APPENDIX VII

DEFENSE CONSTRUCTION PLAN FOR THE BEHRENDS AVENUE TERMINAL ZONE

By: Keith Hart

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CONTENTS

GRAPHICS

FIGURES

MAPS

INTRODUCTION AND BACKGROUND

On March 22, 1962, a major snow avalanche fell onto some two dozen homes in the Highlands area of the City of Juneau, Alaska. Shortly following this disaster, the Department of Highways, at the request of city officials, sent two avalanche specialists[1/] from the avalanche research center near Girdwood to Juneau to determine what immediate defense measures, if any, might be utilized. Their brief study[2/] recommended against further development of the subdivision within the avalanche path and called for construction of defenses at the base of the cliff above Behrends Avenue.

In September 1962, the writer transferred to the Department of Highways Headquarters in Douglas, bringing with him the knowledge that some 100 residents of Juneau's Highlands area continued to live in a major avalanche path.

The present paper is a continuation of that concern which was first formalized in a talk given before the Juneau Chapter of the American Society of Civil Engineers on the subject of snow avalanches and the Behrends Avenue problem. An outgrowth of the talk was a request to the writer from the Juneau Public Works Director to evaluate the continuing avalanche hazard, to determine possible defense measures and to recommend specific courses of action.

The confidential Report of the Preliminary Evaluation of the Behrends Avenue Avalanche Path, dated January 1967, established that major snow avalanches had occurred on the average of once every 13 years from 1890 to 1962. The report as requested, outlined a number of possible defense measures and recommended a variety of plans ranging from removal of exposed buildings to avalanche hazard forecasting and evacuation during critical periods.

1/ The writer then also an avalanche specialist remained at Girdwood.
2/ Unpublished report entitled Mount Juneau Avalanche, March 1962. Prepared by the Planning and Research Section, Department of Highways, Girdwood, (April) 1962.

SCOPE

The scope of this paper is limited to designing a structural defense system for the terminal zone of the Behrends Avenue snow avalanche path. The as yet confidential report to the City of Juneau provides most of the necessary supporting information.

OBJECTIVE

The objective is to design an effective passive defense system which will fulfill the site requirements and can be constructed and maintained at low cost.

LIMITATIONS OF PROPOSED DEFENSE SYSTEM

The proposed defense system will be most effective against small to moderate size damp and wet snow avalanches where downslope motion is confined to the ground. It will be less effective against large or very large avalanches traveling on the ground, and it will be largely ineffectual where large, high-velocity airborne avalanches are involved. As most of the reported major avalanches seem to be those types which travel on the ground, the writer believes that a system consisting of diversion dikes and earthen mounds is appropriate.

The proposed system is only one of a number of necessary measures which must be utilized if the hazard is to be reduced to tolerable levels. See the Report of the Preliminary Evaluation of the Behrends Avenue Avalanche Path (hereafter called the Behrends Avenue report), especially the sections on Avalanche Defenses, beginning page 6, and Some Possible Defense Measures..., beginning page 17.

THE PROPOSED DEFENSE SYSTEM

In 1955 the Alaska Road Commission constructed a few experimental earthen-mound, avalanche breakers in the terminal zones of avalanche paths near Girdwood and on Pioneer Peak about nine miles south of Palmer. The first of their kind in

North America, they soon proved themselves by reducing the number and size of snowslides reaching the highway. Continued observation of the avalanche breakers has shown that their effectiveness can be increased greatly by adding to their height and by adding a third or even fourth row. See Figures 1 and 2 for profile and diagram.

Alaska's first avalanche diversion dikes were built in 1961 on Pioneer Peak in the main slide path above what is now called the Old Glenn Highway. Until the dikes were built, avalanches annually closed the highway. The closures sometimes lasted a full day, as the slide may have deposited snow some 50 feet deep and 200 feet wide on the highway. Now seven years old, the dikes have kept all but one snowslide off the road. That one was excusable; it was triggered by the Good Friday earthquake in March 1964, and is the largest slide ever observed there.

