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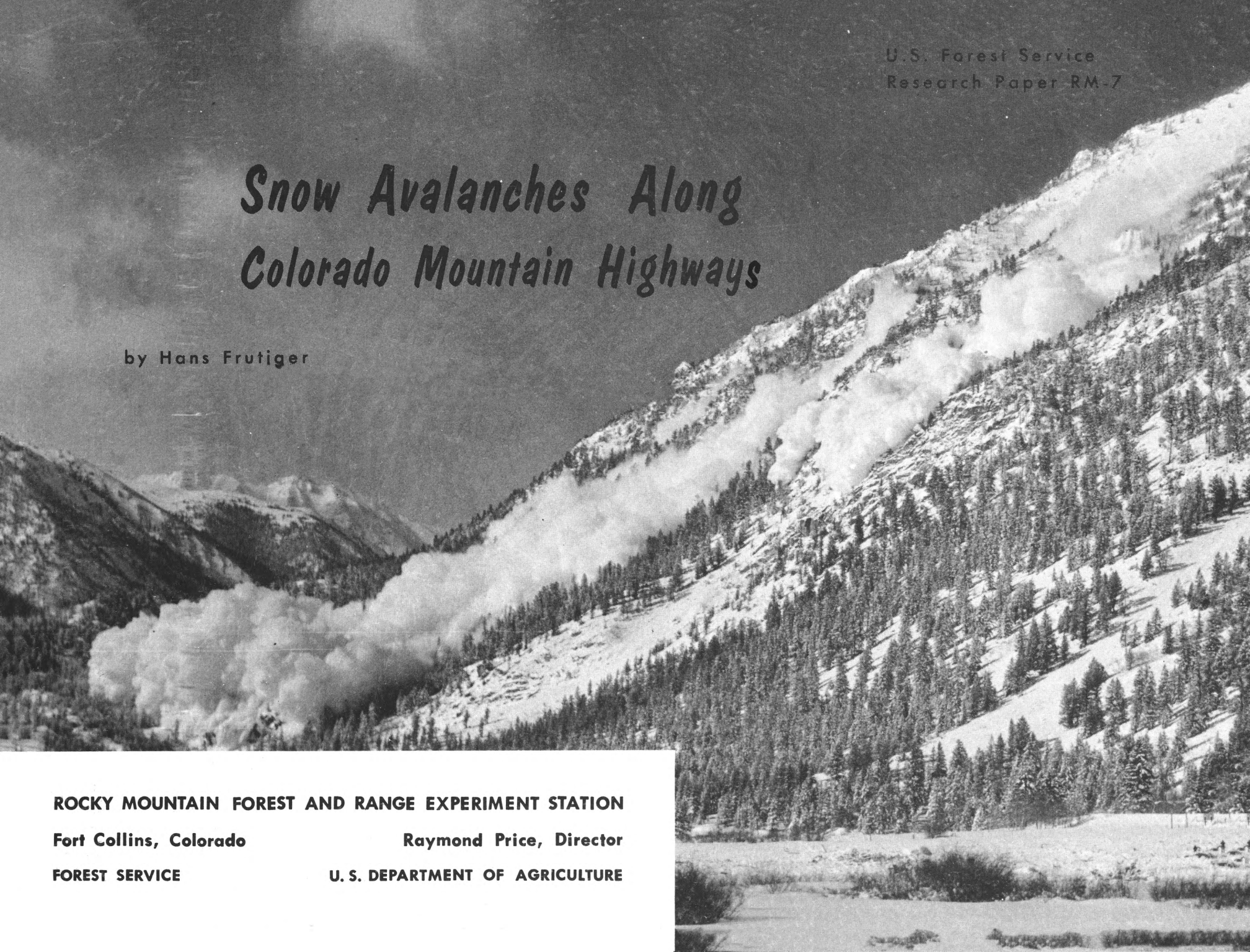

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
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SNOW AVALANCHES
ALONG COLORADO MOUNTAIN HIGHWAYS

by

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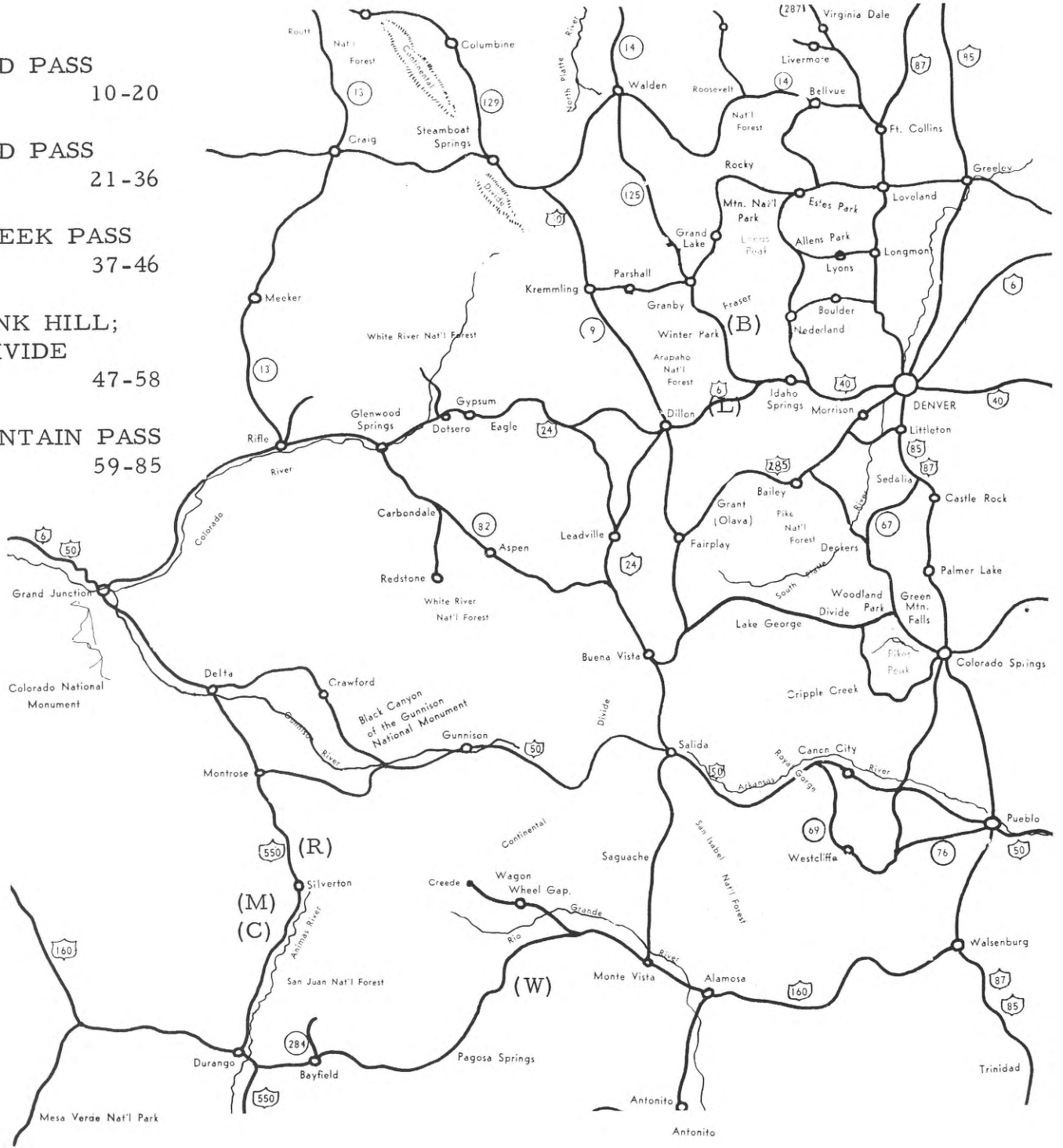

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SCOPE OF THE REPORT

One of the first steps in any avalanche control program is to inventory and assess problem areas. Since a complete inventory of all the avalanches in Colorado is not feasible at this time, four mountain passes were chosen for study.[3] Two of the areas, Highways 40 across Berthoud Pass and 6 over Loveland Pass, are in the Front Range of central Colorado; the others, Highways 160 over Wolf Creek Pass and 550 over Red Mountain Pass, are in the San Juan Mountains of southwestern Colorado. These four areas form a representative sample of the avalanche problems in the Colorado mountains. A discussion of avalanche characteristics and control possibilities in the study area will give general information that should be helpful in planning avalanche control measures based on practices currently used in central Europe.

The intent of this report is twofold: (1) to give a generalized picture of avalanches in the mountains of Colorado, their number, frequency, size, general configuration, and structural control possibilities; and (2) to identify, locate, and illustrate the avalanches in the four areas chosen for study.

Structural control possibilities described here are based on current practices in central Europe. For our purposes, the following control possibilities will be considered:

1. Supporting structures in the starting zone: These are concrete and metal snow bridges (Schneebrücke), snow rakes (Schneerechen), and snow nets (Lawinennetze). Such structures prevent avalanches from starting because they literally support the snow cover in the starting zone.

2. Structural control in the track or runout zone: Retarding, deflecting, and catching structures intended to slow down, deflect, or stop avalanches in the runout zone or the lower part of the avalanche track. These are usually massive earthen mounds or dams. They are often armored on the uphill side with concrete or masonry.

3. Direct protection structures: These are primarily avalanche sheds. Such structures carry the avalanches over the road without interrupting traffic. Large earthen catchment dams near the road are also considered in this category.

Avalanches along Colorado highways are currently controlled by the use of explosives. Artillery shells fired into the starting zones either stabilize the snow in place or release avalanches at a time when highway crews are ready to clear the road. This system has proven effective in most cases,[4] and it is not certain whether structural controls would be better. Of course, each control system has its advantages and disadvantages. The use of explosives to control avalanches permits the use of existing crews and equipment at a low annual cost. Explosives are no protection to the roads during heavy storms, however, and the roads are often closed by slides. This technique also perpetuates and

[3] *Quadrangle maps of the U. S. Geological Survey have been used to show locations of the avalanches.*

[4] *Miles, George N. Snow removal. 9 pp. Paper presented by Colo. Dept. Highways, 47th Ann. Mtg., Amer. Assoc. State Highway Officials, Denver, Oct. 1961.*

accentuates the avalanche paths. Structural control, on the other hand, may be very expensive initially, but well designed structural control gives protection for a number of years, and in many cases provides an opportunity to reestablish a forest--one of the best avalanche defenses known.

When structural avalanche control is begun, the first efforts should be concentrated in areas where there is no question about the type of structure to use. After experience has been gained on how avalanche defense systems work in such places, the more difficult and questionable areas can be treated. As an illustration, the STANLEY avalanche near Berthoud Pass starts in a relatively small catchment basin. It spreads over a wide area and crosses the highway twice in its course down the mountain. There is not enough room for diversion or retarding structures above the road. To protect both limbs of the switchback, 2,000 to 3,000 feet of avalanche shed would be needed. On the other hand, supporting structures could be built in the starting zone since the catchment basin is well defined and easily accessible. In this case, stabilization of the starting zone would undoubtedly be the most economical procedure. Afforestation in the lower parts of the avalanche area would make defense work more efficient.

EAST RIVERSIDE avalanche on Red Mountain Pass, on the other hand, is a classic example of a situation where an avalanche shed or a tunnel is the obvious solution. The snow masses start in a big catchment basin and are well channelized in the narrow gully of Curran Gulch. About 1,000 feet of avalanche shed or tunnel would completely protect the highway from both the EAST RIVERSIDE and WEST RIVERSIDE avalanches (see map p. 62). The starting zone of these two avalanches totals 225 acres (90 hectares). All of this area lies at high altitudes and is accessible only with great difficulty.

Further discussion of the principles of structural avalanche control is given in two publications[5] [6] available from the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Field data were gathered during the winter of 1961-62 and the following summer. Direct observations were facilitated and augmented by discussions with Colorado State Highway personnel. Comments in the description section of this report on snow conditions in the starting zones of the avalanches have been kept short. One winter's observations are not enough to permit very definite statements. Detailed winter observations will be needed in any area where structural controls are contemplated. Schaerer's[7] [8] [9] reports are good examples of the type of planning needed to integrate avalanche control measures into the construction and maintenance of a mountain highway.

Avalanche names used in this report are those used by the local people. Names were selected for the few avalanches that had none. In a few cases, avalanches shown on the sketch maps of the Highway Department could not be located in the field; these were omitted from this report.

The designation Red Mountain Pass as used here includes two sections of Highway 550 that are topographically separated from Red Mountain Pass proper. These are Coal Bank Hill from Cascade Creek to Lime Creek, and Molas Divide from Lime Creek to Silverton.

[5] *Federal Inspection of Forests, Berne, Switzerland. Avalanche control in the starting zone: guidelines for the planning and design of permanent supporting structures. Translated by Hans Frutiger in Sta. Paper 71, 60 pp., illus. 1962.*

[6] *Frutiger, Hans. Planning structural control of avalanches. (Being reviewed for publication).*

[7] *Schaerer, P. Avalanche defences for the Trans-Canada highway at Rogers Pass. Canada Natl. Res. Coun. Div. Bldg. Res. Tech. Paper 141, 35 pp., illus.*

[8] *Schaerer, P. The avalanche hazard evaluation and prediction at Rogers Pass. Canada Natl. Res. Coun. Div. Bldg. Res. Tech. Paper 142, 32 pp., illus.*

[9] *Schaerer, P. Planning avalanche defence works for the Trans-Canada highway at Rogers Pass, B. C. Canada Natl. Res. Coun. Div. Bldg. Res. Res. Paper 152, 12 pp., illus.*

AN AVALANCHE CLASSIFICATION SYSTEM

In this section, avalanches are classified into a few types based on size, frequency, and terrain conditions, since these criteria are important for planning structural avalanche control.

Small avalanches that run after or during each snowstorm are more troublesome than large ones that run only at long intervals. On the other hand, after a large avalanche has run, it takes more effort to clear and reopen the highway. While frequency and size determine the seriousness of a given avalanche, terrain conditions determine the possibilities of structural control. A small avalanche can be as hazardous as a large one--it makes no difference to the people involved if they are suffocated in a big or a small snow mass. The cost of snow removal and especially of structural control is very much dependent upon size. It should be emphasized, however, that a small avalanche may be the indirect cause of a great disaster because traffic stopped by a small slide at an unsafe spot may be exposed to the hazard of other avalanches.

Size Classification

As used here, size refers to the extent of the starting zone and not to the amount of snow brought down by the avalanche. The general area of the starting zone is constant; the amount of snow that slides varies greatly with the actual avalanching conditions. Even in the starting zone, there are usually big patches that are safe and do not slide. Thus size, estimated from large-scale maps, is only a rough figure that indicates the order of magnitude rather than an accurate surface area. In all cases, the size given is probably the upper limit of the starting zone.

A rough estimate of the costs necessary to control an avalanche in its starting zone can be determined from the size of the avalanche. In Switzerland, experience has shown that it costs 1 million Swiss francs ($250,000) to control a catchment basin of 10 acres (4 ha).

Bankslides

Bankslides as defined here start in the immediate proximity of the highway and have a track less than 160 feet (50 meters) long. They occur rather frequently and cause a great deal of trouble for snow removal crews, but they are not very dangerous to traffic. The most effective countermeasures depend on the particular slide. Sometimes supporting structures like those proposed for the starting zone of avalanches could be used. Other situations might require better stabilization of the cut bank with walls, wire netting, and later planting to vegetation.

Small avalanches

Small avalanches--those with a starting zone of 7 acres (3 ha) or less--often lie below timberline. In almost all cases, control by supporting structures in the starting zone is possible and economical.

Medium avalanches

Avalanches with starting areas between 7 and 30 acres (3 and 12 ha) are classed as medium sized. In this size class, the nature of the terrain determines how easily the avalanche can be controlled by structures in the starting zone.

Large avalanches

Avalanches with more than 30 acres (12 ha) of starting area are classified as large. Only under the most favorable or special conditions should control in the starting zone be tried for this size avalanche. Good examples of this class are WEST RIVERSIDE and EAST GUADALUPE, both on Highway 550 and both with catchment basins of 150 acres (60 ha).

Frequency Classification

Hazard increases rapidly with density of traffic and frequency of avalanches. Therefore, the frequency of occurrence is a very important criterion for avalanche classification. In recent years, avalanche hazard on mountain highways has increased rapidly because of winter sports. Traffic is densest at the time avalanches are to be expected. The more cars underway during an avalanche cycle, the greater the probability that a car will be hit. It should be pointed out that it takes time to release and clean up an avalanche with explosives, and during this time traffic is stopped. Where traffic is light, this might be practical; with heavy traffic, however, this procedure becomes questionable.

The following frequency classification distinguishes between avalanches that in the words of the highway maintenance crews "give much trouble" and others that "give little trouble." The frequency classifications assigned to specific avalanches in the following sections may be subject to criticism and later revision since they are based on limited information.

Frequent avalanches

An avalanche is classified as frequent when it runs during or after each medium to large snowstorm; in other words, an avalanche that runs once to several times a winter is called frequent. Because they run so often, the track is usually clean and such avalanches normally bring no debris to the road. This means the highway can be reopened soon after the slide has run. Avalanches that are frequent and "give much trouble" are usually well known by the maintenance crews and, in most cases, by the general public.

Occasional avalanches

Avalanches that run to the highway once in every 3 to 6 years are called occasional. Such avalanches normally stop traffic for a longer time than the more frequent ones, since they usually bring down rocks, trees, and other debris that make cleaning the highway a slow job. This class of avalanche runs too frequently to be ignored, yet not frequently enough to justify a great expenditure for control. Terrain conditions will usually determine whether or not structural control is economically feasible.

Erratic avalanches

Avalanches that run to the highway no more often than once in 7 to 10 years are called erratic avalanches. The term "seldom" was intentionally avoided in describing the frequency of these avalanches, even though they may not run for decades. It is quite possible that severe avalanche conditions will develop in several succeeding winters. In this case, such avalanches may run several times in a short span of years. The frequency of intermittent avalanches can be estimated from the vegetation in their tracks. When such slides do run, they usually run big and often bring a mass of debris down to the road.

The terms "erratic," "occasional," and "frequent" refer to how often the avalanches come to the highway. The example of GRIZZLY on Highway 6 might illustrate the situation: GRIZZLY has a tremendous catchment basin; after each medium to large snowstorm, there are avalanches in its starting zone and the middle section of the track. But the track is too long, too curved, and not steep enough to allow these avalanches to run to the highway below. It takes exceptionally severe conditions to cause a large enough avalanche to cross the highway.

Terrain Classification

Terrain conditions are the decisive factors determining whether structural control, especially in the starting zone, is recommended.

Location of starting zone
in relation to timberline

The most important terrain consideration is whether the starting zone is above or below timberline. This distinction has an important bearing on the efficiency of the structures and on their maintenance. Below timberline the help of afforestation cannot be emphasized enough, even though the current thinking in Colorado seems to be that young trees grow too slowly and are too expensive to justify extensive plantings. Structural control and forest cover are needed, however, to give full protection in many areas. There are a considerable number of avalanche areas where control is more a matter of afforestation than of civil engineering.

Also, there is a remarkable increase in wind action above timberline compared to the timbered area. Above timberline, snow depositions are much more irregular than below, and excessive snow depths in particular spots are common.

Steepness of terrain

The ruggedness of the catchment basin is another important criterion in terrain classification. Very steep spots, even quite small ones, are very difficult to control. The general practice in central Europe is to use supporting structures to control avalanches with slopes between 62 and 120 percent. The cost of structural control in very steep starting zones is almost prohibitive.

Types of avalanche tracks

For structural control purposes, it is important to distinguish between channeled avalanches and unconfined avalanches.

The catchment basin of the channeled avalanche is well defined, usually bowl shaped, and the avalanche follows a clearly defined track that is usually a gully or other obvious depression in the slope. In the case of an unconfined avalanche, it is difficult to determine the starting zone and to delineate the course the moving snow masses will follow. The snow spreads over a wide area. It is evident that more observations and care are needed to develop an adequate plan for the control of unconfined avalanches. On the other hand, this kind might be very economical to control if observations show relatively small starting spots compared with the width of the track. In such cases, a few structures might protect a long section of the highway.

A good example of the channeled type is WEST RIVERSIDE on Highway 550. Although the catchment basin is very large (150 acres or 60 ha), the starting spots can be located easily from the topography, and the avalanche always follows a well-defined track, carved forever in the hard rock.

Just the opposite feature is exemplified by SLIPPERY JIM on the west-facing slope about a thousand feet south and across the valley from WEST RIVERSIDE. There is no well-defined catchment basin for this avalanche. It seems that the snow may start to come down anywhere; however, scattered tree groups make it evident that the whole slope does not run, at least under normal conditions. The starting spots and the normal track are not obvious to the casual observer. Other examples of unconfined avalanches are FLORAL PARK on Highway 40, the BROOKLYNS on Highway 550, and IRONTON PARK on Highway 550.

Longitudinal profile
of avalanche track

The longitudinal profile of the track is of great importance for structural control in the track. A steep, narrow track is not favorable for retarding or catchment structures. The longitudinal profile must show some flat section that is both long enough and wide enough to slow down the avalanche naturally. Retarding and catchment structures would be

effective in such a flat section. On Highway 550, there are examples of both types of longitudinal profiles: EAST RIVERSIDE has a narrow track that hits the highway directly without a transition zone. The runout zone is absent. The track of EAST GUADALUPE, on the other hand, shows a long transition zone before it reaches the highway, where, under favorable conditions, the avalanche stops naturally and where retarding or catchment structures would be effective.

BRIEF ANALYSIS OF AVALANCHE AREAS

An analysis of the 80 avalanche areas described in this report permits some generalizations about the characteristics of avalanches in Colorado and their control possibilities (table 1, figs. 1-3).

The avalanches are distributed as follows:

Berthoud Pass, Highway 40	12
Loveland Pass, Highway 6	13
Wolf Creek Pass, Highway 160	12
Red Mountain Pass, Highway 550	43
Total	80

The size of the starting zone varies from 1 acre to 150 acres. Avalanches with 2 to 30 acres (1 to 12 ha) are most common: only about 16, or about a fifth, are larger. The starting zones generally lie at an altitude of about 10,000 to 12,000 feet m.s.l. (mean sea level). Very often the upper parts are near timberline, which is between 11,400 and 11,800 feet m.s.l. in the southern Rocky Mountains.

The length and steepness of the tracks vary considerably. It is logical that short to medium tracks usually have a steeper slope than very long ones. Nearly half the total avalanches (35), have a track between 1,000 and 3,000 feet with an average slope between 50 and 70 percent; slopes between 60 and 70 percent are most common. Only 12 tracks are shorter than 1,000 feet and 23 are longer than 3,000 feet. The longest track is 6,000 feet. The average slope on the longer tracks is between 50 and 60 percent.

Avalanches are grouped according to their significance to traffic and the possibilities of structural control (table 1, fig. 2). Group 1 consists of the small-frequent avalanches. These are very hazardous to traffic, and could be controlled with little effort. In almost all cases, supporting structures in the starting zones and afforestation are recommended.

Group 2 consists of the medium-frequent and medium-occasional avalanches. These cases give trouble to traffic as well as to the avalanche control engineer. They are too frequent to be neglected, but too large to be controlled easily. Special studies of the particular area and, more important, an evaluation of the economic alternatives are needed before any recommendations can be made.

Large-frequent and large-occasional avalanches, group 3, constitute a small group. Control measures for these avalanches will usually have to be direct protective structures such as avalanche sheds or tunnels.

Group 4 includes all erratic avalanches--small, medium, and large. This group is not very important, and the need for control is not pressing. The small avalanches of this group, however, should be treated with the small ones of the two other groups. This is especially true in the case of possible afforestations because plantations are most likely to succeed where avalanches seldom occur.

If bankslides are included, about half the avalanche areas can be controlled without technical difficulties by building supporting structures and making afforestations in the starting zones. Unfortunately, there are only a restricted number of avalanches where the track or the runout zone can be controlled; terrain conditions favorable to retarding, diversion, or catchment structures are found in only six cases. Avalanche sheds are recommended in 10 cases where large avalanches must be controlled or where terrain conditions are unfavorable for other types of structures.

Table 1.--Physical characteristics and control possibilities of avalanche areas along several mountain highways in Colorado, as inventoried in 1961-62

Physical characteristics and possibilities for structural control	Highway No. and mountain pass						
	No. 40 Berthoud	No. 6 Loveland	No. 160 Wolf Creek	No. 550 Coal Bank Hill	No. 550 Molas Divide	No. 550 Red Mountain	Total
	Number						
BANKSLIDES	0	3	1	1	1	6	12
AVALANCHE GROUPS:							
1. Small-frequent	5	0	1	2	1	8	17
2. Medium-frequent, small-occasional, medium-occasional	2	8	9	1	4	10	34
3. Large-frequent, large-occasional	0	0	1	0	0	5	6
4. Small-, medium-, large-erratic	5	5	1	0	2	10	23
Total	12	13	12	3	7	33	80
POSSIBILITIES FOR STRUCTURAL CONTROL:							
1. Supporting structures in the starting zone--							
Class of structures obvious, no problems, not too expensive	10	6	6	2	5	8	37
Doubtful, difficulties expected, may be expensive and uneconomical	0	2	5	0	1	7	15
Control of starting zone out of question because too difficult, uneconomical, and erratic occurrence	0	3	0	0	0	3	6
2. Structural control in the track or runout zone--							
Favorable terrain conditions	0	1	0	1	1	3	6
Doubtful; may not be very effective	0	1	0	0	0	0	1
3. Direct protection structures--							
Avalanche sheds	0	0	1	0	0	10	11
Avalanche dams	2	0	0	0	0	2	4
Total	12	13	12	3	7	33	80

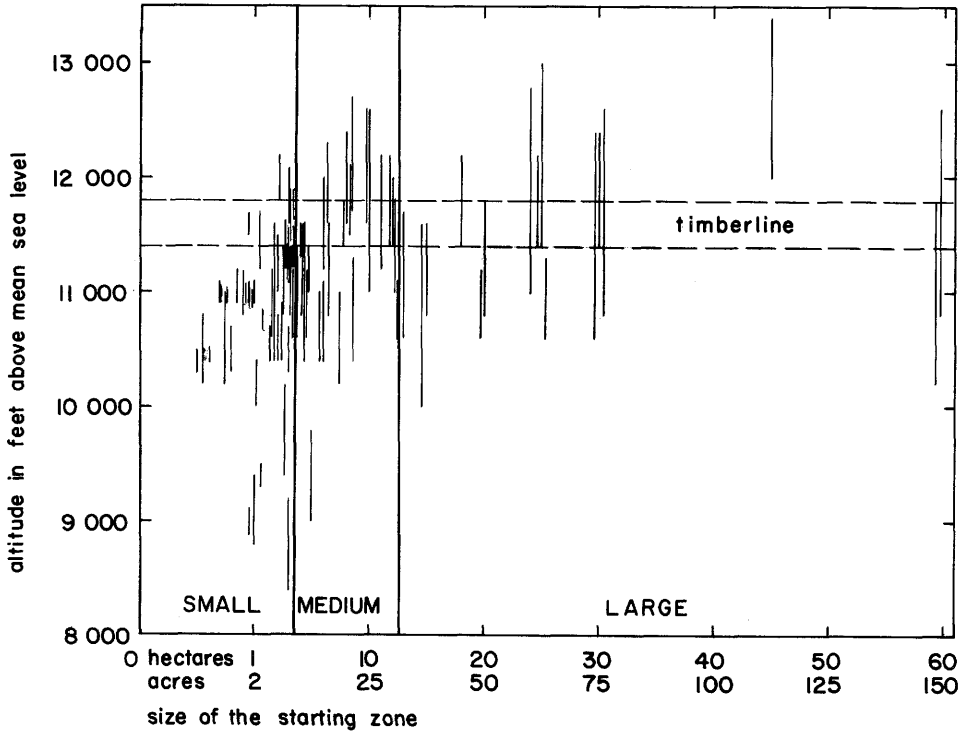


Figure 1.--Size and altitude of the starting zone of 80 avalanches in four mountain passes in Colorado, 1961-62. An expanded scale has been used for the 0- to 2-acre classification.

