The History of Snow Survey and Water Supply Forecasting

Interviews with
U.S. Department of Agriculture Pioneers

USDA NRCS

United States Department of Agriculture
Natural Resources Conservation Service

The History of Snow Survey and Water Supply Forecasting

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Natural Resources Conservation Service

NRCS

Cover photos:

Front

Top right: Glen Brado, U.S. Forest Service, attaches scales to ski pole while Morlan Nelson, Soil Conservation Service, prepares to measure snow sampling tube. SCS photo by Branstead. (114H–IDA–35070, National Archives, College Park, Maryland)

Middle right: Snow surveyors with sampling set and rucksack viewing Ward Creek, a tributary to Lake Tahoe. 2/16/61 (114H–CAL–7264, National Archives, College Park, Maryland

Middle left: R.A. "Arch" Work on a Santa Clause chimney entrance, Crater Lake National Park, 1945. (114G–ORE–40191, National Archives, College Park, Maryland)

Bottom right: Snow surveyor utilizing Tucker Sno-Cat in Crater Lake National Park, Oregon. April, 1945. (114G–ORE–40193, National Archives, College Park, Maryland)

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Weighing the tube and snow core to determine the water content of the snow. Lower snow course, Baker Creek, Great Basin National Park, Nevada. (114H-NV-644, National Archives, College Park, Maryland)

Historical Notes Number 8

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FOREWORD

Just as snow gives the West water, snow surveys give the West's water users the knowledge needed for successful conservation. Major sectors of the region's economy—agriculture, industry, recreation, and government—base their water management plans on information from the Natural Resources Conservation Service (NRCS) Snow Survey and Supply Forecasting Program.

Snowpack and climate data collected by NRCS and key Federal, State, Tribal, and private partners are used to produce water supply forecasts and drought risk assessments—critical tools in the increasingly challenging effort to balance environmental considerations with rapid population growth, agricultural and energy demands, and climate variability.

Following in the pioneering footsteps of Dr. James Church, who conducted the first systematic surveys in the early 1900s, dedicated employees of the NRCS and its predecessor agencies, the Soil Conservation Service and Bureau of Agricultural Engineering, have developed and continuously improved the program's technology, equipment, and methods. As a result, in the intervening 100 years, the program has evolved from a single, manually sampled site (on Mount Rose, near Reno, Nevada) to a real-time data network of more than 700 SNOTEL (SNOwpack TELemetry) sites located in 11 Western States and Alaska.

Most recently, the Internet has revolutionized how we share information derived from the surveys, extending the program's reach and utility to even more water managers and users.

Today's technology and survey and forecasting tools will surely evolve over the next 100 years as demand increases for new products and services. NRCS and our partners will continue leading the charge for wise water management, along with a clean and abundant water supply for all who depend upon it.

Arlen L. Lancaster
Chief, Natural Resources
Conservation Service

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Preface

Since 1935, the U.S. Department of Agriculture (USDA) has coordinated the cooperative effort in snow surveying and water supply forecasting in the Western States, known for many years as the Federal-State Cooperative Snow Surveys. In 1939, the Soil Conservation Service (SCS), predecessor to the Natural Resources Conservation Service (NRCS), assumed responsibility for the cooperative snow survey from the Bureau of Agricultural Engineering (BAE).

The seven oral history interviews and three articles in this volume recount significant historical developments in this program since its establishment through the full implementation of the automated SNOTEL system. Two articles by Douglas Helms that appeared in the proceedings of the Western Snow Conference, "Bringing Federal Coordination to Snow Surveys" and "Snow Surveying Comes of Age in the West," provide an overview of the program. Arch Work was an employee of the BAE at the time that Bureau received Federal funds for the Federal-State Cooperative Snow Surveys in the 1930s. In addition to the interview with Work, he provided a typescript article of his recollections, which is provided here. The remaining interviewees joined the program after World War II, and their interviews are arranged approximately in chronological order.

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Part 1

Introduction

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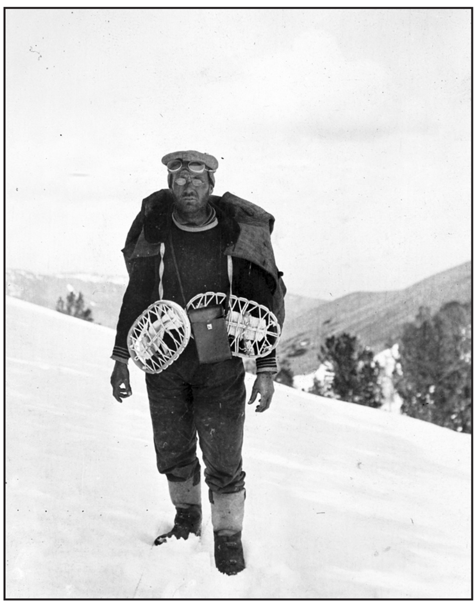
PART I INTRODUCTION

The U.S. Geological Survey (USGS) estimates that as much as 75 percent of water supplies in the Western States are derived from snowmelt. As spring approaches, knowledge of the water content of the mountain snowpack is invaluable in the West. The potential for flooding is of immediate concern. During the summer, the water available for human consumption, agriculture, industry, transportation, and recreation affects economic decisions. The Mediterranean climate that dominates west of the Sierra Nevada provides little summer rain, while the rain shadow on the leeward side of the mountains leaves the Great Basin dry. There is scant rainfall during the growing season, but the ability to time the application of irrigation water makes for a very productive agriculture. The significance of the annual variation in streamflow from the mountain snowpack was obvious. To make the leap from this observation to trying to predict annual streamflow required a belief that practical methods could be devised. Recognizing the practicality of predicting streamflow followed upon a sequence of interrelated contingencies and events.

The genesis of the USDA's role in snow surveying leads back to Dr. James E. Church of the University of Nevada. The young professor of classics enjoyed mountain trekking. He had read about the Weather Bureau's Alexander McAdie's desire to have weather instruments on high mountain peaks. Church determined to test the possibility. In March of 1905, Church attempted to ascend Mount Whitney. Along the way, he discovered a "forlorn" thermometer abandoned the



Church Papers, Special Collections, University of Nevada Library, Reno

1.1 James E. Church

preceding September in a failed attempt to establish a station. Church determined to select a peak, or peaks, where instruments would be accessible throughout winter. The Weather Bureau furnished the maximum and minimum thermometers, and the Nevada Academy of Sciences provided funds to build the instrument shelter. On June 29, 1905, Church and his party ascended Mount Rose with the equipment and recorded the first readings of the thermometers at the new observatory.[1]

Nevada had taken advantage of the Hatch Act of 1887, which provided some Federal funding for State agricultural experiment stations, but many stations had little money for basic or applied research. To partially remedy this situation, the Adams Act, signed March 16, 1906, doubled the Federal funds available to the State agricultural experiment stations. The USDA's Office of Experiment Stations was to exercise greater supervision to ensure that the funds were spent on research projects with some prospect of aiding agriculture.

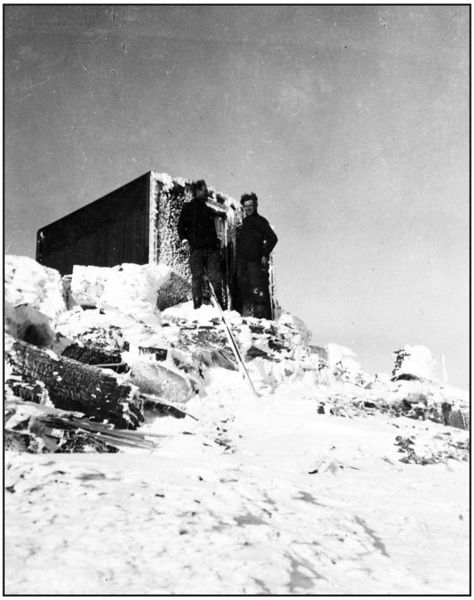
The Nevada Agricultural Experiment Station requested Adams Act funds to support Church's work on Mount Rose. The USDA Office of Experiment Stations approved $500 for the project. Neither the station's official publications nor Church's subsequent writings explain their discussions, the decision to apply for the funds, or their aspirations for the work. No correspondence between Church and the Nevada Agricultural Experiment Station on this matter appears to have survived. But some indication of Church's initial research agenda may be found in the response of Alexander G. McAdie of the Weather Bureau Office in San Francisco to a communication from Church.

> *In reply to yours of June 30th I admire your perseverance and firmly believe we will yet see an observatory on Mt. Rose. The frost work seems to be of practical value. With regard to the effect of timber on windswept areas would it not be well to take this matter upon with the Bureau of Forestry as it seems to lie directly in their field.*
>
> *Congratulations on the windfall.*[2]

1 J.E. Church, The Mount Rose Weather Observatory, *Monthly Weather Review* Vol. 34, No. 6 (June 1906): 255.

2 Alexander G. McAdie to Professor Church, July 3, 1906, *James E. Church Papers*, Special Collections, University of Nevada, Reno.

Church and coworkers carried material up Mount Rose in August 1906 to construct a shelter. Working on weekends, Church and party completed construction of the observatory in which two people could stay overnight.[3] The ability to stay overnight would greatly facilitate the work including the study of the distribution of snow, which evolved into snow surveying. With the designation of the Adams Act funds, Church's work formally became the Department of Meteorology and Climatology of the Experiment Station.



Church Papers, Special Collections, University of Nevada Library, Reno

1.2 The Observatory Building, Thanksgiving 1906

In the spring of 1906, Church and P. Beveridge Kennedy, botanist with the Experiment Station, investigated the eastern side of the Sierra Nevada, west of Reno. The two took notes and photographs of the "distribution and disposal of the snowfall …" Kennedy stated the full implications of their objective: "There are many important problems in connection with the runoff, streamflow, evaporation, and influence of the forest and forest cover on the waters of the Truckee River that should be investigated."[4] It seems that this first Church-Kennedy spring excursion took place after it was known that some of the Adams Act money would be available to the Experiment Station. The two could have been collecting information for a request to the USDA Office of Experiment Stations.

3 J.E. Church, The Mount Rose Weather Observatory, 1906–1907, with notes on the progress of the observatory, 1907–1908. Bulletin No. 67 (Reno: Agricultural Experiment Station, University of Nevada, 1908, Plate V.

4 P. Beveridge Kennedy, Botany, Horticulture, and Forestry, in State of Nevada. *In* Annual Report of the Board of Control of the Agricultural Experiment Station for the Fiscal Year Ending June 30, 1906 (Carson City, Nevada, 1907), p. 22.

The agricultural benefit of supporting Church's work was soon confirmed when he demonstrated that temperature readings from Mount Rose could be used to predict the timing of frost at lower elevations. But the research charge that led to Church's contributions as a snow scientist was that of relating snow conservation to forest cover on the mountains. Water users in the West were very much interested in the impact of timber cover on spring and summer runoff that would be available for irrigation and other uses. Did dense timber cover increase or decrease the snowpack and runoff? Mount Rose and surrounding areas had been cut over during the Comstock Lode mining boom. But forest cover in the future could be managed for maximum water yields, if one but knew the answers to the critical questions.

At least by 1908, Church became aware that measuring the depth of snow was insufficient, as the water content of the snow varied. During the winter of 1908–09, Church developed the Mount Rose Snow Sampler, which measured and provided the water content in a column of snow. He announced the development of the sampler in February 1909.[5]

Now that Church could measure the water content of snow, he announced that in the upcoming season, 1909–10, his department would "study this process of anchorage and of evaporation and melting over typical areas throughout the coming season, and to obtain exact data at frequent intervals—in other words, to determine the life history of snow under the various conditions to which it is exposed."[6] Church planned snow courses for three locations where measurements would be made: Mount Rose, Lake Tahoe, and the Ruby Mountains. Time and fatigue eventually eliminated planned snow courses on the Ruby Mountains for the 1909–10 season. Lake Tahoe offered a "never-freezing lake surface and shoreline of 72 miles gave access to various types of mountain slopes and forests."[7] Thus, Church recorded the first snow course data as being collected in 1909.[8]

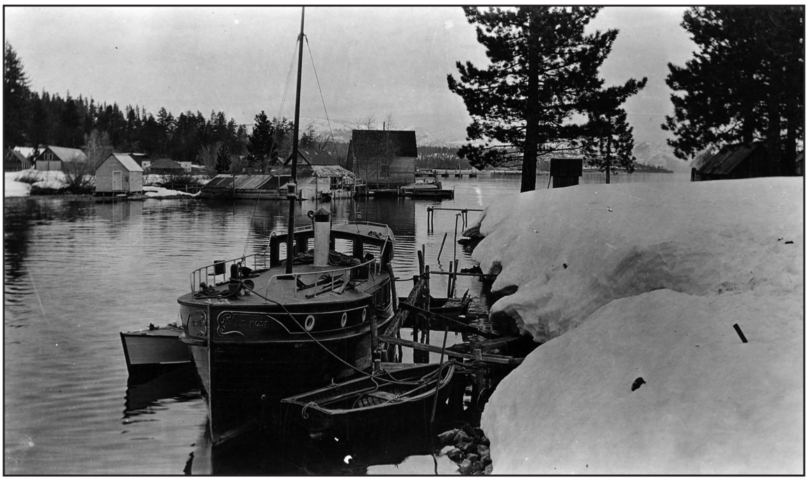
5 Bernard Mergen, Seeking snow: James E. Church and the beginnings of the snow science, *Nevada Historical Society Quarterly*, Vol. 35 No. 2 (summer 1992): 80.

6 University of Nevada. Agricultural Experiment Station. Annual Report of the Board of Control, The Director, and the Members of the Station Staff for the Fiscal Year Ending June 30, 1909. Bulletin No. 72 (Reno: University of Nevada, December 1909), p. 54.

7 J.E. Church, The human side of snow, *Scientific Monthly* Vol. 44, No. 2 (February 1937). p. 147.

8 J.E. Church, Principles of snow surveying as applied to forecasting stream flow, J*ournal of Agricultural Research* Vol. 51, No. 2 (July 15, 1935): 97–130.

Before a long-term sequence of data was available, a demand came for use of the data for correlation of snow survey data to runoff. Church recalled, “The heavy year of 1910–11 came with menace and fear. The Sierra Pacific Power Company begged the use of our snow data to determine how much moisture was latent on the watershed. Thus was born the forecasting of streamflow.”[9] Church concluded that “it was quickly seen that the winter snow in percentage of its normal equaled that of the summer rise of the lake. Rivers followed the same rule, but more closely.”[10] Building upon Church’s pioneering work, Nevada and other Western States developed snow survey programs.