The obvious success of these two types of low cost defenses in a comparable climatic zone and similar geologic setting indicates their suitability for the Behrends Avenue area.

Site Details and Considerations

The proposed construction site is on the transitional slope at the base of the glacially truncated, southwestern face of Mount Juneau. See Map 1. Slope angle at the proposed dikes averages about 19 degrees and is somewhat less steep (about 17 degrees) at the proposed breaker locations. An adequate amount of suitable borrow material is available at the construction sites. Because of the high frequency of avalanches, vegetation for the most part consists of berry bushes, devils club and alder.

Somewhat below the upper dike and breaker system there is an existing system of stream collectors and a large culvert which carries the water to the

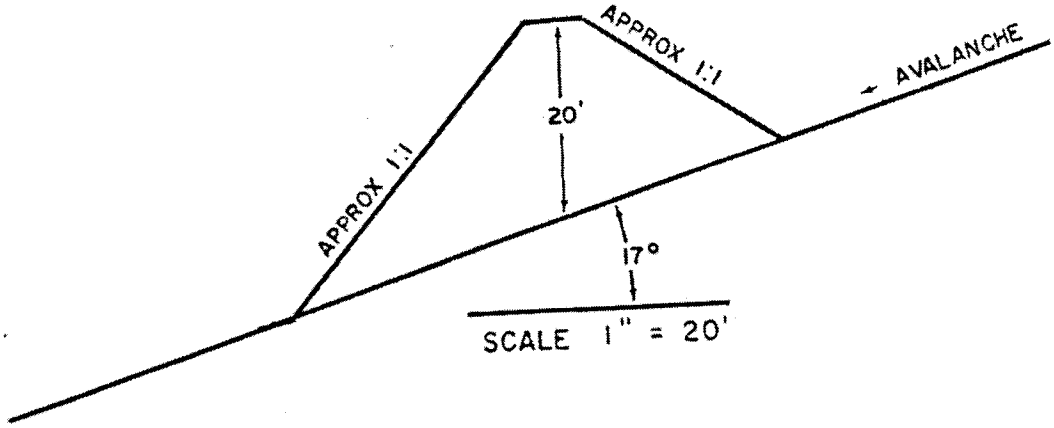


FIGURE 1 - PROFILE OF PLANNED AVALANCHE BREAKER

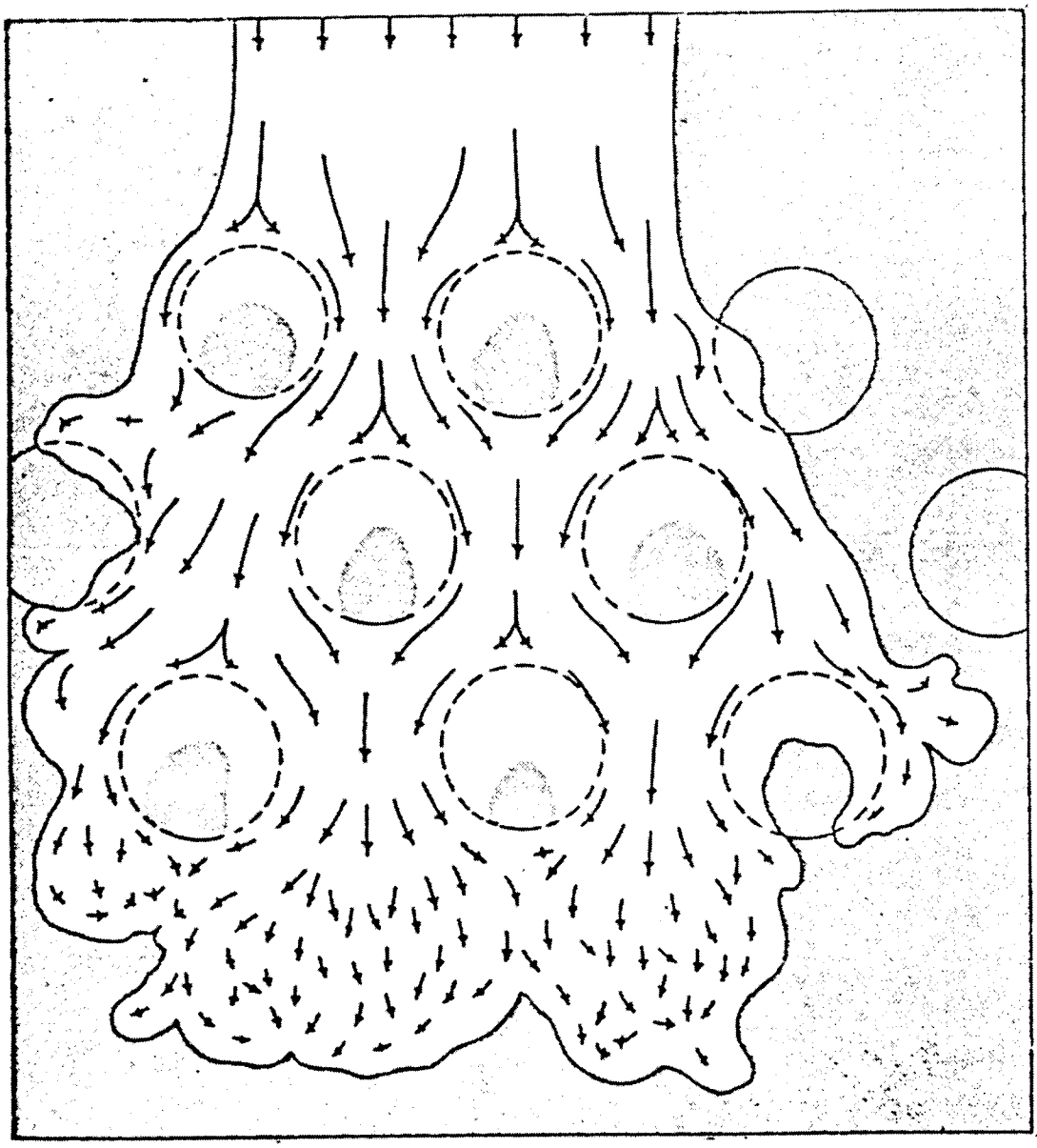
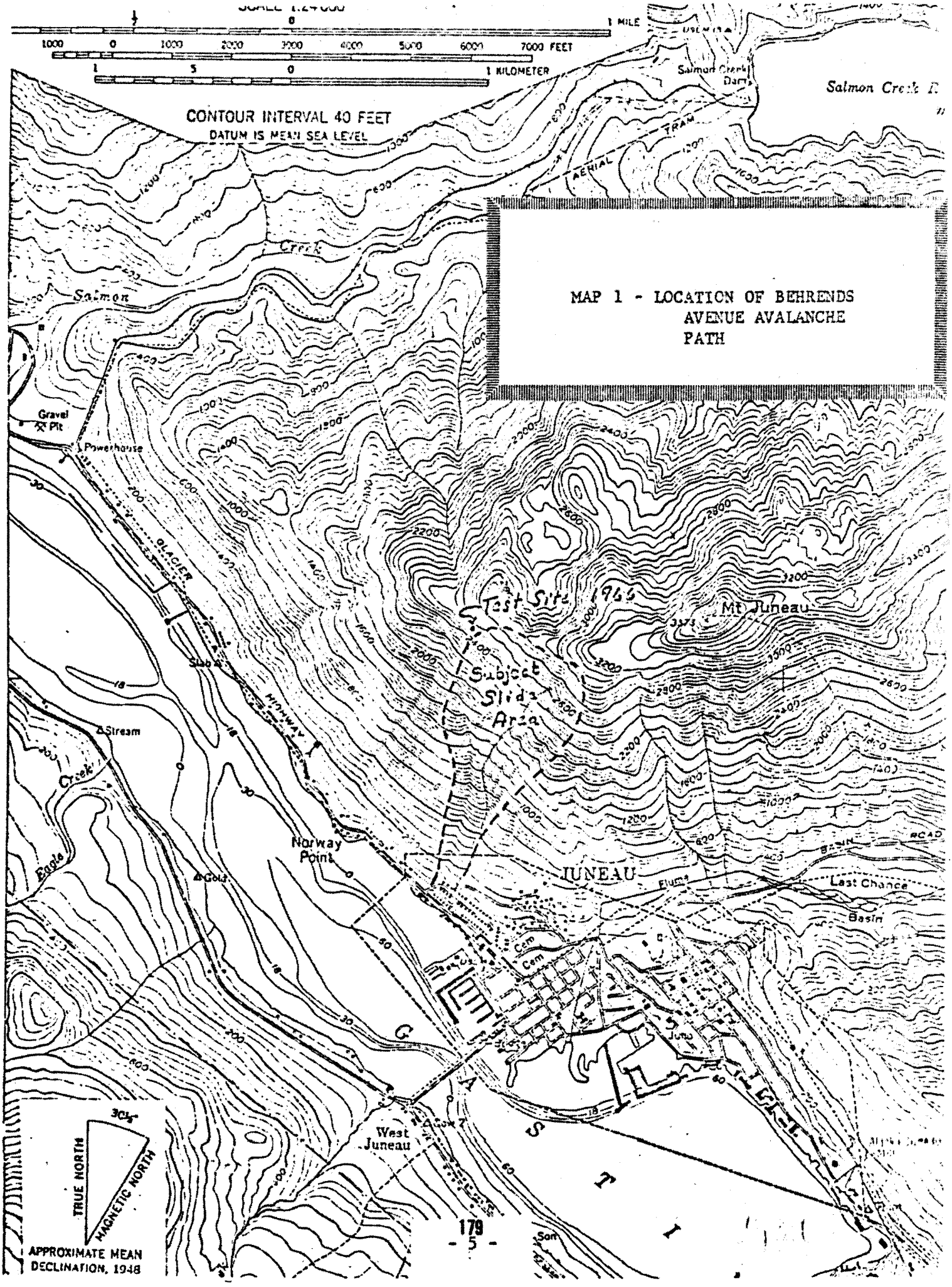


