STATE OF WASHINGTON

Albert D. Rosellini, Governor

Power Bulletin No. 2

Division of Power Resources

GLACIOLOGICAL RESEARCH PROGRAM OF THE STATE OF WASHINGTON

INTERIM REPORT

By

F. D. HAHN

DEPARTMENT OF CONSERVATION

Earl Coe, Director

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STATE PRINTING PLANT OLYMPIA, WASH., 1961

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FOREWORD

Since its inception, the glacier research program of the State of Washington's Department of Conservation has stirred the imagination and stimulated considerable public interest, particularly among those groups seriously concerned in the conservation movement and in water resource development. Evidence of this is borne out by the fact that Electrical World, a publication with nationwide distribution, devoted several pages to the subject in the February 13, 1961 issue.

For the benefit of those unfamiliar with the purpose and objectives of this study, or those who desire further amplification of the background and procedures, we are pleased to offer this brochure. It is our sincere hope that this booklet will provide a better understanding of what is involved, as well as the reasons for undertaking such a study.

EARL COE, Director,
Department of Conservation.

GLACIOLOGICAL RESEARCH PROGRAM

OF THE

STATE OF WASHINGTON

By

Fred D. Hahn

Project Hydrologist

INTRODUCTION

As a means of liberating water from the frozen reservoirs of ice and snow in the Chilien Mountains of northwestern China, the Tunhuang peasants annually send more than a hundred men over the 125-mile distance to the glacier region, where cow dung, withered grass, and leaves are collected, burned to ashes, and then spread over the glacier surface. This procedure by the peoples of China's Hohsi District has been practiced as far back as the Ching Dynasty and has been their principal means of fighting drouth. So convincing have been the results that the method has spread to other areas of western and northwestern China, and the Chinese Academy of Science is now sponsoring a number of scientific experiments to better understand the principles involved and the potential benefits that ultimately may be realized.[1]

Isolated melting tests have been carried out in previous decades in Russia, but the U.S.S.R. began placing particular emphasis on the program in 1950. Most of the experiments to date have followed the technique of spreading blackening substances on the surface of the ice or snow so that the heat of the sun's rays will be absorbed by the materials and thus transmitted rapidly and in concentrated amounts to the cold mantle beneath to accelerate thawing action. Small-scale operational use has been limited to practices by the Ministry of Marine Fleet in forming access channels through frozen waterways and to minimize formation of spring ice jams in estuaries.[2]

Other articles pertaining to isolated experiments on snow and ice control have appeared in scientific journals, but the correlation of many aspects of snow and ice hydrology with meteorological factors remains relatively unexplored.

Dr. Mark F. Meier, Project Hydrologist in the Tacoma office of the U. S. Geological Survey, estimates the glacial area of the state of Washington to be about 135 square miles, and the present water-content volume of this ice is approximately 44 million acre-feet—an amount comparable to nearly 10 times the usable storage impounded behind Grand Coulee Dam. This glacial mass comprises 90 percent of the totals of all the states except Alaska, and results from the unique pattern of moist air sweeping in from the North Pacific and coming in contact with the Olympic and Cascade Mountain Ranges.

As none of the scientific investigations made to date contain sufficient data to predict the results that might be expected from controlled melting when applied in the Pacific Northwest, it was felt that a research program should be undertaken in an effort to better understand hydro-meteorological relationships and to promote water resource development techniques. The program was formulated and begun in the spring of 1960 by the State of Washington Department of Conservation through the Division of Power Resources.

[1]Glaciers To Serve Production, by Wang Wei, *Scientific Exploration*, 1960.

The glacier terminates in a small lake, which has an excellent gaging station site at its outlet. A unique feature of the ice field is a large blow-out on the northerly side several hundred feet above the terminus; this blow-out may ultimately contribute some valuable information in glaciology and hydro-meteorology.