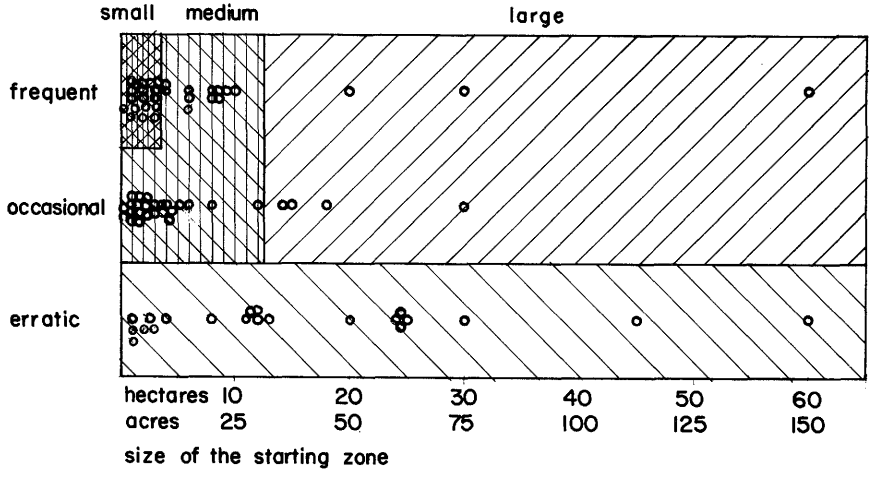


Figure 2.--Frequency of occurrence and size of 80 avalanches in four mountain passes in Colorado, 1961-62. Frequency classifications--erratic, occasional, and frequent--refer to how often the avalanches reach the highway. The size classifications--small, medium, and large--refer to the extent of the starting zone; not to the amount of snow brought down by the avalanche.

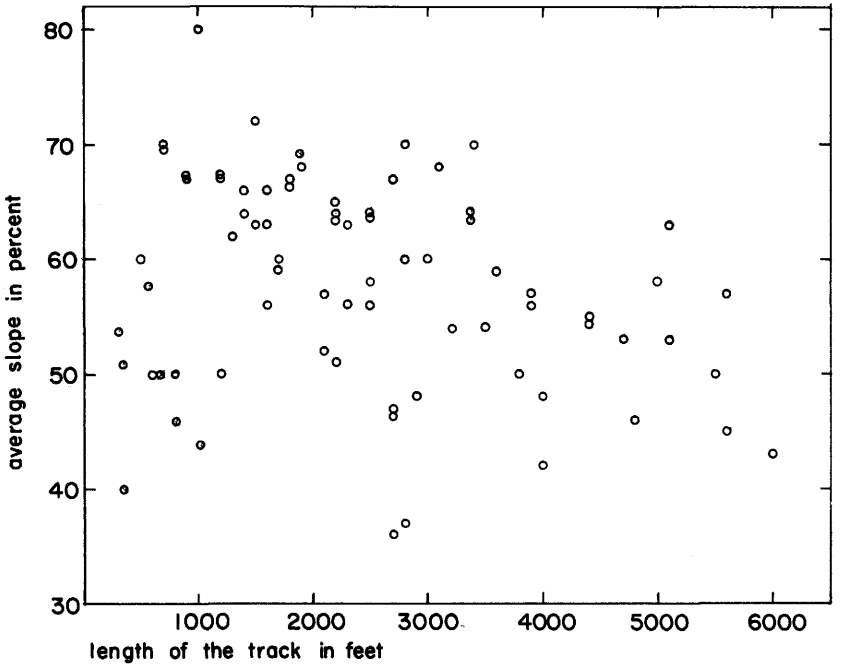


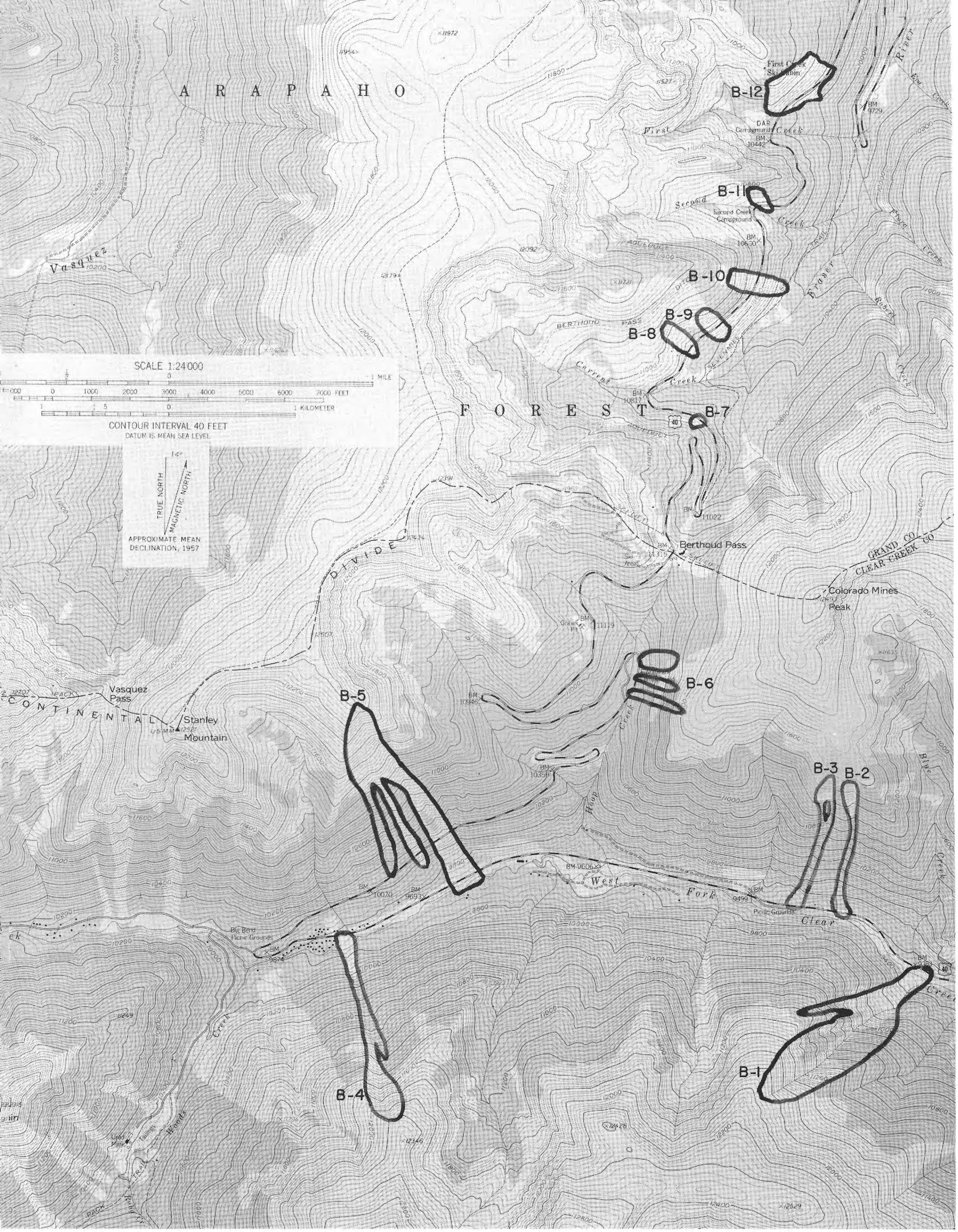
Figure 3.--Length and average slope of the tracks of 80 avalanches in four mountain passes in Colorado, 1961-62.

GENERAL PLANNING FOR STRUCTURAL CONTROL

Structural avalanche control should be started in areas where it is obvious what class of structural control will work, and where control measures will not be too expensive for the values involved. A group of neighboring avalanches should be considered as a single unit for control purposes. Control plans for any one of the group should be part of a more comprehensive project designed for controlling the entire group.

Enough time should be allowed to study the winter terrain conditions of all doubtful cases. Structural avalanche defenses cannot be started in a day; careful winter observations are necessary to do a good job. In areas where supporting structures will be built, observations of snow conditions in the starting zone should be started as soon as possible. Where avalanche sheds are being considered, a close inspection of winter conditions in the runout zone is necessary. Of course, for any avalanche defense planning, records of frequency, size, and type of avalanches are very important and should be continued even after the structures are installed.

Structural control does not stop with the completion of the structures. Maintenance of the structures is vital and never ending. Later adjustments or additions will often have to be made to insure complete protection.


ARAPAHO
FOREST
CONTINENTAL
DIVIDE
B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-8
B-9
B-10
B-11
B-12
Berthoud Pass
Colorado Mines Peak
Stanley Mountain
Vasquez Pass
Vasquez
GRAND CO
CLEAR CREEK CO
SCALE 1:24 000
1 MILE
7000 FEET
1 KILOMETER
CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1957

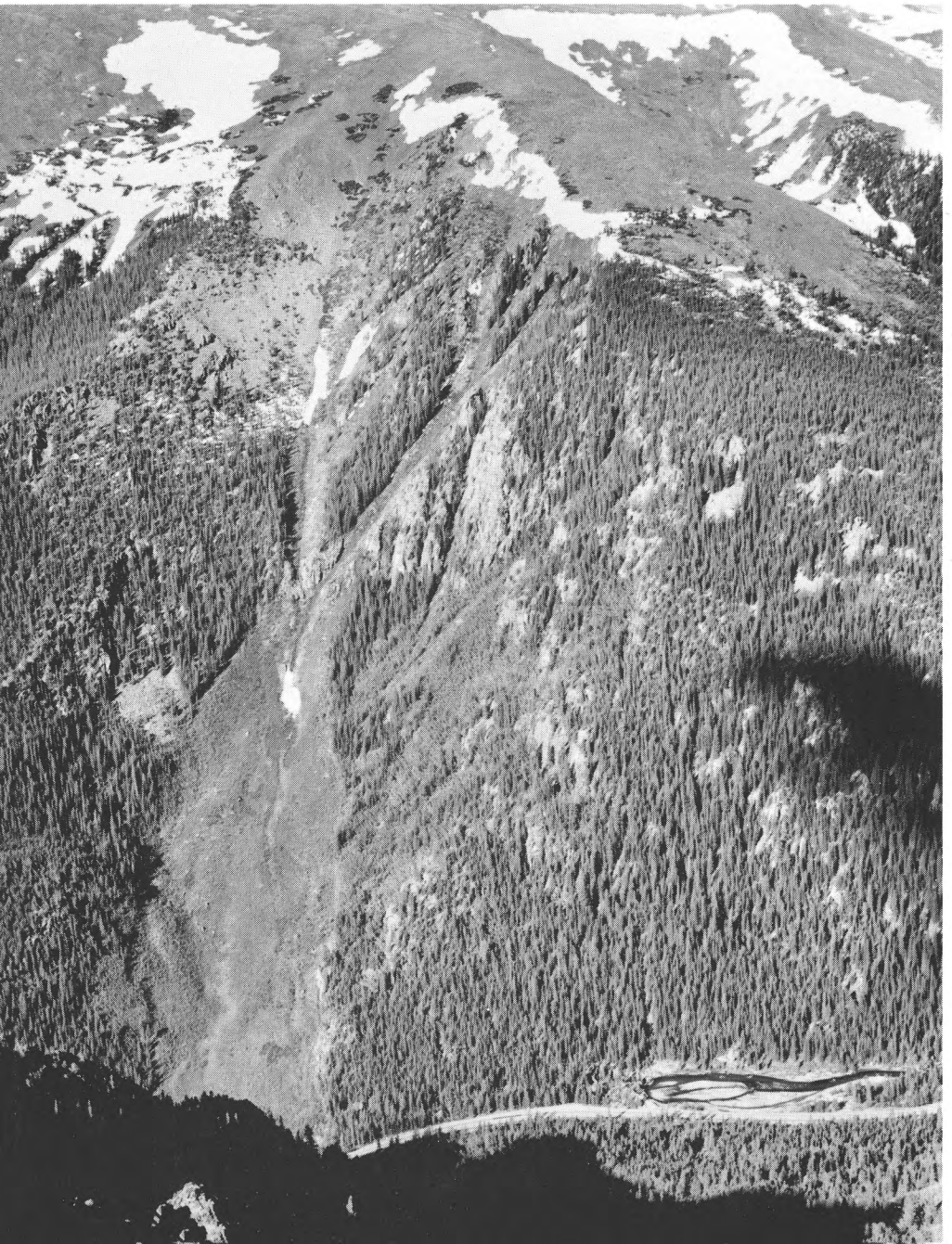
SUMMARY FOR HIGHWAY No. 40: BERTHOUD PASS

Berthoud Pass has large avalanches on the south side only. The snowslides on the north side, essentially large bankslides, run in spots where fire denuded the slopes. A few small plantations have been established in these areas.

Of the six avalanches on the south side, four are on the same slope as the highway. ASPEN and CAMPGROUND reach the road so seldom they need not be controlled. FLORAL PARK can be easily controlled with lightweight supporting structures and afforestation. STANLEY is the only avalanche for which structural control will require much effort. The other two avalanches, DAM and BERTHOUD FALLS, run down the slope across the valley from the highway and reach the road only under very severe conditions.

The six avalanches on the north side are small and easily accessible. Control with supporting structures and more extensive afforestation is recommended.

Of the five mountain passes considered in this report, structural protection against avalanches would be easiest on Berthoud Pass.



Highway No. 40 --
Berthoud Pass
Photo: June 19, 1962

DAM (B-1)

LOCATION:
Front Range; Berthoud Pass south; northeast slope of the east shoulder of Engelmann Peak.

CATCHMENT BASIN:
A V-shaped depression in the slope; above and below timberline; 11,800-10,800 feet m.s.l.; 50 acres (20 ha).

TRACK:
Gully; vertical drop, 2,120 feet; length, 3,600 feet; average slope, 59 percent.

RUNOUT ZONE:
Lower section of gully, Clear Creek valley bottom, and opposite slope where highway lies. Highway is 40 feet above Clear Creek and 200 feet away from it. Runout zone in lower section of gully; length, 1,500 feet; average slope, 27 percent. Usually, avalanches stop on this gentle section or in bed of Clear Creek. Large avalanches, however, reach highway and beyond.

AVALANCHES:
Avalanche, shot down April 8, 1957, ran to highway; killed two men.

CLASSIFICATION:
Large-erratic. Erratic designation relates to frequency with which avalanche reaches highway, not to frequency of runs below road.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Parts of catchment basin are rugged with cliffs, starting area is large. Control of starting zone would be expensive. If structural control is undertaken, a very large catchment dam between Clear Creek and highway might be a solution.

Highway No. 40 --
Berthoud Pass
Photo: November 14, 1963

ASPEN (B-2)

LOCATION:
Front Range; Berthoud Pass south; south slope of Colorado Mines Peak.
CATCHMENT BASIN:
Depression in slope at upper end of an ephemeral stream; mostly below timberline; 11,600-11,000 feet m.s.l.; 4 acres (2 ha).
TRACK:
Steep narrow gully; vertical drop, 2,160 feet; length, 3,400 feet; average slope, 63 percent.
RUNOUT ZONE:
Above road, 300-400 feet long; average slope, 35 percent.
CLASSIFICATION:
Small-erratic.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structure in starting zone and afforestation. Snowfences on slope to windward of catchment would reduce snow depths in catchment and might help natural reforestation.

CAMPGROUND (B-3)

LOCATION:
Front Range; Berthoud Pass south; south slope of Colorado Mines Peak; 1,000 feet west of ASPEN avalanche track.
CATCHMENT BASIN:
Lee side of a small ridge; mostly below timberline; 11,600-11,200 feet m.s.l.; 5 acres (2 ha).
TRACK:
Two narrow slots in timber merging part way down the ridge; vertical drop, 2,120 feet; length, 3,400 feet; average slope, 62 percent.
RUNOUT ZONE:
Above road, 500 feet long; average slope, 30 percent.
CLASSIFICATION:
Small-erratic.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structures in starting zone and afforestation. Snowfences to windward of catchment area might help trees get started by reducing snow depths.

Highway No. 40 --
Berthoud Pass
Photo: April 23, 1962

BERTHOUD FALLS (B-4)

LOCATION:
Front Range; Berthoud Pass south; north face of north spur of Engelmann Peak.

CATCHMENT BASIN:
A bowl-shaped depression on slope; above timberline; 12,200-11,200 feet m.s.l.; 27 acres (11 ha).

TRACK:
Gullylike depression in slope; avalanches have cut a slot in heavy timber; vertical drop, 2,200 feet; length, 3,900 feet; average slope, 57 percent.

RUNOUT ZONE:
Gentle section of lower track and Clear Creek valley bottom. Highway lies on opposite slope 30 feet above and 380 feet beyond Clear Creek. Although there are no records of this avalanche ever having reached the highway, it is possible. Normally, avalanches stop before reaching Clear Creek, in gentle section of lower track which is 700 feet long with average slope of 36 percent.

AVALANCHES:
For many years this avalanche has not given trouble to the highway.

CLASSIFICATION:
Medium-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Since avalanche very seldom runs to highway, need for structural control is questionable. Technically speaking, supporting structures in starting zone as well as a catchment dam near highway would be possible.

Highway No. 40 --
Berthoud Pass
Photo: June 18, 1962

STANLEY (B-5)

LOCATION:
Front Range; Berthoud Pass south; southeast slope of the east shoulder of Stanley Mountain. The top of the avalanche area (ridge face southeast of point 12,507) is erroneously called "Stanley Mountain" by local people. Stanley Mountain is actually 1 mile farther west.

CATCHMENT BASIN:
A bowl-shaped depression on the slope; above timberline; 12,400-11,600 feet m.s.l.; 20 acres (8 ha).

TRACK:
Not confined; three slots in timber; vertical drop, 2,400 feet; length, 4,400 feet; average slope, 55 percent.

RUNOUT ZONE:
Lower section of the track with a more gentle slope and valley bottom of Clear Creek; length, 900 feet; average slope, 33 percent. Width of track and runout zone, 2,000 feet.

AVALANCHES:
Blocked the highway on the following dates: February 6, 1951; December 30, 1951; January 28, 1955; February 16, 1956; January 22, 1959; February 4, 1960; March 3, 1960; February 28, 1961; January 21, 1964; and March 6, 1964. Avalanches ran but did not reach the highway on February 6, 1959, December 19, 1960, December 27, 1961, January 23, 1963, and February 25, 1963.

CLASSIFICATION:
Medium-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Structural controls in the catchment basin or an avalanche shed are the two possibilities. A detailed study has been made of the possibility for structural control of this avalanche.[10]

[10] *See footnote 6, p. 2.*

Highway No. 40 --
Berthoud Pass
Photo: April 23, 1962

FLORAL PARK (B-6)

LOCATION:
Front Range; Berthoud Pass south; west slope of Colorado Mines Peak.

STARTING SPOTS:
On steep, sparsely timbered slopes with local snowdrifts; starting areas are not well defined; below timberline; 11,600-11,300 feet m.s.l.; 10 acres (4 ha).

TRACKS:
Slight depressions in the slope or through the trees; indefinite; vertical drop, 920 feet; length, 1,400 feet; average slope, 66 percent.

RUNOUT ZONE:
No transition zone above highway; avalanches cross the highway and run out into the flat bottom of Hoop Creek just below the highway.

AVALANCHES:
Ran to the highway on: December 30, 1951 (caught a car); April 1, 1957; February 16, 1958; April 18, 1958; February 15, 1960; March 21, 1961; and January 7, 1962.

CLASSIFICATION:
Medium-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
No problems for control in the starting spots. Afforestation of the openings in the timber is the most important part of the control work. Lightweight supporting structures will be needed to control the area, however, until the trees are large enough to stabilize the snow.

Highway No. 40 --
Berthoud Pass
Photo: Date unknown

EIGHTY (B-7)

LOCATION:
Front Range; Berthoud Pass north; starts about 200 feet north of first switchback on north side of Berthoud Pass.

CATCHMENT BASIN:
Three small, rocky slots; below timberline; 11,000 feet m.s.l.; 1 to 2 acres (less than 1 ha).

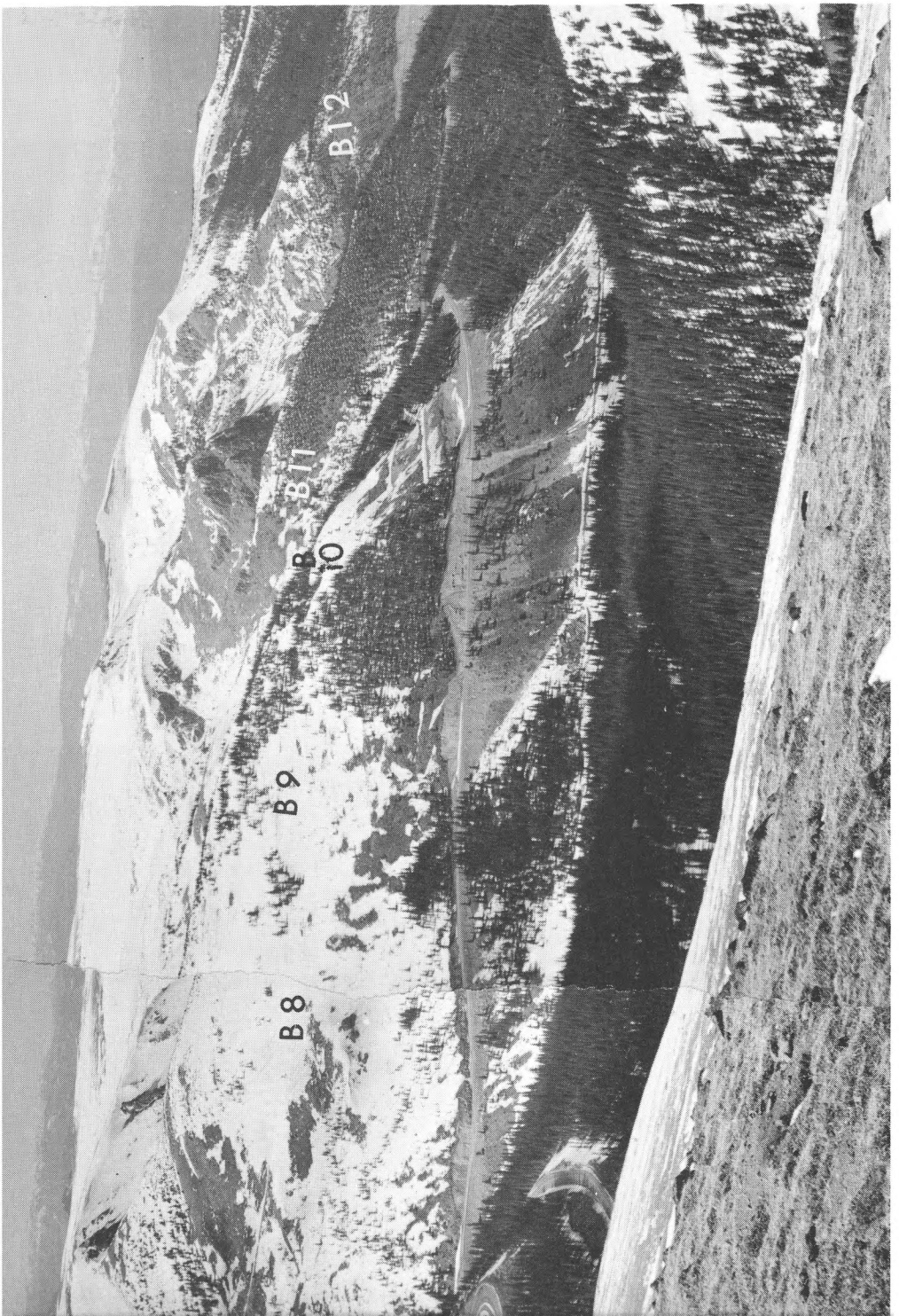
TRACK:
Uniform, open talus slope; vertical drop, 160 feet; length, 300 feet; average slope, 53 percent.

RUNOUT ZONE:
None. Drops over cut bank onto the highway.

AVALANCHES:
Has run at least 6 times in the last 9 years.

CLASSIFICATION:
Small-frequent. This is essentially a large bankslide.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Access is easy, so supporting structures would present no problem. Afforestation may be difficult on the talus.



Highway No. 40 --
Berthoud Pass
Photo: April 23, 1963

(NORTH SIDE GROUP)

ONE-TEN (OR WEICKER) (B-8)

LOCATION:
Front Range; Berthoud Pass north; southeast slope of point 11,721 between Current Creek and Second Creek.

STARTING ZONE:
Open slope with scattered small trees; some small rocky outcroppings; below timberline; 11,100-11,000 feet m.s.l.; 3-4 acres (less than 2 ha).

TRACK:
Open, uniform slope denuded of trees by fire; vertical drop, 440 feet; length, 1,000 feet; average slope, 44 percent.

RUNOUT ZONE:
None above road.

AVALANCHES:
Has run at least twice in past 9 years.

CLASSIFICATION:
Small-frequent. This is essentially a large bankslide.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Structures plus afforestation. Access is very simple.

ONE-TWENTY (B-9)

LOCATION:
Front Range; Berthoud Pass north; southeast slope of point 11,721 between Current Creek and Second Creek; 1,000 feet north of slide 110.

CATCHMENT BASIN:
Open slope with scattered small trees; below timberline; 11,000 feet m.s.l.; 1 acre (1/2 ha).

TRACK:
Open slope. Vertical drop, 320 feet; length, 700 feet; average slope, 46 percent.

RUNOUT ZONE:
No transition above road. Snow comes over cut bank to the highway.

CLASSIFICATION:
Small-frequent. Another large bankslide.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Easy access makes structure and afforestation the obvious choice.