FIGURE 2 - SIMPLIFIED DIAGRAM SHOWING SPLITTING ACTION OF AVALANCHE BREAKERS



MAP 1 - LOCATION OF BEHRENDS AVENUE AVALANCHE PATH

shoreline. Equipment operating in the area will have to avoid damaging the collector system and must not change the stream patterns. It will also be necessary that construction equipment does not unnecessarily destroy the natural protection afforded by the terrain and vegetation.

The land where the defenses are to be constructed is under governmental ownership or control. Therefore, there should be no great difficulty in obtaining permission to install the defense system.

Diversion Dikes

A dike sometimes may be used to deflect avalanches away from the object being defended or, as in the case of the proposed defense system, it can divert the avalanche to an area where avalanche breakers can arrest it. See Figure 3. Plan of Dike and Breaker System. The experience gained from the Pioneer Peak project has helped to establish site requirements and design criteria.

Possibly the most basic requirement is that wet and damp snowslides predominate as the airborne, high velocity type will not be controlled by a dike. Other requirements are that the avalanches must be at least partially confined at the point of intersection with the dike and that there must be an adequate depositional area. All of these requirements are met at the selected site.

Dike design criteria include the following:

a. The angle of interception between the diversion dike and the natural path must be slight, probably not greater than 30 degrees, otherwise snowslides will overrun the dike. However, once the slide direction has been changed, it is possible to alter its course rather sharply.