Church Papers, Special Collections, University of Nevada Library, Reno

1.3 Cabin cruiser “Mount Rose” used to sample snow courses along the shoreline of Lake Tahoe

9 J.E. Church, The human side of snow, *Scientific Monthly* Vol. 44, No. 2 (February 1937). p. 148.
10 Ibid.

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Part 2

Snow Survey Sites by State

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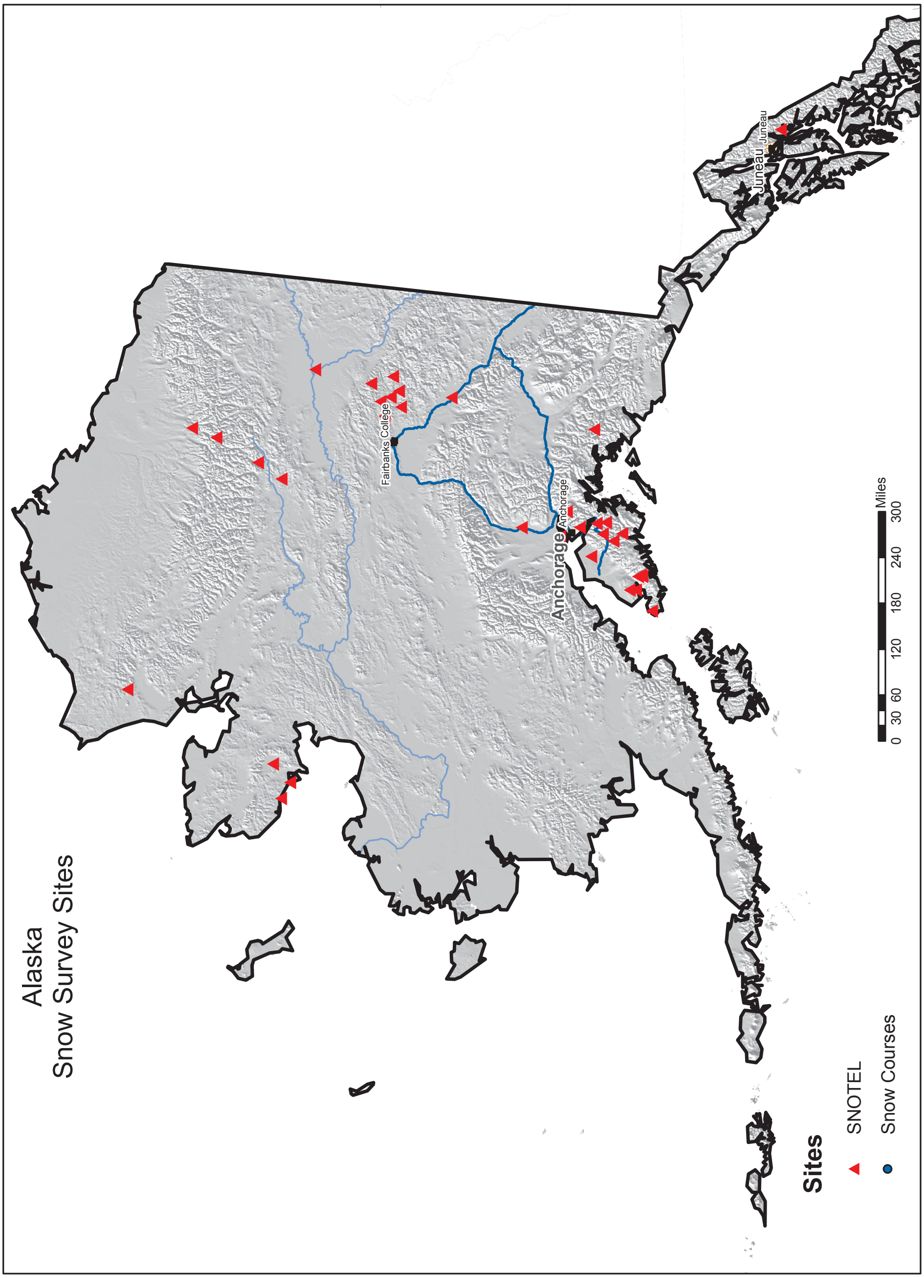
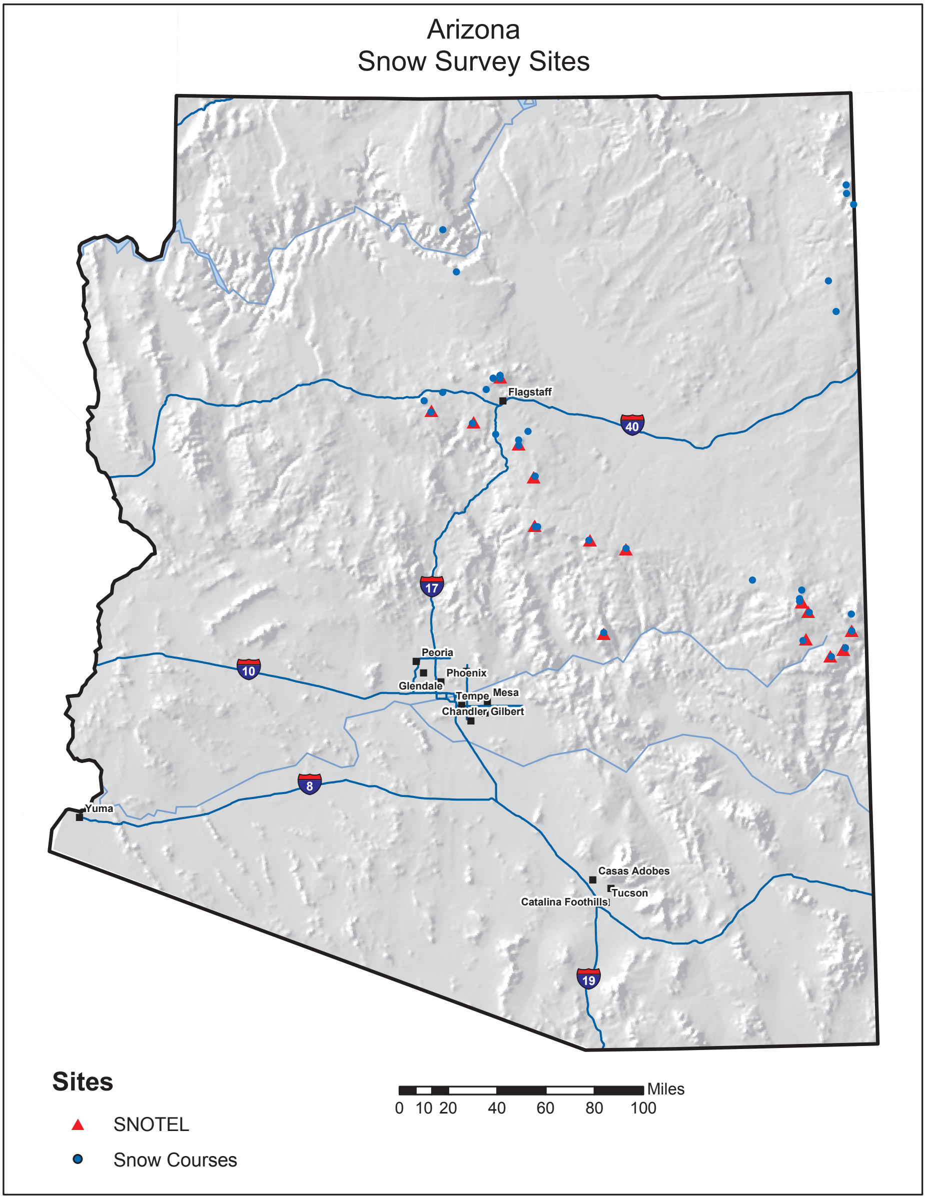
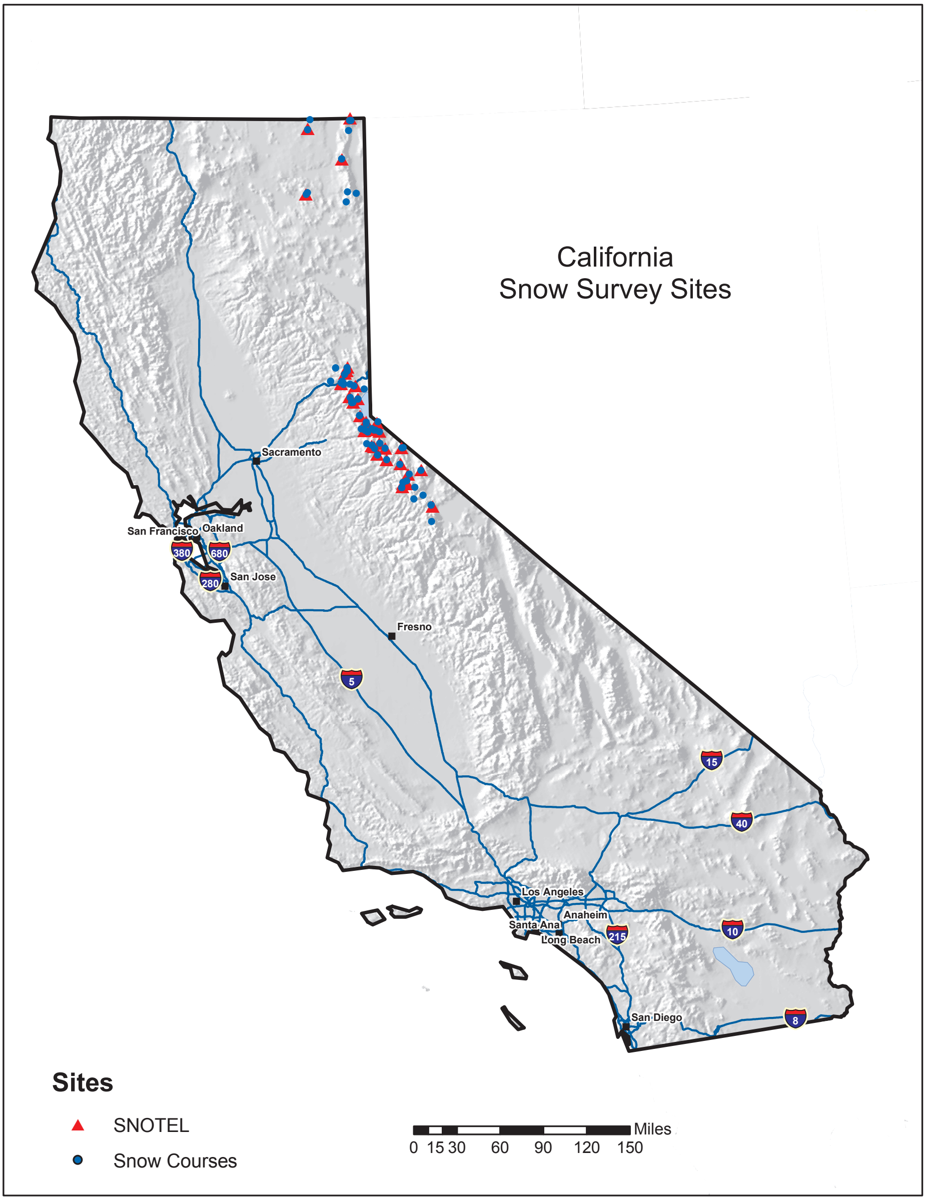
PART 2 SNOW SURVEY SITES BY STATE