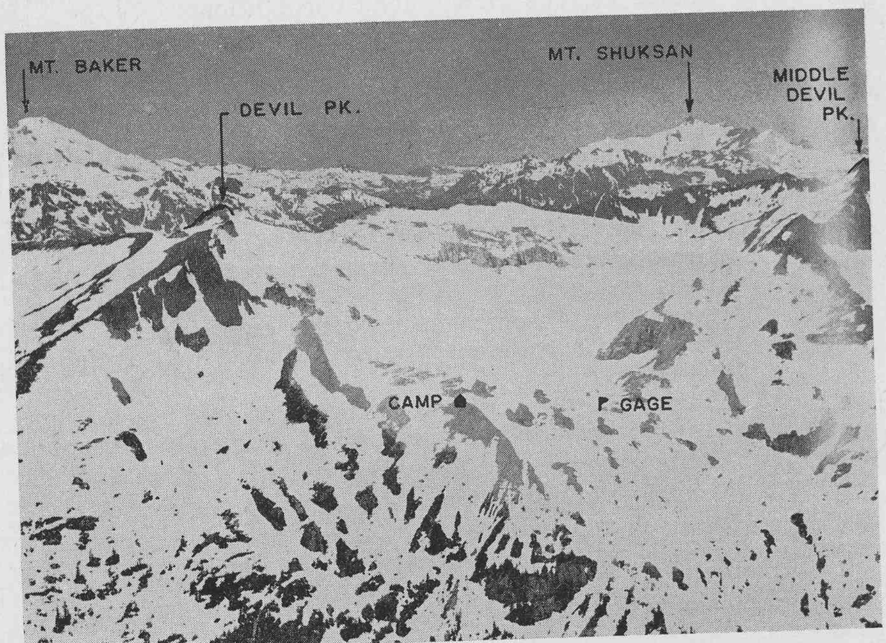

FIGURE 1. Aerial photo of the glacier taken July 6, 1960, indicating prominent features and landmarks. The names of Devil Peak and Middle Devil Peak are given in field notes and on bench marks set by the U. S. Coast and Geodetic Survey as part of their work program of 1950, these names and elevations differing slightly from those shown on U. S. Geological Survey quadrangle maps.

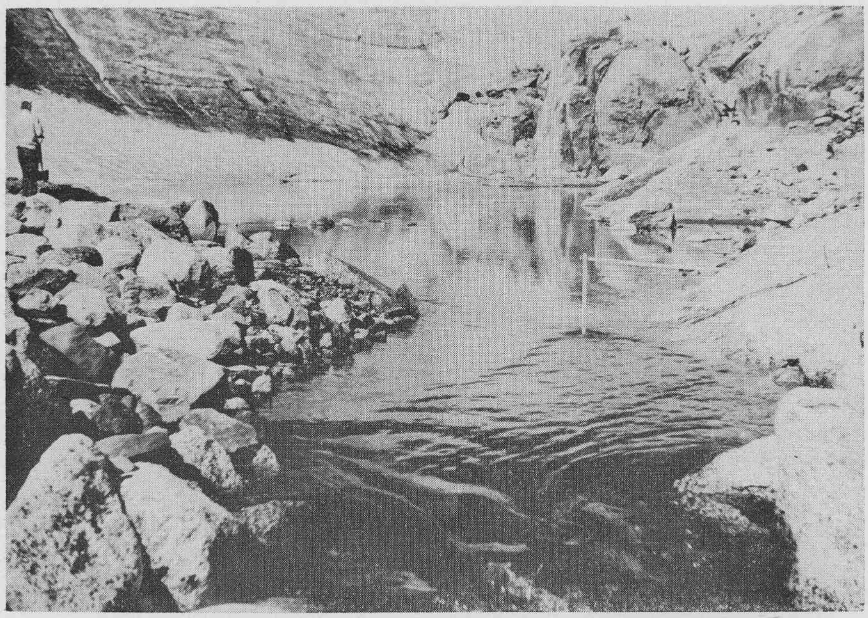

FIGURE 2. Gaging station site at the lake outlet immediately below the glacier terminus, which appears in the upper left of the photo.

LOGISTICS

Following the reconnaissance trip and selection of this particular site for the studies, back-pack trips were made to the area and a location was picked at the upper end of an old lateral moraine for a base camp. The campsite is situated at an elevation of 6,000 feet, and required 2 days of hand leveling by a two-man field party to prepare.

In mid-August a helicopter was brought to Marblemount, and from this point approximately 3,300 pounds of food, equipment, and instruments were flown to the glacier, then relayed to the moraine by the three-man field party. Assembly of a prefabricated platform and frame, and equipping of the base facilities required one day to complete.