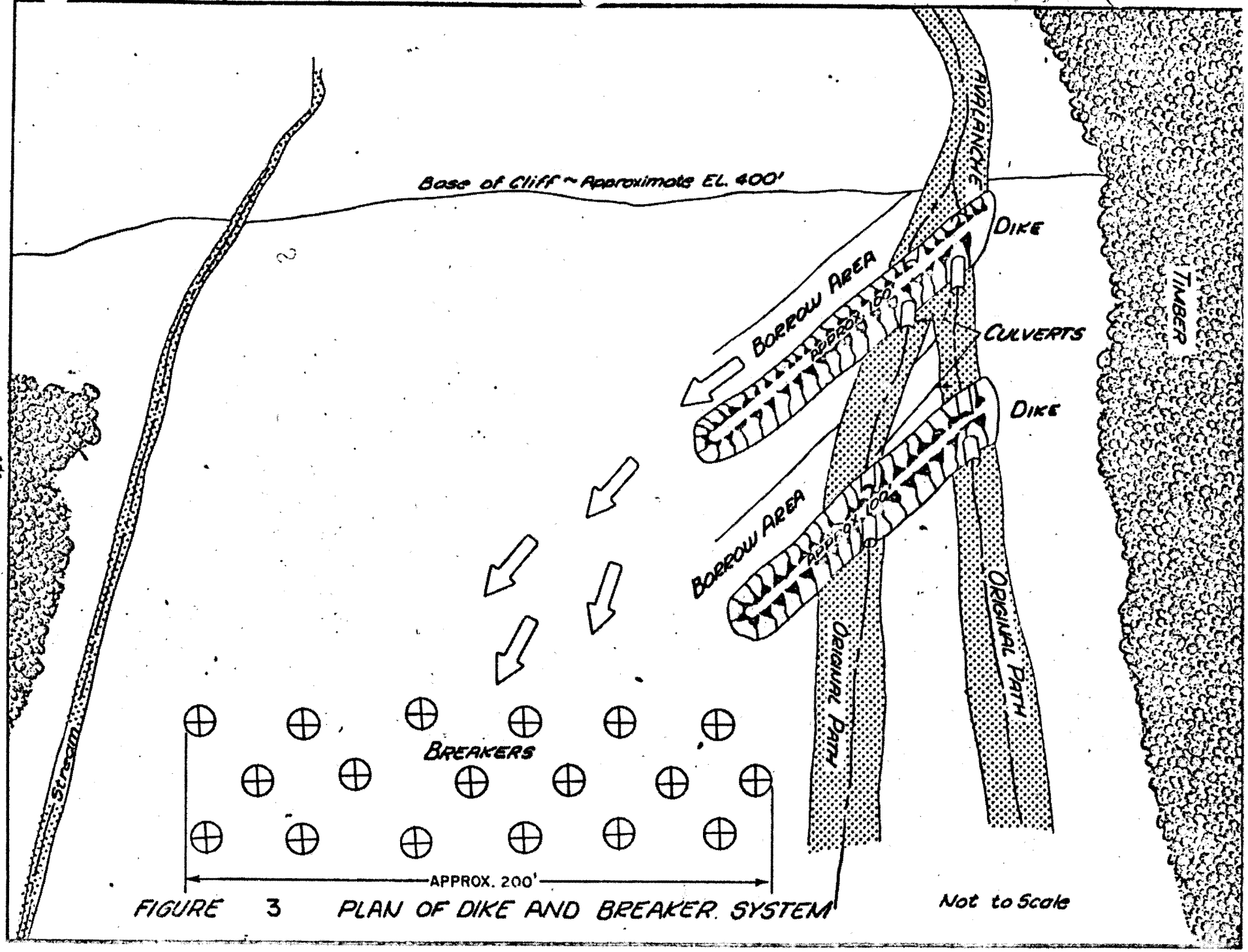


FIGURE 3 PLAN OF DIKE AND BREAKER SYSTEM

Not to Scale

b. Whenever feasible, dike material should be borrowed upslope, thus increasing the effective depth of the new avalanche path while shaping it to obtain minimum resistance.