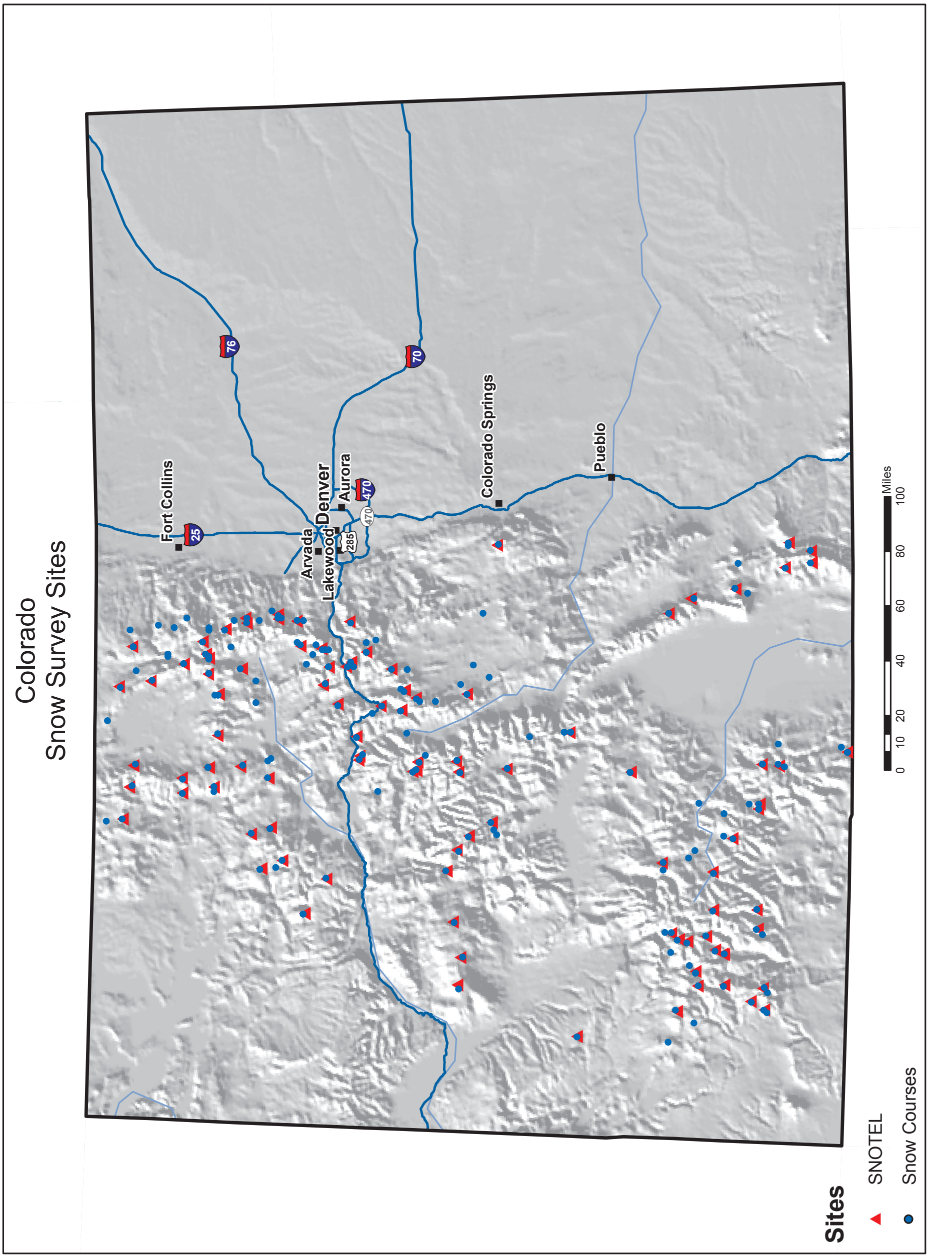
2.1 Alaska Snow Survey Sites



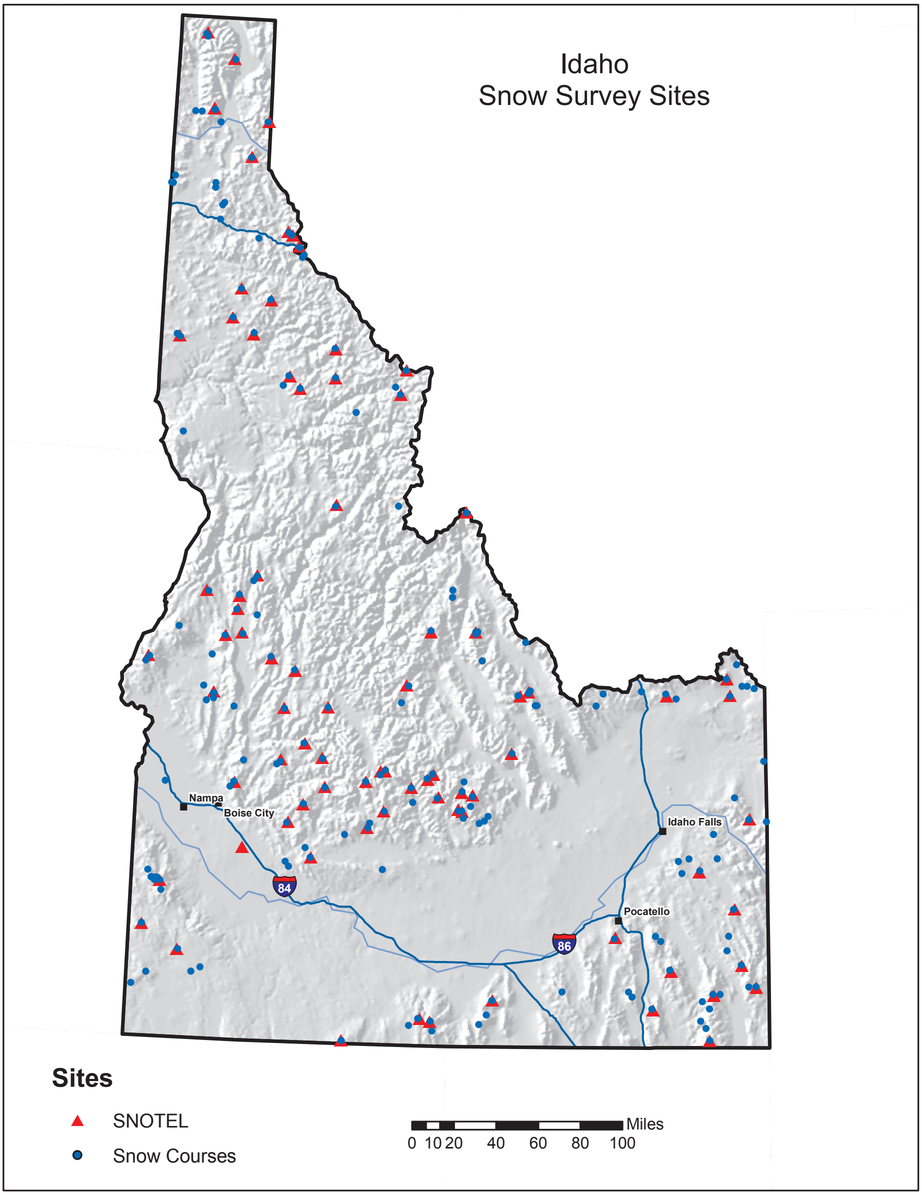
2.2 Arizona Snow Survey Sites



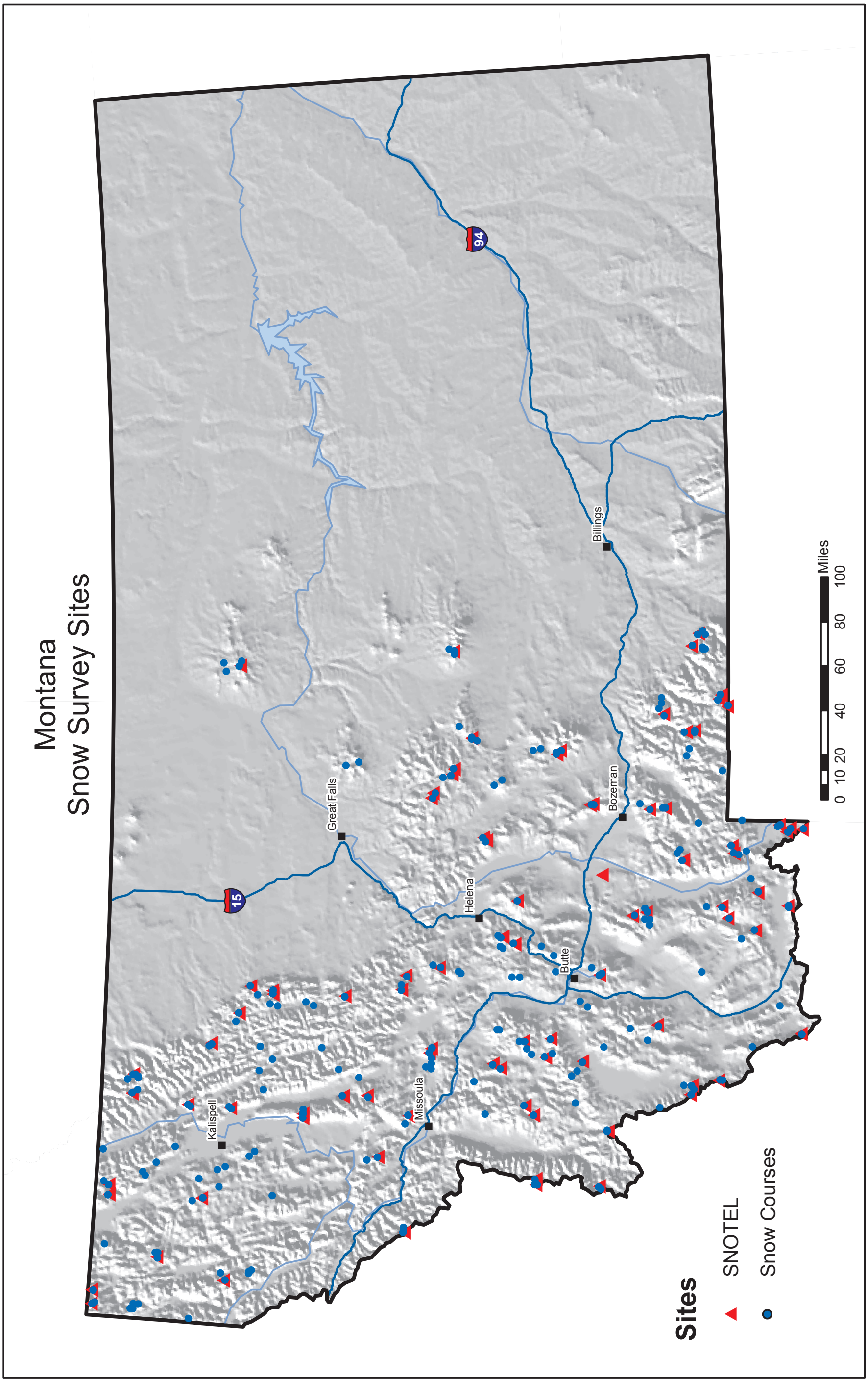
2.3 California Snow Survey Sites



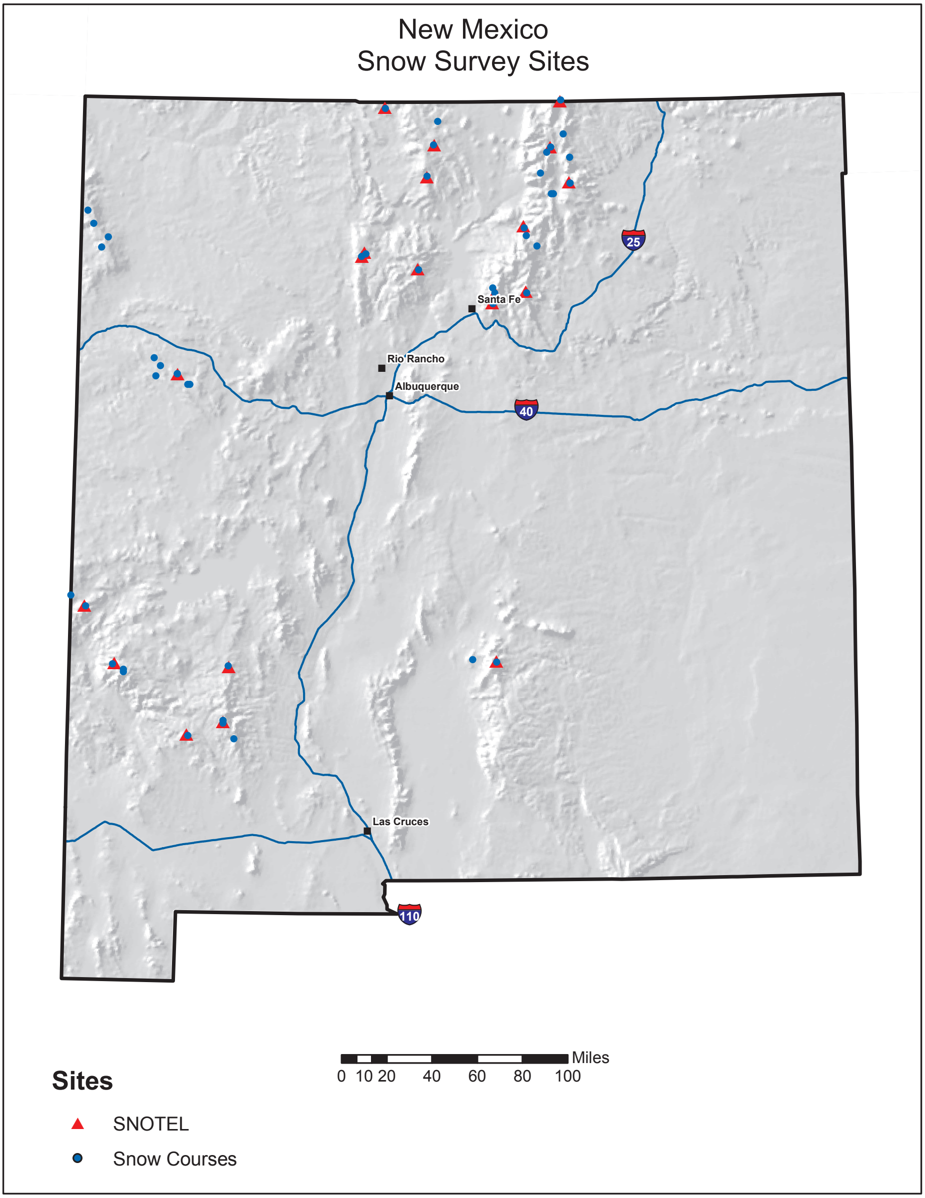
2.4 Colorado Snow Survey Sites



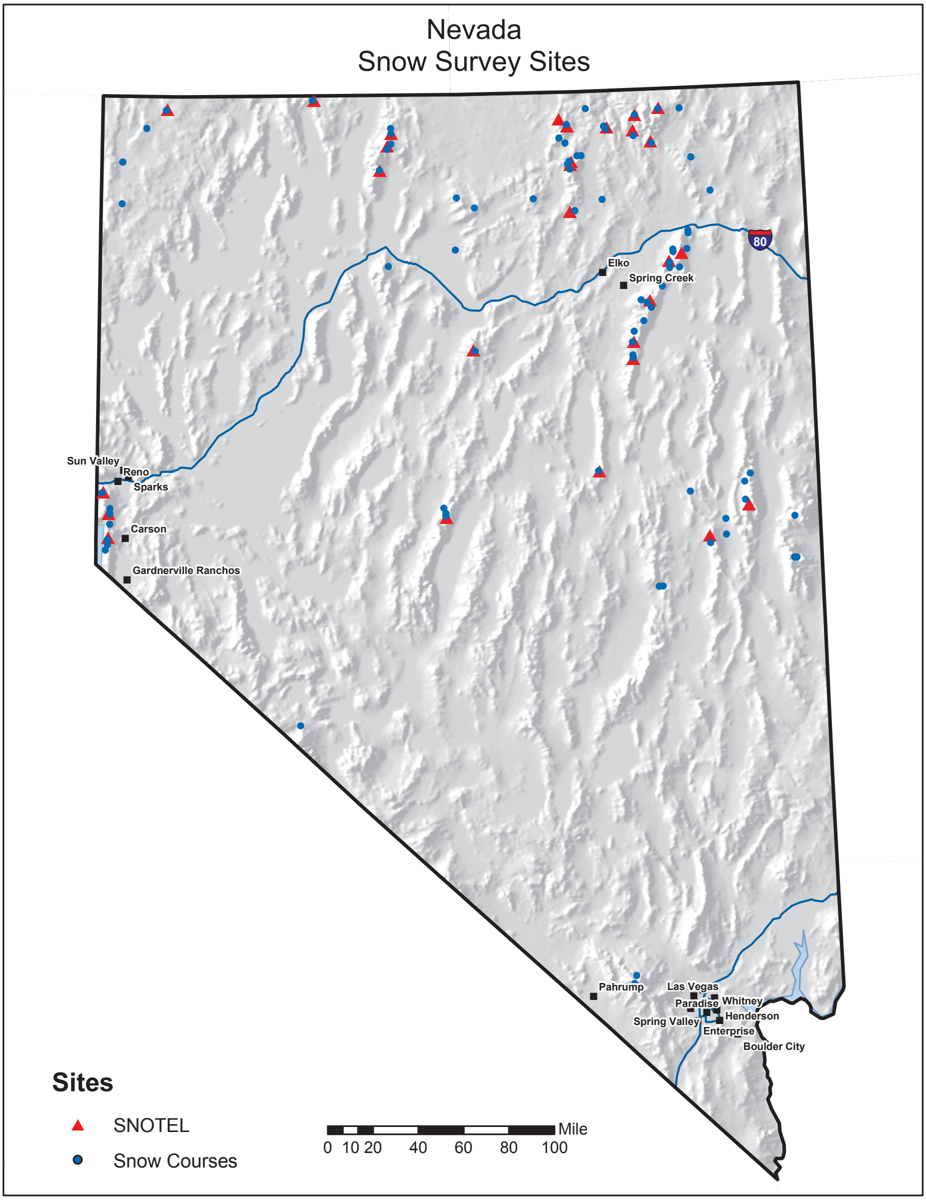
2.5 Idaho Snow Survey Sites



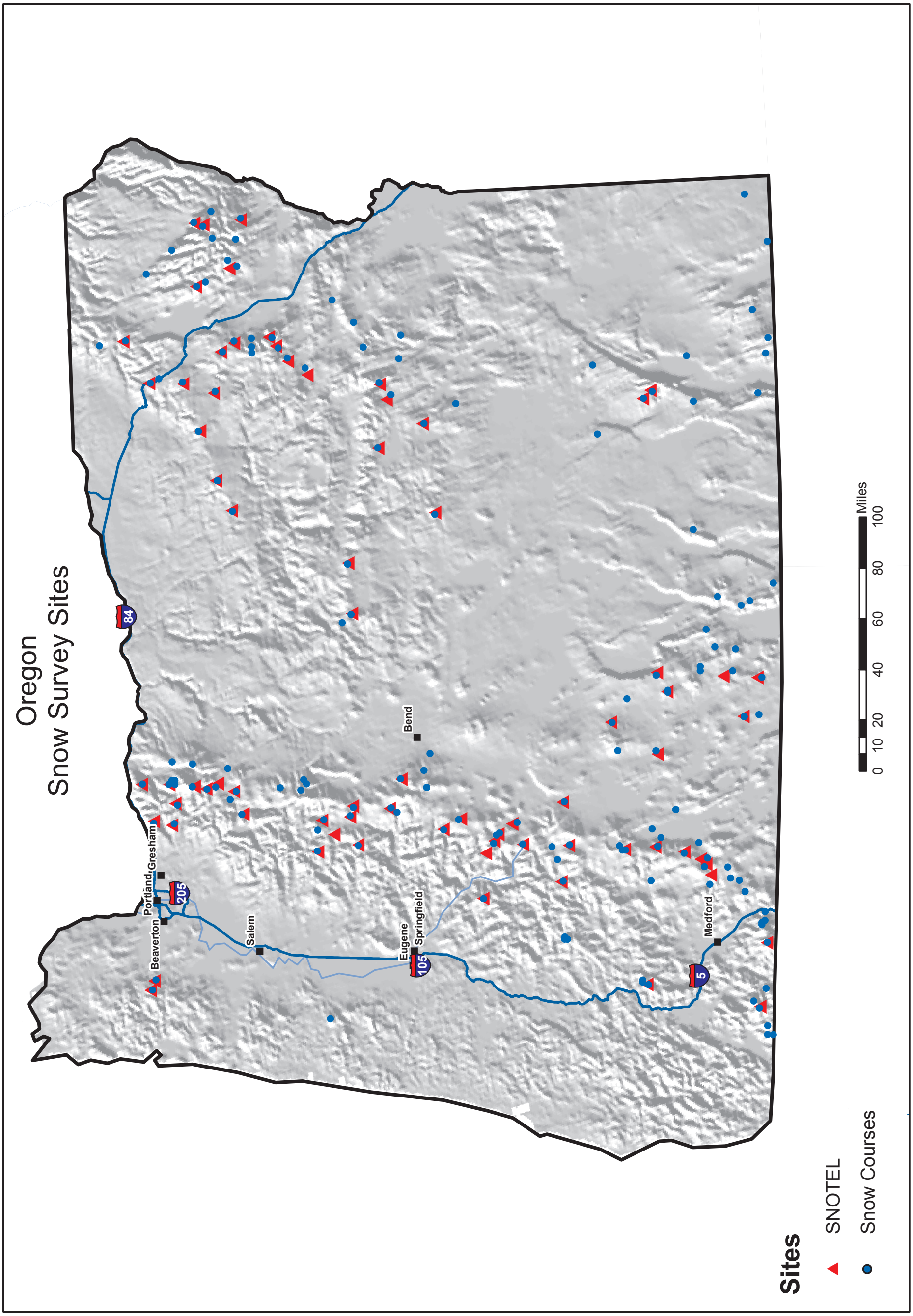
2.6 Montana Snow Survey Sites



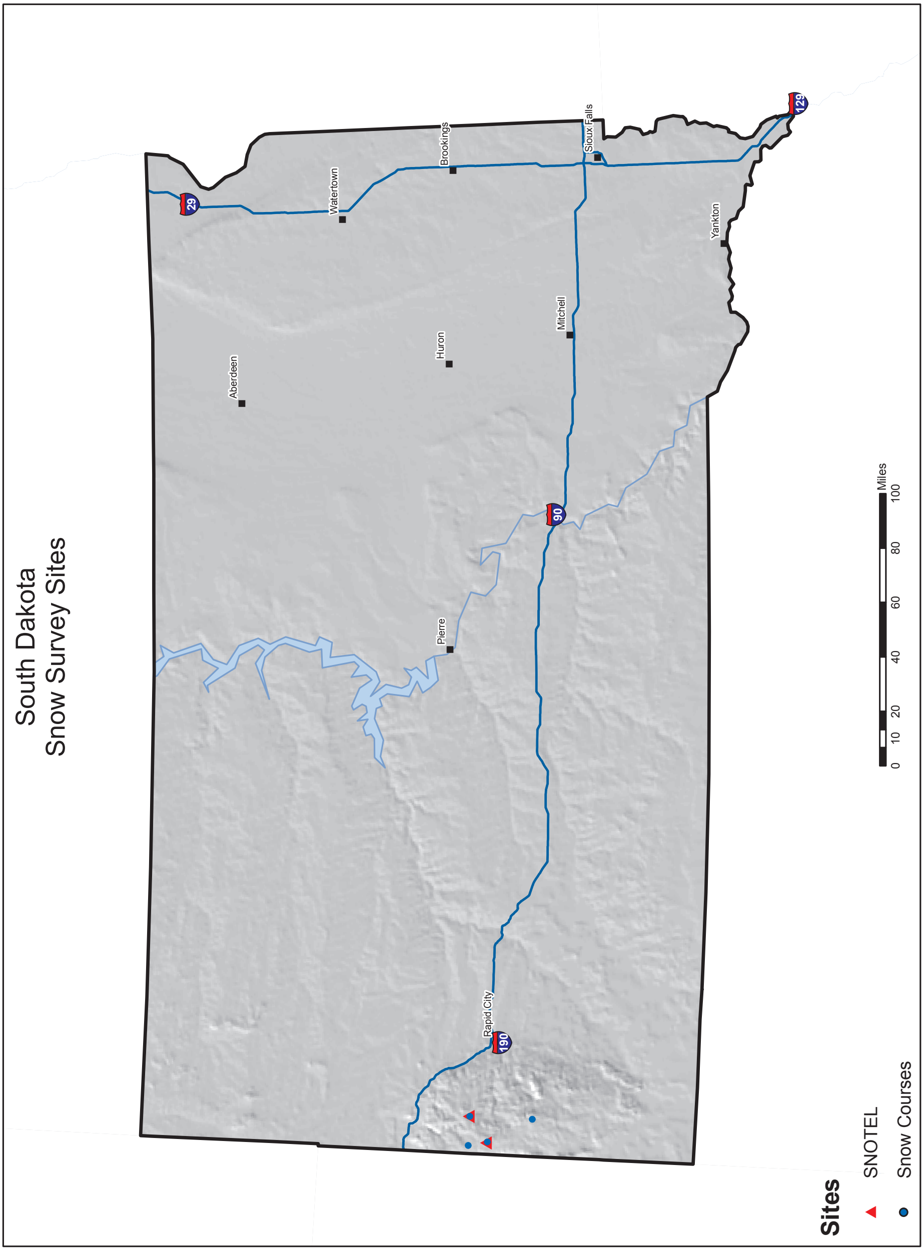
2.7 New Mexico Snow Survey Sites



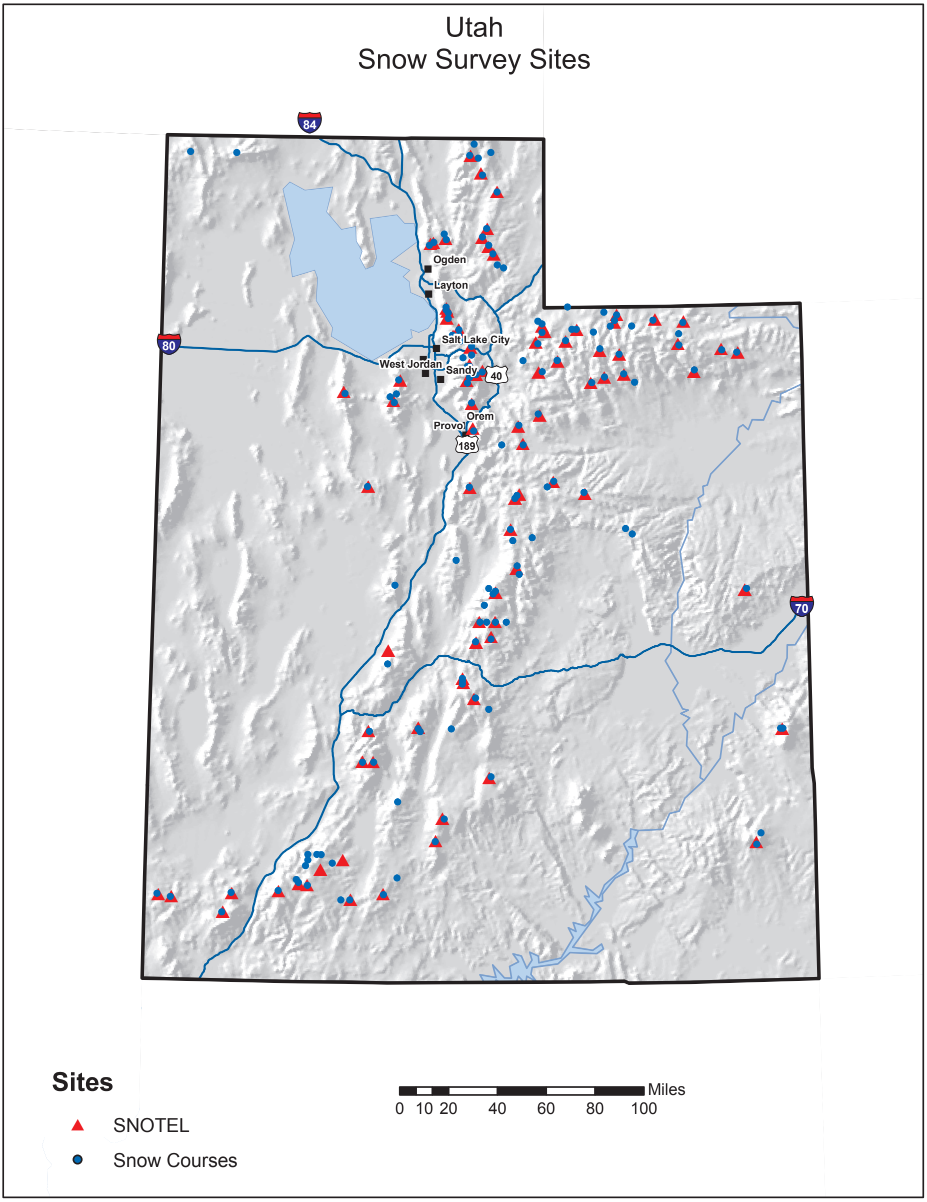
2.8 Nevada Snow Survey Sites



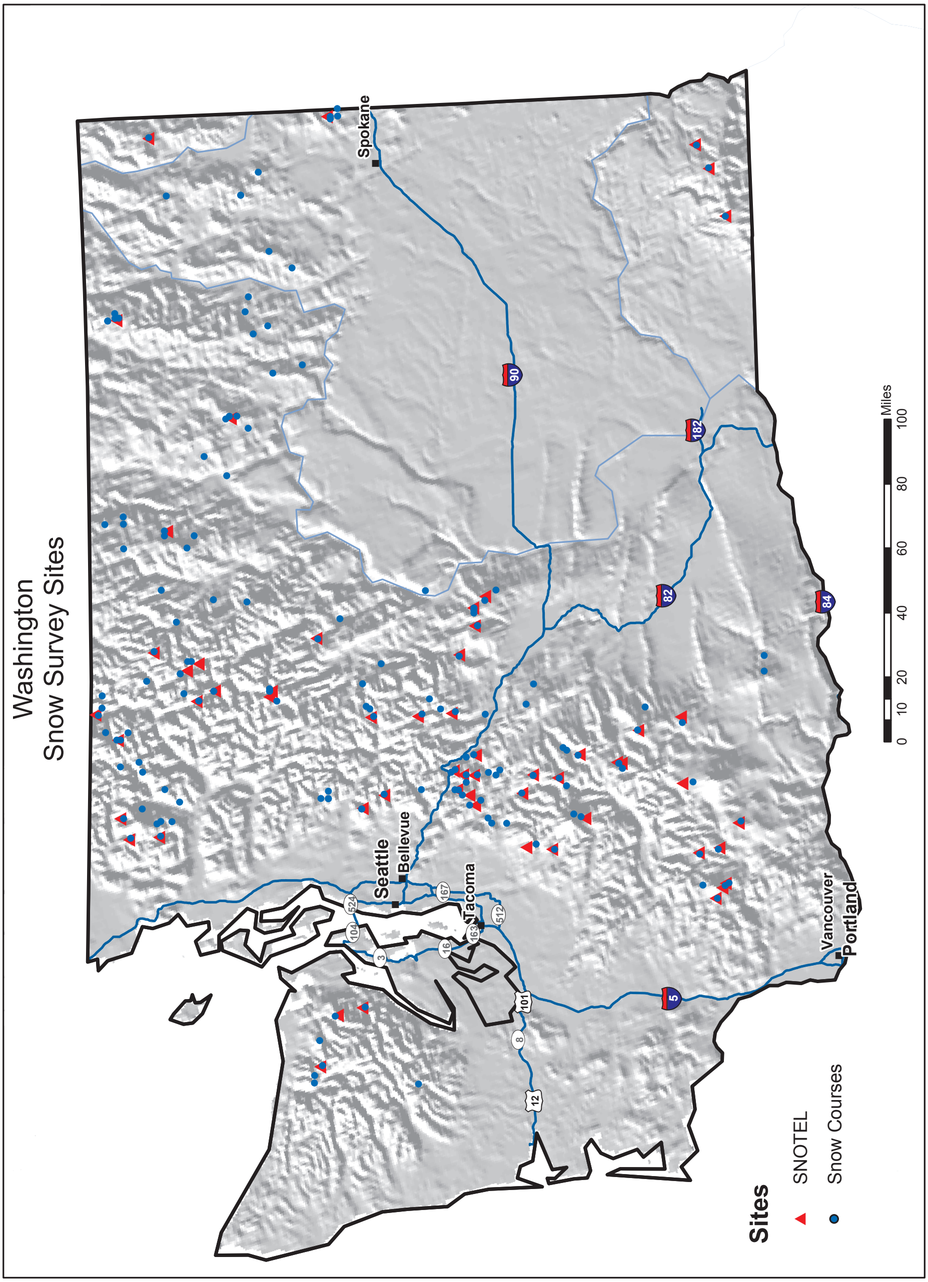
2.9 Oregon Snow Survey Sites



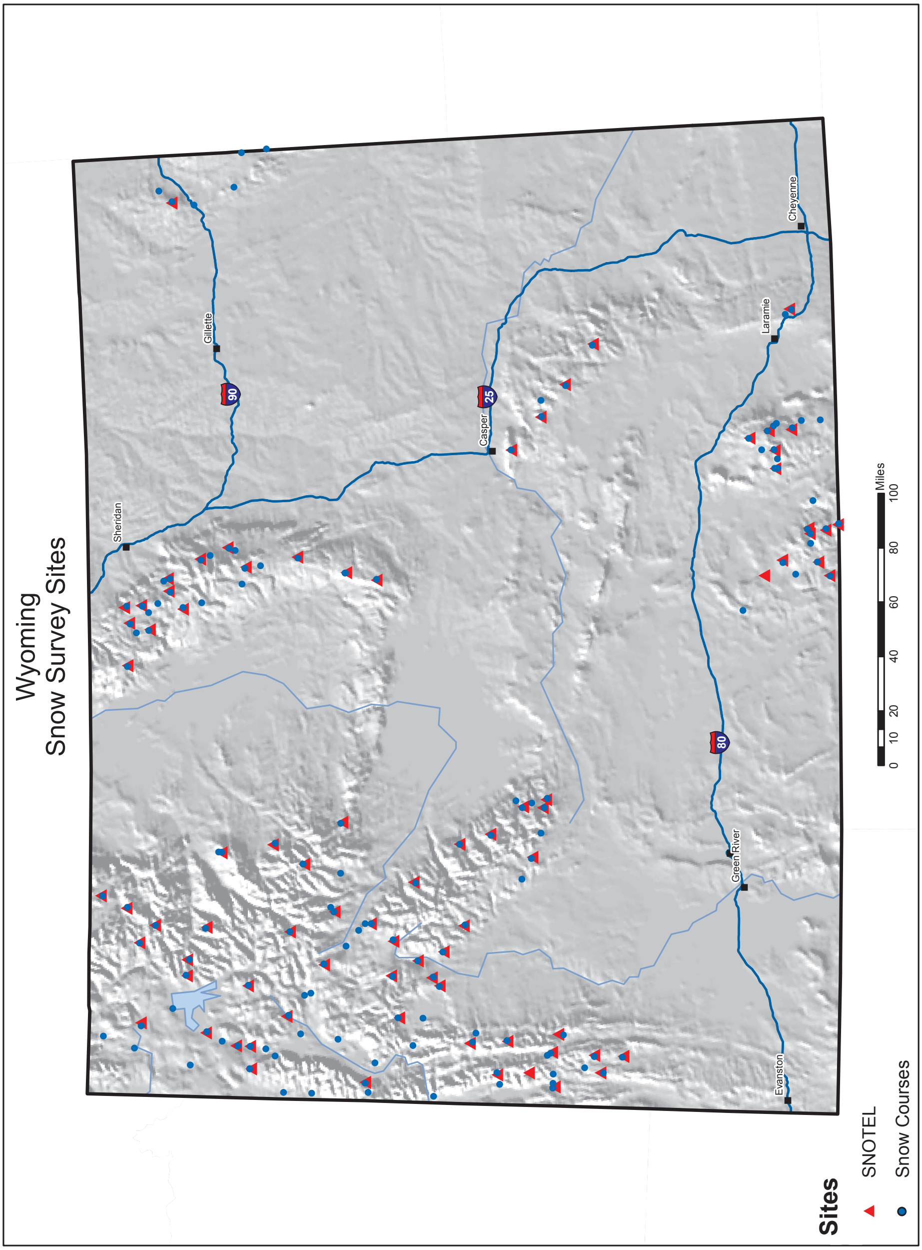
2.10 South Dakota Snow Survey Sites



2.11 Utah Snow Survey Sites



2.12 Washington Snow Survey Sites



2.13 Wyoming Snow Survey Sites

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Part 3

Articles

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Bringing Federal Coordination to Snow Surveys

by J. Douglas Helms[1]