ONE-FORTY (B-10)

LOCATION:
Front Range; Berthoud Pass north; on the eastern flank of point 11,721 between Current Creek and Second creek; 1,500 feet north of avalanche 120.

CATCHMENT BASIN:
Open, uniform slope with scattered trees. 11,000 feet m.s.l.; 1 acre (1/2 ha).

TRACK:
Broad area on the point of the ridge about 400-50 feet wide. Vertical drop, 300 feet; length, 600 feet; average slope, 50 percent. Lower part of the track was steepened considerably in 1960 when material was removed to be used as fill for the highway.

RUNOUT ZONE:
None. Snow falls into a large barrow pit dug to get fill material for the highway. This pit will probably stop the slide before it reaches the highway.

AVALANCHES:
Past records will not apply now that there is a large barrow pit between the highway and the avalanche. Earthen terraces in the track.

CLASSIFICATION:
Small-frequent avalanche or large bankslide.

POSSIBILITIES FOR STRUCTURAL CONTROL:
This area should be checked carefully for a few years, but it seems likely that the barrow pit will protect the road. If more control is needed, the upper part of the track could be controlled with structures and afforestation. Earthen terraces in the track failed to keep avalanches out of the road.

TWO HUNDRED (OR MONUMENT) (B-11)

LOCATION:
Front Range; Berthoud Pass north; the south-facing bank just north of Second Creek.

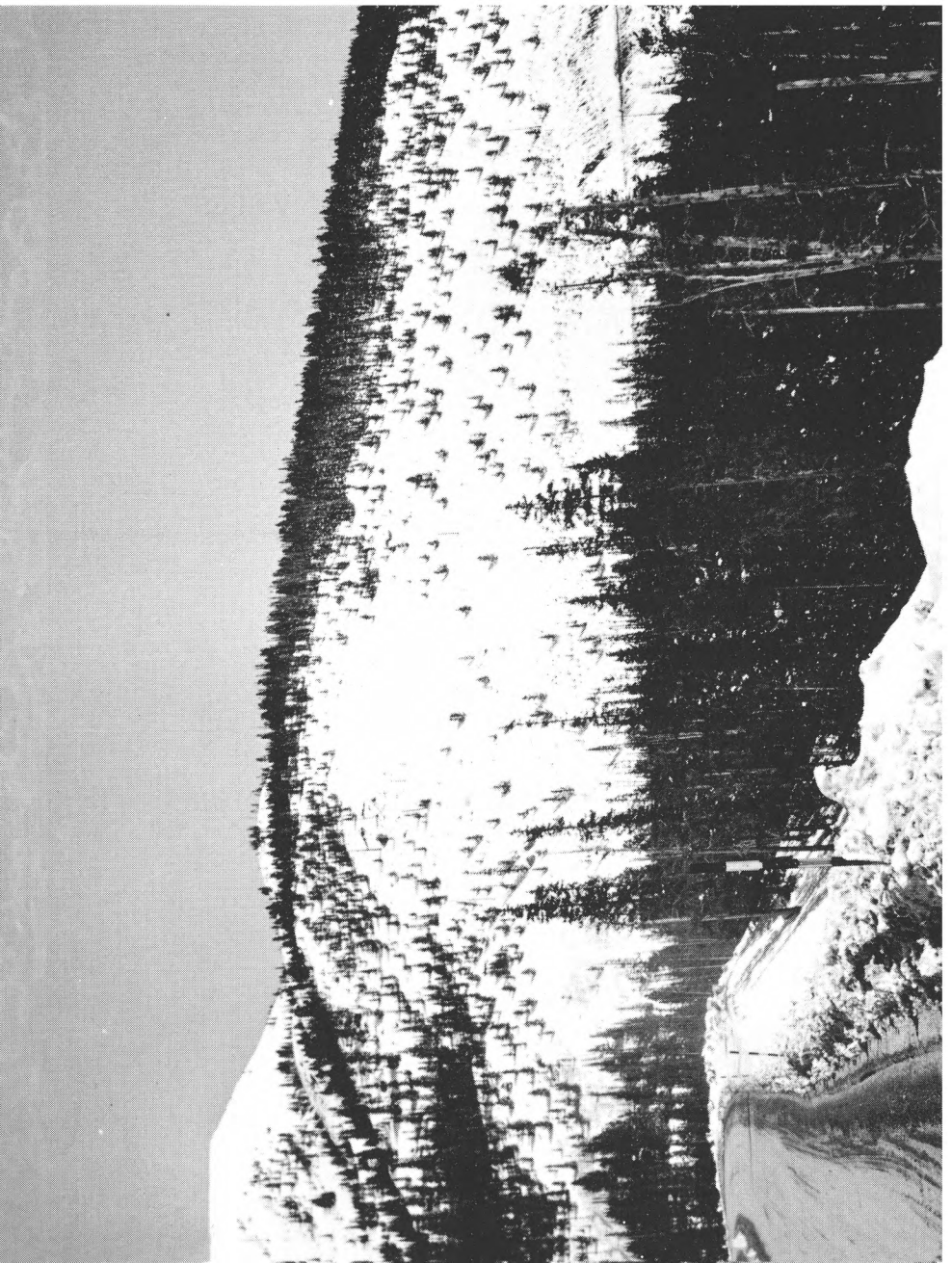
CATCHMENT BASIN:
Open slope with scattered trees; indefinite starting zone - approximately 10,700 feet m.s.l.; 1-2 acres (1/2 ha).

TRACK:
Open slope 200-400 feet wide. Vertical drop, 100 feet; length, 200-300 feet; average slope, 40 percent.

RUNOUT ZONE:
None above the road.

CLASSIFICATION:
Small-erratic avalanche or large bankslide.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Afforestation protected by supporting structures.



Highway No. 40 --
Berthoud Pass
Photo: Date unknown

TWO-FORTY (B-12)

LOCATION:
Front Range; Berthoud Pass north; about 1,000 feet north of First Creek.

CATCHMENT BASIN:
Open slope with scattered small trees; below timberline; 10,800 feet m.s.l.; 2-1/2 acres (1 ha).

TRACK:
Open slope. Vertical drop, 400 feet; length, 700 feet; average slope, 57 percent.

RUNOUT ZONE:
Below highway.

CLASSIFICATION:
Small-erratic avalanche or large bankslide with scattered small trees in parts of it.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structures plus afforestation. Access is easy.

SUMMARY FOR HIGHWAY No. 6: LOVELAND PASS

Avalanches along Highway No. 6, may be classified into seven groups based on their proximity, and on similarity of recommended control measures. The individual avalanches within each group can be treated separately, but the entire group should be handled as a single control project.

Group 1: Silver Plume--PINKERTON GULCH, SILVER CLOUD, BARD SHOULDER
Group 2: BETHEL
Group 3: SEVEN SISTERS
Group 4: GRIZZLY
Group 5: North Arapaho--LITTLE PROFESSOR, ASSOCIATED LITTLE PROFESSOR, BLACK WIDOW
Group 6: PALLAVICINI
Group 7: Afforestations -- LAZY SUSAN, FIVE CAR, HAPPY END.

As far as avalanche hazard is concerned, the Seven Sisters, Bethel, and North Arapaho groups are the most important. Control by supporting structures and afforestation is indicated for the Seven Sisters, but may not be economical for the North Arapaho and Bethel groups. For these two groups, avalanche sheds might be more economical.

The Silver Plume and Grizzly groups are all medium to large avalanches of erratic to very erratic occurrence. The control of these two groups can probably be postponed unless the new road through Straight Creek moves the highway closer to these avalanches.

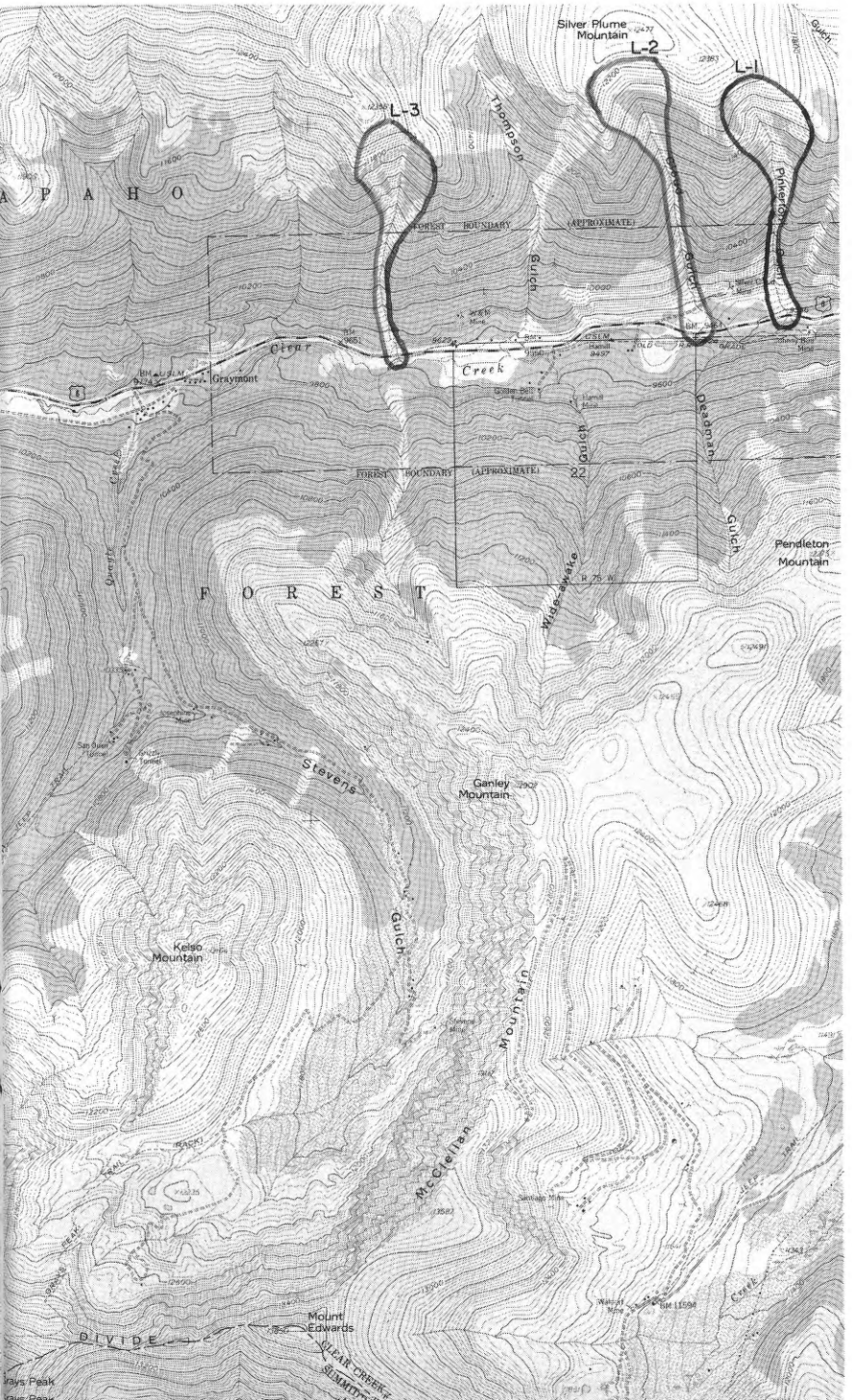
Group 6, Pallavicini, is a special case. Control by structures in the starting zone would be possible, but, because of ski use, this type of control is not very likely.

All avalanches in Group 7 (Afforestation) are small and can certainly be controlled by supporting structures supplemented by afforestation of the starting zone and the track.

Since structural avalanche control, especially in the starting zone, is something new in this region, projects should begin with the easier cases and not with the larger and more difficult ones. Some experience must be gained, first, and that can be done with less risk on little projects.

When the tunnel is completed through the Continental Divide from Clear Creek to Straight Creek, Bethel and Silver Plume groups will become very important. On the other hand, since this means the heavy traffic will no longer be subjected to the hazard of the other groups, there would be a good opportunity to start some experimental defense works in these areas. If the old highway over Loveland Pass is kept open, the SEVEN SISTERS and LITTLE PROFESSOR would be excellent study sites.

Mount Bethel
L-4
Dry
Gulch
Gulch
Gulch
A R
Clear
Creek
Mount Trelease
L-5
R E S T
Creek
Loveland Ski Area
Clear
L-6
Mount Sniktau
N A T I O N A L
Kearney
Gulch
Mountain
Baker
Grizzly
DIVIDE
Loveland Pass
CLEAR CREEK CO
SUMMIT CO
Loveland Pass Tunnel (Exploratory Bore)
Pass Lake
L-7
North Fork Snake River
L-12
L-9
L-10
L-8
Grizzly Peak
Arapaho Basin Ski Area
CONTINENTAL
Torreys Peak
L-13
Snake River Falls
Snake River
L-11



1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

14°
TRUE NORTH
MAGNETIC NORTH

APPROXIMATE MEAN
DECLINATION, 1958

Highway No. 6 --
Loveland Pass
Photo: September 1, 1962

PINKERTON GULCH (L-1)

LOCATION:
Front Range; south slope of Silver Plume Mountain.

CATCHMENT BASIN:
Bowl-shaped depression in the south-facing slope; above and below timberline; 12,000-11,400 feet m.s.l.; 30 acres (12 ha).

TRACK:
Pinkerton Gulch; vertical drop, 2,400 feet; length, 4,400 feet; average slope, 55 percent.

RUNOUT ZONE:
The alluvial fan of Pinkerton Gulch; length, 1,000 feet; width, 700 feet; average slope, 30 percent. Distance from the mouth of Pinkerton Gulch to the highway is 800 feet. The avalanche snow is confined when it reaches the alluvial fan.

AVALANCHES:
The last one occurred in spring, 1957.

CLASSIFICATION:
Medium-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Because it runs only in very severe winters, structures would not be economical. There are no difficulties for supporting structures. The possibilities of control in the runout zone are very limited because this zone is too short and too steep to build effective retarding or catchment structures.

Highway No. 6 --
Loveland Pass
Photo: September 1, 1962

SILVER CLOUD (L-2)

LOCATION:
Front Range; south slope of Silver Plume Mountain.

CATCHMENT BASIN:
Bowl-shaped depression in the south-facing slope; above and below timberline; 12,400-11,400 feet, m.s.l.; 75 acres (30 ha).

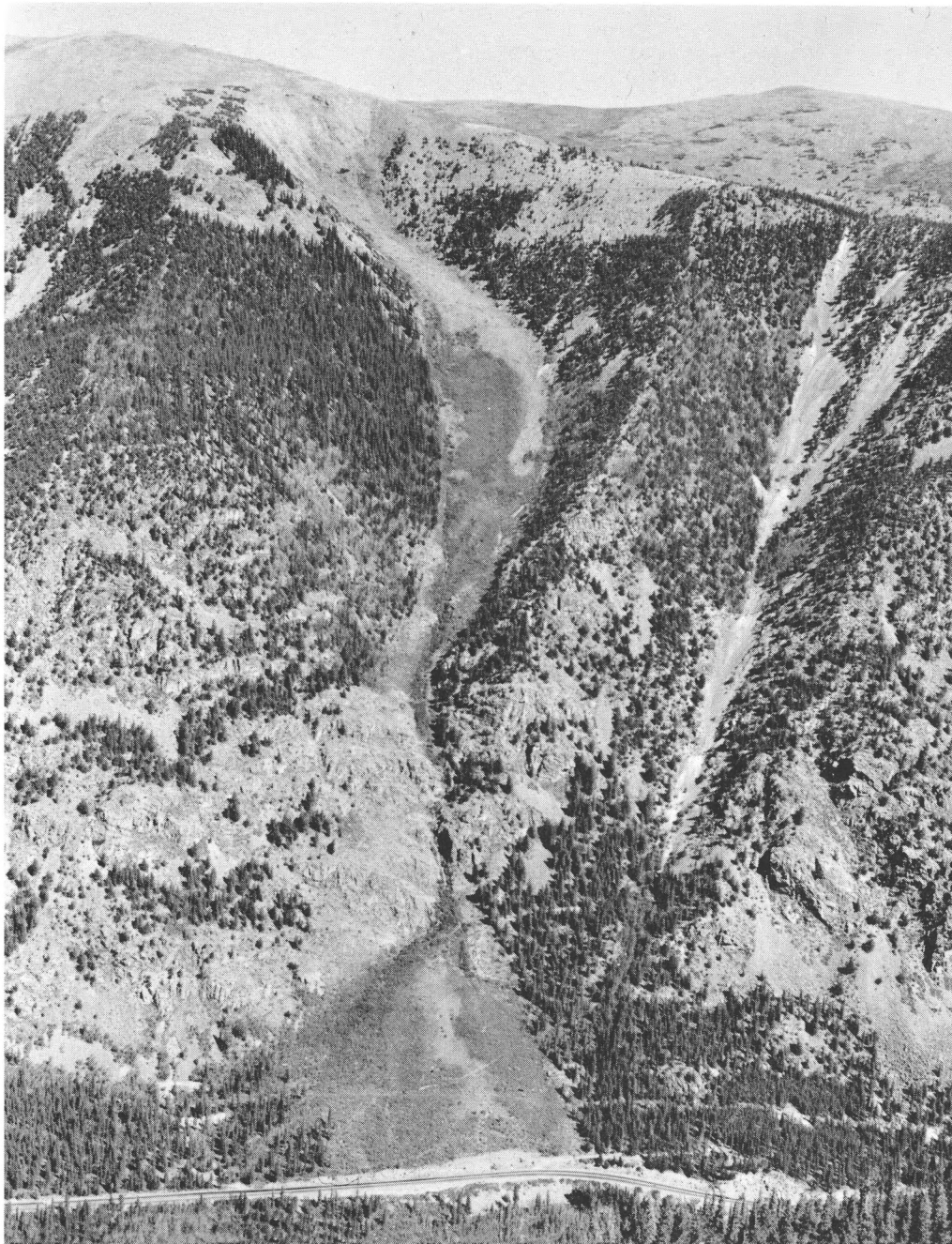
TRACK:
Cloud Gulch; vertical drop, 2,700 feet; length, 5,500 feet; average slope, 50 percent.

RUNOUT ZONE:
Alluvial fan of Cloud Gulch, the slope of which varies from very gentle to moderate. Avalanche will be unconfined on the fan. Distance from the mouth of the gulch to the highway is 900 feet; width of the fan where it reaches the highway is 1,500 feet; the fan has an average slope of 25 percent.

AVALANCHES:
On April 12, 1951, an avalanche reached the highway.

CLASSIFICATION:
Large-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Because it is an erratic, large avalanche, structural control seems to be not very economical, especially supporting structures. The runout zone offers some possibilities for the installation of retarding structures. Whether such control is possible can be answered only by a detailed study of the frequency of occurrence and the terrain conditions in the runout zone.



Highway No. 6 --
Loveland Pass
Photo: September 1, 1962

BARD SHOULDER (L-3)

LOCATION:
Front Range; south slope of southeast end of the Bard Peak Shoulder.

CATCHMENT BASIN:
Bowl-shaped depression in the south-facing slope; rugged and very steep in places; above and below timberline; 12,200-11,400 feet m.s.l.; 30 acres (12 ha).

TRACK:
Unnamed gulch; vertical drop, 2,200 feet; length, 3,900 feet; average slope, 56 percent.

RUNOUT ZONE:
Gentle slope in the lower section of the gulch; width, 500 feet; length, 1,100 feet; average slope, 35 percent.

CLASSIFICATION:
Medium-very erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Because of the ruggedness of the starting zone, the steepness of the track, and the steep runout zone, successful control by either supporting structure or retarding structure seems quite unlikely. Since the avalanche occurs very seldom, control is not pressing.

Highway No. 6 --
Loveland Pass
Photo: June 18, 1962

BETHEL (L-4)

LOCATION:
Front Range; southeast slope of Bethel Mountain.

CATCHMENT BASIN:
A bowl-shaped depression in the slope on the west, and steep regular slope on the east; both above timberline; 12,600-11,000 feet m.s.l.; 25 acres (10 ha).

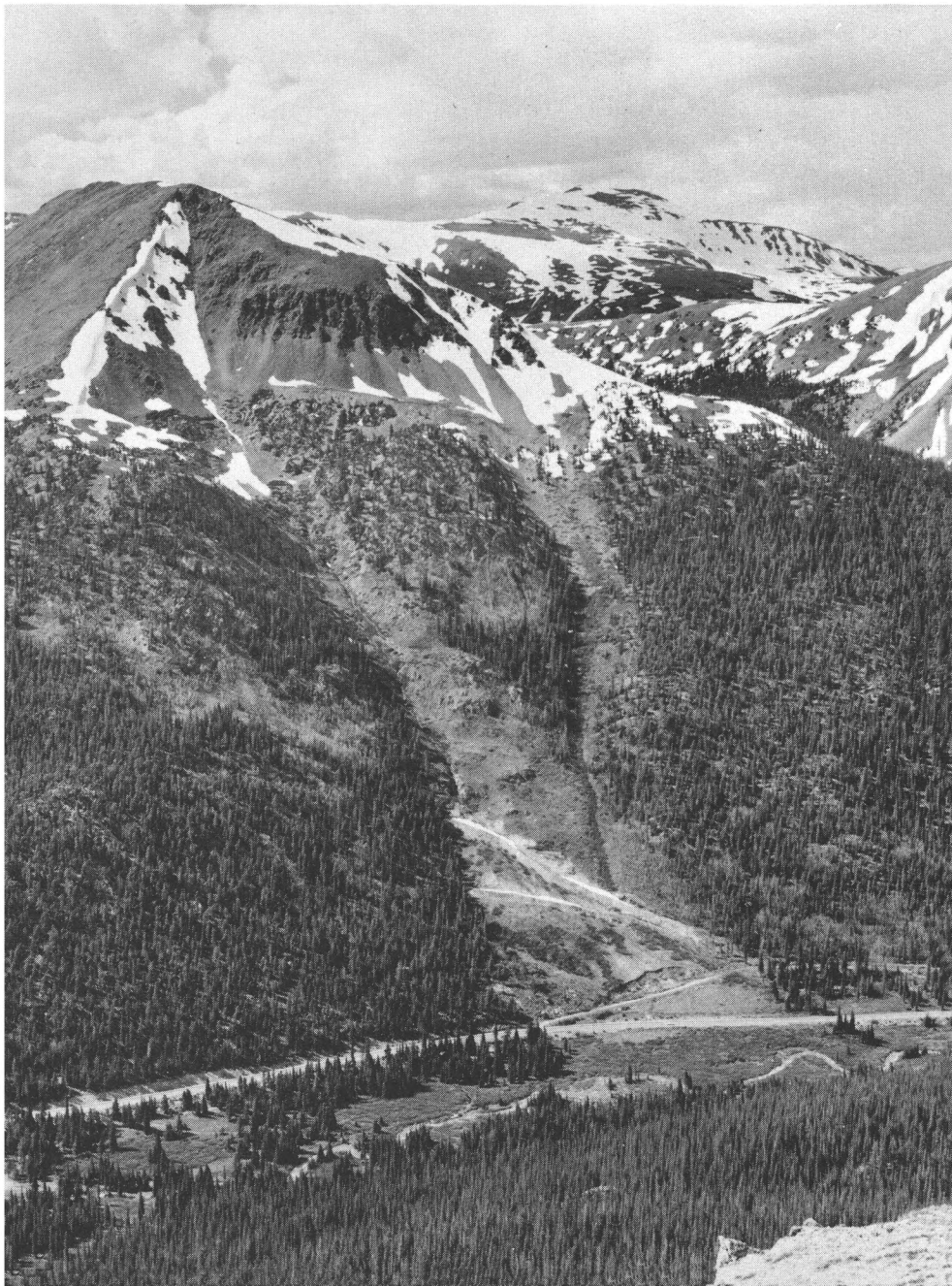
TRACK:
The tracks from the two separate catchment basins join at an elevation of about 10,800 feet. These two tracks are gullylike. The main avalanche is the one that starts in the bowl-shaped depression; vertical drop, 1,800 feet; length, 3,000 feet; average slope, 60 percent.

RUNOUT ZONE:
The lowest section of the main track. This slope is 1,100 feet long, 700 feet wide, with an average slope of 40 percent.

AVALANCHES:
Runs to the road about once every 2 years.

CLASSIFICATION:
Medium-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
The ruggedness and steepness of the catchment basin, together with the excessive snow accumulations (drifts), create some problems for supporting structures. Two diversion dams already installed, are not always effective because the runout zone is too steep and the dams too small. Control measures either in the track or in the runout zone are out of the question if full protection is expected from all avalanches. Only very expensive supporting structures or an avalanche shed would give full protection to the road. Guide walls parallel to the avalanche track could be used with an avalanche shed to shorten the length of the expensive shed.



Highway No. 6 --
Loveland Pass
(No photo)

LAZY SUSAN (L-5)

LOCATION:
Front Range; southeast slope, one-third mile below the parking lot for the Loveland Basin ski area.

CATCHMENT BASIN:
Little cliffs in an area of scattered timber, at an altitude of 11,000 feet m.s.l.; 2-1/2 acres (1 ha).

TRACK:
Poorly defined in scattered timber. Vertical drop, 300 feet; length, 600 feet; average slope, 50 percent.

RUNOUT ZONE:
No transition zone, track hits highway directly.

AVALANCHES:
Has run to the road at least twice in past 10 years. New highway construction is going through this area and will alter conditions considerably.

CLASSIFICATION:
Small-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Some starting points in the cliffs may cause difficulty for structural control. However, the small starting zone and the fact that it lies in a generally timbered area would render control with supporting structures easy and economical. Afforestation in connection with some protecting structures should be studied immediately.

Highway No. 6 --
Loveland Pass
Photo: May 10, 1962

SEVEN SISTERS (L-6)

LOCATION:
Front Range; north slope near Loveland Basin ski area.

CATCHMENT BASINS:
At and below timberline; north slope 11,800-11,400 feet m.s.l. There are seven small, bowl-shaped starting zones that are separated by timbered ridges. The whole starting area of all seven avalanches is about 20 acres (8 ha).

TRACKS:
Seven gullylike tracks on a timbered slope; vertical drop, 900 feet; length, 1,400 feet; average slope, 64 percent.

RUNOUT ZONE:
No transition zone between the tracks and the highway. The avalanches, after filling the road cut with snow, travel across the road down to Clear Creek.

AVALANCHES:
Very frequent; usually released four to six times a winter by artillery fire. Avalanche cycles are recorded as early as mid-November and as late as the end of April.

CLASSIFICATION:
A group of seven, small-frequent avalanches.

POSSIBILITIES FOR STRUCTURAL CONTROL:
The terrain offers no special difficulties for control by supporting structures. Since the avalanches are frequent, control measures should be studied immediately. Control by supporting structures in connection with snowdrift control and afforestation is the most economical procedure. Because of the proximity of Loveland Basin ski area and the chair lift, it would be a good test and study field.