c. Dike height will vary with location, but 15-20 feet has proved adequate.

d. Greatest height of the dike should be at the point where the avalanches are intercepted. At this point the dike may be 25 feet or higher.

e. Slide velocity should not be appreciably reduced, otherwise deposition will occur in the diversion system and its effectiveness against later slides will be impaired.

f. Premature deposition will be minimized if the artificial path is made steep and narrow. At Pioneer Peak, the upper part of the artificial path is about 22 degrees gradient, whereas the original slope was only 1½ degrees steeper. Width of the Pioneer Peak diversion channel varies from about 35 feet at the top to about 25 feet at the lower end. Narrowing the channel apparently reduces surface friction and thus helps maintain slide velocity beyond the dike.

Avalanche Breakers

As Figure 2 shows, avalanche breakers divide the descending snow mass into smaller streams which are then redirected against one another and against the mounds or breakers in succeeding rows. The braking action of well placed earthen mounds is considerable.

The breakers should be built 20 feet high and be as closely spaced as possible, usually a bulldozer blade apart at the base. Material is borrowed from the upslope side of the mound.

It is recommended that seedling, native spruce and hemlock trees be planted on the lee slopes of the breakers. In time the trees will provide additional avalanche protection.

Periodic maintenance will be necessary to keep the breaker system free of debris and to maintain the mounds. The breakers at Girdwood and Pioneer Peak did not require maintenance for the first 10 years.

COST ESTIMATES

The costs are based upon construction near Girdwood and on Pioneer Peak some years ago and, therefore, should be regarded as being very rough. A D-9 Caterpillar tractor was used to build the diversion dikes and D-6 to D-8 size tractors were used to construct the breakers.

Diversion Dikes		
200 L.F. of earthen dike @ $12/L.F.[1/]	$2,400	
160 L.F. of 36 in. Dia. C.M.P. @ $12.50/L.F.[2/]	2,000	
Diversion Dikes Total		$4,400
Avalanche Breakers		
16 @ $400 each[3/]	$6,400	
Avalanche Breakers Total		6,400
SYSTEM TOTAL		$10,800

1/ Fifty percent higher than 1961 Pioneer Peak project.
2/ It may be possible to reduce the diameter of the pipe and/or to combine the two streams which could reduce the costs.
3/ One hundred percent higher than Girdwood area breakers cost in 1956. The Girdwood breakers are only 12 feet tall but are located on much more difficult terrain.

CONCLUSIONS

The proposed defense system, consisting of two diversion dikes and possibly 16 avalanche breakers, will appreciably reduce the hazard from medium to moderately large, damp and wet type snow avalanches. It probably will not greatly reduce the danger from very large slides of these types; and it will be no deterrent to the large, high-velocity, airborne avalanches of the type that fell on March 22, 1962.

However, it is a structural defense system that appears to be within the financial capabability of the area. Even if it stops only one potentially destructive avalanche, it will have repaid the initial investment many times over.