Daily, even hourly, the Federal Government is monitoring numerous aspects of the environment. Though not so well known as satellite images or the daily weather report, stations in the mountains of the West keep track of the amount of snow. A major objective is to know the amount of runoff in the spring and summer. Snow surveying is part of the development of science in government, as well as the growing demand for information by individuals and businesses in the interest of economic growth. Also, snow has been one of the more striking examples of Federal, State, and local cooperation. This article recounts the entrance of the Federal Government into the snow surveying field.

As agriculture and recreation expanded in the West, some individuals, universities, and companies began collecting information on winter snows so as to predict snowmelt runoff in the spring and summer. Of necessity, these surveys were limited to the watersheds of immediate interest; the forecasts were directed to specific purposes such as irrigation, hydroelectric power, and predicting floods. The idea of coordinating snow surveys so that forecasts of spring runoff would be available for all the West may have occurred to many people, but Walter Wesley McLaughlin, chief of the Division of Irrigation in the U.S. Department of Agriculture's (USDA) Bureau of Agricultural Engineering (BAE) was in a position to promote the idea. A Nebraska native, McLaughlin had earned a degree in civil engineering at Utah State University in 1896, and an M.S. degree in soil physics and irrigation from the University of California at Berkeley in 1924. McLaughlin embarked on a career in irrigation engineering in 1904 in the USDA while also teaching at Utah State University. In 1925, he became head of the irrigation division, which was in the Bureau of Public Roads, before being transferred to the BAE.

Since Utah was one of the pioneering States in snow surveying, McLaughlin undoubtedly knew about its value. From his headquarters in Berkeley, California, he followed the growth of snow surveying in the West and participated in some of the snow survey meetings in 1933 and 1934. By mid-1934, he had decided the time was ripe for getting the Federal Government involved. He sent his supervisor, Samuel Henry McCrory, chief of the Bureau of Agricultural Engineering, a project proposal entitled "Snow Survey and Stream Flow Forecasting." McLaughlin had observed that neither the Weather Bureau nor the Water Resources Division of the U.S. Geological Survey was particularly active in snow surveying. The pioneers in snow surveying were the users and their allies in industry, public utilities, State agencies, and agricultural experiment stations. Viewing the vacuum, McLaughlin proposed

1 Presented at the Western Snow Conference, Juneau, Alaska.
National Historian, Soil Conservation Service, U.S. Department of Agriculture, P.O. Box 2890, Washington, DC 20013.
Reprinted Western Snow Conference 1991.

"to set up at the proper time a snow survey project under the Bureau of Agricultural Engineering, believing it to be the logical agency to undertake this work and the best agency to make the greatest possible use of the information in the interest of agriculture."

According to McLaughlin, he was waiting for the perfect opportunity; the drought of 1934 provided it. In May 1934, he had an opportunity to explain the importance of snow surveys to Secretary of Agriculture Henry A. Wallace. He told Wallace how snow surveys could have helped farmers adjust to the drought.[2] Also, McLaughlin saw the emergency employment programs under the Public Works Administration (PWA) and the Works Progress Administration (WPA) as an opportunity to expand snow surveys and provide a way for coordinated forecasting. The Great Depression and employment programs of the New Deal elicited hundreds of proposals for a more activist Federal role in social and natural resources areas. Thus the economic conditions provided the climate in which the Federal Government expanded its responsibilities in numerous areas.

The Farm Bureau Federation endorsed McLaughlin's proposal in 1934, and he submitted a request for PWA funds for snow measuring stations, snow courses, shelters, equipment, and maintenance for the first year. Despite their inactivity to date, McLaughlin believed the Department of the Interior would make a similar request if the USDA did not take the initiative.[3] McLaughlin specified mostly research projects in his proposal.

McCrory agreed that the drought and depression had indeed provided an excellent opportunity, but McLaughlin was taking the wrong tactic. The emphasis must be placed on actually providing forecasts to farmers and other water users, rather than on research.[4] McCrory knew how to spot opportunities. His agency was one of the smallest in USDA, and he had won a reputation for aggressively competing with larger agencies for funding. BAE had neither the manpower nor the large constituencies of agencies such as the Weather Bureau or the Forest Service.[5] In addition to the $36,000 requested from the Bureau of the Budget for research, McCrory requested $40,000 of the emergency drought funds from USDA for making snow surveys and forecasts.[6]

The Bureau of the Budget rejected both requests.[7] Having become a convert to the idea, McCrory pushed the issue. In November 1934, Secretary Wallace met with Harry Hopkins, head of the Federal relief effort, to discuss money for snow surveys. Rather than having a large project at the Federal level, Hopkins suggested requests for the snow survey work should come from the States through their regular procedure for requesting project approval.[8] Meanwhile, in late 1934, McLaughlin continued his campaigning in the West. The Association of Western State Engineers and the National Reclamation Association adopted resolutions calling on the Secretary of Agriculture to undertake

2 Walter Wesley McLaughlin to Samuel Henry McCrory, July 25, 1934, File 3–234, General Correspondence, 1931–1939, Records of Bureau of Agricultural Engineering, Record Group 8, National Archives and Records Administration, Washington, DC. All of the correspondence cited in this article is from the same file.

3 McLaughlin to McCrory, August 6, 1934.

4 McCrory to McLaughlin, August 23, 1934.

5 Wayne Rasmussen, former historian of USDA, knew McCrory and provided this characterization. Conversation with Rasmussen, March 25, 1991.

6 McCrory, Memorandum for the Secretary, September 4, 1934.

7 McCrory to McLaughlin, November 18, 1934.

8 McCrory to McLaughlin, November 27, 1934.

a coordinated, comprehensive snow survey in the West. McLaughlin and his allies blocked moves to have the Weather Bureau and the Forest Service named as the agencies to lead the effort. They much preferred that the Secretary of Agriculture delegate the authority. In the interest of making sure that the BAE was given the authority, McLaughlin reminded McCrory to keep the Secretary advised. "We must, however, put the matter up to the Secretary so he will be prepared for any move by Forestry or Weather Bureau. Forestry grabs at every thing all the time."[9]

Legislation

Having failed, at least temporarily, with the regular budgetary process and the emergency employment funds routes, the campaign now turned to the legislative process. Governor C. Ben Ross of Idaho wrote to U.S. Senator James P. Pope of Idaho to introduce him to McCrory.[10] McCrory kept the Secretary informed of these meetings and his activities to promote snow surveys.[11]

The western congressional delegation was easily convinced of the need for snow surveys and requested funding in 1935. The Senate Appropriations Committee discussed the item, but did not include it in the bill submitted to the full Senate. They wanted to resolve the matter of who was going to be in charge of the snow surveys. Senator Frederick A. Steiwer of Oregon contacted Assistant Forester Earle H. Clapp and others in USDA, who told him that authority should be assigned to the BAE. The amendment to the appropriations bill in the Senate gave BAE authorities and funding for "snow surveys and forecasts of irrigation water supplies."[12]

Designing the program

Before the appropriations bill was signed on May 17, 1935, McLaughlin had already asked James C. Marr, a Division of Irrigation engineer at Boise, Idaho, to familiarize himself with snow surveys in the northwestern States.[13] McLaughlin traveled to Logan, Utah, to discuss snow surveys with George D. Clyde, a professor of engineering at Utah State University and head of Utah's snow survey effort. McLaughlin considered Clyde "the best informed man in the country on this subject." In addition to his expertise, Clyde already had "very pleasant contacts with other agencies," which would be crucial to the success of a cooperative snow survey effort.[14]

McLaughlin thought Clyde would be the only additional employee BAE would need for their new role in snow surveying. He would be a collaborator for 2 or 3 months each year. Marr would have general supervision of the snow survey work. Clyde and Marr worked on the general plan of action in early May, preparatory to visiting existing snow surveying operations and prospective cooperators. Clyde and Marr would locate the snow courses in the States selected for work the first summer.

Despite McLaughlin's original intentions, he also signed on James Edward Church to help get the cooperative snow survey program started in the summer

9 McLaughlin to McCrory, December 8, 1934.

10 C. Ben Ross to James P. Pope, December 27, 1934.

11 McCrory, Memorandum for the Secretary, January 31, 1935.

12 U.S. Congress, Senate, Congressional Record, 74th Cong. 1st. sess., 1935, 79, pt. 5: 4699; Public Law No. 62, 74th Congress.

13 James C. Marr to M. R. Lewis, April 26, 1935.

14 McLaughlin to McCrory, May 6, 1935.

of 1935. Church's interest in snow led him from his fairly obscure position as a classics professor at the University of Nevada in Reno to being the most renowned figure on snow surveying in the United states. Undoubtedly, it was a wise move to solicit Church's advice and to add his reputation to the cause. Unlike Clyde, who immersed himself in developing the structure of the program and laying out snow courses, Church conferred with officials in the various States and explored the areas where cooperation could be had. He talked to the hydroelectric power interests in Los Angeles, the irrigators in the Imperial Valley, and the Forest Service and National Park Service people in Arizona. One of the cooperators referred to Church's "goodwill tour." Church liked the term and continued the tour at Marr's behest.[15]

Church was a willing cooperator. If he resented the fact that Clyde had a greater hand in designing the coordinated system, he did not betray it in writing to McLaughlin or Marr. Furthermore, there was much in the operations of the new group to enhance his reputation. Church felt that the Weather Bureau had rebuffed his earlier efforts to prod them into developing a national system. Worse, some of the Weather Bureau people preferred snow stakes for measurement, rather than Church's snow courses and tube sampling. (McLaughlin's group would use Church's methods.) Finally, Church held that streamflow forecasting required engineering, rather than meteorological analysis. Accordingly, most of the recent conferences had been held with engineers rather than meteorologists.[16]

15 James Edward Church to McLaughlin, July 23, 1935.

16 Quotes of a letter from Church to McLaughlin found in McLaughlin to McCrory, August 9, 1935.

Early decisions on standardization

The survey was obviously going to rely on a great deal of cooperation. But McLaughlin believed some of the methods and equipment must be standardized. His group decided to spend their scant funds, $15,000, on equipment. A standard type would be selected and purchased in volume so as to reduce costs. His group well understood that experience in the field would lead to improvements and correction of defects. Nonetheless, they intended to start out with established standards for the equipment and methods. They would use Church's method for snow cover measurements, rather than the stake method. The former involved taking a core sample of the snow so as to measure volume and water content. The stake method simply measured snow depth without regard to density or water content. Another Church contribution, "the Mount Rose tube in its original form or as modified in Utah," would be used.[17]

The scale to measure the weight of the snow sample would also be standardized. As two of the innovators of snow surveying equipment, Church and Clyde both had a personal interest in the writing of standards. During the first year, the BAE purchased 150 sets of snow sampling equipment, with half going to Marr and the other half to Clyde for distribution.[18] But when they received the equipment, Clyde and Church both had some objections. Church found a deficiency in the weighing mechanism; Clyde found fault with the sampling tube from Nevada. McLaughlin wryly noted that

17 McLaughlin to Church, August 3, 1935.

18 McLaughlin to George R. Boyd, Acting Chief, Bureau of Agricultural Engineering, August 3, 1935.

snow surveyors from Colorado had no difficulty in using the equipment, and attributed "some of the comments of Clyde and Church to a little prejudice. This is only natural, since we all have our weakness in this regard."[19] In addition to the snow sampling tubes and the weighing mechanism, the group also supplied skis and snow shoes in some cases.[20]

Organization

The absence of long-term data plus the need to emphasize the cooperative nature of the work influenced McLaughlin's organizational decisions. There would be regional offices, rather than a national one. Without historical data, personal knowledge of the rivers and streams would be required if the snow survey group expected to make worthwhile forecasts in the first few years. They needed, and wanted, to make their presence known. They definitely planned to make forecasts from the new snow course data the first year. After some years' accumulation of data, McLaughlin believed it would be possible to have a national office. But there was another reason for regional structure. McLaughlin wanted to have the State agencies involved not only in the surveying, but also in the forecasting. The matter of organization illustrated the sensitivity required in Federal-State cooperation on the project and how such cooperation could best be achieved. McLaughlin thought his bureau should insist on being involved in all local forecasting. He wrote to McCrory, "Otherwise the work would soon drift out of our hands, and we would find ourselves in a position of supplying funds and some State agency making the forecasts."[21]

19 McLaughlin to McCrory, January 23, 1936.
20 McLaughlin to McCrory, October 19, 1935.
21 McLaughlin to McCrory, December 30, 1935.

Establishing snow courses

The first year McLaughlin planned to expand existing networks in the key drainages and the most accessible areas of Oregon, Idaho, Utah, Wyoming, Colorado, Nevada, and California. As Clyde and Marr traveled about, locating snow surveys, they were "to interest local and State agencies and stimulate an interest in local agencies for snow surveys so they will demand the work."[22]

McLaughlin's group hoped, and suggested, that the cooperators in Nevada, California, Utah, and Oregon who already had extensive networks of snow courses would establish additional ones, as well as surveying and mapping existing courses. BAE was to supply the additional snow surveying equipment needed. During the summer of 1935, Marr concentrated on the Snake River and Clyde on the Colorado in establishing new snow courses in Wyoming, Idaho, and Colorado.[23] In selecting the new snow courses, the two considered serviceability, accessibility, and the key areas in a statewide plan, as well as the most urgent requests from cooperators.[24]

During the first 10 days of August, 1935, Marr covered 2,300 miles over little traveled roads and trails as he established snow courses in Wyoming and Yellowstone National Park. To avoid the cost of installing a course, he selected areas where little construction work would be needed. Where work was needed he managed to get the cooperation of the Civilian Conservation Corps (CCC). Thanks to the cooperation of agencies, the only cost

22 McLaughlin, Memo–Snow Surveys, July 5, 1935.
23 Marr to H.P. Boardman, August 12, 1935.
24 McLaughlin to McCrory, December 30, 1935.

to BAE would be the snow sampling equipment.[25]

Marr's enthusiasm for the work even brought a reaction from McCrory in Washington. He advised McLaughlin to "put on the brakes on a little in his case. He is working so hard that I am afraid he faces a nervous breakdown if he does not ease off somewhat."[26] At the end of 1935, Marr thought the snow surveying group had about a fourth of the 1,000 courses they would eventually need.[27]

Cooperation with other Federal agencies

McLaughlin believed the Forest Service, as part of their cooperation, would clear and mark courses, build and equip snow shelters at their own expense and with CCC labor. He hoped that some of the cooperating State agencies such as the State Engineers would be able to use CCC labor and successfully apply for Federal Emergency Relief Act funds for similar work. McLaughlin planned to use all of the scant $15,000 appropriation for equipment. To establish the whole network in the West would eventually require about $100,000 to $300,000.[28]

The Division of Irrigation group never quite secured the large allocation of emergency funding with which to rapidly expand the network by clearing snow courses, building snow cabins, and doing other construction work. Thus, they tended to work through the states or with the Federal land management agencies. Marr helped Idaho prepare applications for funds to work on snow courses.[29] The Federal land management agencies eventually did much of the construction on the lands in their charge. Seeing that BAE had only $15,000 to get the work started, the other agencies knew well that success depended upon their cooperation. Evan W. Kelly, the U.S. Forest Service's regional forester in Missoula, Montana, wrote to his forest supervisors: "The Bureau of Agricultural Engineering is pitifully short of the necessary appropriation from which to finance this important activity;...the various agencies of the government directly or incidentally interested, must cooperate to the fullest practical extent."[30] The BAE had reason to be pleased with the degree of cooperation the first year. They wrote not only to cooperators, but also to their supervisors thanking them.[31] Success the first year accelerated the degree of cooperation. The Corps of Engineers had been doing some snow surveying work on the watershed of the Missouri River. In 1936, they contributed $3,000 so that BAE could set up courses on the Columbia River Basin.[32]

Expansion of work

Following the forecasting work in the spring of 1936, BAE expanded the program in the summer. In all the States, there was cooperation with the State Engineer and the land-grant agricultural college. Each of the district representatives of the Division of Irrigation made arrangements for the snow cover surveys, provided the equipment, and stocked the cabins. Essentially they handled all of the operations in their State. They reported the snow survey

25 Marr to McLaughlin, August 12, 1935.

26 McCrory to McLaughlin, August 12, 1935.

27 McLaughlin to McCrory, December 30, 1935.

28 Marr to H.P. Boardman, August 12, 1935.

29 Marr to H.P. Boardman, August 12, 1935.

30 Evan W. Kelly to Forest Supervisors, July 24, 1936.

31 McLaughlin to McCrory, August 12, 1936.

32 McLaughlin to McCrory, August 10, 1936.

data to the Berkeley office and the Boise office. Clyde handled the work in Utah while Church handled Nevada. Marr, at Boise, and Louie T. Jessup at Yakima, Washington, did Idaho and part of the Columbia drainage. Ralph Parshall at Fort Collins was responsible for Wyoming and Colorado; and temporarily responsible for New Mexico and Arizona. Arch Work surveyed Oregon and northern California from his office at Medford, Oregon. The State Engineer of California did the rest of that State. The district engineer of the U.S. Geological Survey at Helena, Montana, did the Missouri River. The Berkeley and Boise offices jointly publicized the information.[33]

By the second season, they had perfected the publicity arrangements. They made measurements monthly from January 1 to May 1. Water supply forecasts were made following the February measurement and the April or May measurement, depending on the State. Broadcasts of information went out on the Farm and Home Hour and various State stations. The cooperating agencies, usually the State Engineer or the State agricultural college, put out mimeographed releases. The Weather Bureau also published the data for the Federal Government. As part of the original agreement with the Weather Bureau, BAE supplied information to them for flood predications. Sampling for flood predictions required additional visits to the snow courses. The snow survey work was actually a part-time duty for the BAE people, except Marr, who would work full-time on it until no longer needed.[34]

33 McLaughlin to McCrory, January 23, 1937.

34 McLaughlin to McCrory, January 23, 1937.

Winter sports radio broadcasts

By the second year of forecasts, the snow survey group began receiving requests for information from winter sports enthusiasts. McLaughlin wanted to get immediately involved since it was a public service and was another "most worthwhile public contact for us...."[35] Initially McCrory resisted, believing that BAE had to strictly limit itself to the authority in the legislation for forecasting irrigation water.[36] Never easily discouraged, McLaughlin managed a meeting with Paul Appleby, Assistant to the Secretary of Agriculture, and got his endorsement. Following the meeting with Appleby, McLaughlin worked out an agreement with the National Broadcasting Company to devote 5 minutes each Friday on the Farm and Home Hour to reports from each State. Also, many of the State weather bureaus and State highway departments agreed to issue the forecasts. As far as McLaughlin was concerned, the service was "an excellent contact with the public."[37]

Different verisons

The issue of the winter sports forecasts illustrated some of the differences in outlook, or zeal, between McCrory and his people in the West. McCrory saw the value for irrigated agriculture and strongly supported the work, but he saw it as only one aspect of BAE's work. When he thought he detected Marr and others working exclusively on the snow survey project, yet charging a large part of their salaries to other accounts, he chided them. He warned McLaughlin to stay within the appro-

35 McLaughlin to McCrory, February 3, 1937.

36 McCrory to McLaughlin, February 6, 1937.

37 McLaughlin to McCrory, July 13, 1937.

priation for snow surveys and vowed not to siphon funds from other work for it.[38] He wanted to adhere strictly to the authorization for predicting irrigation water supplies. As far as he was concerned, the agreement with the Weather Bureau was well understood by both parties, and each group would cleave honorably to the agreement.