Highway No. 6 --
Loveland Pass
Photo: May 11, 1962

FIVE CAR (L-7)

LOCATION:
Front Range; between the two legs of the second switchback on the west side of Loveland Pass on both sides of Pass Lake Creek.

STARTING SPOTS:
East slope between the two legs of the highway. The starting spots lie near timberline at an altitude of 11,600 feet m.s.l.; 2-1/2 acres (1 ha).

TRACK:
The moving snow travels only a short distance in a poorly defined path; average slope, 51 percent.

RUNOUT ZONE:
The track hits the highway without any transition zone.

AVALANCHES:
December 20, 1951: covered the highway and blocked traffic from 4:30 p.m. to 8:55 p.m.; caught five cars, two trucks; buried two men. January 7, 1957: covered highway for 250 feet to a depth of 10 feet. Has run to the road at least 14 times in the past 10 years.

CLASSIFICATION:
Small-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
A spot highly qualified as a test field for supporting structures because the starting spots lie immediately below the highway, so there is no transportation problem. The area is easy to observe.

Highway No. 6 --
Loveland Pass
Photo: May 11, 1962

GRIZZLY (OR WEST PATROL) (L-8)

LOCATION:
Front Range; west face of Grizzly Peak.

CATCHMENT BASIN:
Big bowl shaped, west face of Grizzly Peak; above timberline; 13,400-12,000 feet m.s.l.; 110 acres (45 ha).

TRACK:
Narrow gulch; vertical drop, 2,200 feet; length, 4,800 feet; average slope, 46 percent. Upper half of track is very steep, 64 to 70 percent; lower half is more gentle with average slope of 32 percent. The gulch is curved, especially in the lower half, which is actually part of the runout zone since avalanches normally stop here.

RUNOUT ZONE:
In case of a large avalanche, the runout zone extends to the highway. This part of the runout zone is the alluvial fan of the gulch and the wide bottom of North Fork of Snake River. Length, 1,100 feet; width, 100 feet; average slope, 18 percent.

AVALANCHES:
This avalanche has not given trouble on the highway for a long time.

CLASSIFICATION:
Large-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Control is not urgent, but if it is desirable to protect the highway, terrain conditions are rather favorable for a diversion dam in the runout zone. Control in the starting zone is out of the question because it is too big and rugged.

Highway No. 6 --
Loveland Pass
Photo: May 11, 1962

LITTLE PROFESSOR (L-9)

LOCATION:
Front Range; southeast slope of summit point 12,293, northwest of Arapaho Basin ski area.

CATCHMENT BASIN:
Uniform southeast slope; above timberline; 12,100-11,600 feet m.s.l.; 7 acres (3 ha).

TRACK:
Wide opening in the timber of the slightly bowl-shaped slope; vertical drop, 1,260 feet; length, 2,700 feet; average slope, 47 percent. This avalanche has a tendency to spread out in the lower part; the width of the track is 800 feet near the highway.

RUNOUT ZONE:
No transition zone above the highway; avalanches reach the parking lot of Arapaho Basin ski area.

AVALANCHES:
December 30, 1951, covered the highway 5 feet deep. Has run to the road at least six times in past 10 years.

CLASSIFICATION:
Small-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
The terrain conditions are favorable for control in the starting zone. Because of the danger to the ski area parking lot, supporting structures in the starting zone are the only logical type of control. Since access to the starting zone is easy and very good observations can be taken from the opposite slope during the whole winter, this avalanche would be a good study field for supporting structures. Snow conditions in the starting zone may be difficult because heavy snowdrifts must be expected.

Highway No. 6 --
Loveland Pass
Photo: May 11, 1962

ASSOCIATED LITTLE PROFESSOR
(OR CLIFF) (L-10)

LOCATION:
Front Range; south slope of summit point 12,293 northwest of Arapaho Basin; 1,000 feet west of the LITTLE PROFESSOR avalanche.

STARTING ZONE:
Funnel-shaped erosion surface below timberline; very few trees on the steep, rocky slope; 11,600-11,200 feet m.s.l.; 7 acres (3 ha).

TRACK:
Opening in the woods; slightly bowl shaped; vertical drop, 800 feet; length, 1,300 feet; average slope, 62 percent; width, 200 feet.

RUNOUT ZONE:
No transition zone above highway; track hits highway directly.

CLASSIFICATION:
Small-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Since the starting zone shows a tendency to erode by rockfall, its stabilization should be studied. Except for the unstable ground and some very steep spots, there are no difficulties for control with supporting structures. Afforestation would be the most important control measure.

Highway No. 6 --
Loveland Pass
Photo: May 9, 1962

PALLAVICINI (L-11)

LOCATION:
Front Range; north slope of summit point 12,144 southwest of Arapaho Basin ski area.

CATCHMENT BASIN:
Bowl-shaped depression in the north-facing slope; above and below timberline; 12,000-11,200 feet m.s.l.; 15 acres (6 ha).

TRACK:
Wide opening in the heavily timbered slope; vertical drop, 1,280 feet; length, 2,700 feet; average slope, 47 percent.

RUNOUT ZONE:
Flat bottom of the Snake River Valley; under severe conditions the avalanche may run across the 500-foot-wide valley bottom and reach the highway on the opposite slope.

AVALANCHES:
The starting zone is controlled intensively by explosives and protective skiing because it lies within the Arapaho Basin ski area.

CLASSIFICATION:
Intensive skiing stabilizes the snowpack in the starting zone. Therefore, it is very unlikely that big snow masses will start. During prolonged and severe storms, however, when no skiing is possible, the snow masses may become big enough to form an avalanche that reaches the highway.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Terrain and vegetation conditions would be favorable for control by supporting structures; however, structural control is out of the question because of ski use of this avalanche track.

Highway No. 6 --
Loveland Pass
Photo: January 9, 1962

BLACK WIDOW (L-12)

LOCATION:
Front Range; south slope of summit point 12,293 northwest of Arapaho Basin ski area.

CATCHMENT BASIN:
Bowl-shaped depression in the slope above and below timberline; 12,100-11,500 feet m.s.l. Also a narrow and very steep opening in the timber to the west of the main avalanche. The two tracks join just before reaching the highway, 20 acres (8 ha).

TRACK:
Main track--steep trough in the slope; wide in the upper part; narrow in the lower part. Vertical drop, 1,400 feet; length, 2,500 feet; average slope, 56 percent. Secondary track--steep slot in the timber; vertical drop, 920 feet; length, 1,500 feet; average slope, 61 percent.

RUNOUT ZONE:
No transition zone above highway; track is 200 feet wide where it crosses highway; runout zone is below road in valley bottom.

AVALANCHES:
Ran on January 6, 1962. Has run to the road at least six times in past 10 years and usually brings debris to the highway.

CLASSIFICATION:
Medium-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Terrain conditions are favorable for control by supporting structures. Since this is a medium-size avalanche, an avalanche shed should also be considered. Some guide walls in the track would make a shorter shed possible.

Highway No. 6 --
Loveland Pass
Photo: May 11, 1962

HAPPY END (OR FINGER) (L-13)

LOCATION:
Front Range; southeast slope of a timbered ridge (11,820 feet), 1-1/2 miles west of Arapaho Basin ski area.

STARTING ZONE:
A very steep channel-like depression in the slope with a tendency for erosion. It is partly rocky and has scattered timber; 11,500-11,000 feet m.s.l.; 5 acres (2 ha).

TRACK:
Narrow opening or slot in the forest; vertical drop, 1,060 feet; length, 1,600 feet; average slope, 66 percent.

RUNOUT ZONE:
No transition zone above highway; track crosses highway and runout zone lies below road in valley bottom.

AVALANCHES:
Has run to the road at least twice in past 10 years.

CLASSIFICATION:
Small-occasional. In an average winter, only a little snow would be expected in this area.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Since the starting zone shows a tendency to erode, mostly by rockfall, its stabilization should be studied. Other than some cliffs and very steep spots, there would be no difficulties for controlling it with supporting structures. Afforestation would be the most important control measure.

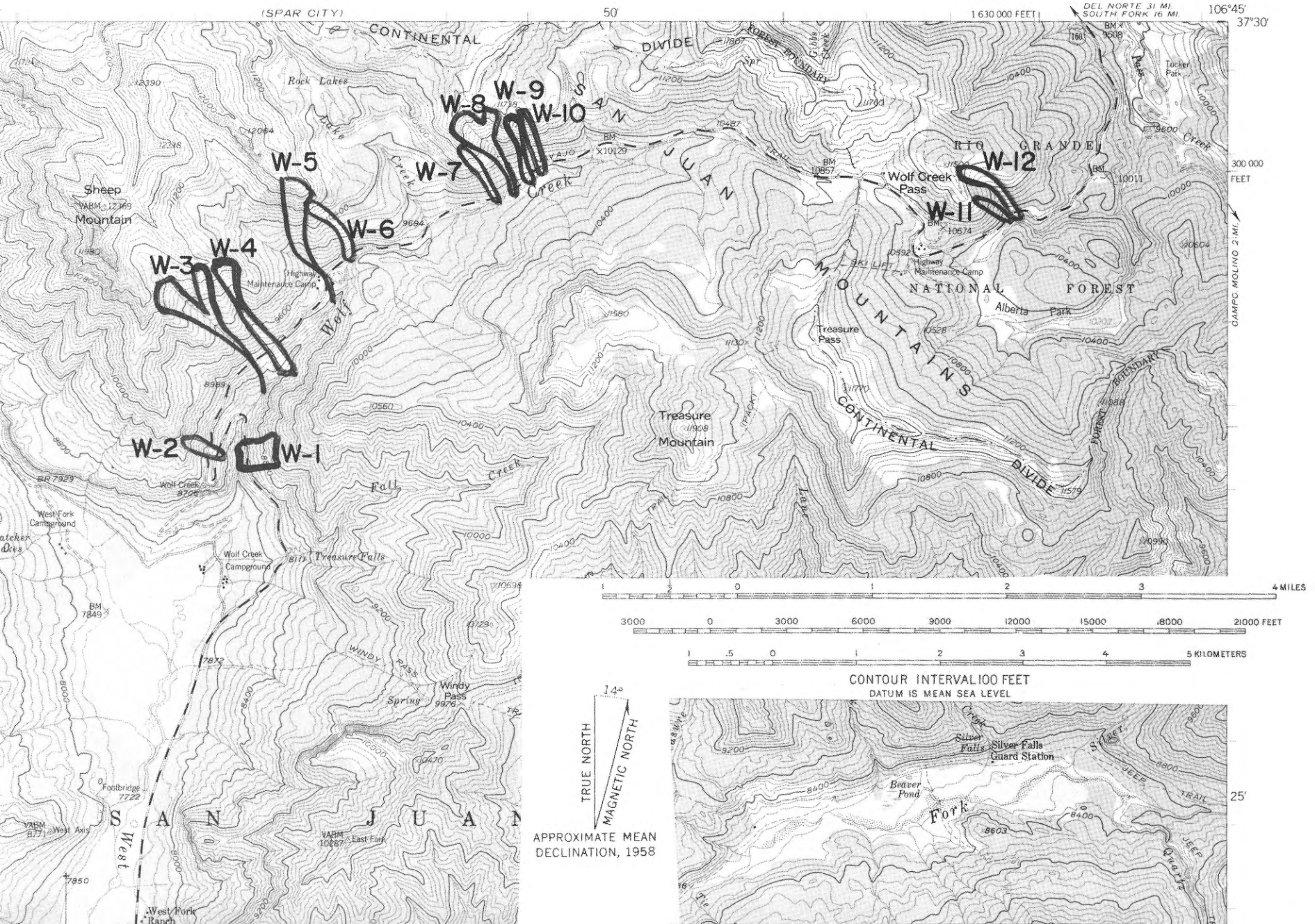
SUMMARY FOR HIGHWAY No. 160: WOLF CREEK PASS

The avalanches on Wolf Creek Pass can be easily classified into four very distinct and homogeneous groups:

Group 1: Albertas--ALBERTA, ALBERTA'S COUSIN
Group 2: Organ Pipes--STEPHEN, DANIEL, ANDREW, KATHY (160 EAST II, 160 EAST I, 160 WEST)
Group 3: Sheep Mountain--PIT, CAMP, SNOWFLAKE, BOULDER CREEK
Group 4: Afforestations--SWITCHBACK, PALISADES
The Coyotes or Cliffs are considered bankslides.

A general structural defense plan should start with the two easiest groups, the Albertas and the Afforestations. There is little question that control of the starting zone is the appropriate procedure for these two groups. Special precautions may be needed for the steep places in the PALISADES.

The Organ Pipes and Sheep Mountain groups have several features in common and the appropriate type of structural control is still in question. Access to the starting zone is often difficult and the possibility of help from afforestation is limited. The larger avalanches of these groups might be controlled by avalanche sheds while the small ones offer a better chance for supporting structures in the starting zones. More information and observations are needed before definite recommendations can be made.


(SPAR CITY)
50'
1 630 000 FEET
DEL NORTE 31 MI.
SOUTH FORK 16 MI.
106°45'
37°30'
CONTINENTAL DIVIDE
Rock Lakes
Duke Creek
W-1
W-2
W-3
W-4
W-5
W-6
W-7
W-8
W-9
W-10
W-11
W-12
Sheep Mountain
Highway Maintenance Camp
Wolf Creek
Wolf Creek Campground
West Fork Campground
Treasure Falls
Treasure Mountain
Treasure Pass
Wolf Creek Pass
Alberta Park
Tucker Park
Silver Falls
Silver Falls Guard Station
Beaver Pond
Windy Pass
Footbridge
West Fork Ranch
SAN JUAN MOUNTAINS
RIO GRANDE NATIONAL FOREST
CONTINENTAL DIVIDE
FOREST BOUNDARY
TRAIL
JEEP TRAIL
SKI LIFT
300 000 FEET
CAMPO MOLINO 2 MI.
4 MILES
21000 FEET
5 KILOMETERS
CONTOUR INTERVAL 100 FEET
DATUM IS MEAN SEA LEVEL
14°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1958
25'

Highway No. 160 --
Wolf Creek Pass
Photo: March 26, 1962

PALISADES (W-1)

LOCATION:
San Juan Mountains, Wolf Creek Pass west; west slope of Treasure Mountain.

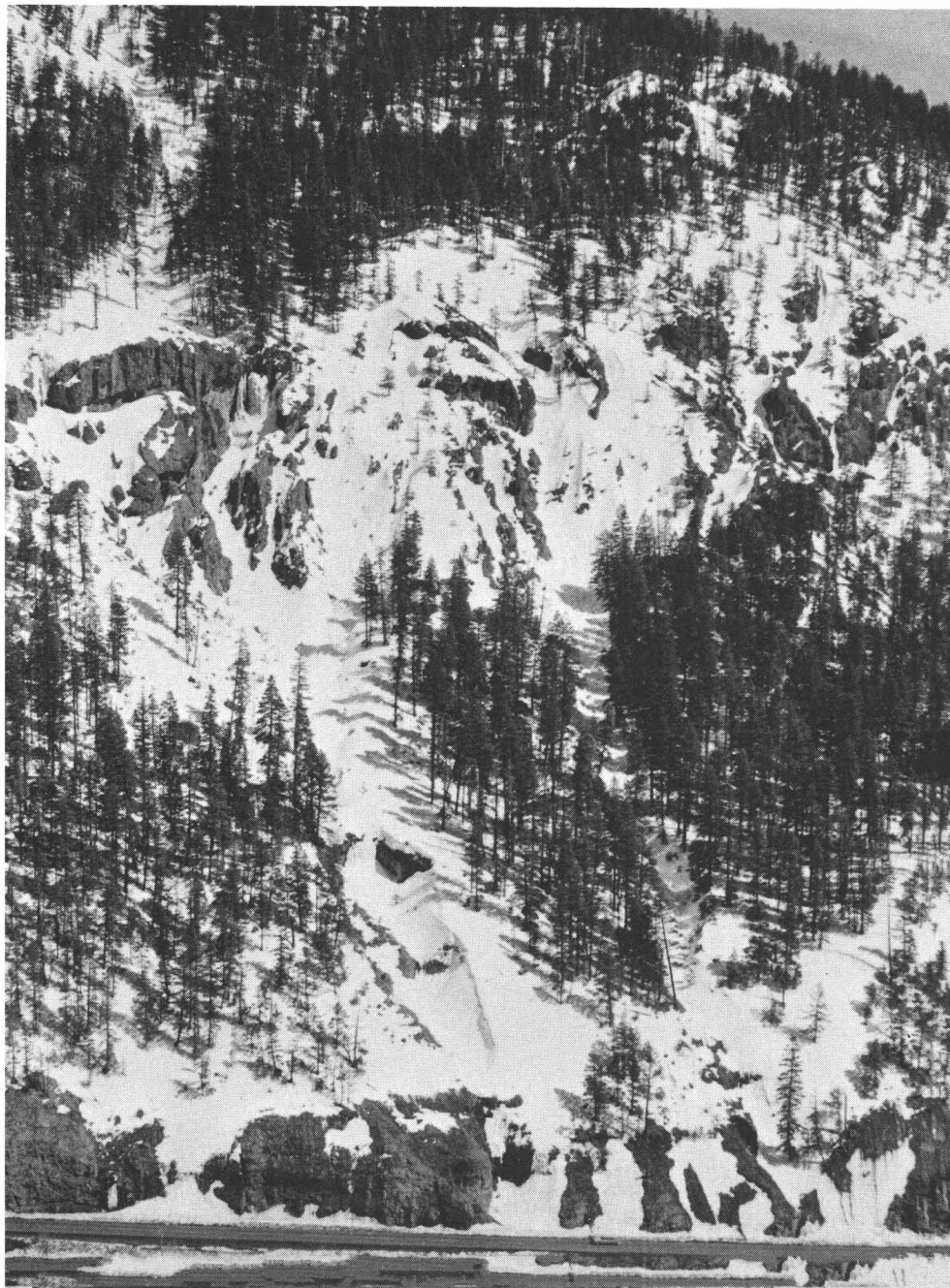
STARTING ZONE:
In steep cliffs just above the highway. On the cliffs are scattered trees; starting spots are indefinite, 9,200-8,400 feet m.s.l.; 7 acres (3 ha).

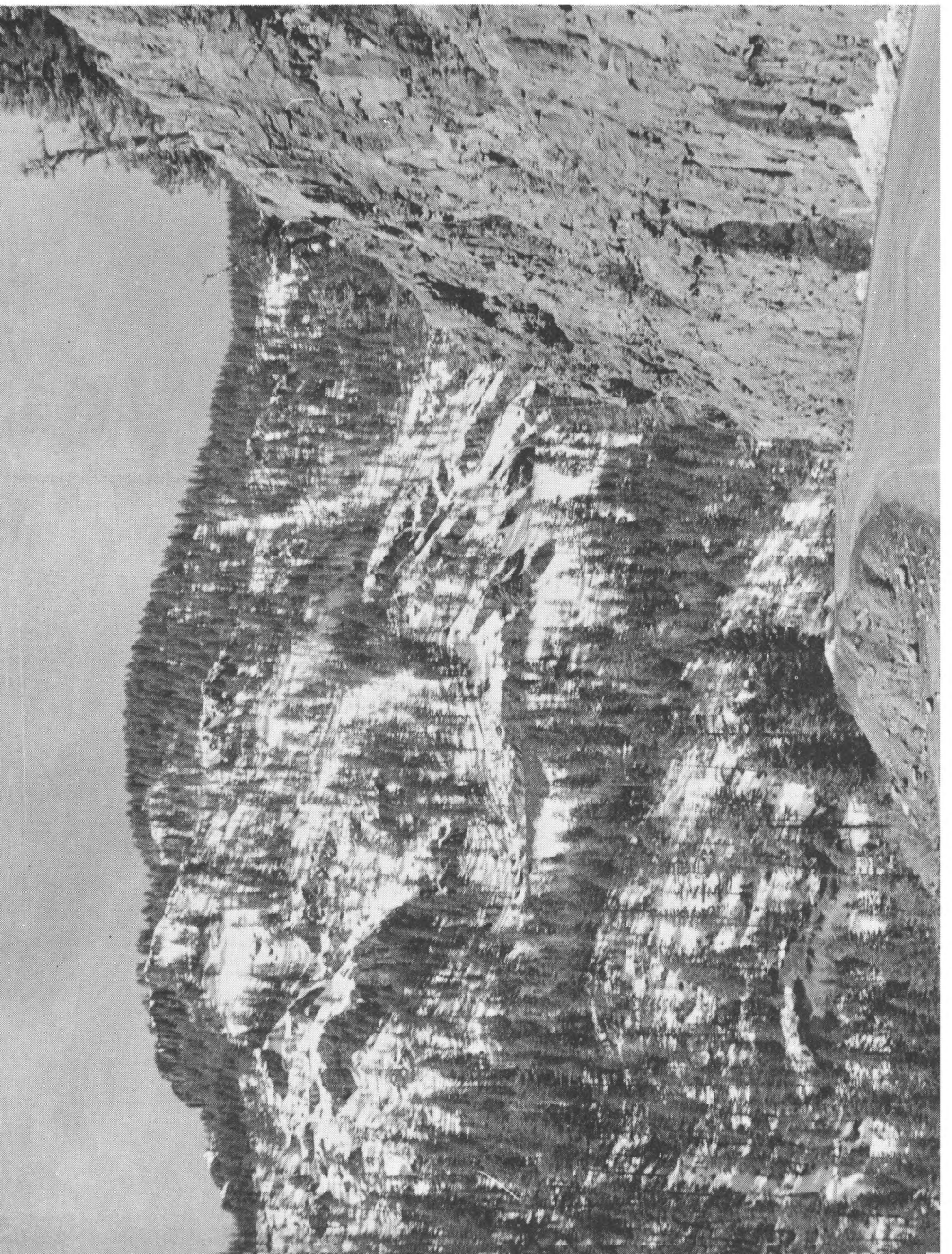
TRACKS:
Indefinite; the snow may fall from several spots and gullylike depressions in the cliffs; vertical drop, 800 feet; length, 1,200 feet; average slope, 67 percent. For a distance of 800 feet along the road avalanches hit the highway directly; the snow masses fall almost vertically into the road cut.

RUNOUT ZONE:
In the bed of Wolf Creek below the highway.

CLASSIFICATION:
Small-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Most obvious is the control of the starting zone by supporting structures. Because the cliffs will give considerable difficulties, the conditions must be studied further.





Highway No. 160 --
Wolf Creek Pass
Photo: March 26, 1962

SWITCHBACK (W-2)

LOCATION:
San Juan Mountains, Wolf Creek Pass west; southeast slope of Sheep Mountain.

STARTING ZONE:
In little cliffs and on steep spots of a generally timbered slope; 9,400-8,800 feet m.s.l.; 2 acres (1 ha).

TRACK:
Several slots in the timber, not confined; vertical drop, 600 feet; length, 900 feet; average slope, 67 percent; sliding snow masses may cross the switchback twice.

RUNOUT ZONE:
No transition zone above highway.

CLASSIFICATION:
Small-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Adequate control could definitely be obtained by means of supporting structures and afforestation.

Highway No. 160 --
Wolf Creek Pass
Photo: July 5, 1962

BOULDER CREEK (W-3)

LOCATION:
San Juan Mountains, Wolf Creek Pass west; southeast slope of Sheep Mountain.
CATCHMENT BASIN:
Two separate bowl-shaped basins on the south- and southeast-facing slopes of Boulder Creek; the basins are steep and somewhat cliffy; below timberline; 11,100-10,600 feet m.s.l.; 30 acres (12 ha).
TRACK:
Two tracks join at elevation of 10,000 feet m.s.l.; track of the south-facing basin, 2,200 feet; average slope, 51 percent. Southeast-facing track, 2,700 feet; average slope, 36 percent. Below 10,000 feet m.s.l.; common track follows gully of Boulder Creek: length, 2,000 feet; average slope, 45 percent. Usually, only avalanches of south-facing catchment basin run to highway; width of track near highway 200 feet.
RUNOUT ZONE:
Track is steep where it crosses highway; runout zone lies in gorge of Wolf Creek below highway.
CLASSIFICATION:
Medium-occasional.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Control in starting zones is technically possible, but uneconomical due to remoteness and extent of catchment basins. Mouth of Boulder Creek is bad spot because of rockfalls; an avalanche shed would be best, and would help eliminate bankslides of earth and boulders.

SNOWFLAKE (OR BIG) (W-4)

LOCATION:
San Juan Mountains, Wolf Creek Pass west; southeast slope of Sheep Mountain.
CATCHMENT BASIN:
Bowl-shaped depression on ridge; some cliffs; below timberline; 11,100-10,400 feet m.s.l.; 15 acres (6 ha).
TRACK:
Gullylike depression in slope; vertical drop, 1,900 feet; length, 4,000 feet; average slope, 48 percent; width of track near highway, 500 feet.
RUNOUT ZONE:
No transition zone above highway; crosses highway and runs down to gorge of Wolf Creek.
CLASSIFICATION:
Medium-occasional.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Control of starting zone, including afforestation, is most obvious.

Highway No. 160 --
Wolf Creek Pass
Photo: July 5, 1962

CAMP (W-5)

LOCATION:
San Juan Mountains, Wolf Creek Pass west.
STARTING ZONE:
Grooved and rugged south slope of ridge between Camp Creek and Lake Creek below timberline; 11,400-10,600 feet m.s.l.; steep slope shows some cliffs and has scattered timber; 10 acres (4 ha).
TRACK:
Two distinct parts; upper two-thirds of length follows two depressions in slope; vertical drop, 1,440 feet; length, 2,300 feet; average slope, 63 percent; at lower end of this first section, the avalanche turns a right angle to left and follows for 1,500 feet the gully of Camp Creek at an average slope of only 30 percent.
RUNOUT ZONE:
Only under exceptionally severe conditions would the avalanche run down the second section in the narrow gully and reach the highway. Normally, avalanches stop at foot of steep first section of track.
CLASSIFICATION:
Medium-erratic.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Starting zone lies entirely in timber; control here is unlikely because of ruggedness and size. Diversion dams or catching dams might be possible in lower part of track. A more detailed examination is necessary.

PIT (W-6)

LOCATION:
San Juan Mountains, Wolf Creek Pass west; south slope of ridge between Camp Creek and Lake Creek.
STARTING ZONE:
Depression in ridge; 11,200-10,800 feet m.s.l.; below timberline; 2 acres (1 ha).
TRACK:
Slot in timbered slope; steep track comes down to highway and hits it full speed. Vertical drop, 1,720 feet; length, 3,200 feet; average slope, 54 percent. Track shows a gentle middle section, but is very steep where it crosses road. Width of track near highway, 500 feet.
AVALANCHES:
Two trucks were knocked off road in winter of 1957-58; slide is hard to control with artillery.
CLASSIFICATION:
Small-occasional.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Control of starting zone is probably most economical control measure. Since whole track lies on timbered slope, afforestation would be an integral part of project.