RECOMMENDATIONS

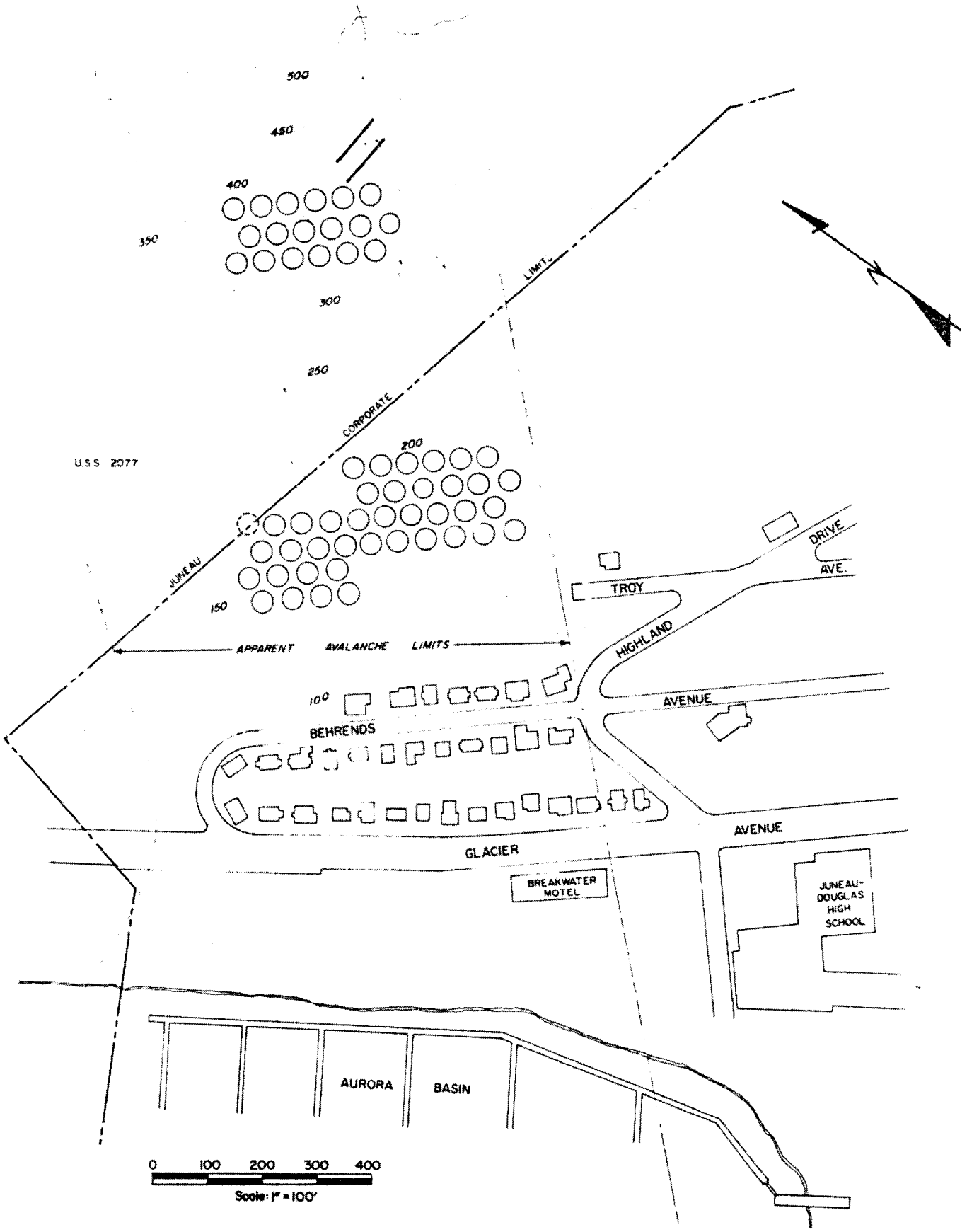
It is recommended that the City of Juneau and the Greater Juneau Borough make plans to implement this proposed defense plan as soon as possible.

It is recommended also that the appropriate governmental body determine if the cost of the proposed defenses should be borne wholly or at least in part by the benefitted property owners.

Further, it is recommended that an additional breaker system somewhat as shown on Map 2 be built as soon as possible. This second system is not of such high priority as the other. Ideally, they would all be built at the same time and preferably during summer 1968.

REFERENCES

The references are listed on page 20 of the Behrends Avenue report.



MAP 2

TERMINAL ZONE OF BEHRENDS AVENUE AVALANCHE PATH SHOWING APPROXIMATE LOCATION OF PROPOSED DEFENSES.