In practically all these matters, McLaughlin had a different view. Success in the snow survey required a quick success the first year and thus demanded almost undivided attention. Though an irrigation engineer by training, he understood the other uses and potential for the snow survey and moved aggressively into those areas. Given the sparse BAE staff in the West, compared to other Federal agencies, McLaughlin cherished the publicity value and resulting clout that came from activities such as the winter sports radio broadcasts. McLaughlin's operation depended upon the cooperation of the land management agencies, but he also viewed them as potential competitors for the snow survey prize. In his opinion, the Weather Bureau had to be watched at every turn. Offers of cooperation must be analyzed closely for ulterior motives.[39] For all these reasons, McLaughlin and his people in the Division of Irrigation zealously set out to make the program a success.

Summary

More than 50 years after Federal coordination of snow surveys was begun, its value is recognized more than ever. The competition for water in the West due to the explosion in population, industry, and agriculture created a demand to know as precisely as possible the amount of water available from snowmelt. The various enterprises whose operations cut across political boundaries demand the basinwide information that a coordinated system produces.

In retrospect, many of the decisions made by McLaughlin and his colleagues were wise beyond their time. One thing they wanted, but did not get, was a large appropriation or allotment from the emergency employment funds to rapidly clear snow courses, build snow cabins, and do other types of construction associated with snow surveys. Would this have changed the course of the history of snow survey? It is difficult to know. As it developed, the enforced reliance on the State and other Federal agencies to do much of the work probably was beneficial to the strength of the program. Although the snow survey is operated under the Soil Conservation Service, it is responsible to, and draws strength from, all the cooperating agencies. In a sense, it has a separate existence. The users and gatherers of the snow survey information seem likely to continue to demand some coordination at the Federal level for the foreseeable future.

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38 McCrory to McLaughlin, January 6, 1937 and January 18, 1937; McLaughlin to McCrory, January 12, 1937.

39 McLaughlin to McCrory, December 21, 1936, McLaughlin to George R. Boyd, Acting Chief, Bureau of Agricultural Engineering, August 16, 1937.

Snow Surveying Comes of Age in the West

by J. Douglas Helms[1]

Snow surveying and water supply forecasting entered a new era when the U.S. Department of Agriculture (USDA) abolished the Bureau of Agricultural Engineering (BAE) and transferred the Division of Irrigation to the Soil Conservation Service (SCS) on July 1, 1939. The Division of Irrigation was headquartered at Berkeley, California, with Walter W. McLaughlin as chief. The irrigation engineers in field offices in the Western States had been in charge of the Federal coordination of snow surveys since the U.S. Congress appropriated money for the work in 1935. Previously existing networks, such as those in Nevada, Utah, and California, continued under the agricultural experiment station or a State agency as was the case in California (Helms, 1991). The individuals who eventually came to be called snow survey supervisors were James C. Marr in Boise, Idaho; R.A. "Arch" Work at Medford, Oregon; Ralph Parshall in Fort Collins, Colorado; and Lou T. Jessup at Yakima, Washington. They generally operated independently, though Marr was the acknowledged leader. Since the beginning of snow surveys, Marr had devoted all of his working hours to building up the snow surveying activities and had dropped his irrigation work (Marr correspondence).

The early years had been a time of rapid expansion—laying out snow courses, working out agreements with cooperators and users, compiling data, making forecasts, and reproducing the forecasts for distribution. Arch Work recalled that the group had decided working independently was the most efficient operation.

> *We were pretty decentralized. I understand perfectly the need to centralize snow survey work under SNOTEL ... But in those early days, we believed it was more practical and more profitable, in terms of public relations, to decentralize. I think it was a profitable position to take because they weren't restricted by regulations superimposed upon them by someone who didn't know very much about the business.* (Work interview, 1989).

The group created enough interest that the requests for additional snow courses eventually exceeded the meager appropriation and manpower available (Work interview, 1989; Marr correspondence).

The move to the SCS increased the area covered by snow courses as well as the application of forecasts (Work, 1989). The SCS had begun in 1937 to encourage the creation of conservation districts under State law. The districts had locally elected supervisors and directors. After a district signed a cooperative agreement with USDA, the SCS would assign staff to work with the district. The move added a large number of SCS employees as potential snow surveyors. Also, snow survey offices were opened at Reno, Nevada, and Logan, Utah (Work, 1948).

In terms of applications, the SCS had become the primary agency of the USDA advising farmers on technical matters concerning the storage, movement, and use of water on the farm. SCS assumed responsibility for advising farmers on irrigation and drainage

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along with water supply forecasting. Working through the field staffs and the conservation districts, there was great potential for using snow surveys in irrigation.

Arch Work believed that the snow surveying generally received strong support from the leadership of SCS, especially Chiefs Hugh Hammond Bennett and Don Williams, as well as the important staffs in administration, engineering, and public information (Work, 1989). The public information group especially appreciated the romance of "snow surveys" as a means of publicizing the agency. When most research functions of the SCS were transferred to the Agricultural Research Administration effective November 15, 1952, the water supply forecasting remained in SCS.

Snow surveying publication

The Division of Irrigation group realized that future expansion of the snow courses and water supply forecasting would be greatly enhanced by a snow survey manual. When the Division of Irrigation got involved in the work, the division's field people learned from experienced snow surveyors George D. Clyde and James E. Church (Helms, 1991). Also, literature on the subject was accumulating since the Western Interstate Snow-Survey Conference, begun in 1933, published articles on methods and procedures in its proceedings. But new snow surveyors and forecasters needed a manual, a compendium of the existing knowledge on snow surveys. James C. Marr, who had general supervision of the snow surveying work from his office in Boise, Idaho, called upon the experts in the field for help in writing a manual on principles, purposes, and procedures of snow surveying. *Snow Surveying* (USDA Miscellaneous Publication No. 380) appeared in 1940. In addition to his own experiences, Marr solicited information from the other snow survey supervisors (Parshall, Jessup, and Work), as well as George D. Clyde, J.E. Church, O.W. Munson, and Harold Conkling, the deputy State Engineer of California. The manual described the care and use of equipment, snow sampling procedures, field office work, uses of water supply forecasts, maintenance of snow courses, stocking shelters, winter travel, and other topics (Marr, 1939; Marr, 1940). Prior to the use of aircraft, expansion of snow surveys depended in part on making cabins available. Snow surveyors needed cabins to make a trip of several days to remote snow courses. In the 1939 *Transactions*, *American Geophysical Union*, Arch Work and Ralph Parshall published a guide for the construction of snow survey cabins (Work and Parshall, 1939).

Snow survey network

The snow survey work expanded throughout the late 1930s. By the spring of 1940, approximately 753 snow surveyors made readings at 14,295 sampling points on 1,000 snow courses. The brunt of the snow surveying work fell on the rangers of the U.S. Forest Service and the National Park Service. Snow surveyors had available some 339 shelters. Only a portion of those had been built specifically for snow survey work. Others belonged to mining companies, power companies, and lumber interests. As the groups worked to add new cabins they tried to locate them about 16 miles apart, the average day's journey. Altogether the Division of Irrigation had about 50 cooperating Federal, State, and local agencies and companies (McLaughlin, 1940; Work, 1989).

The network of snow courses developed rapidly. By 1943, there were 829 snow courses being surveyed. There had been about 1,000 courses, but the group eliminated some of these as unnecessary. There were 177 active cooperators. The surveyors had about 266 shelter cabins available to them, 77 of which were owned by the Federal Government. The network stocked 115 of these with food. In addition to the mimeographed releases, there were some 153 radio broadcasts made during 1943 (McLaughlin, 1943).

Publicity

Winter sports enthusiasts recognized the value of the snow surveys for skiing and other activities. In the summer of 1937, the Division of Irrigation was asked to provide information on conditions for winter sports. The snow supervisors took to the airwaves on the National Broadcasting Company. The offices at Berkeley, Medford, Boise, Fort Collins, and Logan collected information on 64 winter sports areas and had the information ready for a Friday broadcast at 9 p.m. The National Broadcasting Company carried "Snowcasts" on the San Francisco station as well as two stations in Idaho, two in Washington, four or five in Utah, and one in Colorado (Work 1989; Work, n.d.; McLaughlin, 1940).

Actually some of the broadcasts contained more than just the information on snow. For instance, James Marr in Boise received information from the U.S. Forest Service and the Sun Valley Lodge. Listeners to Winter Sports Broadcast on December 31, 1937, over KIDO in Boise would have heard that a new ski lift and two new ski hills would open at the Payette Lakes winter sports area. At Sun Valley, the University of Washington and Dartmouth College competed in a ski meet. Marr encouraged McLaughlin to include the Sun Valley forecast in the broadcast from San Francisco since the lodge drew many of its patrons from the West Coast and, in fact, preferred them to local clientele. He wrote to McLaughlin, "In fact, the presence there of local people is looked upon as an obligation rather than an asset. That is, they are taken care of but their coming is not overly encouraged." (Marr correspondence).

The snow survey scored a major publicity triumph in 1942 with the appearance of "Engineers Survey Snow" in the April 1942 issue of *Life* magazine. Readers saw photographs of Arch Work and Jack Frost surveying near Oregon's Crater Lake. *National Geographic* magazine featured snow surveys in their November 1949 issue. Arch Work assisted one of the magazine's writers, Leo Borah, in 1946 when he transported Borah to Crater Lake in a "Sno-Cat." Work suggested to Borah that a trip from the California-Oregon border along the crest of the Cascade Range to the Columbia River would provide National Geographic with a splendid article. The Tucker Sno-Cat Company furnished the transportation and a mechanic-driver (the son of the owner) for the 23-day trip. The party of seven included Work, writer Andrew H. Brown, National Geographic photographer Jack Fletcher, SCS photographer Robert F. Branstead, Jasper Tucker, Harvey Woods, and Gaeton Sturdevant. The trip commenced in mid-March, presumably after the heaviest snows. But snow fell all but 2 days during the trip. It snowed about 10 feet along the journey. While publicity was an unannounced motivation, there was an operational objective. During the snow surveying season, surveyors ascended to various points near the crest of the Cascade Range from the valley floor. The snow survey group had conjectured that one trip along the spine of the range in "Sno-Cat" might be a more efficient method of surveying. The trip convinced the group to stick with the earlier method (Work, n.d.; Brown, 1949).

Accuracy of forecasts and improvement of methods

Some of the long-time users of snow surveys in the West were dedicated believers in their value. After the beginning of Federal coordination in 1935, the snow survey supervisors added new cooperators and users rapidly. Credibility with these new users rested on the reliability of forecasts. The group chose to use the percentage method developed by James E. Church, which assumed that normal snow cover produced normal runoff. Snow course measurements were correlated with streamflow data collected by the U.S. Geological Survey and used in succeeding years to predict streamflow from the snow course measurements. The method assumed that the most important factor was precipitation and that losses could be grouped together and given a fixed value depending upon the particular watershed. The accumulation of several years or decades of records would supply values pertinent to the watershed (Clyde, 1939). Snow surveyors believed they needed at least 10 years of data for reasonably reliable forecasts (Work, 1989).

However, where there was no historical record, and there was none for many of the courses, the methods sometimes did not work well in the seasons of subnormal or above-normal rainfall. In these cases when the forecast was off, it could be off 30 to 60 percent; in a few cases, it was off by 100 percent (McLaughlin, 1943). Also, the reliability of forecasts varied from one region to another, as the forecasters quickly realized when they moved into the Southwest. The variability of spring and summer rainfall meant that forecasts for New Mexico generally had a 55.7 percent error rate (Beaumont, 1957).

Early snow survey supervisors realized there were many factors which could influence total runoff as well as distribution, but which were not taken into account in the percentage method. The proceedings of the Western Interstate Snow Survey Conference, later the Western Snow Conference, included numerous articles on attempts to accommodate these various factors in forecasting.

First of all, not everyone agreed that snow surveys were the best indicators of streamflow. The Weather Bureau maintained that precipitation, even if it came from the valleys rather than the mountain, was just as good an indication. In commenting on a paper by George D. Clyde and Arch Work at a Western Interstate Snow Conference in 1943, Merrill Bernard of the Weather Bureau's Washington office made the case for relying on precipitation:

> *It is not in accord with known facts to discredit the "Valley Station" as a significant index to precipitation at higher levels. Precipitation events (storm periods) have within themselves a unity which expresses itself in a high degree of dependency of precipitation measured at points of different elevation (including those below and within significant distance of the average snow-line), even though the character of the precipitation (rain or snow) is different at the points compared.* (Clyde and Work, 1943; Discussion by Bernard).

While the snow survey supervisors disagreed with this attitude, they did come to acknowledge the value of snow courses below the permanent snowpack.

Low flows, peak flows, and distribution of flows concerned users for a variety of reasons and involved many interrelated and complicated factors. On rivers without large storage reservoirs, the concern of irrigation farmers was not merely the total supply, but the daily distribution of flow. Using historical records for the Logan, Ogden, Weber, and Provo Rivers in Utah, George D. Clyde developed a daily hydrograph and was then able to relate it to forecast curves (Clyde, 1939). One result of this concern was that the groups began forecasting for the date of the low flow in addition to the streamflow forecasts for April through September (Work, 1989).

Operators of multiple-purpose reservoirs particularly needed information about total flow and peak flow to make the maximum use of reservoirs for flood control, irrigation water storage, and hydroelectric power production. Fred Paget of California's Division of Water Resources believed temperatures at low elevation stations could be indexed to mountain temperatures and be used to assist in operation of reservoirs for flood control on the Kings River (Paget, 1943). Quite a number of the SCS group, such as Arch Work, Morley Nelson, and others in university and State agencies, published various articles pointing out the influence of soil moisture, ground water levels, rainfall, and temperature on streamflow. Work summarized many of the considerations in his *Stream-Flow Forecasting From Snow Surveys* (Work, 1953). Collectively, the early group of snow surveyors knew many of the factors that influenced runoff. Essentially, they knew the right questions to ask. Relying on monthly snow surveys, however, did not give them timely information on soil moisture, temperature, and precipitation. The current SNOTEL system can provide not only the information on snowpack, but also information on precipitation, temperature, soil moisture, and other factors on a timely basis to be used in forecasting. More powerful computers allow forecasters today to assess the relative importance of various factors in streamflow.

Uses of snow surveys

Although water supply forecasters perceived a need to refine and improve forecasting methods, the percentage method was sufficient to make dramatic demonstrations of the value of snow surveys. The forecasters gradually accumulated examples of the value of snow surveys. George D. Clyde of the Utah Agricultural Experiment Station had made the most dramatic demonstration of the value of snow surveys. Clyde's April 1934 forecast predicted most watersheds in Utah would receive only 25 to 50 percent of their normal streamflows. The governor immediately made Clyde his special representative to contact all the water users to assist them in developing plans to use the limited amount of water that would be available (Clyde, 1934). Evidently, Clyde performed admirably in getting farmers to adjust their planting schedules and acreage planted. This demonstration was one of the reasons Congress provided for Federal coordination of snow surveys. In the late 1940s Clyde, a longtime professor of engineering at Utah State University, became the head of the Division of Irrigation and Water Conservation in the SCS. He moved the office from Berkeley to Logan, Utah.

The snow survey supervisors gradually added to these examples and used these in their publicity. Agencies doing construction and rehabilitation work on rivers needed streamflow information to determine the type measures needed to protect the construction. When the area below Elephant Butte Reservoir was going to be worked on in 1942, New Mexico wanted to know the total runoff from the Upper Rio Grande into the Elephant Butte Reservoir. The prediction was 1,941,000 acre-feet, and the actual total was 1,938,000 acre-feet. Another forecast of the flow of the Columbia River allowed the Corps of Engineers to avoid unnecessary protection work for their construction near The Dalles (McLaughlin, 1943).

Even the most ardent believers in snow surveys could not predict all the uses. They received inquiries, especially in times of water shortage, from financial institutions, mercantile companies, eastern wholesale houses, power companies, mines, municipalities, navigational interests, and agriculture (McLaughlin, 1943). In agriculture, of course, the main interest was in being able to adjust the timing, as well as the amount of acreage planted. The sugarbeet companies soon learned to await the water-supply forecasts before signing contracts and adjusting the acreage contracts to the forecasts (McLaughlin, 1943.) In 1946, snow surveys in early spring indicated that the water supply for Deschutes and Cook counties in Oregon greatly exceeded normal. Farmers were able to plant an additional 6,500 acres of land. The value of the produce was about $500,000 (Work, 1953). The information was particularly valuable in operating multiple-purpose reservoirs, which stored irrigation water, as well as producing some hydroelectric power. With good information, the reservoir manager could maintain the maximum irrigation water and use the surplus to produce power for sale.

Flooding

Although the water supply forecasting group was not to be involved in flood forecasting, the value of the forecasts for determining volume, as well as peak flows, was recognized. In fact, the early reports mentioned specifically the flood hazard. The value of snow surveys for assisting in flood prediction was made dramatically evident in the Columbia River flood of 1948. The May 1, 1948, forecast by James C. Marr from Boise, Idaho, read:

> *Retarded snowmelt and above normal precipitation during April will increase the amount and rate of runoff throughout the northern and western parts of Columbia River Basin. The outlook a month ago in these areas for greater than normal runoff with possible flood hazard has changed to certainty of runoff of flood proportions with attendant damage in vulnerable areas … Also, extra high water may be expected on all of these streams during the latter part of May and June. This same situation may also extend to lower Columbia River.*

The 1948 Columbia River flood resulted in more than 50 deaths and property damage of $100 million. (Clyde and Houston, 1951).

The weather in 1948 provided the exact combination for flooding. The snow cover was above normal in water equivalent. There was cold weather during the early part of the melting period, followed by above-normal temperatures in the latter part of the melting period, followed by above-normal precipitation during the melting period. The Columbia River flood of 1948 had all of the above conditions. Arch Work used this and other conditions in writing *Stream-Flow Forecasting From Snow Surveys* (Work, 1953).