W7
W8
W9
W10

Highway No. 160 --
Wolf Creek Pass
Photo: March 26, 1962

(ORGAN PIPE GROUP)

KATHY (OR 160 WEST) (W-7)

LOCATION:
San Juan Mountains, Wolf Creek Pass west; south slope.

CATCHMENT BASIN:
Depression in ridge forming left shoulder of Lake Valley; below timberline; 11,200-10,600 feet m.s.l.; 7 acres (3 ha).

TRACK:
Steep slope, track falls over cliffs twice; vertical drop, 1,300 feet; length, 2,300 feet; average slope, 56 percent. Track crosses highway without transition zone; width of track, 130 feet.

← *ANDREW*

RUNOUT ZONE:
Valley bottom of Wolf Creek below the highway.

CLASSIFICATION:
Small-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Control of starting zone by supporting structures and afforestation seems most promising.

ANDREW (OR 160) (W-8)

LOCATION:
San Juan Mountains, Wolf Creek Pass west; south slope.

CATCHMENT BASIN:
A large cirque with steep rims above timberline; 11,600-10,800 feet m.s.l.; 37 acres (15 ha).

TRACK:
A gully with irregular slope; terraces alternate with cliffs; vertical drop, 1,670 feet; length, 4,000 feet; average slope, 42 percent.

RUNOUT ZONE:
Alluvial fan of the gully; length (above highway) 1,200 feet; average slope, 30 percent; width of runout zone, 300 feet. Below highway, avalanche crosses to valley bottom of Wolf Creek.

CLASSIFICATION:
Large-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Because of extent of catchment basin, it is unlikely that control of starting zone is economical. Runout zone above highway is too steep to use retarding or catchment structures. The bedrock, a ledge near the highway, is favorable for construction of an avalanche shed.

DANIEL (OR 160 EAST I) (W-9)

LOCATION:
San Juan Mountains, Wolf Creek Pass west; south slope.

CATCHMENT BASIN:
Holes in a band of cliffs and depressions in steep slope. Above and below timberline; 11,600-10,400 feet m.s.l.; 10 acres (4 ha). Starting spots are indefinite.

TRACK:
Irregular, steep, and rocky slope; steep cliffs alternate with flat terraces; vertical drop, 1,600 feet; length, 2,500 feet; average slope, 64 percent. Track is 250 feet wide where it crosses highway.

RUNOUT ZONE:
Above highway is a slight transition zone. Track has an average slope of 40 percent for a length of about 500 feet. Runout zone extends to valley bottom of Wolf Creek below highway.

CLASSIFICATION:
Medium-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Ruggedness of terrain is unfavorable for control of starting zone; starting zone not well defined; further studies needed for economical control.

STEPHEN (OR 160 EAST II) (W-10)

LOCATION:
San Juan Mountains, Wolf Creek Pass west; south slope.

CATCHMENT BASIN:
Depressions in cliffs and several steep slopes; 11,600-10,400 feet m.s.l.; above and below timberline; 5 acres (2 ha); starting spots are indefinite.

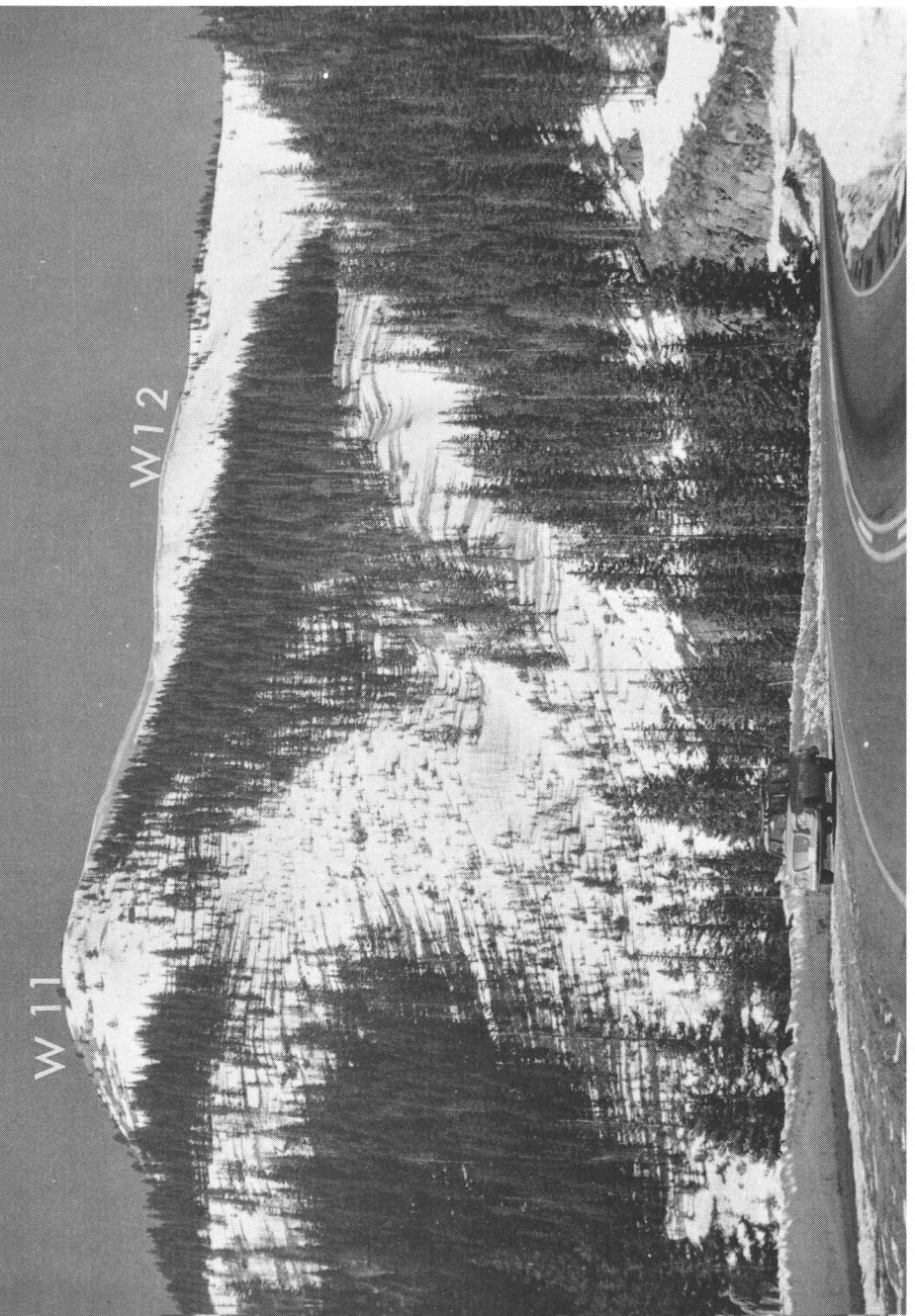
TRACK:
Irregular, steep, and rocky slope; steep cliffs alternate with flat terraces; vertical drop, 1,600 feet; length, 2,500 feet; average slope 64 percent. Track is 200 feet wide where it crosses highway.

STEPHEN →

RUNOUT ZONE:
Runout zone lies mainly below highway in flat valley bottom of Wolf Creek. There is only a slight decrease in slope of track above road.

CLASSIFICATION:
Small-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Control of starting zone may be difficult because the starting spots are rugged and indefinite. Since it is only a small avalanche, the possibilities of controlling the starting zone should be studied in more detail.



Highway No. 160 --
Wolf Creek Pass
Photo: January 5, 1962

ALBERTA (W-11)

LOCATION:
San Juan Mountains, Wolf Creek Pass east; southeast slope of Thunder Mountain.
STARTING ZONE:
Southeast-facing ridge; 11,200-10,900 feet m.s.l.; below timberline; 2 acres (1 ha).
TRACK:
Wide slot in timber; a slight depression in slope; path is covered with thick stand of young trees; rocks and boulders in upper part; vertical drop, 900 feet; length, 1,600 feet; average slope, 56 percent.
RUNOUT ZONE:
Track crosses highway; runout zone is below highway in gully of Pass Creek.
CLASSIFICATION:
Small-occasional.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Starting zone can be controlled with supporting structures. No technical difficulties; forest will later replace almost all structures.

ALBERTA'S COUSIN (W-12)

LOCATION:
San Juan Mountains, Wolf Creek Pass east; east slope of Thunder Mountain.
CATCHMENT BASIN:
Below crest of north-south ridge of Thunder Mountains; top just at timberline; bigger part below timberline; 11,400-11,000 feet m.s.l.; 10 acres (4 ha).
TRACK:
A curved gully; vertical drop, 1,040 feet; length, 2,800 feet; average slope, 37 percent.
RUNOUT ZONE:
Flat middle section reduces average slope to 37 percent. Many avalanches do not pass middle section. Thus, for small avalanches, middle track is runout zone. Large avalanches cross highway and run down to Pass Creek Gully.
CLASSIFICATION:
Medium-occasional.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Terrain is favorable for supporting structures. Some trouble would be caused by excessive snowdrift from gentle west slope of Thunder Mountain into catchment basin. Studies initiated with drift defenses (snow fences) should be continued.

SUMMARY FOR HIGHWAY No. 550: COAL BANK HILL AND MOLAS DIVIDE

Of the 13 avalanches listed by the Colorado Highway Department for this section of Highway 550, the West and East Lime Creek are considered bankslides, and the HENRY BROWN and SWAMP belong together; therefore, our list contains only 10 avalanches. There are four groups of avalanches:

Group 1: ENGINEER
Group 2: COAL CREEK, HENRY BROWN, SWAMP, SPRINGS
Group 3: KINO MINE
Group 4: Champion group--DEADWOOD, CHAMPION, PEACOCK, JENNIE PARKER, GLADSTONES

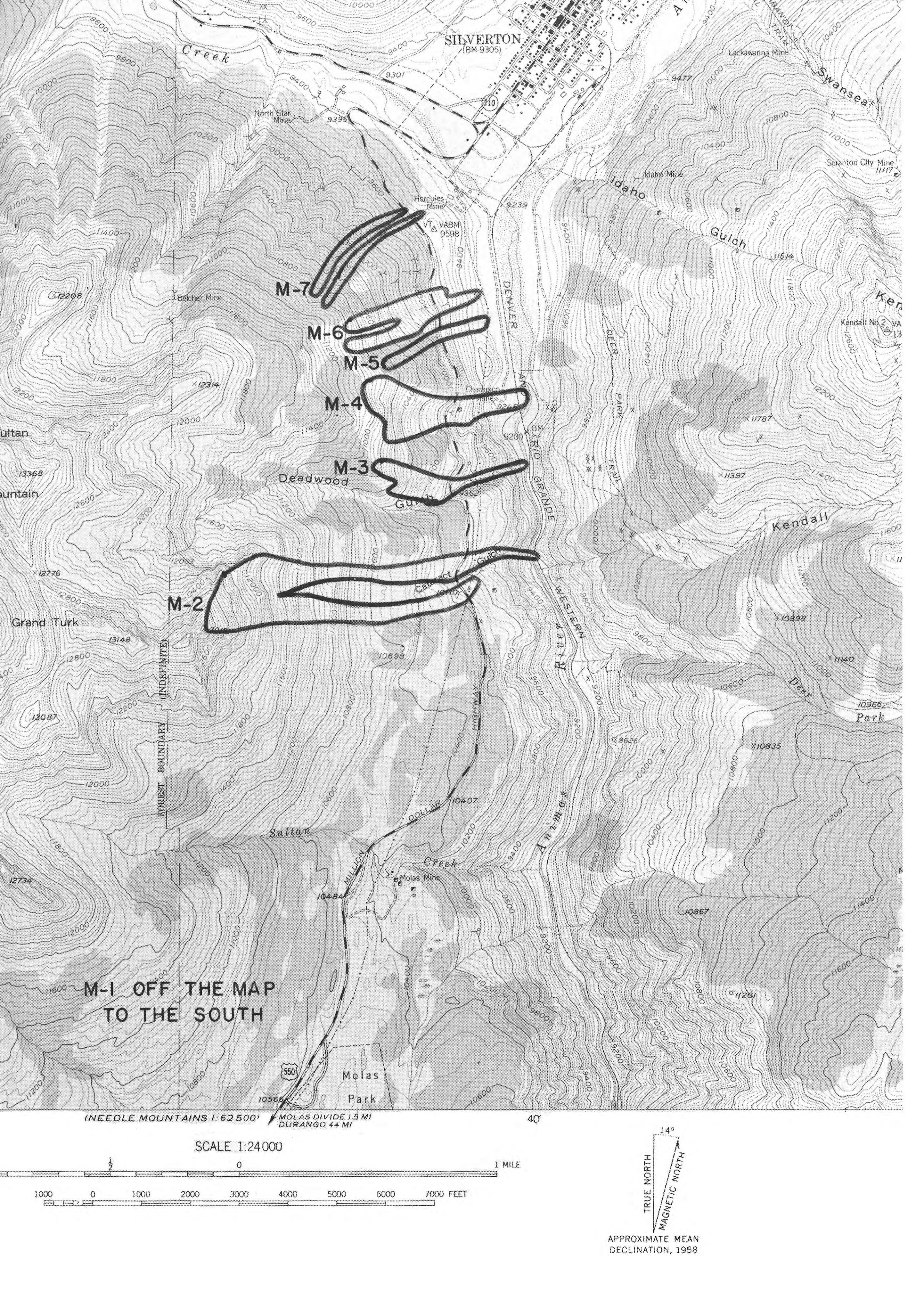
All these avalanches can be controlled by either supporting structures in the starting zone plus afforestation, or by diverting or catchment structures in the runout zone.

Group 2 (COAL CREEK, HENRY BROWN, SWAMP, and SPRINGS), and most of the Champion group, can be controlled by supporting structures and afforestations. CHAMPION and JENNIE PARKER may present some difficulties.

Although ENGINEER can also be controlled fairly well by supporting structures in the starting zone, it offers very little threat to the highway, and a diversion structure might be less expensive.

The large catchment basin above KINO MINE means supporting structures would be expensive. Avalanches might therefore be controlled by diversion and/or catchment structures, or, if detailed studies show that this would not be safe enough, by an avalanche shed in combination with guide dams.

There is no good modern topographic map for the area south of Molas Park. Therefore, map designations start with the Molas Divide group of avalanches. Map designation M-1 would be SPRINGS (or WATERFALL) avalanche; it is off the available map.


SILVERTON
(BM 9305)
Creek
North Star Mine
Lackawanna Mine
Swansea
Idaho Mine
Idaho
Gulch
Scranton City Mine
Hercules Mine
VABM 9598
Belcher Mine
Kendall No.2
M-7
M-6
M-5
M-4
M-3
M-2
Champion Mine
DENVER
RIO GRANDE
WESTERN
DEER PARK TRAIL
Deadwood
Gulch
Kendall
Cataract Gulch
Grand Turk
Sultan
FOREST BOUNDARY (INDEFINITE)
River
Animas
Deer
Park
MILLION DOLLAR HIGHWAY
Sultan
Creek
Molas Mine
M-I OFF THE MAP
TO THE SOUTH
550
Molas
Park
(NEEDLE MOUNTAINS 1:62 500)
MOLAS DIVIDE 1.5 MI
DURANGO 44 MI
40'
SCALE 1:24000
½
0
1 MILE
1000
0
1000
2000
3000
4000
5000
6000
7000 FEET
14°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN
DECLINATION, 1958

Highway No. 550 --
Coal Bank Hill
Photo: July 4, 1962

ENGINEER (C-1)

LOCATION:
San Juan Mountains, near top of Coal Bank Hill; east-facing cliff and east slope on the east shoulder of Engineer Mountain, 600 feet north of highest point (Benchmark 10,664) of Coal Bank Hill.

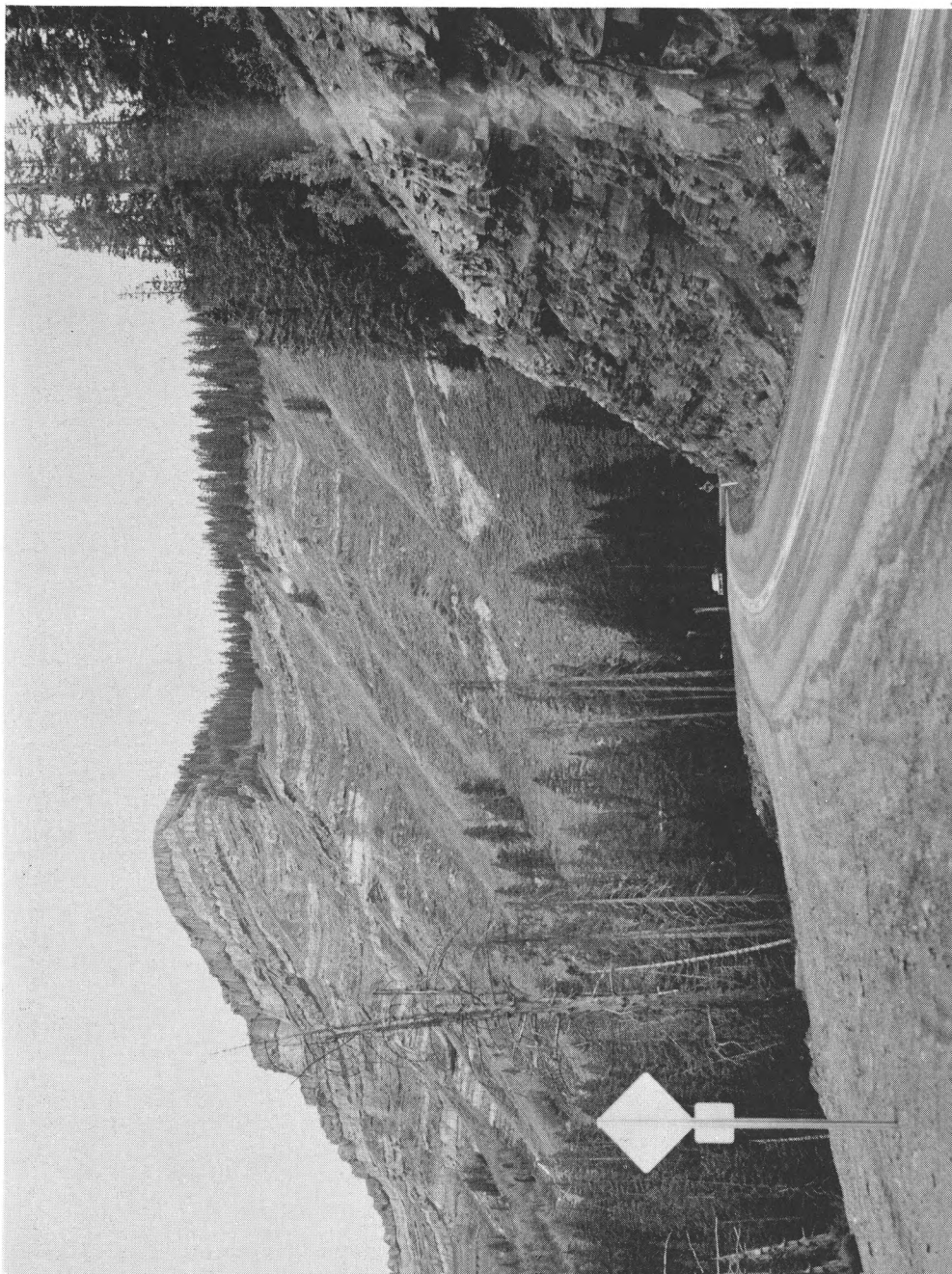
CATCHMENT BASIN:
Cliffs and steep but short slope; below timberline; 11,700-11,200 feet m.s.l.; 2-1/2 acres (1 ha).

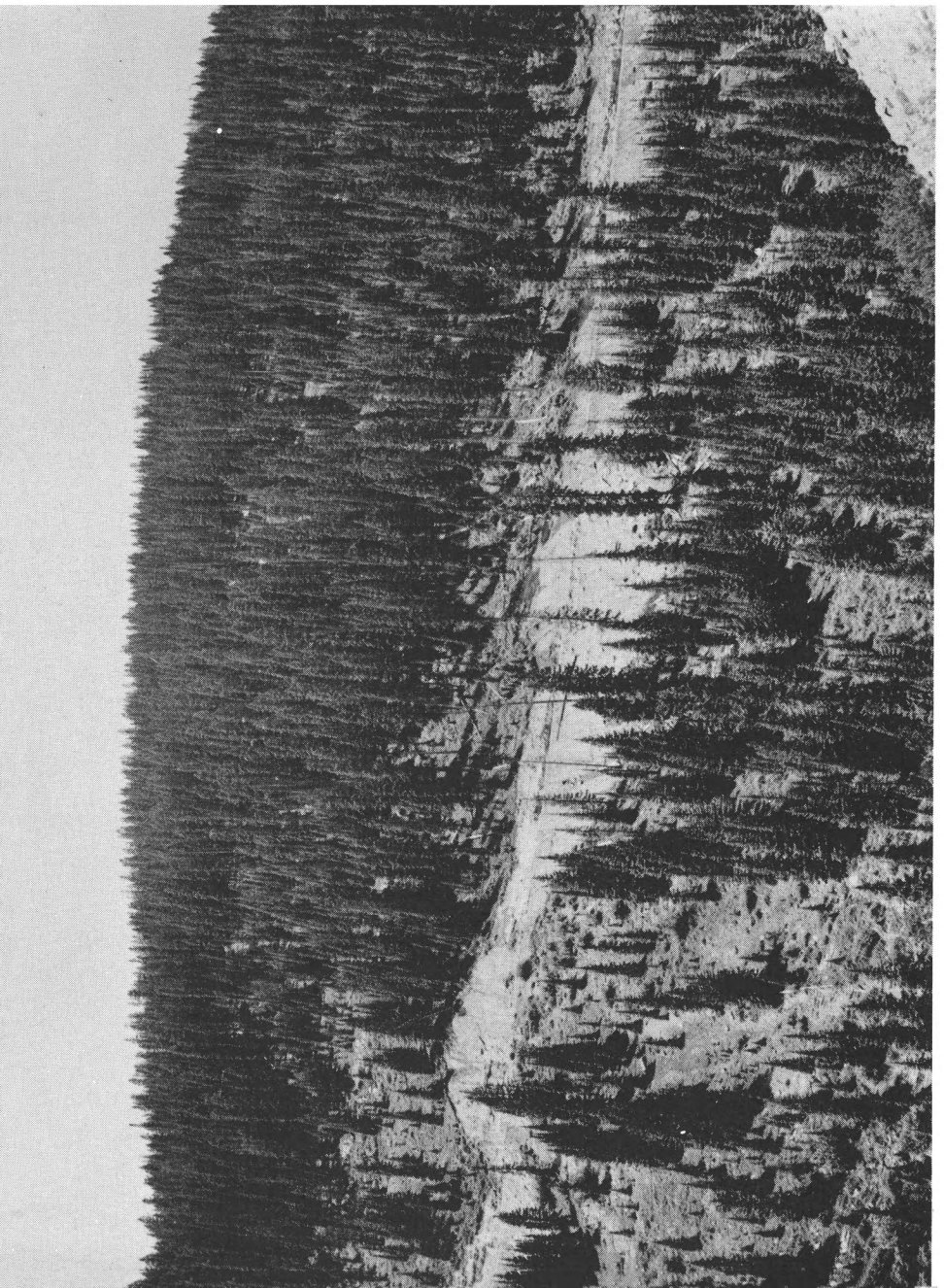
TRACK:
Grooved, steep slope with numerous small cliffs; no definite track; the entire slope may run.

RUNOUT ZONE:
Lower half of slope becomes more gentle, and near highway is nearly flat.

CLASSIFICATION:
Small-frequent. Only in exceptional cases does it reach the highway, however.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Forest on slope was probably cleared off by avalanche. Supporting structures would be possible. Since track is short avalanches do not reach high speeds. A catchment dam in the flat runout zone would also be possible.





Highway No. 550 --
Coal Bank Hill
Photo: July 4, 1962

COAL CREEK (C-2)

LOCATION:
San Juan Mountains; east side of Coal Bank Hill. Northeast-facing scarp of Coal Creek coming down from Engineer Mountain.

STARTING ZONE:
Slides start in light to moderately thick timber on the northeast-facing slope; 10,500-10,300 feet m.s.l.; 1 acre (1/2 ha).

TRACK:
Not confined; avalanches slide through small openings in timber. Vertical drop, 300 feet; length, 500 feet; average slope, 60 percent.

RUNOUT ZONE:
No runout zone above highway; avalanches come down through timber and hit highway directly.

CLASSIFICATION:
Small-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Very easy to control by supporting structures; integral part of defense works would be afforestation of openings in timber.

Highway No. 550 --
Coal Bank Hill
Photo: July 4, 1962

HENRY BROWN (C-3)
SWAMP (C-4)

LOCATION:
San Juan Mountains; east side of Coal Bank Hill; southeast slope of the smooth ridge between Coal Creek and Lime Creek.

STARTING ZONES:
Scarps of the ridge; 10,700-10,300 feet m.s.l.; 2-1/2 acres (1 ha).