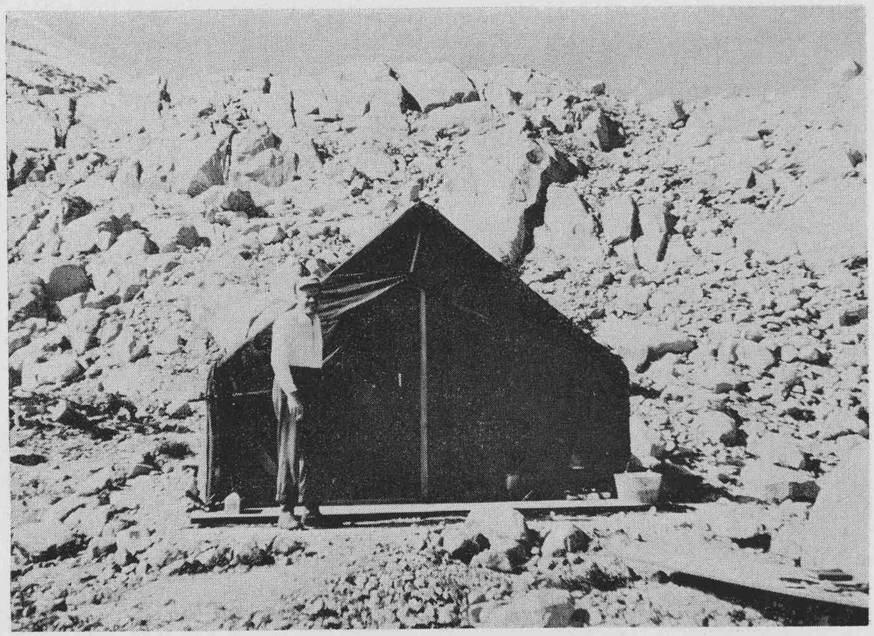

FIGURE 3. Camp is maintained at the 6,000-foot level on one of the few flat areas in the basin. The glacier lies immediately behind the rock ridge at upper portion of photo.

FIGURE 4. The helicopter shown landing on the glacier, brought in 3,300 pounds of food, equipment, and instruments, some of which can be seen at lower right.

INSTRUMENTATION AND STUDIES

The instruments in use at the research site include a variety of equipment. The simplest measuring devices are a set of 1-inch by 1-inch cedar stakes 7 feet long, which are flagged and pressed into the snow at the end of the accumulation season. As the snow melts, periodic measurements are taken at the eight ablation-stake locations, thus providing an accurate record of drop in the snow surface as ablation or wastage progresses through the season. Such stakes were first set on the glacier June 6, 1960. The stakes were spaced laterally and longitudinally to provide maximum coverage on the glacier surface.

Concurrently with ablation measuring, core samples of snow are taken at 6-inch depth intervals from pits dug in the accumulation mantle, and snow density is recorded and plotted in graphic form.

Weather instruments include anemometers, a hygrothermograph, maximum and minimum thermometers, and rain gages, providing wind, temperature, humidity, and precipitation data. Colored smoke flares will be used to determine wind patterns over the glacier basin under differing weather conditions. A streamflow recorder has been obtained and is to be installed at the lake outlet about June 1, 1961.

One net radiometer was used on the glacier in late summer of 1960, and a second instrument will be added for use in the 1961 studies. These will provide net solar radiation measurements on snow surfaces of varying dusted concentrations, and afford comparisons with surrounding untreated surfaces.

Lysimeters, to measure rate of melt, are in an experimental stage at this time, but will be of major importance in the 1961 studies. Thus far, this equipment consists of clear plastic pans, eight inches in diameter and three inches deep, in which snow samples are placed; then the melt water is measured at given intervals of time. Where dusted plots exist, the lysimeter snow surface is dusted to the same degree as the surrounding test area.

Four dusted test plots were set up on the glacier in the late summer of 1960, using equivalent concentrations of 300, 450, 600, and 900 pounds per acre. These experiments will be expanded, using not only various concentrations, but particles of various sizes, both in coal dust form as well as native sands and dirts.