The snow courses provided information from the higher elevations, above the line where melting usually occurred in the winter, while most of the Weather Bureau's precipitation data stations were located in the lower elevations. Regardless of the agreement on flood forecasting, the important fact was that the operators of reservoirs, namely the Corps of Engineers and the Bureau of Reclamation, used the information in storing and releasing water. According to the Corps of Engineers and the Bureau of Reclamation, warnings in 1950 allowed the operation of reservoirs so that $5,600,000 in flood damages could be avoided (Clyde and Houston, 1951). The 1950 estimates had been for heavy snowpack. During 1956, the Corps of Engineers believed they had saved $37 million in flood damages by taking protective measures due to the water supply forecast (Beaumont, 1967). SCS believed that water supply forecasts had been used to avert $70 million in flood damages along the Columbia during 1956 to 1962 by use of reservoir control (Work and Shannon, 1964).

Another case of using snow surveys to lessen flood damages occurred in 1954 on the Kootenai River in Idaho. The April 9 forecast mentioned a potential flood, and the May 10 survey predicted a 35.5 foot river crest. The town was evacuated and the dikes reinforced with the assistance of Federal troops. The river crested at 35.55 feet (Work, 1955).

The Bonneville Power Administration in the early 1970s estimated an annual value of $385,000 for power generation in three reservoirs studied. The Bureau of Reclamation in 1968 estimated they had avoided $495,000 in flood damages from Bull Lake, Pilot Butte, and Boysen Reservoirs in Wyoming. Similarly, the Salt River Project believed it had prevented $600,000 in flood damages in 1960. The snow survey was used to operate the reservoirs in the Columbia River Basin. The average annual savings between 1956 and 1962 was $9.8 million (Soil Conservation Service, 1973).

Maturation of program

By the late 1940s, the program had reached a high degree of maturation. In 1948, the Division of Irrigation and the cooperating agencies made forecasts at approximately 176 gaging stations. About 1,000 snow surveyors made 2,400 different surveys at 950 courses. There was equipment to be repaired and cabins to be built, maintained, and stocked with food. As soon as surveys were made, the information had to be tabulated, forecasts made, and meetings held with forecast committees and local groups of water users.

Snow survey supervisors made forecasts for the Columbia River Basin (5), Rio Grande River Basin (4), Oregon (4), Utah (1), Nevada (2), California (4) by the California Division of Water Rights, Colorado River Basin (4), Missouri and Arkansas River Basin (4), Montana (3), Arizona (3), and British Columbia (4) by the British Columbia Government.

Snow survey supervisors sent out 5,000 mimeographed copies of forecasts. Just as one example of publicity within a State, 56 Oregon newspapers and 13 radio stations publicized the results. At least three magazines published reports covering the entire West, *Reclamation Era*, *Western Construction News*, and *Electrical West* (Work, 1948).

At the end of the first two decades, the snow survey supervisors were generally pleased with the operations. They wanted to expand the system of forecast committees, but believed that additional information and snow survey personnel would be needed. One goal of the group in Arch Work's words was to "provide dependable streamflow forecasts for the benefit of farm operators on the smallest tributaries and on downstream industrial developments on major streams" (Work, 1948). The accumulation of data for more than 10 years made some of this possible, but the group was beset by the time-consuming calculations necessary to deal with the mass of data.

The snow survey supervisors continued to test and promote different modes of mechanizing the snow surveys. They tested over-snow machines produced by private, as well as government agencies. They made more use of airplanes to reach high-altitude snow markers. In time, the water supply forecast group helped develop some of the technology to gather information more rapidly and easily.

Current technology, rather than diminishing our appreciation of snow survey achievements in the decades from 1930 to 1950, helps enhance it. Working with a meager budget, but much cooperation, the snow survey group along with California's Division of Water Resources proved the feasibility of regionwide snow surveys and set the stage for public support of mechanization of the operations.

The author thanks Anne Henderson, J.D. Ross, Jon G. Werner, Lynn Cothern, and David Ballentine of the Soil Conservation Service for their assistance.

References

Beaumont, R.T. 1957. Cooperative snow surveys and water supply forecasting. *Journal of Soil and Water Conservation* 12:115–119.

Brown, A.H. 1949. Sno-Cats mechanize Oregon snow survey. *National Geographic* magazine 96:691–710.

Clyde, G.D. 1939. Forecasting stream flow from snow surveys. *Civil Engineering* 9:237–239.

Clyde, G.D. 1934. Report of water conservation program and drought situation In Utah. Typescript copy in *George D. Clyde Papers*, Department of Special Collection and Archives, Utah State University, Logan, UT.

Clyde, G.D., and C.E. Houston. 1951. Benefits of snow surveying. Prepared for the Western Snow Conference. Copy in *Papers of George D. Clyde*, Department of Special Collection and Archives, Utah State University, Logan, UT.

Clyde, G.D., and R.A. Work. 1943. Precipitation-runoff relationships as a basis for water-supply forecasting. Transactions. *American Geophysical Union*. Vol. 24, Part 3:43–55.

Engineers survey snow. 1942. In *Life* magazine. 12 (16). pp. 49–52.

Helms, J.D. 1991. Bringing Federal coordination to snow surveys. *Proceedings of the Western Snow Conference*. pp. 119–125.

Marr correspondence. Division of Irrigation. Bureau of Agricultural Engineering, Records of the Bureau of Agricultural Engineering, Record Group 8, National Archives and Records Administration, Washington, DC.

Marr, J.C. 1940. Snow surveying. Miscellaneous Publication No. 380. U.S. Department of Agriculture, Washington, DC. 45 pages.

Marr, J.C. 1939. Status of proposed bulletin on principles and practice of snow-surveying. *Transactions, American Geophysical Union*. Vol. 20, Part 1. pp. 53–55.

McLaughlin, W.W. 1943. Some accomplishments in snow-surveying. *Transactions, American Geophysical Union*. Vol. 24, Part 3: pp. 38–42.

McLaughlin, W.W. 1940. Problems of the division of irrigation in forecasting water supplies. *Transactions, American Geophysical Union*. Vol. 21, Part 1. pp. 131–134.

Paget, F. 1943. The use of snow surveys as an aid in flood-control operation of reservoirs. *Transactions, American Geophysical Union*. Vol. 24, Part 3. pp. 28–36.

U.S. Department of Agriculture, Soil Conservation Service. 1973. The Soil Conservation Service Snow Survey and Water Supply Forecast Program. Portland, Oregon.

Work, R.A. 1989. Interview conducted by Douglas Helms for the Soil Conservation Service, Ashland, Oregon, May 12, 1989.

Work, R.A. 1955. Measuring snow to forecast water supplies. *Yearbook of Agriculture*. U.S. Department of Agriculture, Washington, DC.

Work, R.A. n.d. Recollections of R.A. “Arch” Work concerning snow surveys in Western States.

Work, R.A. 1948. Stream flow forecasting. *Merrill G. Burlingame Special Collections*, Montana State University Libraries, Bozeman, MT. Typescript. 18 pp.

Work, R.A. 1953. Stream-flow forecasting from snow survey. Circular No. 914. U.S. Department of Agriculture, Washington, DC.

Work, R.A., and R.L. Parshall. 1939. Construction of snow-survey shelter-cabins. *Transactions, American Geophysical Union*. Vol. 20, Part 1. pp. 125–134.

Work, R.A., and W.G. Shannon. 1964. Snow survey reports help West in years of floods or drought. Soil Conservation 29:213–215.

Recollections of R.A. "Arch" Work Concerning Snow Surveys in Western States

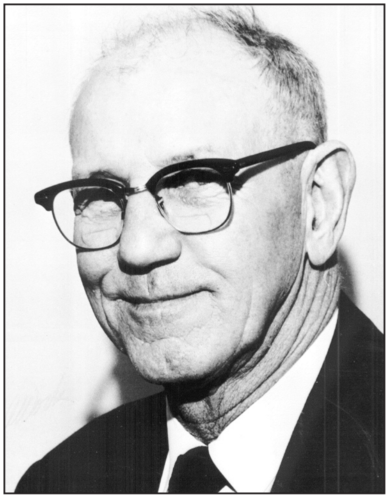
Author's Note:

Responding to a request from the most recent program director of the Water Supply Forecast Unit in the Soil Conservation Service (SCS), herewith some recollections from the memory of R.A. Work, former head of the SCS snow survey and water forecast unit. Work retired from Federal service on August 31, 1964, following 35 years employment in the U.S. Department of Agriculture, with 29 of those years associated with Snow Surveys. He took no records with him into retirement, so the events to be related and the individuals involved are drawn from the recesses of memory. Although many of the individuals identified have passed on, some still live, and could be interviewed.

One of R.A. Work's granddaughters several years ago asked for an account of her Granddad's life, so a narrative account was prepared for her and the other 13 grandchildren and 4 great-grands. That narrative has been drawn on in preparing this record. Parts, therefore, may duplicate pieces of the Jeffrey LaLande interview of 1981. Mr. LaLande has kindly agreed to make available a transcription of his taped interview of 1981, and it is attached herewith.

LaLande's interview traces Work's professional activities prior to July 1929, so that need not be repeated in this introduction.

No effort is made in the following to arrange events chronologically, but more by subject matter.



National Water and Climate Center, Portland, Oregon

3.1 Arch Work

Medford Experiment Station

The fruit growers in Medford [Oregon] were anxious to have a Pear Irrigation Experiment Station established on the heavy clay soils so prominent in the valley. Professor M.R. Lewis, of Oregon State University, and I conducted preliminary irrigation experiments with some cooperating fruit growers in 1930 and 1931 and then participated in establishing the new experiment station, south of Medford, in 1932. I was active in the conduct of that station until the Division of Irrigation was broken up in 1939, at which time my association with the Soil Conservation Service began.

In that breakup, the irrigation research work of the Division of Irrigation was assigned to the U.S. Bureau of Plant Industry, and the snow survey work with which I had become involved was turned over to the U.S. Soil Conservation Service. Having been offered my choice as to which line of work and which agency I would elect, I chose to go with the SCS [Soil Conservation Service] in order to continue working with Snow Surveys.

Old-fashioned Philosophy

Let me digress here to describe a rather simple event which more or less influenced my future professional conduct and career. A few months after my entry into Federal employment, I fractured some rule or the other, although it isn't now recalled just what. We had a very diligent and precise young lady in Berkeley headquarters office by the name of Miss Frank, who snubbed me up pretty short for said infraction. No question but that I was green as grass concerning regulations of the Department.

Now at that time, all of the Department's regulations were between the covers of a little black book, which I had seen in Janie's office, but never had one myself. (Nowadays, the regulations would likely fill a shelf at least as long as a city block.)

So, after about the third time Miss Frank snubbed me up, I wrote to the Chief, explaining my lack of familiarity with all the regulations, so, would he please send me a copy of the little black book? His reply still comes back, almost word for word, as it pretty clearly showed the Chief's philosophy and that of his organization:

> *Dear Mr. Work: We sent you to Medford to do a job for the people there. You are doing fine. We are not sending you the book of Departmental Regulations. Should you ever need information along that line, you will hear from us.*
>
> *Very truly yours,*
> *W.W. McLaughlin, Chief*

There was terrific esprit de corps in our old Division of Irrigation, at least up until the New Deal people abolished our outfit, for the reason that our engineers were not in step with the new economic philosophy of the value of scarcity, whereby every other pig was slaughtered; every other row of corn plowed under; potatoes rendered inedible with purple dye; and other such oddities. Our objective had always been to increase farm efficiency, thereby decreasing production costs.

Most of my professional career seemed to be spent mostly in unploughed fields, so to speak; research into new ideas; expansion of earlier findings; review of accepted theories, etc. The only looking back required was to establish a position from which one could move forward. There was one further guiding precept: We were taught early in the game not to ask anyone to perform a job that we hadn't done, couldn't do, or wouldn't do. Many years later, I tried to teach that to some Turkish pupils.

Snow Surveys

The first snow surveys in the United States were made in the East by a Water Power Company engineer named Charles Mixer. That was back about 1903 or so. Mixer used a large tube (about 4 inches in diameter) to cut snow cores, then melted the cores to determine the water content. Snow is just water and air, and it's the water that counts. Later, Dr. J.E. Church, Professor of Romance Languages at University of Nevada, in Reno, became interested in the subject. His interest sprang from the so-called "Tahoe Water War" then raging between California and Nevada, whereby each State claimed jurisdiction of the Truckee River. It became important to forecast, if possible, the inflow to and subsequent rise of Lake Tahoe, source of the Truckee River, which terminates out in the Pyramid Lake sink.

So, Church devised a smaller diameter tube to more easily cut snow cores in deep western snowpacks. One ounce of snow core weight, equalled 1 inch of water equivalent, on the specially calibrated, but cumbersome, scales he devised. Still later, in the early 30s, George D. Clyde, then Dean of the Engineering School at Utah State University in Logan, Utah, modified the diameter of the snow tube cutting point, so that each ounce of weight of the snow core, equalled 1 inch of water equivalent of the sampled snowpack, thus allowing use of a simple tubular scale. Aluminum tubes took the place of heavy steel tubes.

Later, in 1935, the U.S. Department of Agriculture, through its Division of Irrigation of the Bureau of Agricultural Engineering, was assigned by the U.S. Congress to conduct snow surveys throughout the Western States, and to coordinate, record, and report any snow surveys then being conducted by the States of Utah, Nevada, Montana, Washington, Oregon, and California. The Department was also authorized to issue water supply forecasts.

I happened to be one of the four engineers in the Division of Irrigation assigned to conduct the activity in Western States, as of July 1, 1935. We had the honor, but little money—only $15,000, per year, for work in 12 States. I had previously made snow surveys on my own hook, the first on January 5, 1935, when Andy Smith and I skied into Crater Lake to measure the snowpack. My colleagues in 1935 were Jim Marr in Idaho, Ralph Parshall in Colorado, and Lou Jessup in Washington State. Sometime later Lou's body was found on a mountain trail, victim to heart seizure.

At the time of my assignment to Snow Surveys, I was conducting irrigation experiments for the pear growers of the Rogue River Valley. The irrigation ditches there went dry on July 4, 1934, with consequent crop losses and economic hardship to the entire valley. Had we known in advance that the irrigation supply was to fade out, there were certain farm practices that could have been followed to extend the limited water supply and prevent at least some of the loss. It was that event that led to my interest in the mountain snow survey as the means of forecasting the resultant runoff from mountain snowpack. About 85 percent of the irrigation water to the Rogue River Valley, as in most parts of the arid West, originates from mountain snowmelt.

Following the action by Congress, we soon ran into conflict with the U.S. Weather Bureau, who initiated a rival, but less accurate, forecasting system based on analyses of valley rainfall records. The forecasts of the two agencies were often in conflict. A classic example occurred in 1948, the year of the great Columbia River flood, that cost many lives. In early May, our Boise Snow Survey Office issued this warning: "A devastating flood along the Columbia River is a certainty in the near future." Almost simultaneously, the Weather Bureau opined: "Lowlands along the main Columbia drainage may be covered." Well, the lowlands were covered all right—about 12 feet deep. The river paid scant heed to the Weather Bureau's forecast. The city of Vanport was drowned on Memorial Day, 1948.

All this conflict hampered support to the snow survey activity. The conflict was completely unwarranted, as during the 1935 Senate hearings, the representative of the Weather Bureau conceded that the activity was one for "engineers" and withdrew itself from congressional consideration. That position was also taken by the U.S. Forest Service, whose Acting Chief Forester, Mr. Clapp, at the hearings, said: "We believe the activity is one more for engineers of the Bureau of Agricultural Engineering, and if the

Congress should assign this activity to that Bureau, the Forest Service will support that agency in the activity." And so it has been through the ensuing 54 years—the Forest Service always supported and contributed, without reservation, to the activity.

The Weather Bureau, on the other hand, failed to support its position of 1935, nor did it honor subsequent pledges and agreements to cease its wasteful and less accurate duplication of public water supply forecasting, at least so long as I was connected with the officially sanctioned snow survey program.

The history of Snow Surveys in SCS is one of dedicated individuals, personal and agency relationships, technical development, risks, rewards, a chronic shortage of funding in earlier days, but all tied together over the years by a bond of service to the water users and to the public. Snow surveyors welcomed cooperation just as they opposed those whose objectives and actions were in question.

Let me emphasize that Snow Surveys in SCS always received top-level support and encouragement, beginning with Chief Bennett, and continuing through the regime of Administrator Don Williams. As mentioned elsewhere herein, it was common knowledge with some of us that when the Bureau of Agricultural Engineering was broken up in 1939, with attendant scattering of personnel and projects, that W.W. McLaughlin, then chief of the Division of Irrigation in BAE [Bureau of Agricultural Engineering], and J.C. Dykes of SCS, made the "deal" for the Snow Surveys of BAE to go over to SCS in the breakup.

Others of Washington SCS staff who always provided strong support, friendly attitudes, and good advice included, but were not limited to, Harold Tower, Carl Brown, "Chet" Francis, Carl Dorny, Verna Mohagen, "Bill" Shannon, Bob Branstead, and Frank Harper. If there was any lack of support in those early days from two or three State Conservationists, that might have sprung from the fact that Snow Surveys, prior to SCS responsibility, very early on had inherited or developed enduring ties to numerous State, private, and sister Federal agencies and gave attention to the many needs of those cooperators, as well as to SCS requirements. Longstanding snow survey resistance to Weather Bureau encroachments might also have fed their displeasure.

Risking redundancy, many shifts in national policies accompanied the election of FDR in 1932. The Soil Conservation Service was created. By 1938, the Bureau of Agricultural Engineering fell onto hard times. Sam McCrory, then chief of BAE believed firmly in the need to increase the efficiency of farm production, goals also shared by SCS. BAE worked with soil erosion control, tillage, farm machinery improvement, water spreading, hydraulics, and improved water management practices, etc., all intended to decrease production costs through increased operating efficiencies. Such improvements usually were accompanied by increased production with the same or lesser production costs. But New Deal policies were initiated more along the line of prosperity through scarcity.

Sam McCrory just simply couldn't support such a policy, so his Bureau was done away with. The Division of Irrigation of BAE, of course, also fell victim to the axe. We engineers caught in the breakup were offered the choice of going to SCS, to the Bureau of Plant Industry, or to a newly created Bureau of Agricultural Chemistry and Soils. We four engineers then conducting snow surveys, elected to go with SCS—Marr in Idaho, Parshall in Colorado, Jessup in Washington, and Work in Oregon. Paul McGrew, of the old Soil Erosion Service in BAE, also elected SCS. Paul later served SCS for many years as State Conservationist of Washington State.

In, I believe, 1938, a high-ranking officer of the USWB [U.S. Weather Bureau], came out to Medford from Washington. He invited me to join forces with the Weather Bureau in a capacity and position to be established. I assured him that I was happy in my job and agency, so thanks, but "no thanks."

A few years later when we in Snow Surveys were pursuing effort to sew up a cooperative agreement with the Army Corps of Engineers, to cover *all* of the western district offices of the Corps, it turned out that that particular WB official happened to be a close personal friend of a highly placed civilian employee in the Corps. I was told that we never could achieve the agreement so long as those ties existed—and we never could, although we continued to maintain friendly informal relationships with the district offices of the Corps in Portland, Seattle, Omaha, and California.

A Fateful Decision

Quite early in the game, most likely in the late 30s, but in any event before Lou Jessup's death, Jim Marr arranged a meeting of we four snow survey leaders [identified earlier in these recollections]. We met in a little log cabin motel in Moran, Wyoming. We believed we needed to reach a decision as to either meet the WB head-on or submit to heavy fire power.

We weighed the pros and cons for a couple of days, then concluded that we each would continue to collaborate and provide the best service that we could to the water users and to the public, in order to set the stage for continued improvement of snow survey techniques and even wider application of the results. Our decision was founded on our generally wide associations with water using organizations, and our knowledge that Snow Surveys provided more accurate advance knowledge of water supplies than the Weather Bureau could supply. I'm sure we realized that we were setting the stage for increased controversy with some well-entrenched bureaucrats.