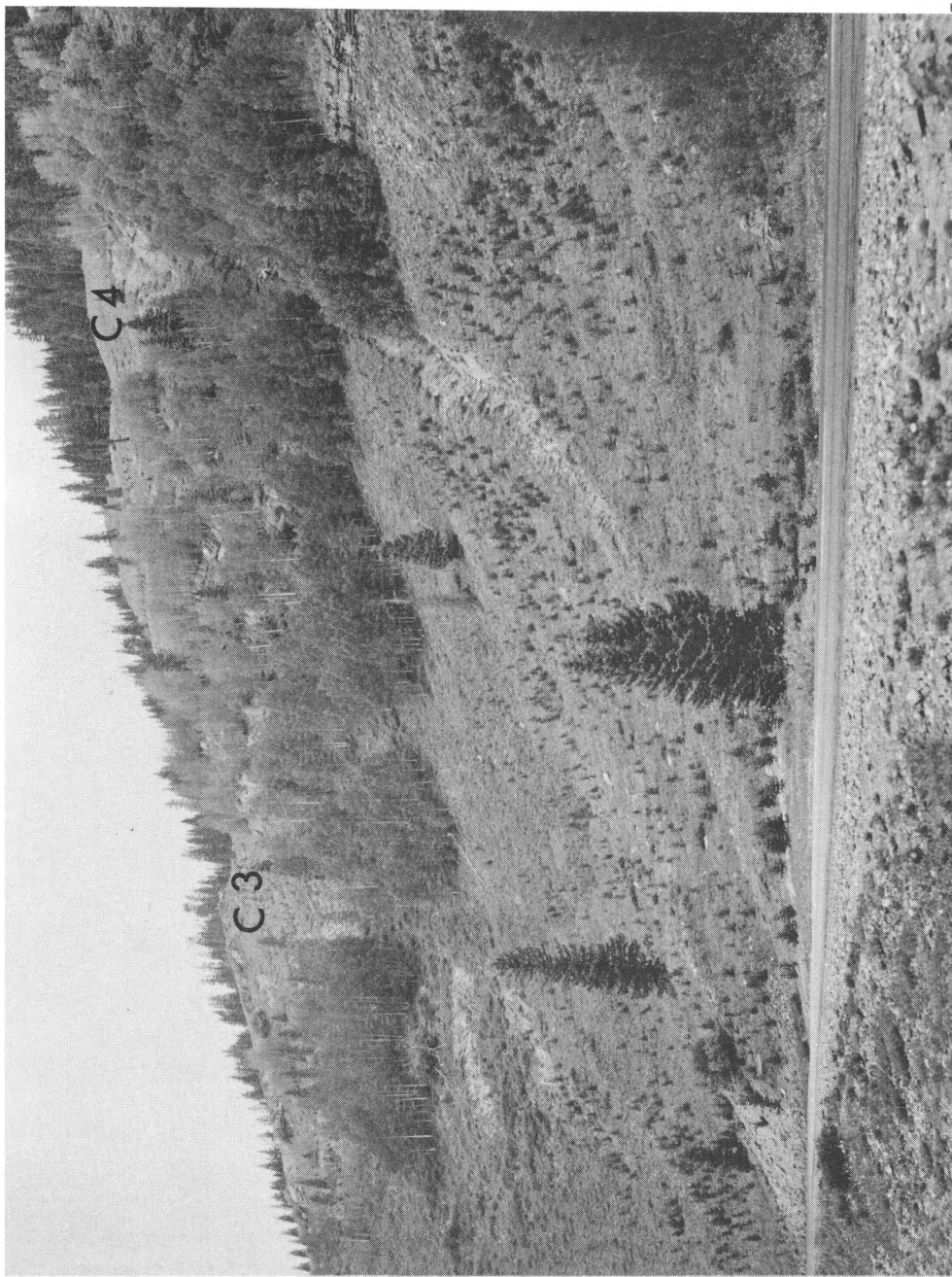
TRACKS:
Two gullylike depressions on slope; upper parts of tracks are steep, becoming more and more gentle in lower parts.

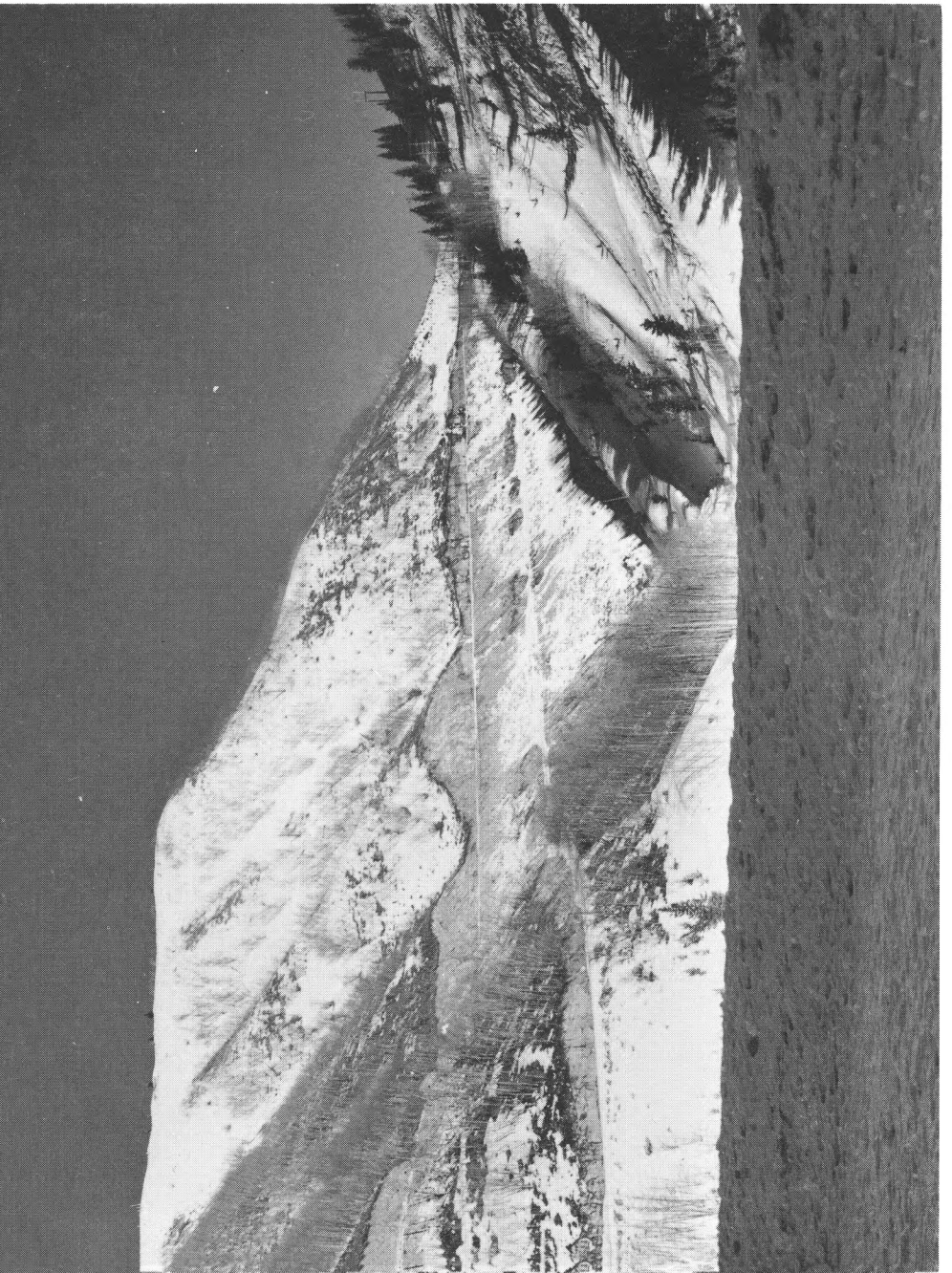
RUNOUT ZONE:
Smaller slides usually do not reach highway. Big snow masses, however, cross the road.

AVALANCHES:
HENRY BROWN is named after a man who was knocked off the road by a slide. SWAMP slide is just north of HENRY BROWN. Both slides have trees planted on both sides of the track but not in it.

CLASSIFICATION:
Small-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Control is principally a matter of afforestation. On steep slopes, supporting structures would help to protect both the highway and the young trees.





Highway No. 550 --
Molas Divide
Photo: January 3, 1962

SPRINGS (OR WATERFALLS) (M-1)

LOCATION:
San Juan Mountains, Molas Divide south; southwest-facing scarp of Lime Creek.

STARTING ZONE:
Three short gullies running down from the flat plateau to a little tributary to Lime Creek; 10,700-10,400 feet m.s.l.; 5 acres (2 ha).

TRACKS:
Vertical drop, 500 feet; length, 700 feet; average slope, 70 percent. Tracks hit highway directly, without a transition zone.

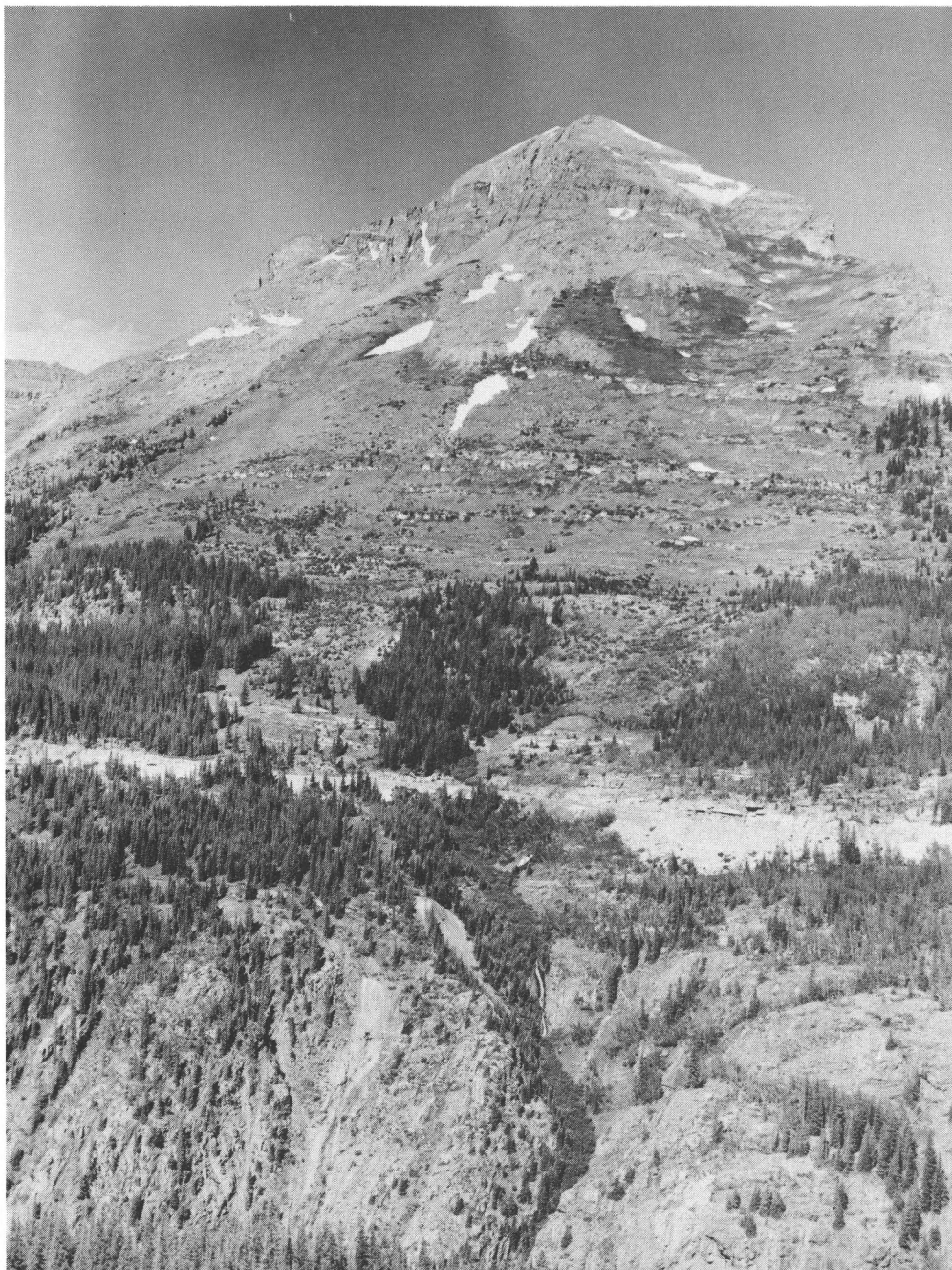
RUNOUT ZONE:
Tracks cross highway, and snow masses run to bottom of creek.

AVALANCHES:
Run during storms; after a storm, snow settles fast and stabilizes quickly.

CLASSIFICATION:
Small-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Control would be principally a matter of afforestation of the steep bank; supporting structures would help to protect both the highway and the plantation of trees.

Highway No. 550 --
Molas Divide
Photo: July 4, 1962



KINO MINE (M-2)

LOCATION:
North and south of Cataract Gulch, San Juan Mountains; Molas Divide north; east slope of Grand Turk.

CATCHMENT BASIN:
Wide, irregular east slope; above timberline; 13,000-11,400 feet m.s.l.; 60 acres (25 ha).

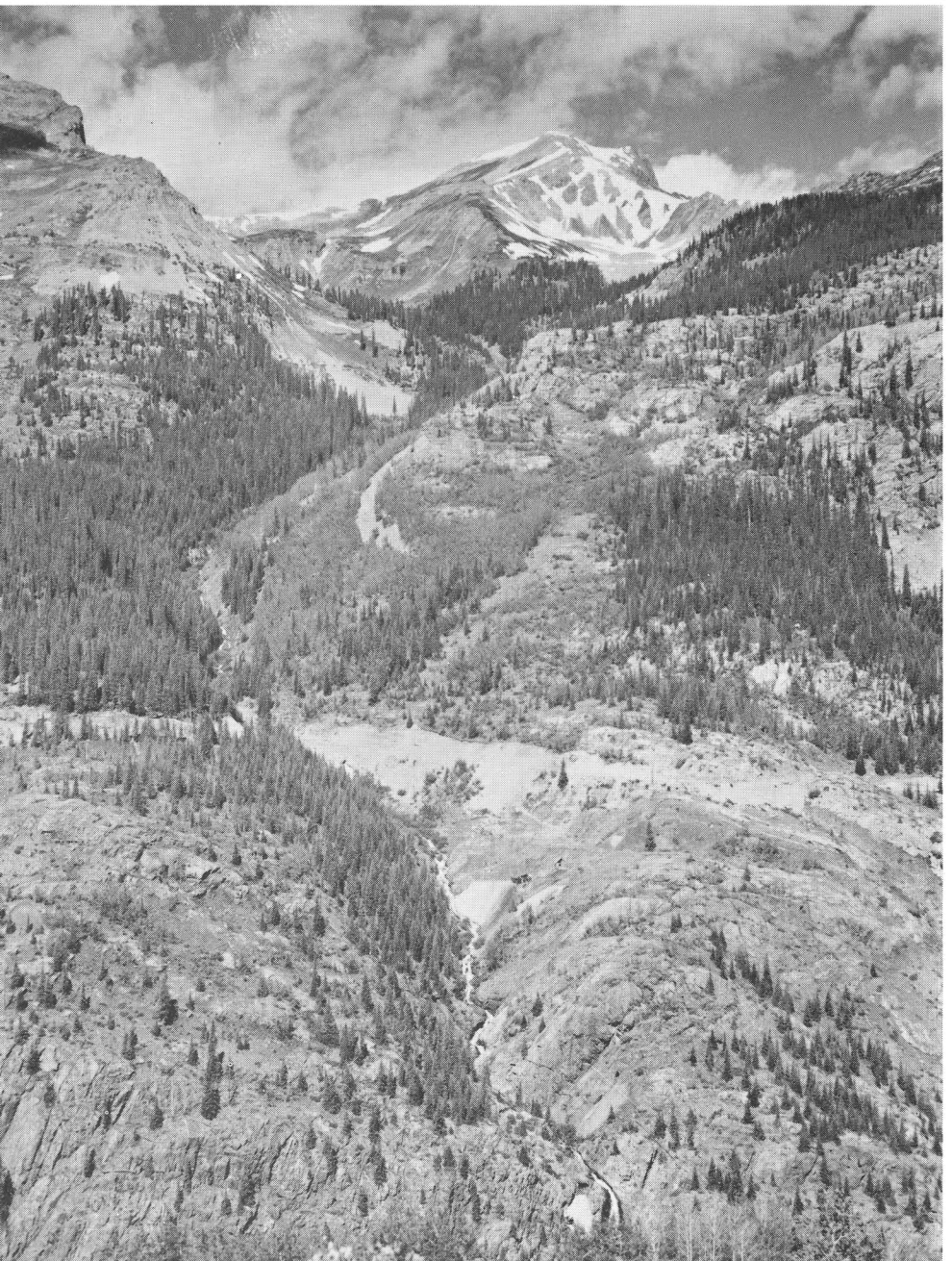
TRACK:
Irregular slope; vertical drop, 2,400 feet; length, 3,400 feet; average slope, 70 percent. End of track is indefinite: slow-moving snow masses stop on flat between highway and contour line 10,600 feet m.s.l.; fast-moving snow masses cross flat section and highway. Upper part of track is ill defined, laterally. Just above highway, two usual paths can be distinguished: Cataract South and Cataract North.

RUNOUT ZONE:
Lower section of east slope of Grand Turk just above highway. Vertical drop, 520 feet; length, 1,800 feet; average slope, 28 percent. Runout zone is 1,000 feet wide near highway. Section of track below contour line 10,600 feet m.s.l. probably is part of runout zone.

AVALANCHES:
Unimportant so far as highway is concerned.

CLASSIFICATION:
Large-erratic; Cataract North may run more easily than Cataract South.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Use of supporting structures is unlikely when extent of catchment basin and erratic occurrence of avalanches dangerous to the highway are considered. The gentle slope below 10,600 feet m.s.l. is favorable for diversion, retarding, or catchment structures.



Highway No. 550 --
Molas Divide
Photo: July 4, 1962

DEADWOOD (M-3)

LOCATION:
San Juan Mountains, Molas Divide north; east slope of a ridge that forms north border of Deadwood Gulch.

STARTING ZONE:
Irregular slope with cliffs; below timberline; 10,900-10,400 feet m.s.l.; 5 acres (2 ha).

TRACK:
Irregular east slope; not confined; vertical drop, 940 feet; length, 1,500 feet; average slope, 63 percent.

AVALANCHES:
Very seldom reaches road.

CLASSIFICATION:
Small-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Terrain and vegetation conditions are favorable for supporting structures.

Highway No. 550 --
Molas Divide
Photo: July 4, 1962

CHAMPION (M-4)

LOCATION:
San Juan Mountains, Molas Divide north; east slope on east shoulder of Sultan Mountain.

STARTING ZONE:
Irregular slope; rounded outcropping bedrock forms some cliffs; scattered timber; 11,000-10,400 feet m.s.l.; 15 acres (6 ha).

TRACK:
Trough-shaped slope above and below highway. For track above the highway--vertical drop, 1,000 feet; length, 1,700 feet; average slope, 60 percent. Track is 500 feet wide where it crosses highway.

RUNOUT ZONE:
Alluvial flat of Animas River, 9,200 feet m.s.l.; well below highway.

AVALANCHES:
Dangerous avalanche that can run almost any time, but usually not large. Snow comes down a narrow slot and hits road at full speed; has taken a bus and a snowplow off road at different times. Artillery control has never been successful.

CLASSIFICATION:
Medium-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Terrain conditions are favorable for installation of supporting structures. Some field checks needed to locate starting spots.

M5
M6
M7

Highway No. 550 --
Molas Divide
Photo: July 4, 1962

PEACOCK (M-5)

LOCATION:
San Juan Mountains, Molas Divide north; northeast slope of the east shoulder of Sultan Mountain.

STARTING SPOT:
Top of narrow opening in woods; 10,800-10,200 feet m.s.l.; 1 acre (1/2 ha).

TRACK:
Very steep, narrow slot in timber; for section of track above highway--vertical drop, 1,080 feet; length, 1,500 feet; average slope, 72 percent. Avalanches cross highway at an elevation of 9,700 feet m.s.l. and continue downward to alluvial flat of Animas River, 9,200 feet m.s.l.

RUNOUT ZONE:
Alluvial flat of Animas River, 9,200 feet m.s.l.

CLASSIFICATION:
Small-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structures until aisle is afforested and avalanche is eliminated.

Highway No. 550 --
Molas Divide
Photo: March 24, 1962

JENNIE PARKER (M-6)

LOCATION:
San Juan Mountains, Molas Divide north; east slope of east shoulder of Sultan Mountain.

STARTING ZONE:
Irregular, partly bowl-shaped east slope; rocky benches and cliffs alternate with flatter sections of slope; sparsely timbered; 11,000-10,200 feet m.s.l. Difficult to delineate starting spots and extent of starting zone. 20 acres (8 ha).

TRACK:
Two paths separated by a timbered spot; vertical drop, 1,300 feet; length, 1,900 feet; average slope, 68 percent. Track is 600 feet wide where it crosses highway.

RUNOUT ZONE:
Gentle slopes below highway and alluvial flat of Animas River.

AVALANCHES:
One of the very bad slides in Molas Divide-Silverton area.

CLASSIFICATION:
Medium-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Because starting spots lie below timberline in a generally timbered area, control appears to be by supporting structures and afforestation. Starting spots are very indefinite and some cliffs may cause trouble, however. If careful field checks indicate that timber could be expected to come in after slides were controlled, then supporting structures would be recommended. If prospects for revegetation were poor, an avalanche shed would be best control method.

GLADSTONES (M-7)

LOCATION:
San Juan Mountains, Molas Divide north; northeast slope on the east shoulder of Sultan Mountain.

STARTING ZONE:
Two narrow aisles in a heavily timbered steep slope; 11,000-10,200 feet m.s.l.; 2-1/2 acres (1 ha).

TRACK:
Two gullylike paths in timber. Vertical drop, 1,400 feet; length, 2,500 feet; average slope, 58 percent.

RUNOUT ZONE:
Track crosses highway; avalanches run down to gentle section of slope below highway.

AVALANCHES:
Cause little trouble for road.

CLASSIFICATION:
Small-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Most obvious counter measure is to replant gullies to trees.

SUMMARY FOR HIGHWAY No. 550: RED MOUNTAIN PASS

This pass has a large number of avalanches; the list shows four bankslides (ROCKWALL, FENCE, SNOWFLAKE, and TWIN BRIDGES) and 30 avalanches. On the south side of Red Mountain Pass from Brown's Gulch near the BROOKLYNS to Porphyry Gulch near the summit of the Pass, there is a nearly continuous belt of avalanches for 3-1/2 miles along the highway. Red Mountain Pass also has the biggest and most striking avalanches--EAST GUADALUPE with its 150-acre catchment basin, and EAST RIVERSIDE with its tremendous shooting track.

The strip map compiled by the Colorado Highway Department shows location and names of several avalanches or slides along U. S. Highway 550 which could not be located exactly on the terrain. These are BENNY LONG, SILVER LEDGE MILL, ROCKWALL, SILVER LEDGE MINE, FENCE, SNOWFLAKE, and BARSTOW. On the other hand, some avalanches that have been added to the list are: BATTLE SHIP, IMOGENE, KING, GOVERNOR GULCH, GALENA LION GULCH, IRONTON PARK, and WEST GUADALUPE.

To help evaluate control measures, the numerous avalanches are classified into groups that show similar features, and/or require the same control measures:

Group 1: Boulder Slopes--WATER GAGE, OLD SOUTH MINERAL ROAD, PIT
Group 2: ZUNI
Group 3: CEMENT FILL
Group 4: Mineral Gorge--BATTLE SHIP, IMOGENE
Group 5: Brooklyns -- BENNY LONG, BROOKLYNS, CEMETERY, TWIN CROSSING, NORTH MINERAL BRIDGE
Group 6: Bullion King -- MULESHOE, TELESCOPE, EAGLE
Group 7: Silver Mine -- PORCUPINE, SILVER LEDGE MILL, ROCKWALL, SILVER LEDGE MINE
Group 8: FENCE, SNOWFLAKE
Group 9: BLUE POINT, WILLOW, BARSTOW
Group 10: Mountain King--GOVERNOR GULCH, GALENA LION GULCH
Group 11: IRONTON PARK
Group 12: South Entrance--EAST GUADALUPE, WEST GUADALUPE, SLIPPERY JIM, EAST RIVERSIDE, WEST RIVERSIDE
Group 13: Uncompahgre Gorge--DUNSMORE, MOTHER CLINE, SILVER POINT, JACK POT
Group 14: Afforestations -- LOWER CEMENT FILL, BARTON

The Cement Fill, Brooklyns, Bullion King, and South Entrance groups are large, very bad avalanches. BLUE POINT is small, but troublesome. The Ironton Park and Mineral Gorge groups have large avalanches that cross the road only under extreme conditions.

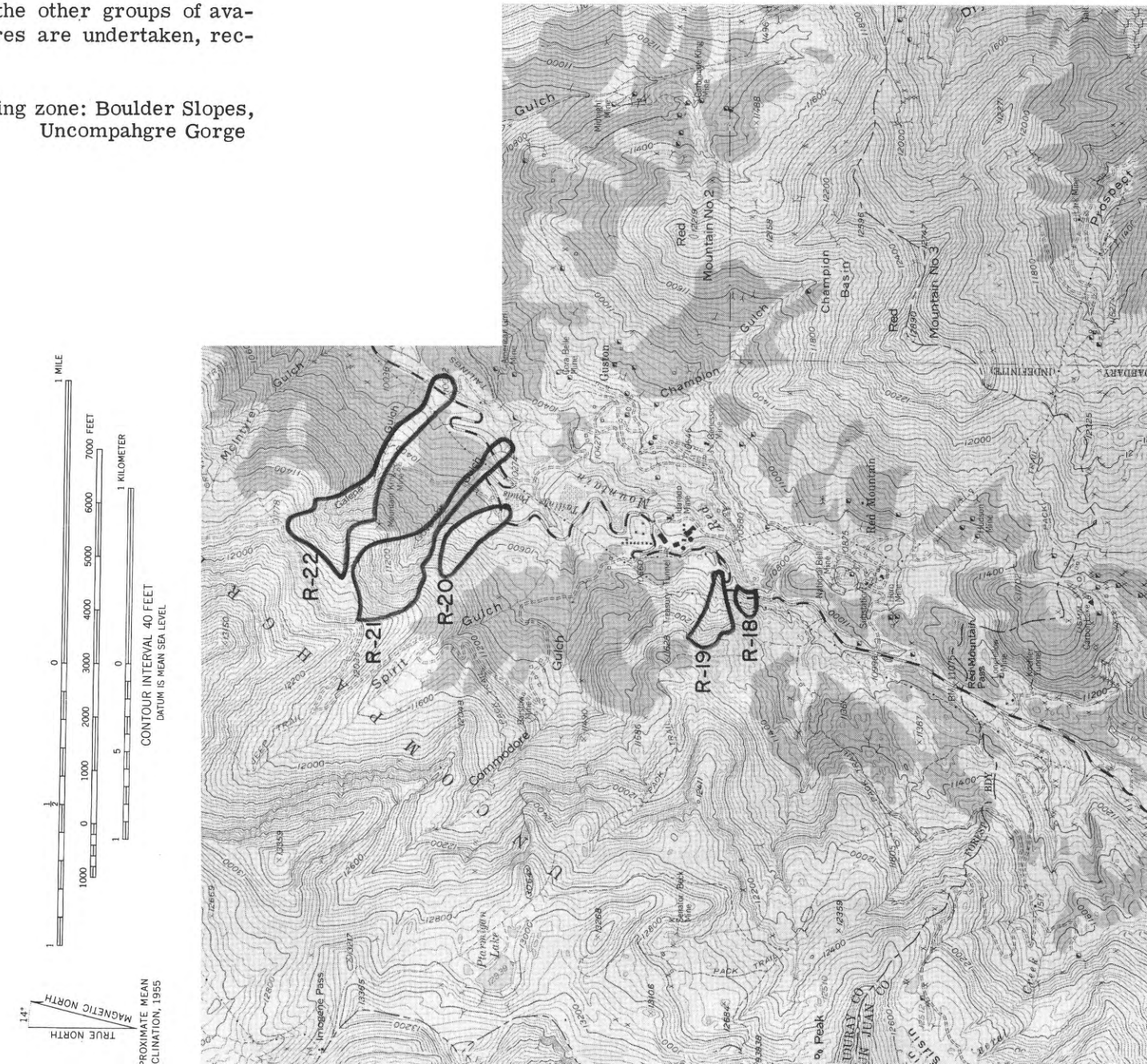
As emphasized several places in this report, control measures should begin with avalanche groups where the type of control is obvious. The Afforestations group can be controlled by structures in the starting zone, followed by afforestation. Avalanche sheds or tunnels are needed for the South Entrance group. SLIPPERY JIM, within this group, might be controlled in the starting zone after the starting spots are located, but it would be better to control the entire group at one time with avalanche sheds. The Blue Point, Ironton Park, Silver Mine, and Fence-Snowflake groups can be controlled easily with supporting structures. The last three groups are less important than the first.

