the number of avalanches onto the Seward Highway recorded by the Department of Transportation. Although several precipitation peaks occurred on March 5th, 9th, and 14th, the release of major and numerous avalanches did not occur until the last precipitation episode of March 19-23. For several weeks preceeding the March storm, weather in the area was clear and cool, and upper layers of the old snow had been weakened by a combination of cold temperatures and recrystalization processes within and on the old snow surface.

4.5 Conclusions

We must re-iterate that the conclusions presented here are tentative due to the paucity of available data from the areas and

FIGURE 4-1
DESIGN STORM-MARCH 1979
Precipitation, temperature and avalanche activity at selected locations



elevations of interest. The large differences in precipitation between sea level and high-elevation stations are shown in monthly totals in Figure 4-2. Many of our conclusions were based on the available low-elevation data. However the limited data does suggest the following:

- Major avalanche activity (including some design avalanches), in this area are associated with a lengthy precipitation period possibly extending for 10 to 20 days.
- The major storm is preceeded by a wet early season where snow fills terrain irregularities and is followed by a cool, clear period that changes snow structure.

Although these conclusions appear to be supported by several large storms and periods of major avalanche activity that nearly meet the selection criterion described in the previous sections, we must emphasize that the data base is limited in area and time. The confidence of our conclusions could be greatly improved given a much longer time period and data collection near the elevations of interest.

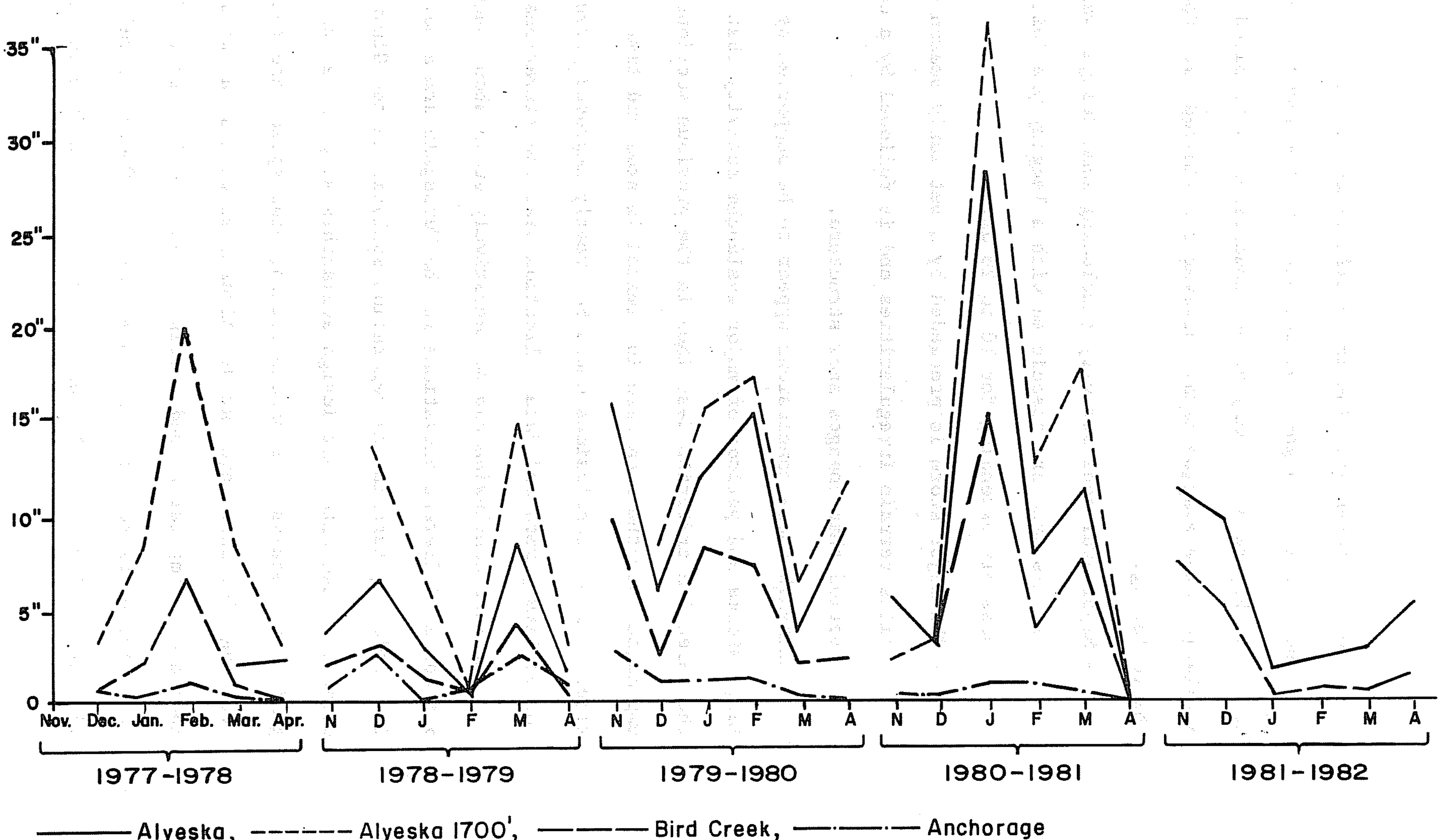
Another conclusion can be tentatively drawn about snowpack conditions at different elevations in the Turnagain Arm area. As noted in Section 3, terrain and vegetation analysis in the Girdwood/Crow Creek area indicate that design avalanches stop on relatively steep gradients. Analysis of precipitation, wind speed, and temperature from the 1700-foot level at Mt. Alyeska shows that as wind speed increases, temperature and precipitation also increase. When wind speed increases to more than 40 mph at the 300-foot level, precipitation at sea level usually turns to rain and the freezing level rises.

FIGURE 4-2

MONTHLY PRECIPITATION

Dec. 1977 – April 1982

Comparative values at selected high altitude and sea level stations



Therefore, the same conditions that produce a widespread, deep, and unstable snowpack at high elevations also tend to produce a dense and wet snowpack at lower elevations. Therefore the most massive design avalanches may encounter damp snow during descent and decelerate abruptly on relatively steep gradients.

We emphasize that the same conditions may not produce design avalanches in South Fork, Eagle River, and other parts of the Municipality, but insufficient data exist to speculate on the weather conditions that do produce major avalanches there.

4.6 Recommendations

In order to improve our knowledge of design avalanche weather, snowpack, and avalanche release conditions, and to improve our understanding of design-avalanche limits and mitigation methods, additional information must be collected. We recommend the following steps to be taken to improve the data base:

- Weather and snowpack data should be collected from locations similar to (but not necessarily in) avalanche starting zones in the Turnagain Arm, South Fork, and Eagle River Areas. Data should include snowfall depth and rate, wind speed and direction, and temperatures.
- Details of all major avalanches should be recorded, photographed, and placed on topographic maps. Data should include date of occurrence, outline of the avalanche path boundaries, type(s) of snow involved in the release and motion, and details of damage.

- The weather and snowpack conditions preceeding the major avalanches should be recorded.

If these recommendations are followed, then, over a period of years our data base will gradually improve so that we will be able to more confidently zone for avalanche hazard, modify existing red and blue zones, and recognize the antecedent conditions prior to major avalanche release.