Some Localized California History

California has some early day snow survey history with which I am not too familiar, especially the initial Nevada-California cooperation on Truckee and Walker Rivers. I'm sure that information can be found in the Church Library on the Reno Campus of University of Nevada. But, in 1935, the State of California was not conducting any snow surveys in the extreme northern parts of the State. Later on, it greatly strengthened its snow survey activity in those parts.

The writer happened to be the Watermaster for the Grenada Irrigation District in 1926, a summer of great drought. Our district pumped water from the Shasta River, but had to defer to downstream prior rights. Thus, there were crop losses in our district that year due to severe irrigation water shortage. Foreknowledge of the shortage would have been extremely helpful.

So, in 1936, the BAE Federal-State-private cooperative snow surveys were extended into the headwaters of the Sacramento, Pit, and Shasta Rivers. The long ski trips required shelter cabins. We built a few—Mount Eddy, Parks Creel, and Buck Mountain in 1936 and

1937. The data of snow surveys acquired by BAE, and later by SCS snow surveyors, were promptly furnished to the California Department of Water Resources. Records were too short to support forecasts of runoff.

When WWII got underway, the snow survey program became affected by manpower shortages and even greater budgetary shortage, so we decided to move out of northern California, especially as Fred Paget, the State of California snow survey supervisor, and I reached amicable agreement concerning the shift. That shift was not intended to affect in any manner the Nevada and California snow survey cooperation of many years standing.

An amusing incident comes to mind. When the Mount Eddy snow survey shelter was built, we believed it to be on Forest Service holdings for which we had the required special use permit. Much later, it developed that we had cut Southern Pacific Railroad Company trees for the logs to build the shelter on Southern Pacific Company land!

Arizona Snow Surveys

Early on, Ralph Parshall established snow survey cooperation in Arizona with the Salt River Valley Water Users Association [SRVWUA]. Later, as I recall, "Bill" Anderson, an SCS engineer, become the first SCS snow survey supervisor in Arizona.

I personally trucked a Sno-Cat from Medford to Arizona, probably in l946, and delivered it to Jake West, the association's hydrographer, for use on long snow survey trips. I gave Jake and someone else instructions in its use up on Mount Baldy.

Here's a little off-the-record sidelight: Driving an empty 5-ton truck with stiff springs back to Medford just about shook my teeth loose, so up at Holbrook, Arizona, on a Sunday afternoon, I traded a fellow a bottle of whiskey for a load of flagstone for ballast. Worked just fine.

Years later, learning that Jake was terminally ill, I went to Mesa, Arizona, to see him in the hospital, where short days later, Jake passed away. Snow Surveys lost a powerful friend.

Following the issuance of a seriously erroneous runoff forecast by the USWB, which caused problems for SRVWUA, Senator Carl Hayden of Arizona introduced an amendment to the WB budget request for that year—which likely was about 1945. The amendment, or rider, was worded about as follows: "provided none of these funds shall be expended to forecast water supplies." Powerful as the Senator was, senators for the East, a WB stronghold, beat the amendment. I'm sure that Senator Hayden had responded to a request from Rod McMullin, then the association's general manager—later an Arizona State senator. Rod and the writer were good friends, though not close friends.

An Event in British Columbia

Perhaps this recollection is best just between us, as it might imply some discredit to people, even though most are likely long gone. But it does form an unrecorded part of the history of Western States snow surveys and underscores the traditional strong alliance between the SCS United States Snow Surveys and that of British Columbia.

Richard "Dick" Farrow, head of the Water Rights Branch of the British Columbia Provincial Government, headed the Snow Surveys there. Dick was called into service in WWII. As an Army major, he was sent to France. Stanley Frame, then in his 80s, was pulled out of a well-earned retirement to look after the B.C. [British Columbia] Snow Surveys during Dick's absence.

Jim Marr had always maintained close contact with British Columbia, as the Snow Surveys there, on the Columbia River headwaters, held emphatic interest to U.S. water users below the international boundary.

I regret not being able to recall the exact date when Stan Frame phoned Jim Marr to state that a takeover of the B.C. Snow Surveys by the National Canadian Government, through its Geological Survey, was well underway. Stan felt obligated to hold the B.C. program together, under Provincial leadership, until Dick's return. Stan appealed for help from his U.S. colleagues.

Jim phoned me. We decided to get together at once and proceed to Victoria to see what, if anything, we might be able to do in Victoria. Stan gave us the details and the name and location of one individual in B.C. having the influence to head off the move. The three of us then headed east to "inspect B.C. snow courses in the headwaters of the Columbia River." Actually, we did inspect some snow courses (the month was late October, with snow on the ground in some parts.) When we reached an inland B.C. city (it seems to me that was Revelstoke), Jim and I paid a courtesy call to the Chief Executive Officer of a well-known B.C. public utility. Stan did not join us in that conference. I'm truly ashamed that I cannot recall the name of this gentleman. He was known to be a trusted advisor of the Premier of British Columbia. We explained to him the importance to U.S. water users of the Water Rights Branch efficient conduct and experienced track record in Snow Surveys and that we hoped no change of leadership would be needed. Our host thanked us for making such a long trip to express our concern and continued support to the Water Rights Branch. He told us he would see "what could be done."

As we returned to Vancouver, Jim thought it a good idea that we, too, pay a courtesy call to the district engineer of the Canadian G.S. [Geological Survey]. We've had better ideas, as about the first comment that gentleman offered when we were ushered into his office was, "We'll thank you Yanks to keep your bloody noses out of Canadian affairs." That was among the shorter courtesy calls on record. But, at any rate, it seemed to disclose that our mission had been helpful.

The British Columbia Snow Surveys, so far as I know, remain today with the originating agency, with which the U.S. Snow Surveys have cooperated for the past 53 years.

Dick Farrow personally participated in the very first ever SCS winter survival training school, arranged by Morley Nelson and held at Ketchum and Sun Valley, Idaho. That must have been about 1944.

R.A. Work was able to represent SCS at Dick's funeral in Victoria, a few years later.

Fireside Forecasts

We used to hear WB technicians in technical society meetings describe Snow Surveys as "redundant." We recall one WB technician asserting that its forecasts could be made while sitting by the fireside rather than by exploring and measuring mountain snow fields. Thenceforth, erroneous forecasts were ironically termed "Fireside Forecasts."

A Repudiated Agreement

Following further problems with the WB, Don Williams asked me to come to Washington to attend a meeting being arranged between Don and Francis Reichelderfer, then chief of the WB; I think that must have been about 1954. Representing SCS at that meeting were Chief Williams, Chief Engineer Carl Brown, and myself. Commander Reichelderfer was backed, as I recall, by "Bud" Hiatt and another subordinate I didn't know and whose name I can't recall.

Don Williams proposed to Commander Reichelderfer the same proposal that A.J. "Tony" Polos, of WB and I, years later agreed to, to wit: SCS would support and assist the WB in any requested manner, within its ability, in the WB's conduct of its flood forecasting responsibility, through supplying data of snow surveys, peak flow forecast formulae possessed by SCS, or opinions or advice, if requested. All that provided that the WB would reciprocate with any requested support to SCS in its congressional mandate to forecast water supplies.

I well remember Commander Reichelderfer's approval and acceptance of Don's proposal. He said "Williams, let's do it."

It takes two parties to ratify an agreement, and it quite soon became clear that Reichelderfer's staff repudiated his agreement. The arrangement was never consummated by the WB, and SCS had no reason to execute it unilaterally.

So for as I know, many, perhaps all of those at that meeting except for the writer, have passed on.

The Polos-Work Agreement

In 1962, give or take a year or so, the Weather Bureau and SCS agreed at top level to appoint A.J. "Tony" Polos to represent the Weather Bureau and R.A. Work to represent SCS in an effort to resolve the long-standing rivalry between the two agencies. It was stipulated, according to what I was told, that any agreement reached by these two representatives would be final and binding on their parent agencies.

Polos and Work paid personal visits to western water-using agencies. After gathering extensive evidence of water users' needs and wishes, the two negotiators prepared a mutually agreed upon report and foundation for an interagency formal agreement and submitted signed copies to their respective agencies.

SCS accepted our report, but the Weather Bureau declined to abide by the mutually agreed upon terms. The agreement that Polos and Work developed and signed, on behalf of their agencies, was substantially the same as the one previously agreed to by the chiefs of SCS and the WB, so there is no need here to repeat the terms.

I clearly recall a statement to Tony and me by the Chief Executive Officer of a Western States utility corporation:

> *In my opinion, and that of my Company, the Soil Conservation Service should have the total responsibility west of the Mississippi River, not only for its own activities, but for those of the U.S. Weather Bureau, as well.*

I'm not sure which of us, Polos or myself, was the more startled by that unsolicited opinion.

Sno-Casts

Skiing, though practiced for centuries, began gaining important sporting status in the U.S. in the 30s. In 1938, the Red Network of NBC asked our Division to cooperate in the winter production of a weekly announcement of snow, road, and weather conditions at the more popular western ski resorts.

Those reports were termed "Sno-Casts." We snow survey supervisors collected the information hot off the griddle first thing each Friday morning from forest rangers or other cooperators on the spot at such resorts, then shot the information into Berkeley for collation and relay to NBC for Friday evening's national broadcast.

In Oregon, we collected the reports by shortwave radio from the numerous reporters. There was, at that time, one rather odd restriction on our use of government-licensed radio transmission—imposed one might suppose by Western Union, or maybe by AT&T (or whoever?). Each radio transmission had to be confirmed by a telegram or a costly long distance telephone call. Sometimes the telegrams didn't even reach us until the following Monday—talk about a dead horse! With gas rationing in World War II, sports skiing was pushed onto a back burner. In 1941, we dropped this particular offshoot activity.

Mechanized Snow Travel

When I entered the snow survey program in 1935, such surveys, as existed, were made by men traveling on skis or snowshoes. Sometimes, when practical, by people riding horseback. There were few pioneer over-snow machines in existence at that time. There was an attachment to Ford cars, called the "Bluebird," for over-snow travel, but it wasn't familiar out West. The Eliason Company produced a machine, powered by a motorcycle engine and supported on skis, called the "Motor Toboggan." Jim Marr acquired one of those machines and used it in 1936. On one trip, Jim came to a washed out bridge. The machine couldn't cross the open stream, so he had to leave the Toboggan and finish his journey on skis. When Jim got back, the porcupines had eaten all the insulation off the motor wiring. More skiing!

Jim loaned his outfit to another agency—I think a Fish and Game group. It broke through an ice bridge somewhere over in Idaho's lava beds, fell into a deep crevice, and broke the operator's leg. As I recall, Jim allowed that machine an honorable death where it lay.

In about 1938, I acquired an airscrew machine, custom-built by Fred Abercrombie, over in Jackson Hole, Wyoming. That type of machine is powered by an aircraft engine and a pusher-type propeller, either two-blade or three-blade—can carry two persons. Body of aluminum tubing and treated canvas or fiber glass. Supported on three skis, two behind and one forward, which serves to steer the machine. This rig had no effective brakes and could not reverse. To reverse the machine, the operator simply picked up the front end and "bulled" the machine around. When descending steep hills, power always had to be slightly applied to keep the machine from crabbing. So, to maintain safe speed, the operator simply leaned out of the cab and dropped a fan belt or a loop of chain over the tip of each rear ski. That served as a rough lock and controlled the speed. The machine could sidehill in one direction only. If the opposite direction was attempted, engine torque would flip the machine down the hillside. In short, the machine had serious limitations, but was great sport to operate.

Drivers of such machines had to be quick thinkers, as one had only the merest fraction of a second in which to act. My machine was clocked at 120 miles per hour out on Jackson Lake during its acceptance trials. One day, it ran the 24-mile round trip from snow line to New Dutchman Flat Snow Course in 38 minutes. That was normally a 2-day trip on skis. In sticky snow, that machine was absolutely dead, nor could it travel in trees or heavy brush. Clyde Houston and I sat beside a fire one day for 5 hours waiting for sunset and some freeze to set in so we could get that machine moving again.

In the early 40s, E.M. Tucker brought one of his Sno-Cat machines up from Grass Valley, California, where his shop was then located. (E.M. Tucker was the inventor of spoke tighteners for wooden-spoked auto wheels.) Seems to me we rode that first machine into Crater Lake. Somewhere along that route into Crater Lake lay the carcass of a double screw machine that Tucker had invented some years previously—unsuccessful. At any rate, his Sno-Cat was a success from the very start because the only torque it possessed was centered in the driving chain around supporting pontoons. Tucker always claimed, to me, that the idea for his Sno-Cat came to him one night in a dream.

The John Deere tractor people tried to adapt one of their farm tractors to over-snow travel by bolting long cleats to the track, so as to reduce the machine's psi on the snow. That machine was demonstrated for us at West Yellowstone in January 1957. Quite a sight. The machine reared its snout in the air like some prehistoric dinosaur and then spun around like a pinwheel. Only it wasn't the 4th of July; the thermometer that night dropped to 56 degrees below zero.

Montana State University tried its hand at developing a machine. Ash Codd, our Montana snow survey supervisor, played in that scenario. But, that machine, called the Bug, couldn't move in mud and had some other unacceptable features. One day, Ash was traveling with the Bug in the bed of his pickup truck. He stopped for lunch in a Montana farming community. When he came out of the restaurant, an admiring group of farmers had collected around his machine, studying the Bug. One of them quizzed Ash: "Say, mister, is that there potato digger for sale?"

Utah State University produced the Snowmobile, in testing of which I participated several times. Later, the Thiokol Chemical Company (the Company whose booster rocket destroyed the Challenger) got hold of the patents along with the engineer mostly responsible for the improved versions of that machine, later called the Trackmaster. We had one of those machines at Medford and tested it extensively, but we always came back to Sno-Cat machines for reliable use in rough country and bad snow.

Then the Idaho Sno-Ball came on the scene, but wasn't very successful and never got into production. Torque killed that one.

Bill Schomers in Wyoming invented a machine especially adaptable to sidehilling, as the center of gravity could be shifted to the uphill side, by moving a lever. We bought a couple of those for testing, but the machine never got into production, as Bill was killed when he flew his National Guard plane into a railroad embankment.

The Iron Fireman Company of Portland, Oregon, built a machine called the Sno-Motor back in the early 30s, or maybe late 20s, that was steered by a unique cable cross hitch arrangement to a heavy trailer with deep steel keels. The engine was inside the track, which was quite wide—belt with cleats—like maybe 5 feet wide.

The Army had some over-snow machines in World War II, such as the Weasel, which loved to throw its tracks on most any sort of sidehill. Allis-Chalmers produced the M–7 for the Army, and it really was a pretty good little machine but, of course, out of production after the war, although there were surplus M–7s around for a few years after the war.

A Canadian factory produced the Bombardier, quite a large commercial, passenger-carrying type of over-snow machine. We never used that machine in Snow Surveys, but knew of a couple in use in Yellowstone Park, carrying sightseers into the Park from West Yellowstone.

Then, along came Polaris, producing small two-man, fresh air (no cab) machines in a factory at Roseau, Minnesota. Their demonstrations of that machine were impressive, so I went back to Roseau and went through the factory. It was a business-like enterprise and seemed adequately financed. We bought a couple of those machines for testing, and the results heightened our interest in that type of machine. Later, as sportsmen caught onto snowmobiling, any number of manufacturers, including the Japanese, got into the act. It's been said that as many as 40 manufacturers are now in that game, producing little one-man or two-man machines for winter sportsmen. The Snow Surveys, nowadays, are using quite a few of those small machines, but not necessarily Polaris, though that company was a pioneer in that particular field.

A big commercial type Sno-Cat, such as might be used in Arctic oil field exploration or servicing, now costs well over $100,000—a far cry from the $3,500 that Snow Surveys paid for its first Sno-Cat back in the early 40s.

Flying Snow Surveyors

In the late 30s, Snow Surveys began using ski-equipped planes to land at, or near, remote snow courses. We contracted all of that work and never owned any planes ourselves, although some of our men were flyers. At one snow survey meeting, one of our more successful contract flyers was invited to describe his activity. So happened that man built his own planes. One of the snow survey leaders queried: "How do you decide what equipment to put on your plane?" The flyer, whose name I can't presently recall, replied: "Oh, that's easy—you just hold it out at arm's length and let go; if it falls, you don't use it." That particular pilot later was killed in a crash on a snow survey.

In the late 40s, we began use of helicopters, again on contract basis, to reach remote areas. It wasn't long until we began running into complaints from environmentalists, Sierra Clubbers and folks of that ilk, who objected to the construction of helicopter landing pads in wilderness areas. Antinoise restrictions began cropping up, even though there most likely wasn't a living soul within 50 miles of a snow surveyor flying in a winter-isolated wilderness. That brings to mind an old question: If a giant tree in the forest crashes to the earth, with no one to hear, is there any sound? Sound waves—yes. Sound—no.

Electronic Snow Surveys

So, we initiated exploratory work into remote recording devices and the telemetry required to transmit the findings of sensors to the offices producing the streamflow forecasts. All of this pioneering was conducted at a snow laboratory we established on the southwest flank of Mount Hood, Oregon. Almost all of the research there was planned and conducted by our own engineers, although, in one case, we let a contract to a couple of ex-Boeing engineers, and, after my retirement, a substantial contract to Western Union Company for some telemetry work.

By 1962 or 1963, we were successfully transmitting automatically, by radio, into our Portland headquarters, sensor reports of the water equivalent of the snowpack at the Mount Hood laboratory. At time of this writing, there are more than 400 installations in western mountains of snow water sensors, telemetering by means of meteor-burst technique from every station, upon radio request, a variety of data to the central SCS computers.

Before long, with modernization such as this, the old-time snow surveyor, with his skis, goggles, mitts, and sack of instruments, is likely to become as extinct as the dodo bird—just another legend from bygone times.

A Narrow Squeak

Back about 1942 came a telephone call from LaSelle Coles, manager of the Ochoco Irrigation District at Prineville, Oregon. The snow course at Ochoco Meadows showed inordinately heavy snow cover—the most ever since the course was first measured. LaSelle was concerned lest the inflow to his reservoir exceed the carrying capacity of both lake and dam spillway. It appeared that his board of directors, area farmers, had seen that reservoir fail of filling more years than not, so they opposed Coles' spilling any water from the reservoir.

Mr. Coles wanted a judgment from our office to bolster his own. Though we had only 7 or 8 years of snow survey and runoff records to work with, our analysis showed that the reservoir would unquestionably overfill. The runoff impending would far exceed reservoir capacity. We furnished LaSelle our charts, calculations, and the recommendation to immediately reduce the reservoir's water level. The board of directors, probably reluctantly, then authorized the immediate release of reservoired water.

Something broke in the outflow system from the valve tower, so that lake water release couldn't be continued. Mother Nature then dealt the cards. As the snow melted, the reservoir rapidly filled. Water started rushing over the spillway. The eroding power of the churning current began breaking big chunks of concrete off the spillway end. It started eating back.

Oregon's State Engineer, then Charlie Stricklin, who had police power over Oregon dams, ordered the posting of a 24-hour guard on the dam and spillway, so as to immediately alert downstream residents of any more dangerous development. As snowmelt decreased, the situation resolved itself, but the spillway had to be rebuilt.

LaSelle Coles later became president of the National Reclamation Congress. That Congress supported Snow Surveys through thick and thin, year after year.

Alaska

In 1951 or thereabouts, the Bureau of Reclamation requested the establishment of some snow surveys in Alaska, on a river of particular concern to the Bureau. Will Reedy, a USBR engineer from Denver, and I flew up to Anchorage and made our way up to Palmer in early April, or possibly early May. We planned to establish a snow course or two at the headwaters of Eklutna Lake.

By that time of year, Alaska days were becoming quite long. Daylight came to Palmer about 3 a.m., so we got off to an early start across the frozen lake, on snowshoes. We were accompanied by a local USBR employee. A snow course we named "Ptarmagin" was established and measured in the headwaters and another at a lower elevation on a glacial moraine. Those were the first snow surveys ever made in Alaska, although now it is a widespread, well-recognized activity.