Control will be difficult for the Brooklyns, Cement Fill, and Bullion King groups. Supporting structures are recommended for the Brooklyns group, and avalanche sheds for the other two, although the best type of control is uncertain without further study.

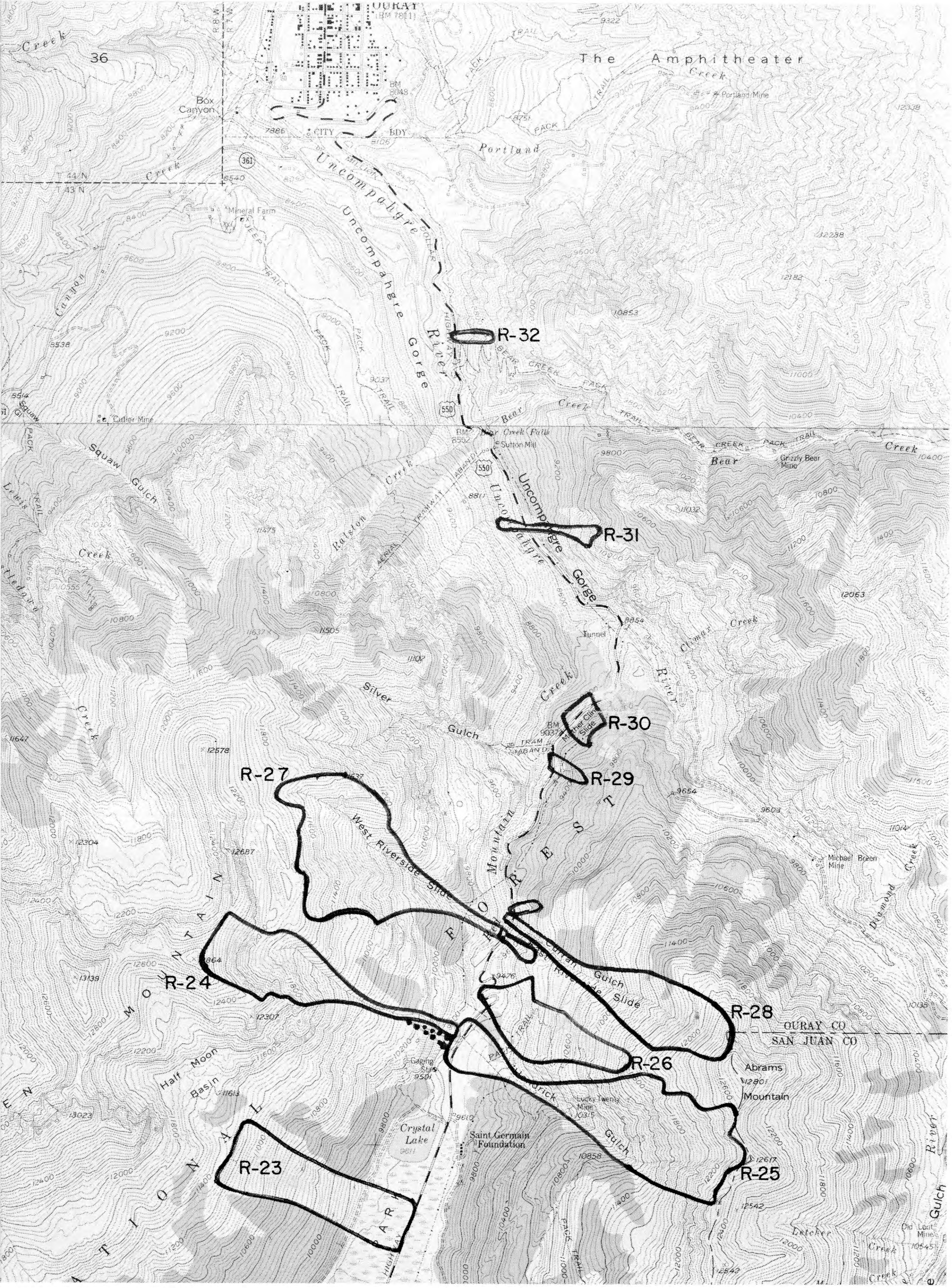
Control is not pressing for the other groups of avalanches, but when control measures are undertaken, recommendations are:

Supporting structures in the starting zone: Boulder Slopes, Uncompahgre Gorge

Avalanche sheds: Zuni
Catchment dams: Mineral Gorge
Diversion dams: Mountain King




R-1
R-2
R-3
R-4
R-5
R-6
R-8
R-10
R-11
R-12
R-13
R-17
SILVERTON
Mineral Creek
Cement Creek
Chattanooga
Ohio Peak
McMillan Peak
U S Basin
Anvil Mountain
Minnesota Gulch
Porcupine Gulch
Ohio Gulch
Topeka Gulch
Niagara Gulch
Browns Gulch
Big Horn Gulch
Georgia Gulch
Fairview Gulch
Henrietta Gulch
Soda Gulch
San Juan National Forest
Forest Boundary (Indefinite)
Pack Trail
Highway
550



OURAY
The Amphitheater
Box Canyon
Portland
Uncompahgre Gorge
Uncompahgre River
R-32
R-31
R-30
R-29
R-28
R-27
R-26
R-25
R-24
R-23
Bear Creek
Bear Creek Falls
Sutton Mill
Squaw Gulch
Ralston Creek
Silver Gulch
Climax Creek
Grizzly Bear Mine
Michael Breen Mine
Diamond Creek
West Riverside Slide
Curran Gulch
Mineral Farm
Cutler Mine
Tunnel
OURAY CO
SAN JUAN CO
Abrams Mountain
Half Moon Basin
Crystal Lake
Saint Germain Foundation
Lucky Twenty Mine
Gulch
Letcher Creek
Old Lout Mine
FOREST
MOUNTAIN

Highway No. 550 --
Red Mountain Pass
No photo

WATER GAGE (R-1)

LOCATION:
San Juan Mountains, Red Mountain Pass south; southwest slope of Anvil Mountain.

CATCHMENT BASIN:
Trough in southwest slope of Anvil Mountain below timberline; 11,300-10,400 feet m.s.l.; 20 acres (8 ha).

TRACK:
Gully with steep slopes in upper part and moderate slopes in lower part; vertical drop, 1,900 feet; length, 3,500 feet; average slope, 54 percent.

RUNOUT ZONE:
Some avalanches may stop on lower part of track, which has a length of 2,000 feet and an average slope of 40 percent. Big, fast-moving snow masses will reach highway and flat bed of Mineral Creek.

AVALANCHES:
Not much trouble on highway in recent years.

CLASSIFICATION:
Medium-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Structural control would not be economical for two reasons: big snow masses are unusual because of exposure and elevation; and rock and talus are not favorable for foundation of supporting structures. Reforestation probably would not be successful.

Highway No. 550 --
Red Mountain Pass
No photo

OLD SOUTH MINERAL ROAD (R-2)

LOCATION:
San Juan Mountains, Red Mountain Pass south; southwest slope of Anvil Mountain.

STARTING ZONE:
Southwest-facing cliffs and very steep boulder field; below timberline; 10,700-10,300 feet m.s.l.; 5 acres (2 ha).

TRACK:
Slightly expressed gully in scree slope running down to road. Lower part, gentle; vertical drop, 1,200 feet; length, 1,800 feet; average slope, 67 percent.

RUNOUT ZONE:
Some avalanches stop in lower section of track which is 1,000 feet long, with 50-percent average slope. Big, fast-moving snow masses reach the highway.

AVALANCHES:
Little trouble on highway in recent years.

CLASSIFICATION:
Small-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Since occurrence is erratic and terrain shows some cliffs and is unstable, no structural control can be recommended. The dry southerly exposure is unfavorable for reforestation.

Highway No. 550 --
Red Mountain Pass
Photo: March 25, 1962

PIT (R-3)

LOCATION:
San Juan Mountains, Red Mountain Pass south; southwest slope of Anvil Mountain.

STARTING ZONE:
Southwest-facing cliffs and very steep boulder field; below timberline; 10,800-10,500 feet m.s.l.; 5 acres (2 ha).

TRACK:
Slightly expressed gully in boulder slope running down to road. Vertical drop, 1,400 feet; length, 2,200 feet; average slope, 64 percent. Lower part has average slope of only 55 percent.

RUNOUT ZONE:
Smaller avalanches may stop in lower section of track; larger snow masses will reach highway.

AVALANCHES:
Runs to road each year; brings rocks and debris with it.

CLASSIFICATION:
Small-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Runout zone is too steep for effective use of retarding or catchment structures, although such structures might bring some relief from rockfalls and debris. Supporting structures cannot be recommended without further study because of the cliffs and the unstable ground. A small earth mound has been built above the road for avalanche control. This splits avalanches into two parts, but is not completely effective.

Highway No. 550 --
Red Mountain Pass
Photo: March 25, 1962

ZUNI (R-4)

LOCATION:
San Juan Mountains, Red Mountain Pass south; south slope of Anvil Mountain.

CATCHMENT BASIN:
Two big basins in south slope of Anvil Mountain; above and below timberline; 12,200-11,400 feet m.s.l.; 60 acres (25 ha).

TRACK:
Narrow and curved rocky gully of Zuni Gulch; vertical drop, 2,580 feet; length, 6,000 feet; average slope, 43 percent. Longitudinal profile of track is very irregular.

RUNOUT ZONE:
Alluvial fan of Zuni Gulch and flat bed of Mineral Creek; average slope, 22 percent; indefinite lateral limits.

AVALANCHES:
Ran big in 1932 and 1952.

CLASSIFICATION:
Large-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Runs very seldom, but when it runs, very big snow masses with much debris are expected. If control is desired, the only possibility would be an avalanche shed.

Highway No. 550 --
Red Mountain Pass
Photo: July 3, 1962

LOWER CEMENT FILL (R-5)

LOCATION:
San Juan Mountains, Red Mountain Pass south; west slope of Anvil Mountain.
STARTING ZONE:
Indefinite; west-facing slope with scattered timber; below timberline; 11,400-10,800 feet m.s.l.; 7 acres (3 ha).
TRACK:
Depression in slope: upper part is steep; lower part, moderate; vertical drop, 1,200 feet; length, 1,800 feet; average slope, 67 percent. Aspen and spruce are regenerating naturally in track.
RUNOUT ZONE:
Lower section of slope; length, 800 feet; average slope, 45 percent.
CLASSIFICATION:
Small-frequent.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Good chance for control with supporting structures and afforestation.

CEMENT FILL (R-6)

LOCATION:
San Juan Mountains, Red Mountain Pass south; west slope of Anvil Mountain.
CATCHMENT BASIN:
Bowl-shaped depression on west slope of Anvil Mountain; above and below timberline; 12,400-10,600 feet m.s.l.; 75 acres (30 ha); catchment basin has four compartments.
TRACK:
Bowl-shaped depression on slope; vertical drop, 2,600 feet; length, 5,000 feet; average slope--upper half, 58 percent, lower half, 39 percent; track is 500 feet wide where it crosses highway.
RUNOUT ZONE:
Mineral River gorge below the highway.
CLASSIFICATION:
Large-occasional.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Catchment basin is too extended to be controlled economically with supporting structures. No possibilities exist for diversion or retarding structures. Avalanche shed with guide dams is recommended.

Highway No. 550 --
Red Mountain Pass
Photo: March 25, 1962

BATTLE SHIP (R-7)

LOCATION:
San Juan Mountains, Red Mountain Pass south; northeast slope of summit spot elevation, 12,442.
CATCHMENT BASIN:
Three basins on northeast slope; above timberline; 12,200-11,400 feet m.s.l.; 45 acres (18 ha).
TRACK:
Narrow gully; vertical drop, 2,500 feet; length, 5,600 feet; average slope, 45 percent.
RUNOUT ZONE:
Highway runs 250 feet above Mineral Creek on opposite mountain slope. Small, wet snow avalanches stop in Mineral Creek ravine; in bad conditions, dry dust avalanches ascend slope and reach highway.
CLASSIFICATION:
Large-occasional; seldom reaches highway.
POSSIBILITIES FOR STRUCTURAL CONTROL:
If considered necessary, a catchment dam could be built to protect highway from influence of avalanche blast.

BARTON (R-8) (No photo)

LOCATION:
San Juan Mountains, Red Mountain Pass south; west slope of Anvil Mountain.
STARTING SPOTS:
Two narrow, steep gullies in heavily timbered slope; 11,400-10,800 feet m.s.l.; 5 acres (2 ha).
TRACKS:
Gullylike openings in the forest, long but narrow; vertical drop, 1,400 feet; length, 2,900 feet; average slope, 48 percent.
RUNOUT ZONE:
Some avalanches stop on lower, more gentle section of track above highway. Bigger and faster moving snow masses cross highway and shoot down into gorge of Mineral Creek.
CLASSIFICATION:
Small-frequent.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structures with afforestation of forest openings.

Highway No. 550 --
Red Mountain Pass
Photo: March 25, 1962

IMOGENE (R-9)

LOCATION:
San Juan Mountains, Red Mountain Pass south; east slope of Imogene Mountain; spot elevation, 12,692.
CATCHMENT BASIN:
Trough in east slope of Imogene Mountain; above timberline; 12,300-11,600 feet m.s.l.; 15 acres (6 ha).
TRACK:
Narrow gully; vertical drop, 1,900 feet; length, 3,800 feet; average slope, 50 percent.
RUNOUT ZONE:
Alluvial fan of gully and bottom lands of Mineral Creek; length, 1,100 feet; average slope, 25 percent.
AVALANCHES:
No records. A dry, dust avalanche may cross Mineral Creek and reach highway on opposite bank.
CLASSIFICATION:
Medium-occasional.
POSSIBILITIES FOR STRUCTURAL CONTROL:
If control is considered necessary, a catchment dam could be built to protect highway from influence of avalanche blast.

BLACKBURN (No photo)

LOCATION:
San Juan Mountains, Red Mountain Pass south; west slope of southwest shoulder of Ohio Peak; between BARTON (R-8) and IMOGENE (R-9) on east side of road; exact location not determined in field so not designated on topographic map.
STARTING ZONE:
Steep scarp above highway; scattered timber; about 10,200 feet m.s.l.; 2-1/2 acres (1 ha).
TRACK:
No confined track; avalanches are really just bankslides.
CLASSIFICATION:
Small-occasional.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structures and afforestation.

Highway No. 550 --
Red Mountain Pass
Photo: January 3, 1962

BROOKLYNS (R-10)

LOCATION:
San Juan Mountains, Red Mountain Pass south; west slope on the northwest shoulder of Ohio Peak.

STARTING ZONE:
In cliffs at top and on steep talus slopes below, with a few widely scattered trees and scattered clumps of timber; below timberline; 11,200-10,600 feet m.s.l.; 50 acres (20 ha).

TRACKS:
Many groovelike depressions in slope; vertical drop, 1,000 feet; length, 1,600 feet; average slope, 63 percent. Individual tracks are so many and so close together that whole slope avalanches for a distance of 4,000 feet.

RUNOUT ZONE:
Some snow may stop in lower section of tracks above highway. This section has a length of 500 feet and an average slope of 48 percent. Most snow, however, crosses highway and runs to bed of Mineral Creek.

CLASSIFICATION:
Large-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Although the rugged top of starting zones and scree slopes give some problems, control by supporting structures is possible for a considerable number of the tracks.


R 13
R 12
R 11

Highway No. 550 --
Red Mountain Pass
Photo: January 3, 1962

CEMETERY (R-11)

LOCATION:
San Juan Mountains, Red Mountain Pass south; west slope of point 12,171.

STARTING ZONE:
Steep, uniform slope; below timberline; 11,200-10,600 feet m.s.l.; 5 acres (2 ha).

TRACK:
Not definite; upper half of track is steep slope--vertical drop, 800 feet; length, 1,200 feet; average slope, 67 percent; lower half is gentle slope--vertical drop, 160 feet; length, 700 feet; average slope, 23 percent.

RUNOUT ZONE:
Small avalanches stop in lower half of track. Larger snow masses run across highway to Mineral Creek; runout zone not well defined.

CLASSIFICATION:
Small-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Can be controlled by supporting structures or possibly by retarding and catching structures.

TWIN CROSSING (R-12)

LOCATION:
San Juan Mountains, Red Mountain Pass south; southwest slope of point 12,171.

CATCHMENT BASIN:
Bowl-shaped, rugged depression in southwest-facing slope; below timberline; 11,600-10,800 feet m.s.l.; 15 acres (6 ha).

TRACK:
A gullylike depression in slope; upper half--vertical drop, 1,000 feet; length, 1,700 feet; average slope, 59 percent; lower half--vertical drop, 560 feet; length, 1,600 feet; average slope, 35 percent.

RUNOUT ZONE:
Small avalanches stop in lower half of track; large avalanches cross highway and stop in Mineral Creek flats. Width of runout zone, indefinite.

CLASSIFICATION:
Medium-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structures are possible, but difficulties should be expected because of ruggedness of starting zone.

NORTH MINERAL BRIDGE (R-13)

LOCATION:
San Juan Mountains, Red Mountain Pass south; west slope of point 12,171.

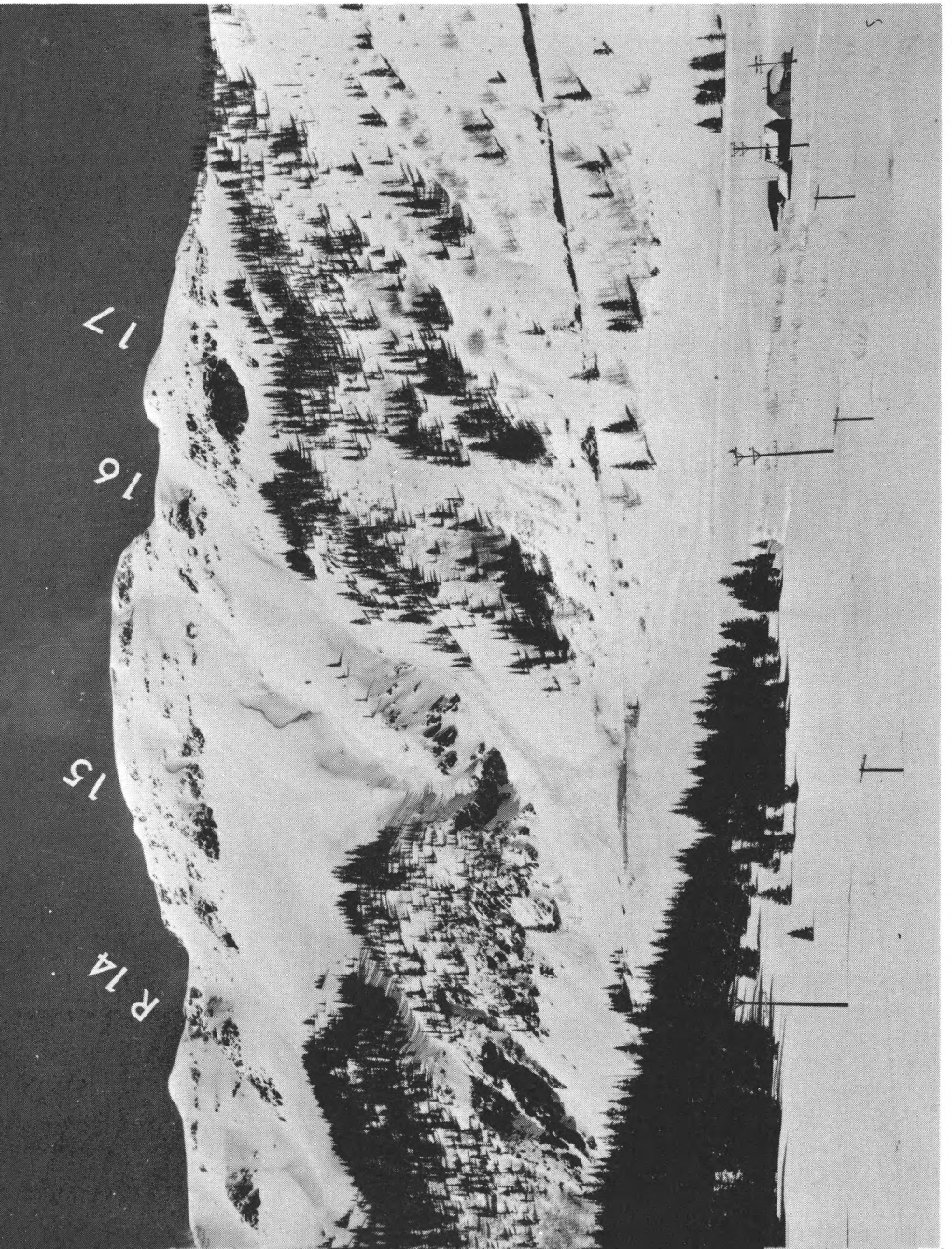
STARTING ZONE:
Rugged, irregular slope with cliffs; starting spots are not confined. Below timberline; 11,600-10,800 feet m.s.l.; 10 acres (4 ha).

TRACK:
Not confined; upper half--vertical drop, 800 feet; length, 1,000 feet; average slope, 80 percent; lower half--vertical drop, 520 feet; length, 1,200 feet; average slope, 43 percent.

RUNOUT ZONE:
Small avalanches stop in lower half of track; larger ones cross the highway and run to Mineral Creek flats.

CLASSIFICATION:
Medium-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structures not recommended because of rugged starting zone; retarding structures might be possible.



Highway No. 550 --
Red Mountain Pass
Photo: March 24, 1962

MULESHOE (R-14)

LOCATION:
San Juan Mountains, Red Mountain Pass south; southeast slope of Bullion King Mountain.
CATCHMENT BASIN:
Bowl-shaped depression on slope; above timberline; some cliffs; 12,700-11,700 feet m.s.l.; 20 acres (8 ha).
TRACK:
Very steep gully; vertical drop, 2,100 feet; length, 3,100 feet; average slope, 68 percent.
RUNOUT ZONE:
Alluvial fan of gully and valley bottom of Mill Creek; length, 800 feet; average slope, 25 percent. Runout zone is indefinite.
CLASSIFICATION:
Medium-frequent.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Diversion dam.

TELESCOPE (R-15)

LOCATION:
San Juan Mountains, Red Mountain Pass south; southeast slope of Bullion King Mountain.
CATCHMENT BASIN:
Uniform slope topped with a cliff; above timberline; 12,200-11,800 feet m.s.l.; 5 acres (2 ha).
TRACK:
Gullylike depression in slope; vertical drop, 1,420 feet; length, 2,200 feet; average slope, 65 percent. Lower part of track is a series of cliffs formed from bedrock.
RUNOUT ZONE:
Alluvial fan of gully; length, 700 feet; average slope, 40 percent. Highway cuts fan in half.
CLASSIFICATION:
Small-frequent.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structures in the starting zone or an avalanche shed, depending upon the decision made for the control of the neighboring EAGLE avalanche.

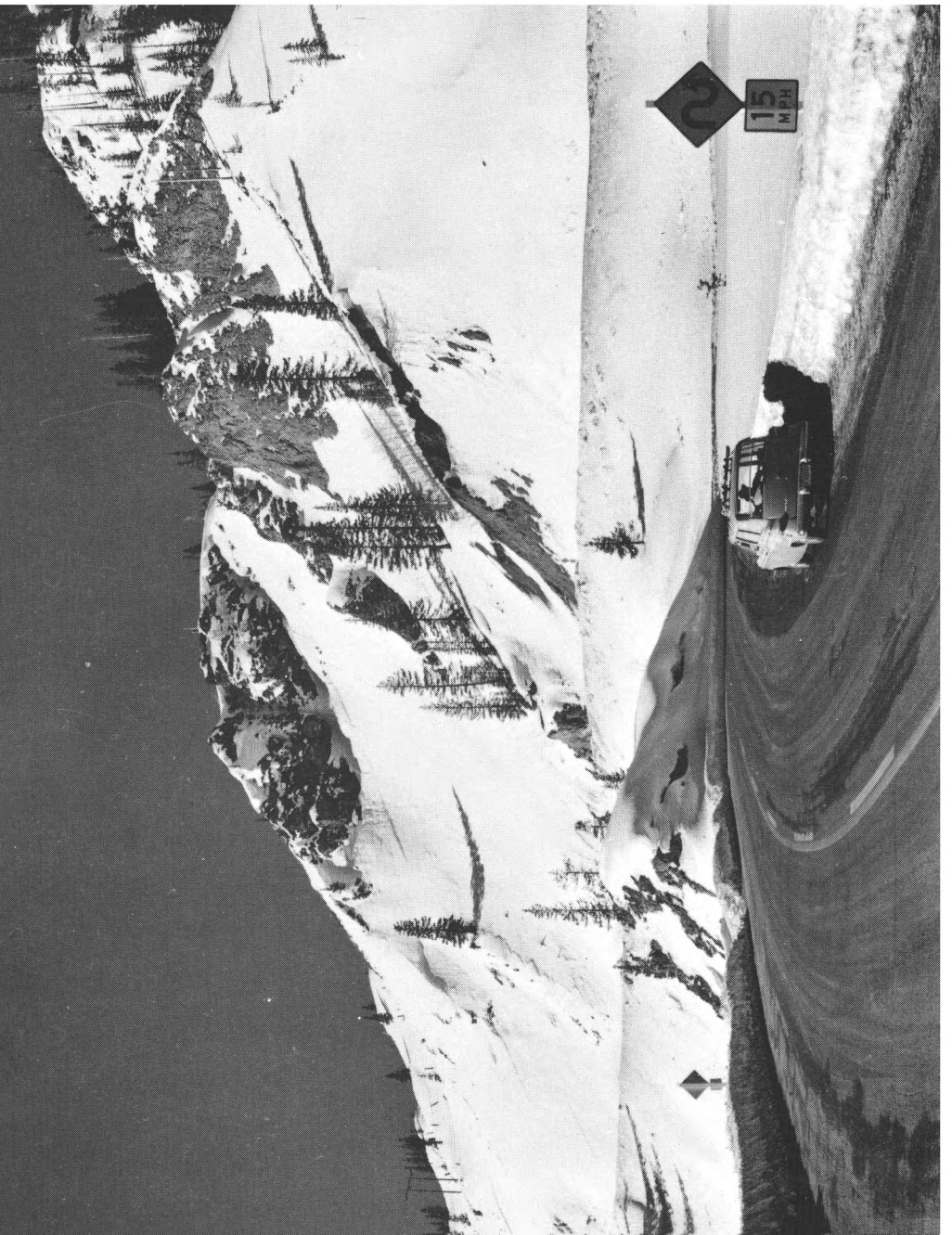
Highway No. 550 -- Red Mountain Pass Photo: July 3, 1962

EAGLE (R-16)

LOCATION:
San Juan Mountains, Red Mountain Pass south; southeast slope of Bullion King Mountain.
CATCHMENT BASIN:
Bowl-shaped depressions on slope; above timberline; top is very steep and has some cliffs; 12,600-11,600 feet m.s.l.; 25 acres (10 ha).
TRACK:
Two gullylike depressions that join in lower section of track. Main track: vertical drop, 1,800 feet; length, 2,700 feet; average slope, 67 percent. Secondary track: vertical drop, 1,400 feet; length, 2,200 feet; average slope, 64 percent.
RUNOUT ZONE:
Alluvial fan; length, 1,300 feet; average slope, 34 percent. The lateral extent of runout zone is indefinite, but is at least 800 feet wide. Highway crosses this fan twice (both limbs of the switchback cross it).
CLASSIFICATION:
Medium-frequent.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Extent and ruggedness of the catchment basin are unfavorable for use of supporting structures. Because the runout zone is very wide and crosses the highway twice, avalanche sheds would probably be no more economical than supporting structures.