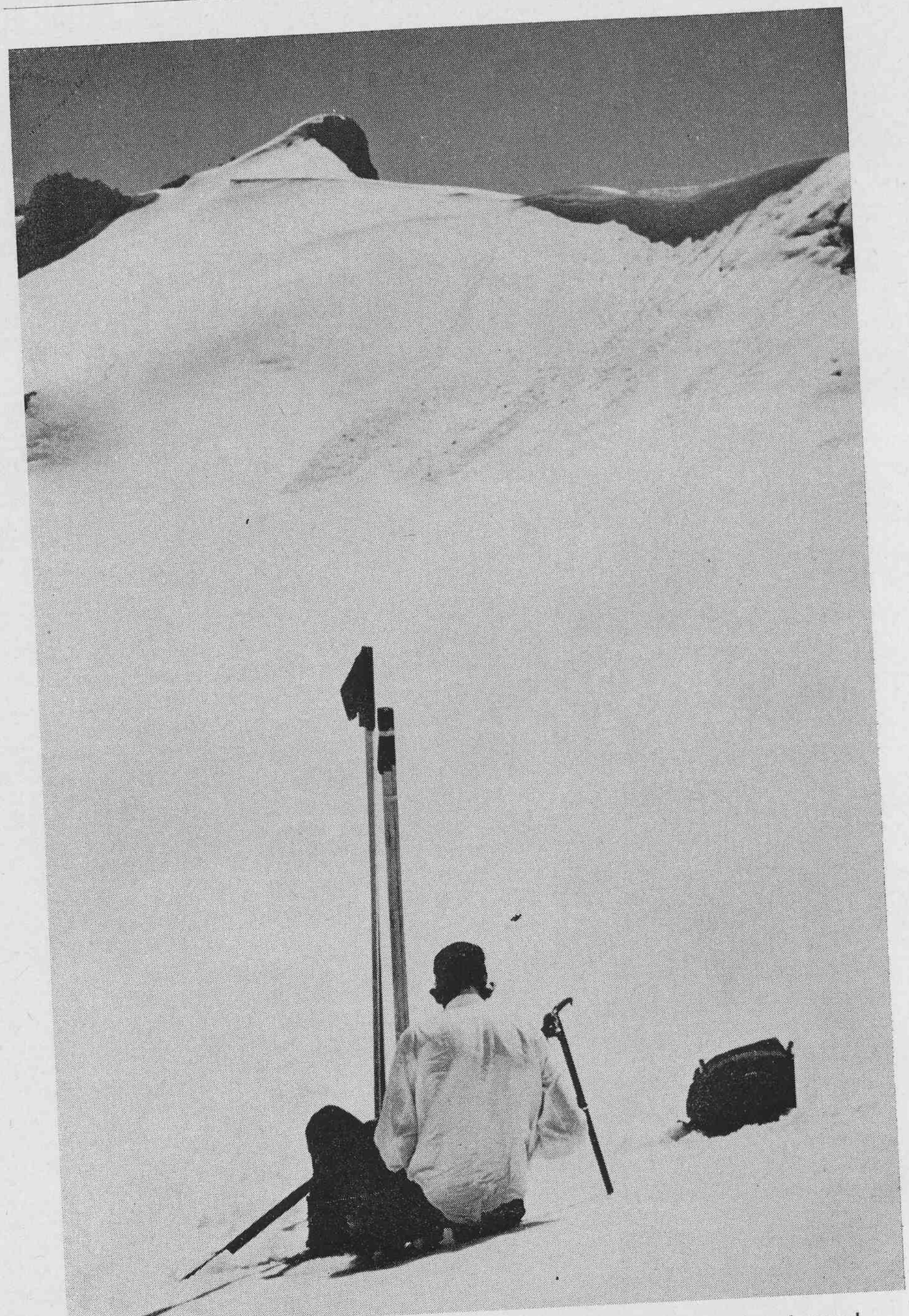

FIGURE 5. Placing of ablation stakes. The stake being set here is referenced by compass bearing to the summit of Devil Peak.