PORCUPINE (R-17)

LOCATION:
San Juan Mountains, Red Mountain Pass south; southeast slope of Bullion King Mountain.
CATCHMENT BASIN:
Slight depression below prominent cliff; 11,900-11,700 feet m.s.l.; 4 acres (2 ha).
TRACK:
A narrow slot through scattered timber; vertical drop, 1,320 feet; length, 1,900 feet; average slope, 69 percent.
RUNOUT ZONE:
No transition above road. Natural runout zone is below upper road.
CLASSIFICATION:
Small-frequent.
POSSIBILITIES FOR STRUCTURAL CONTROL:
If the decision is made to control the Bullion King Mountain group of avalanches, this one can be handled with an avalanche shed.



Highway No. 550 --
Red Mountain Pass
Photo: January 3, 1962

BLUE POINT (R-18)

LOCATION:
San Juan Mountains, Red Mountain Pass north; east slope of Senator Ridge.

STARTING SPOT:
Hollow in scarp just above highway at an elevation of 11,000 feet m.s.l.; 2-1/2 acres (1 ha). It must be considered a bankslide rather than an avalanche, because the track has a length of only about 200 feet.

AVALANCHES:
Run to the road after almost every snowstorm.

CLASSIFICATION:
Small-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Snow nets are recommended. This is a good example of where supporting structures should be used.

Highway No. 550 --
Red Mountain Pass
Photo: January 3, 1962

WILLOW SWAMP (R-19)

LOCATION:
San Juan Mountains, Red Mountain Pass north; broken ground east of Senator Ridge just above the upper switchback of highway near Idarado Mine.
STARTING SPOTS:
In a deep hollow in slope; it might be head of an earth slip; below timberline; scattered trees; 11,400-11,100 feet m.s.l.; 7 acres (3 ha).
TRACK:
Short trough above highway; vertical drop, 600 feet; length, 1,200 feet; average slope, 50 percent.
RUNOUT ZONE:
On gentle section of slope where two switchbacks of highway lie.
AVALANCHES:
Crosses both limbs of the highway switchback.
CLASSIFICATION:
Small-frequent.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Control of starting spots with supporting structures and afforestation would be most economical. The few terraces and earth mounds that have been built in track would be a useful part of a larger, more comprehensive control project when one can be developed.

KING (R-20) (No photo)

LOCATION:
San Juan Mountains, Red Mountain Pass north; southeast-facing slope on a ridge between Spirit Gulch and Governor Gulch.
STARTING ZONE:
Uniform slope below timberline; 11,200-10,600 feet m.s.l.; 10 acres (4 ha).
TRACK:
Indefinite; snow follows a slight depression in slope; vertical drop, 500 feet; length, 700 feet; average slope, 70 percent.
RUNOUT ZONE:
Lower, more gentle half of slope; length, 800 feet; average slope, 30 percent. Runout zone is indefinite, approximately 400 feet wide.
CLASSIFICATION:
Medium-occasional.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Control of starting zone by supporting structures and afforestation; diversion dam could also be used to reduce number of supporting structures.

Highway No. 550 --
Red Mountain Pass
Photo: July 2, 1962

GOVERNOR GULCH (R-21)

LOCATION:
San Juan Mountains, Red Mountain Pass north.

CATCHMENT BASIN:
Deep and well pronounced erosion hollow; 11,800-11,000 feet m.s.l. Highest part is just a little above timberline; very steep and rugged surface; 30 acres (12 ha).

TRACK:
Narrow, curved gully; vertical drop, 1,200 feet; length, 2,100 feet; average slope, 57 percent.

RUNOUT ZONE:
Alluvial fan of Governor Gulch; length, 2,100 feet; average slope, 21 percent.

CLASSIFICATION:
Medium-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
The erosion funnel of Governor Gulch gives more trouble with floods carrying boulders and mud to the highway than with avalanches, which occur very seldom. Structural control of the rugged catchment basin would be very difficult and expensive. The runout zone is long enough to plan diversion or retarding structures if necessary.

Highway No. 550 --
Red Mountain Pass
Photo: July 2, 1962

GALENA LION GULCH (R-22)

LOCATION:
San Juan Mountains, Red Mountain Pass north.

CATCHMENT BASIN:
Deep and well pronounced erosion hollow; highest point just a little above timberline; 11,700-10,600 feet m.s.l.; 32 acres (13 ha).

TRACK:
Narrow and curved gully; vertical drop, 1,100 feet; length, 2,100 feet; average slope, 52 percent.

RUNOUT ZONE:
Alluvial fan of Galena Lion Gulch; length, 2,300 feet; average slope, 23 percent.

CLASSIFICATION:
Large-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Since the runout zone is very gentle and long, avalanches seldom reach the highway. A cut in the aspen stand shows that in exceptional situations it does happen, however. If control is considered necessary, the terrain features are favorable for diversion structures.

Highway No. 550 --
Red Mountain Pass
Photo: July 3, 1962

IRONTON PARK (R-23)

LOCATION:
San Juan Mountains, Red Mountain Pass north; southeast slope of Hayden Mountain.

STARTING ZONE:
Wide, uniform slope below Half Moon Basin; below timberline; 11,300-10,600 feet m.s.l.; 60 acres (25 ha); starting zone is indefinite.

TRACK:
The entire slope; vertical drop, 1,640 feet; length, 2,800 feet; average slope, 60 percent.

RUNOUT ZONE:
Level bottom of Ironton Park; large avalanches have traveled over the flat ground to the highway--a distance of 1,200 feet.

AVALANCHES:
Avalanches of 1958 reached the road and crossed it.

CLASSIFICATION:
Large-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
The even slope, lying below timberline, would be favorable for supporting structures and afforestation. Because of the extent of the starting zone and the erratic behavior of the avalanche, however, such a control would not be economical. Another good possibility is a catchment dam in the flats of Ironton Park.

Highway No. 550 --
Red Mountain Pass
Photo: July 3, 1962

WEST GUADALUPE (R-24)

LOCATION:
San Juan Mountains, Red Mountain Pass north; east slope of Hayden Mountain.

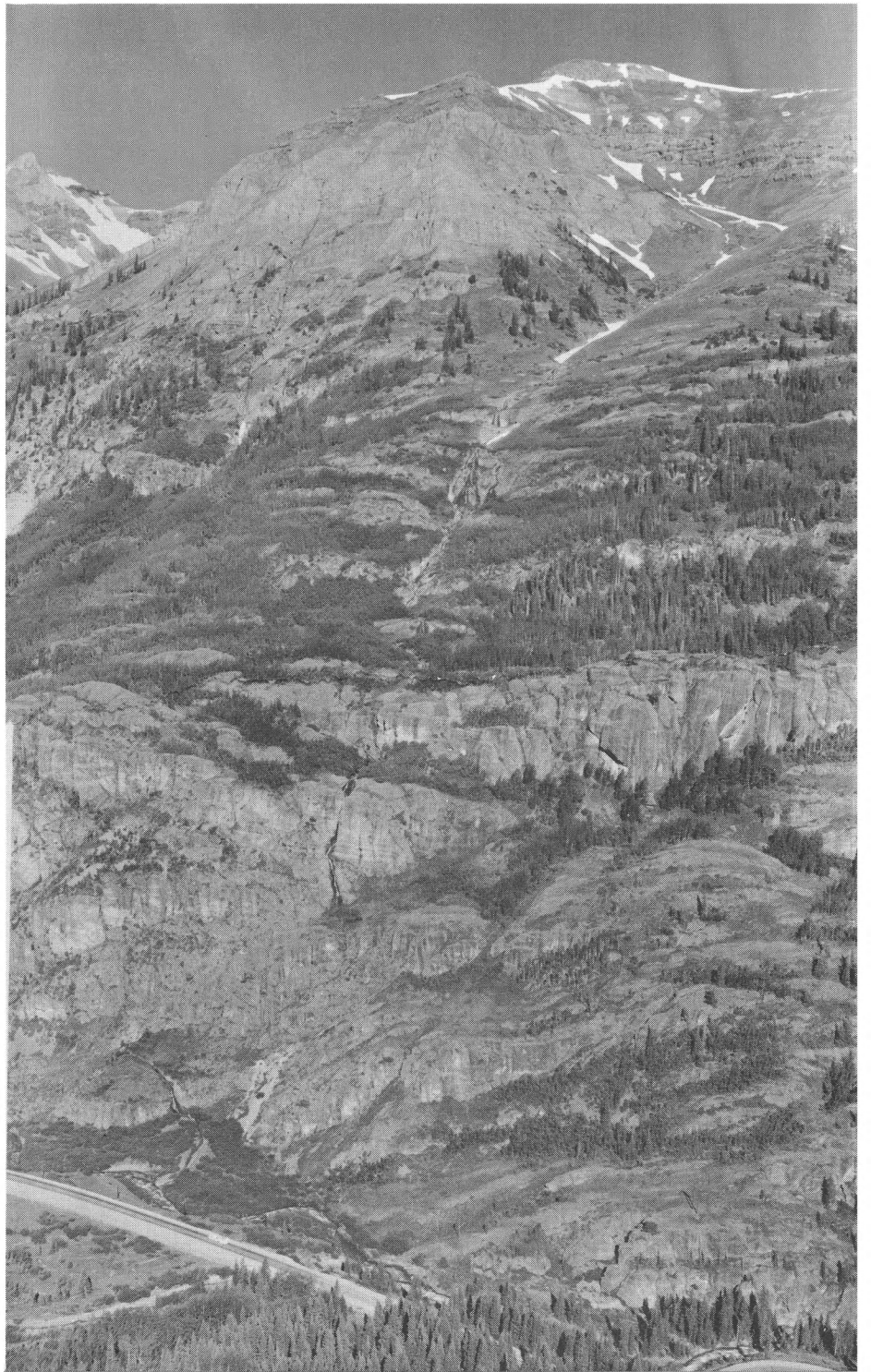
CATCHMENT BASIN:
Wide, rugged, bowl-shaped depression on the slope with cliffs; above timberline; 12,800-11,000 feet m.s.l.; 60 acres (25 ha).

TRACK:
Few expressed depressions on the bedrock, cliffs, and terraces; vertical drop, 3,200 feet; length, 5,600 feet; average slope, 57 percent. A cliff 400 feet high immediately above highway; avalanches hit road with full speed.

RUNOUT ZONE:
Flat, alluvial bottom of Red Mountain Creek.

CLASSIFICATION:
Large-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
The only possible control is an avalanche shed, which would serve at the same time as protection against the EAST GUADALUPE avalanche.



Highway No. 550 --
Red Mountain Pass
Photo: July 2, 1962

EAST GUADALUPE (R-25)

LOCATION:
San Juan Mountains, Red Mountain Pass north; west slope of Abram's Mountain; Hendrick Gulch.

CATCHMENT BASIN:
Wide, steep, and rugged bowl-shaped depression on the slope; above timberline; 12,600-10,800 feet m.s.l.; 150 acres (60 ha).

TRACK:
Narrow ravine of Hendrick Gulch; vertical drop, 2,680 feet; length, 5,100 feet; average slope, 53 percent.

RUNOUT ZONE:
Wide alluvial fan of Hendrick Gulch; length, 1,600 feet; average slope, 20 percent; width of fan near highway, 1,000 feet.

AVALANCHES:
Run some place in the upper basin every year, but cross the road only when a large avalanche breaks loose.

CLASSIFICATION:
Large-erratic.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structures are out of the question because of extent and ruggedness of starting zone. Runout zone is favorable for a diversion dam. If protection is desired against both EAST GUADALUPE and WEST GUADALUPE avalanches, an avalanche shed would be the most economical solution.

Highway No. 550 --
Red Mountain Pass
Photo: March 24, 1962

SLIPPERY JIM (R-26)

LOCATION:
San Juan Mountains, Red Mountain Pass north; west slope of Abram's Mountain.

STARTING ZONE:
Indefinite, irregular, rocky slope with many terraces and little cliffs; light stands of aspen and spruce; 11,600-10,000 feet m.s.l.; 37 acres (15 ha).

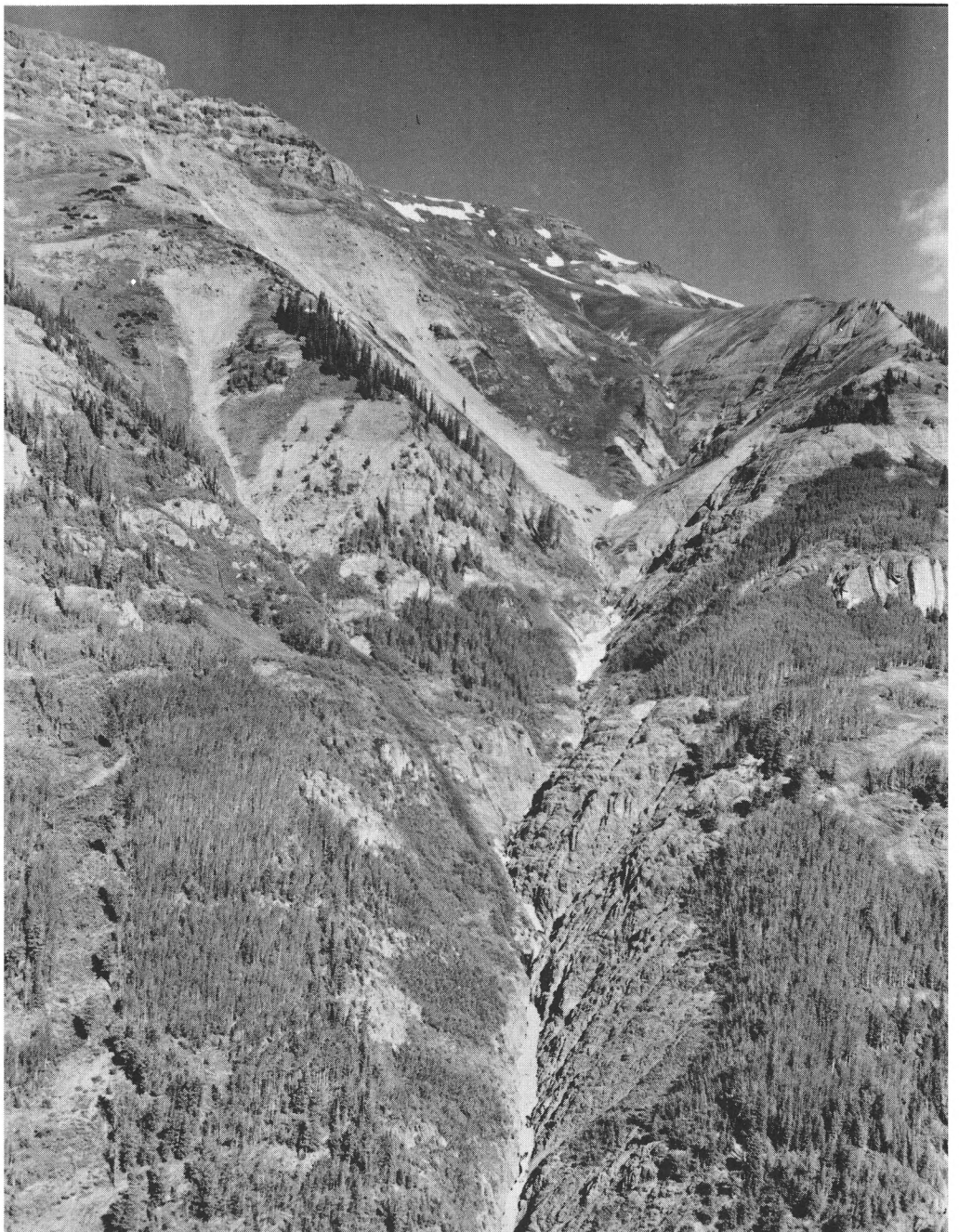
TRACK:
Very wide; indefinite; whole width of the slope can run; longitudinal profile is irregular; flat sections alternate with little cliffs; vertical drop, 2,000 feet; length, 2,800 feet; average slope, 70 percent.

RUNOUT ZONE:
There is only a short transition zone above the highway with a length of 200 feet; average slope, 40 percent. The avalanche crosses the upper portion of the switchback of the highway in two places.

AVALANCHES:
Very bad, from the standpoint of the highway. It has run to the road at least 5 times in the past 10 years.

CLASSIFICATION:
Large-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Control of the starting zone is possible. However, considering neighboring avalanches (EAST and WEST RIVERSIDE) the simplest solution would be a tunnel.



Highway No. 550 --
Red Mountain Pass
Photo: July 3, 1962

WEST RIVERSIDE (R-27)

LOCATION:
San Juan Mountains, Red Mountain Pass north; east slope of Hayden Mountain.

CATCHMENT BASIN:
A large, irregular and rocky basin with very steep spots; above timberline; 11,800-10,200 feet m.s.l.; 150 acres (60 ha).

TRACK:
Narrow, steep, and curved gully; vertical drop, 2,480 feet; length, 4,700 feet; average slope, 53 percent.

RUNOUT ZONE:
Track ends in bottom of Red Mountain Creek gorge without a transition zone. Highway lies 50 feet up on opposite slope. Dust avalanches that hit the bottom with full speed will climb up the opposite slope and reach the highway. This is especially true for the avalanche blast.

AVALANCHES:
The EAST RIVERSIDE and WEST RIVERSIDE avalanches hit the highway from opposite sides. It is not uncommon for both slides to run at the same time. WEST RIVERSIDE has run to the road at least 7 times in the past 10 years.

CLASSIFICATION:
Large-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Heavy avalanche shed or tunnel to protect the highway from both WEST and EAST RIVERSIDE.

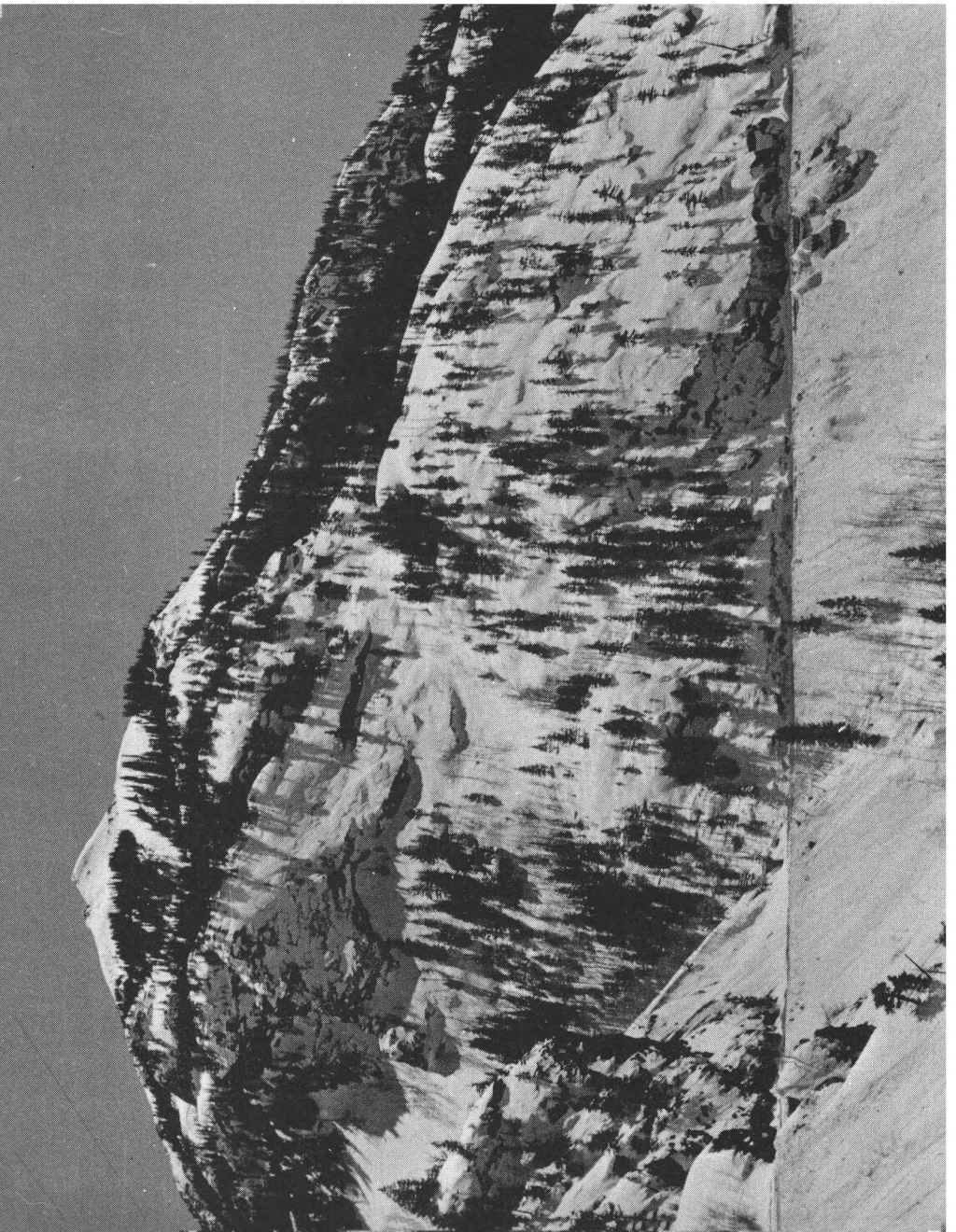
Highway No. 550 --
Red Mountain Pass
Photo: July 2, 1962

EAST RIVERSIDE (R-28)

LOCATION:
San Juan Mountains, Red Mountain Pass north; northwest slope of Abram's Mountain.
CATCHMENT BASIN:
Bowl-shaped depression in the slope; above timberline; 12,600-10,800 feet m.s.l.; 75 acres (30 ha).
TRACK:
Steep, rocky gully of Curran Gulch; vertical drop, 3,200 feet; length, 5,100 feet; average slope, 63 percent; avalanches hit highway directly.
RUNOUT ZONE:
Bottom of Uncompahgre Gorge below the road.
AVALANCHES:
A very bad avalanche that has run over the road at least 25 times in the past 10 years.
CLASSIFICATION:
Large-frequent.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Tunnel or a heavy avalanche shed.

DUNSMORE (R-29) (No photo)

LOCATION:
San Juan Mountains, Red Mountain Pass north; on opposite slope of Silver Gulch in Uncompahgre Gorge.
STARTING SPOTS:
Indefinite; in the cliffs (bedrock) with scattered trees; elevation about 9,400 feet m.s.l.; approx. 2 acres (1 ha).
TRACK:
Indefinite; slides fall down off the cliffs.
CLASSIFICATION:
Small-occasional.
POSSIBILITIES FOR STRUCTURAL CONTROL:
Starting spots must be examined in more detail before any suggestions can be made. Since the starting zone is very rugged an avalanche shed seems the most logical structural defense.



Highway No. 550 --
Red Mountain Pass
Photo: March 25, 1962

MOTHER CLINE (R-30)

LOCATION:
San Juan Mountains, Red Mountain Pass north; in Uncompahgre Gorge, one-third mile above the junction of Red Mountain Creek and Uncompahgre River.

STARTING ZONE:
Just a little above highway on bare, rock slabs. Sparsely timbered; 9,800-9,000 feet m.s.l.; 10 acres (4 ha).

TRACK:
Indefinite; vertical drop, 400 feet; length, 800 feet; average slope, 50 percent.

RUNOUT ZONE:
Slide crosses highway, and runs down into Red Mountain Creek Gorge.

AVALANCHES:
Has run over the road at least 21 times in past 10 years. Often runs in spring when melt water forms ice over rocks.

CLASSIFICATION:
Medium-frequent.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structures in starting zone are possible. Good rock would permit snow nets. Another possibility is an avalanche shed.

Highway No. 550 --
Red Mountain Pass
No photo

SILVER POINT (R-31)

LOCATION:
San Juan Mountains, Red Mountain Pass north; Uncompahgre Gorge between Uncompahgre River Tunnel and Bear Creek Falls.

STARTING ZONE:
West-facing rock walls of Uncompahgre Gorge; 10,200-9,400 feet m.s.l.; 5 acres (2 ha).

TRACK:
Very steep couloir in the rock wall. Avalanches strike highway directly; vertical drop, 1,500 feet; length, 1,600 feet; average slope, 94 percent.

RUNOUT ZONE:
None; snow masses do not run, but literally fall off the rock walls.

CLASSIFICATION:
Small-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Starting spots cannot be controlled economically; best control is an avalanche and rock fall shed.

Highway No. 550 --
Red Mountain Pass
No photo

JACKPOT (R-32)

LOCATION:
San Juan Mountains, Red Mountain Pass north, between Bear Creek Trail Tunnel and Ouray.

STARTING SPOTS:
At foot of high rock wall at an elevation of 9,000 feet m.s.l. in an opening in the timber; 2 acres (1 ha).

TRACK:
Small slot in the timber running down to strike the highway directly; vertical drop, 600 feet; length, 900 feet; average slope, 67 percent.

RUNOUT ZONE:
Bottom of Uncompahgre Gorge.

CLASSIFICATION:
Small-occasional.

POSSIBILITIES FOR STRUCTURAL CONTROL:
Supporting structures in the starting spots, with afforestation.

Frutiger, Hans.
1964. Snow avalanches along Colorado mountain highways. U. S. Forest Serv. Res. Paper RM-7, 85 pp., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Describes and illustrates characteristics of 80 avalanches along four highways in the Colorado mountains; discusses possibilities for structural control. The avalanches -- in Loveland Pass, Berthoud Pass, Wolf Creek Pass, Coal Bank Hill, Molas Divide, and Red Mountain Pass -- are located on topographic maps.

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