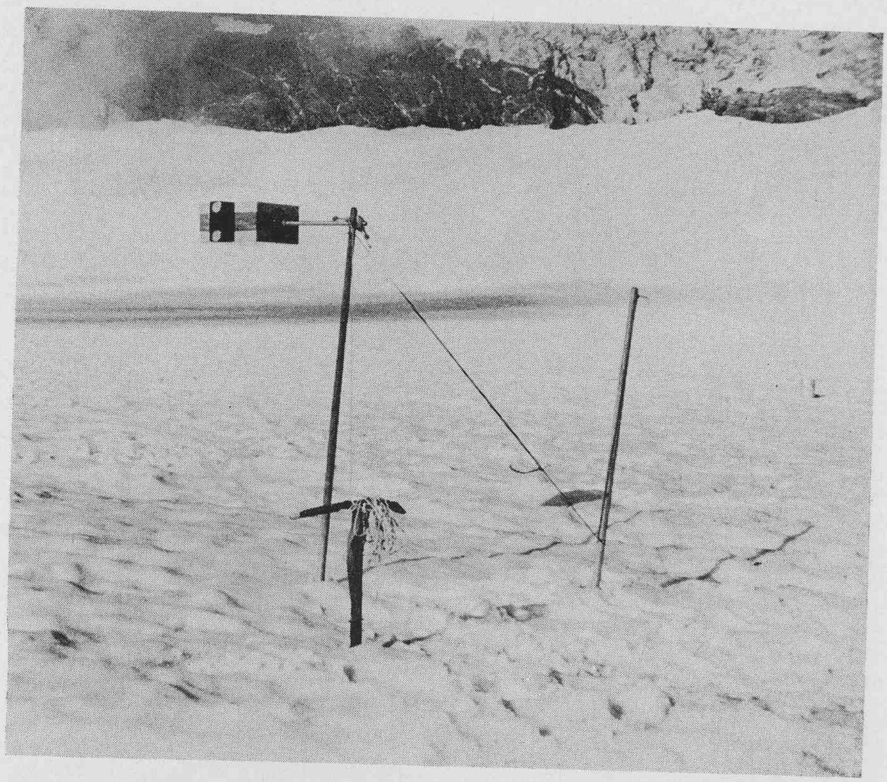

FIGURE 6. Radiometer setting near the headwall in the upper accumulation area. A rain-gage can be seen at the center right.

FIGURE 7. Test plots showing various concentrations of coal dust spread. Dark concentrations at the center of the plots indicate location of the lysimeters which collected melt water for measurement.

FUTURE STUDIES

Ultimate experiments will be directed toward methods of reducing melt, as well as inducing it, thereby providing a means of control over melting processes. Since evaporation demands about seven times as much energy as melt, techniques will be sought to dissipate the sun's heat through vaporization, thereby conserving a much higher percentage of water in the snowpack for release during periods of maximum water demand.

Melting processes may eventually be combined with cloud-seeding activities in a double-pronged program of weather modification for water-resource development. Induced melting alone would be limited to periods of critical low flows in the glacier-fed streams. If seeding were conducted annually over the glacial areas, thereby increasing glacier build-up, it might be possible to apply annual induced melting to release the net increase in accumulation.

RESULTS OF SEEDING OPERATIONS

Seeding operations over the Pend Oreille Basin, conducted by the Water Resources Development Corporation between 1954 and 1958, increased stream flows an estimated 10.6 percent in the mountainous sections.[3] Based on a 10 percent increase in flow, seeding meant an increase of 530 million KWH annually at critical-flow conditions, and 469 million KWH under median-flow conditions. In dollar terms, the benefits were $1,240,000 and $1,086,000, respectively; and the cost of the 1958 program was $139,470.[4] The benefit-to-cost ratio was 9 to 1.

An even higher benefit-to-cost ratio was achieved by Pacific Power and Light Company, as a result of seeding operations over the North Fork Lewis and White Salmon River basins in the Mount Adams area of southern Washington.

CONCLUSIONS

If benefits to fisheries resources, industrial and domestic water supply, irrigation supply, flood control, navigation, and recreation were added to the power benefits, this ratio might easily double.

It is for these reasons, then, that the state is interested in our glacier resource—not with any desire or intent of destroying them, but with the hope of building the glaciers up, where possible, to act as cold storage reservoirs, and controlling the release of their valuable water content when season supplies become critically low.

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[3]Report of the American Institute of Aerological Research, Denver, Colo. July, 1958.
[4]Ibid. Supplemental Evaluation—J. Stevens.