I still retain a pretty distinct recollection of that Eklutna trip, since a government regulation required us to pack along a .300 Magnum rifle, by reason of Ursus Horribilis. That gun weighed close to a ton by sundown (figuratively speaking). Had it been fired, the barrel might have blown up, as it most likely was full of packed snow, as I had used it for a climbing staff.

Later, Will Reedy and I made some aerial reconnaissance of mountainous terrain near Juneau for future reference and snow survey development.

What's in a Name

Should any reader of this narrative delve into ancient snow survey archives and come upon an early day inventory of shelter cabins, the name Kreukom would come to view. An odd name indeed, but readily explainable.

Bill Childreth and I built that shelter cabin over in Idaho on the route to South Mountain Snow Course. Since we could reach the cabin site by pickup truck, we used some finished lumber we picked up really cheap down in Jordan Valley. As we worked, a horrible invasion of Morman crickets marched upon us. They'd eat anything and everything—even ate my "going to town" hat which was carelessly left within their reach. Bill and I ventured small wagers most every evening as to who was the best shot—by targeting in on any one of the horde with a .22 rifle from 25 yards.

We dropped into a sheep camp one evening in search of some information. The camp tender, a Basque whose English was somewhat less than perfect, asked us, "You gottem Kreukoms you camp?" It finally dawned on us that he was wondering if the crickets were bothering us.

So, for lack of better identification, that shelter went into the cabin inventory as Kreukom Cabin. . . Bill had to go back there later to nail tin patches all over it. Seems the lumber we bought at bargain prices was wormy or at least, for some reason, attractive to woodpeckers. Those rascals drilled the cabin walls so full of holes that it required 100 or more tin patches to foil the winter winds. That shelter really should have been named the "Tinpatch Cabin."

A Historical Monument

Three or four years ago [1981], a historian for the U.S. Forest Service came to Ashland to glean from me what he could of recollections of old snow survey cabins in the Rogue River National Forest. He had in mind especially an old cabin called Whaleback, which was being nominated as a historical monument, or shrine, or something of that nature. He had noticed that the stove was too large to fit through the doorway.

I remember quite well the reason the stove and the doorway didn't match. When building that cabin, after about three rounds of logs were laid and the freeze-proof grub box built, the stove was simply lifted over the log parapet already in place and put in place on the grub box, before construction of the cabin proceeded. A tarp was spread over it to keep wood chips and other debris from falling into the cook's thrice-daily preparations, as the walls went up and the roof went on. The reason for having such a large stove lay with the fact that we bought those wood-burning stoves for $5 each from the local power company. The company took them on trade toward new electric stoves, So, when we needed one for this cabin, the one we got was the only one available, at the moment, but it was a dandy.

Operation Sno-Cat Cascade

In 1946, an author representative, Leo Borah, of *National Geographic* magazine, visited Medford. He had been commissioned to prepare an illustrated article about Oregon. He wished very much to see Crater Lake in its pristine winter garb. Since all the roads into the lake were snow-blocked, he was referred to me. It was a pleasure to take him into the lake by Sno-Cat. His article appeared in the December 1946 issue of *National Geographic* magazine.

That also provided an opportunity to broach a subject to Mr. Borah that had been in my mind for awhile. Briefly, it was proposed to him that our Snow Surveys and National Geographic Society mount a joint endeavor such as a first in traveling the spine of the Cascade Range, by Sno-Cat, over the snow from California to the Columbia River. The idea appealed to Mr. Borah, and before long came word from the Society indicating its interest in the proposed project. Final plans were agreed upon so that in the fall of 1947, I was able to survey and mark the entire route, as well as establish 55-gallon gasoline caches at strategic intervals in order to satisfy the Sno-Cat appetite for that particular fluid.

The Tucker Sno-Cat Company was eager to participate in the venture, so that company furnished a Sno-Cat trailer and driver-mechanic for the trip.

Andy Brown, the observer-author and Jack Fletcher, the observer-photographer, flew into Medford in mid-March 1948. The expedition departed from Greensprings Summit, which is about 8 miles north of the Oregon-California border, on March 19, 1948. That particular departure date was selected since our rather limited historical records suggested that much the greater part of winter's snowfall had occurred prior to that date, thus promising favorable weather for the trip. Nothing could have been farther from the truth. Of the 23 days required to execute the mission, it snowed on all but two. More than 10 feet of snow fell on the two machines and seven men while making the journey.

It isn't proposed here to go into details concerning the trip, as it was all written up by Andy Brown and published in *National Geographic* magazine in November 1949. However, we crossed and re-crossed the crest of the Cascade Range 15 times, as we needed to travel in rights-of-way wide enough to accommodate the machines, each of which towed a trailer containing our tools, camp gear, food—even a portable welding outfit. As I recall, our over-snow mileage was somewhat under 600 miles. We carried a portable radio transmitter and maintained contact each evening with our Medford office.

A principal object of the trip was to determine the practicality of one mechanized snow survey crew, measuring all of the snow courses that were then in operation along the length of the Oregon Cascades, rather than sending two-man crews up from valley floors at numerous locations. It didn't take long to conclude from results of this trip that the system in vogue was the more practical.

A further, though unadvertised, objective was to obtain wider public recognition of the Snow Surveys, with attendant support, as the activity had perennial financial problems.

This trip, we feel sure, will never be forgotten by any of the participants now living.

Hermits of the Canyon

Back in the late 40s (probably in March 1947) a writer by name of Oren Arnold telephoned me from Phoenix, Arizona, with a proposition. He had been commissioned by the *Saturday Evening Post* to write a feature story about the two caretakers at the Grand Canyon North Rim Lodge. Those men were snowbound there for months on end, as they looked after the safety of those Union Pacific Railroad holdings. Arnold wanted transportation for himself and a free-lance photographer into North Rim to interview those people and gather data and photos for his story. He had heard somewhere about the Sno-Cat Chinook, hence his inquiry. His proposal fell upon receptive ears, as for some time we had wanted a strategically located snow course in that area, where permanent observers could be located and trained.

It was finally arranged that Clyde Houston, our then snow survey supervisor for Nevada who was also looking after our business in Arizona, and I would meet Arnold and his photographer somewhere along the line—I just don't remember exactly where, maybe Kanab—and take them along with us when Houston and I established and measured a snow course at North Rim. (We commissioned and equipped the caretakers there to continue the measurement schedule.)

There was nothing notable about the Sno-Cat trip in and out from Jacob Lake, Arizona. If I recall correctly, the one-way trip was about 45 miles, but that's a long time ago. The snow was good—well settled, as the month was March. It was a nice day, too, which wasn't always the case in winter months. We picked up the mail for the caretakers that had accumulated since the previous October at Jacob Lake.

Of course, during the 5 days devoted to this expedition, it's not surprising that Arnold was pumped full of all kinds of snow survey lore, history, et cetera, from both Houston and myself. Enough so that Arnold began taking notes and asking questions. Before we parted company, Arnold mentioned that he seemed to have enough material that he could write another story—one about snow surveys. He telephoned a couple of months later and said,

> *Hi. Appreciated that lift you fellows gave us into the North Rim. Thought you'd like to know that the Saturday Evening Post rejected my story about the caretakers, but they liked my snow survey story so much that it will appear in a forthcoming issue.*

It did—issue of January 31, 1948.

The caretakers had a "tin lizzie" sitting out on the pavement a few feet in front of their winter quarters. The surrounding snow surface was almost level with the car's rooftop, but the snow had all been dug out and kept away from the entire perimeter of the car. One of them explained, "Well, I like to go out and sit in it. Of course, we can't go anyplace, but I like to toot the horn and pretend."

We were sitting around in their quarters, night of our arrival, as they opened their mail that had accumulated at Jacob Lake in the 6 months since their last visit there, just before they got snowed in. One of them exclaimed, "Hot ziggety! Here's my Standard Oil credit card—well, what the heck—the darned thing has already expired!"

Other snow survey write-ups appeared at various times in *Country Gentlemen*, *Life* magazine, *Readers Digest*, *Saga* magazine, *National Geographic* magazine, the book *White Danger*, and elsewhere. Our activity was young, underfinanced, but growing stronger.

OMB on the Prowl

Following my retirement and during the Carter administration, the OMB [Office of Management and Budget] conceived the idea (later aborted) that Snow Surveys, a Western States expenditure, just as well be done away with and a few dollars saved. OMB scheduled a series of public hearings throughout Western States to see what public opposition to Snow Surveys could be gathered before the President's next budget was prepared.

I was told by a source that I consider impeccable that the cost to the government of those numerous hearings was $250,000. The same source, who had access to the final summation of those hearings, advised me that of all the written public comments submitted to the several hearings officers, the ratio of comments supporting Snow Surveys versus adverse comments was 999 to 1. One irate water user, at one of the hearings where I gave testimony, stormed, "If they had Snow Surveys in Georgia, we wouldn't be hearing one damned word about this." Those hearing results were never made public, to the best of my knowledge, and the whole affair was quietly slipped under the carpet.

Better Safe than Sorry

Early on in the Snow Survey game, as new people came aboard, the need for training of new people in all aspects was apparent, especially the teaching of winter safety and survival. Such instruction included sleeping in the snow, winter first-aid, and avalanche avoidance and rescue, among other subjects. At first, we used the teaching abilities of our older surveyors with particular skills, such as advanced Red Cross training, or men who were experienced woodsmen. But, a little later, we were able to induce teachers with established national or international reputations to instruct at our westwide training schools, which were held in mid-winter every other year—folks like Monte Atwater, world-renowned avalanche expert; Ed Mongeon, sent by the American Red Cross to teach mouth-to-mouth resuscitation (that was before CPR technique was generally practiced), et cetera.

The schools were moved through the West to make it easier and less expensive to allow exposure to snow surveyors in the various States—Utah, California, Colorado, Montana, Idaho, Nevada, et cetera. This training paid good dividends. Shortly before my retirement, the record showed that in the many years following the latest fatality, our snow surveyors had traveled 1 million consecutive man-miles over snow without a single fatality.

Computers

Ancestral SCS snow survey supervisors relied on slide rules, manual computers, and schoolboy arithmetic in making forecast computations. Initial use of electronic computers by the SCS Snow Surveys dates back to Ash Codd's regime as Montana snow survey supervisor.

Ash was stationed on the campus of Montana State University at Bozeman. He gained access to a computer on campus and soon found himself fascinated by its versatility and capacity for intricate tasks in the production of his forecasts and *Bulletins*.

He was anxious to share his knowledge with his colleague snow survey supervisors. It was arranged for all of the SCS snow survey supervisors to assemble at MSU [Montana State University] in Bozeman for indoctrination and classwork. I simply cannot recall the date or year and really should because that meeting in Bozeman marked the beginning of a significant new era in snow survey technology. The numerous snow survey supervisors took to that innovation like ducks to water.

Measuring Snow Course Canopy

It was well known in snow survey circles that alterations of tree or brush cover alongside snow courses could produce changes in snow cover at measurement spots. It was important to evaluate and record such changes.

Ash Codd developed what he described as the “pin-hole” camera for this purpose. He adapted a cheap box camera to take vertical 360-degree photographs. Periodic photos at same points on a snow course could be scanned and evaluated by his “canopyometer” scale to show any chances over the years in over-story vegetation. Ash modified box cameras and furnished them to his colleagues. Even after he retired, Ash maintained a dark room in his home for developing film for SCS snow survey supervisors who called for his service. For further and more detailed information on that development, contact Phil Farnes, who still may be the Montana snow survey supervisor.

Western Snow Conference

The first meeting of this group was held in Reno, Nevada, in 1933 or 1934. A printed *Bulletin* was issued. I had that publication at one time in our SCS archives. Should that copy no longer exist, then most likely, a copy can be found in the Church library at the University of Nevada, Reno. That *Bulletin* is historically important. I’ll not attempt to go into any detail concerning that conference (the original name was Western Interstate Snow Survey Conference.) Any information desired can no doubt be secured from the current secretary, Jim Marron. Several SCS snow survey supervisors served as general chairmen of that conference from time to time through the years.

Cloud Seeding

SCS snow surveys were pioneers in analysis of success or failure of cloud seeding.

Along in the early 40s, Dr. Vincent Schaefer of General Electric went public with his earliest work dealing with the effect of silver iodide crystals in condensing atmospheric moisture into droplets of such size as to fall as rain or snow crystals.

To the best of my knowledge, one of the very first and possibly the first commercial cloud seeding projects undertaken in the United States was initiated at Medford, Oregon, by two aviators—Harvey Brandau and his partner Kooser, Brandau and Kooser, as they were known—flying WWII fighter planes. They flew and dispensed dry ice from their plane in effort to create snowfall on valley watersheds—rather hazardous missions since their flights necessarily took place when weather conditions were such that most pilots would rather stay grounded. (If memory serves me right, Harvey Brandau was able to walk away from one crash). Ground generators, supplanting aerial seeding, were a later development.

The Talent Irrigation District (a long-time Snow Surveys cooperator) funded this pioneer experiment. The district asked the Snow Surveys, then headquartered at Medford, to analyze success of the project. Bob Beaumont of our staff, a meteorologist (and former Navy carrier pilot) carried that analysis.

His findings were, briefly, that the cloud seeding did result in increased precipitation in the form of snow, but unfortunately not in the target area in the nearby Siskiyous and Cascades watersheds but over in the Bend area, more than 100 miles distant from the desired accumulation area. Nevertheless, that was a very significant finding.

The district didn't choose to continue the project, but many, many cloud seeding projects have been undertaken in many places since that pioneer effort at Medford.

Years later, Gregory Pearson, a member of my Portland staff and a former snow survey supervisor in Utah, performed an extensive analysis of a major cloud seeding project in Utah. Greg made that analysis after his retirement from SCS, so that might have been about 1970, give or take a year or two. Greg sent to me his analysis for review.

I think it quite important that you query Greg directly about his findings and methods of analysis.

Construction Snowload Analysis

I shall stand corrected, if wrong, when stating that SCS Snow Surveys led the pack in making data available concerning snowload on buildings in Western States mountainous resort areas.

I suggest that you contact Tommy George (on SCS Washington, D.C., staff) for history and details of that particular application of snow surveys.

(Ask Tommy if he remembers our first interview when his first daughter, then aged about two and a half, sat on yours truly's knee!!)

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Part 4

Interviews with Department of Agriculture Pioneers

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Part 4 Interviews with Department of Agriculture Pioneers

R.A. "Arch" Work
Ashland, Oregon
May 12, 1989

by Douglas Helms
National Historian, U.S. Department of Agriculture,
Soil Conservation Service
(now the Natural Resources Conservation Service)

Douglas Helms: Before we get into the snow survey, will you tell me where you were born and something about your early childhood leading up to your college education?

Arch Work: That's covered in the narrative given to you, the interview with Jeffrey LaLande, of which you have a copy. So you can rephrase it anyway you choose, the facts are there.

Helms: Okay. Could you start with getting involved in agricultural engineering and snow surveying? I think, as you mentioned, for this interview we are going to attach what you have already written here, which you tell me touches on some of the questions I have.

The interview by Jeffrey LaLande, Forest Archaeologist of the Rogue River National Forest (now the Rogue River-Siskiyou National Forest), Forest Service, with R.A. "Arch" Work of October 1981, is reproduced in full at the end of the Helms interview with Work. A few statements about Work's childhood and education are inserted at this point.

LaLande: Mr. Work, would you tell me something of your early life, where you were born and raised, and where you were educated?

Work: I was born in Denton, Texas, in 1904. My father was the founding president of what is now the Texas Woman's University, a very large institution.[1] We came to California when I was a young boy. I went through high school in California and graduated from the University of California, in irrigation, in 1927. It took me several years to graduate because I worked my way through. I dropped out occasionally to work.

LaLande: At Berkeley?

Work: Yes, I graduated from Berkeley, but I spent much of my time at what was called the cow college at Davis. After graduation, my first employment was with the Miller and Lux Cattle Company [the huge western land and cattle operation]. At that time, I think it was the largest cattle producer in the United States. That was the Double H brand. I left them after 2 years and accepted employment with the Division of Irrigation of the Bureau of Agricultural Engineering in the Department of Public Roads, as an assistant irrigation engineer. I was sent to Medford, Oregon, on my first assignment, to make a drainage survey of the Rogue River Valley.

LaLande: What year was that?

Work: It was in 1929. I've resided in the Valley, except for a period of 13 years when I was in Portland, since that time. We initiated some irrigation experiments in connection with some of the drainage problems that we found. We established the Medford Irrigation Experiment Station in 1931. My colleague was Dr. W.W. Aldrich. Now, in 1934, we had a very severe drought in the Rogue River Valley and elsewhere. As I recall, water ran out on the 4th of July on the main canal of the Medford Irrigation District. No more water for irrigating after the 4th of July.

LaLande: So Fish Lake [a lake in the mountains east of the Rogue valley that had been impounded and raised into an irrigation reservoir for the Medford Irrigation District] was dry?

Work: Oh yes, there was no further source for irrigation water. The reservoirs were drained. Well, there was considerable economic loss, to the

1 Cree T. Work was president of the Girls Industrial College of Texas, 1903–10

fruit industry particularly, that year. Now, we had heard of the science of snow survey, which is the practical means of the measurement of the actual amount of water stored in the mountain snowpack, relative to the subsequent discharge of the streams. That program in Nevada was initiated by Dr. J.E. Church, who was the Professor of Romance Languages at the University of Nevada. But this was a hobby of Church's. He made his first snow survey, we're told, in 1911. We'd heard of his work.

Resume the interview of Helms with R.A."Arch" Work

Helms: Could you describe the situation after the Department of Agriculture was supposed to have had general coordination of the snow surveys?

Work: The Federal Congress in 1935 assigned the snow survey water supply forecasting activity to the Bureau of Agricultural Engineering, which at that time was in the Bureau of Public Roads. There were limited snow surveys underway in the States of Utah, Nevada, and California. They actually originated in the Western United States in the State of Nevada. Some surveys were started in the State of Oregon in 1933, but were suspended in 1934. The Bureau of Reclamation was making some snow surveys as early as 1919, on the headwaters of the Snake River. Congress' objective was to place all of these widespread but separate activities under one agency that would coordinate and expand the program and make it as applicable as possible to the operations of the Nation's irrigated farmers. The amount of money allocated was not very great. Congress allocated $25,000 to this activity to carry it out in all of the Western States. Of that allocation, $15,000 filtered down to us four engineers in the field who were charged with executing the program.

Helms: Those four were?

Work: The four engineers were Ralph Parshall in Colorado; Jimmy Marr in Boise, Idaho; Lou Jessup in Washington; and myself in Oregon. I was located at Medford at the Experiment Station, which Professor M.R. Lewis of Oregon State University and I had helped establish in 1932. We were conducting experiments at the station on the effects of varying methods of irrigation upon production of pear fruits. In 1934, the Medford Valley suffered a very severe drought. The main canal of the Medford Irrigation District went dry on the 4th day of July. There subsequently was great economic loss in this valley. Had we known in advance that such a water shortage was going to occur, there were a good many farming practices that could have been adopted to reduce the damage. That led to my interest in the mountain snow surveys as a means of predicting the stream runoff. As a matter of fact, I became interested in the snow surveys prior to the time the Congress assigned the activity to the Department of Agriculture. I made snow surveys on my own hook beginning in January of 1935.

Helms: Who had the general overall supervision? Did you have a supervisor in the snow survey work?

Work: Yes. Of course, our administrative supervisor, our chief, was W.W. McLaughlin, the chief of the Division of Irrigation of the Bureau of Agricultural Engineering. We four engineers collaborated with each other, but we operated more or less independently. In fact, that was one of the early precepts of the snow survey. It was an infant activity; it needed public support. It had very little money. So one of our first objectives was to seek cooperation from water-using agencies, from farm agencies, from power companies, and from municipalities—all of whom had a vital interest in their annual water supply. So we decided that the only way the program could serve the best needs of the people was to enlist cooperation from the people who needed the information and would benefit from it. So then the snow surveys began to grow. The applications of the data were quite numerous. They were needed by irrigation districts, municipalities, and particularly by the public utilities that relied upon the power generation from falling water. Many other government agencies needed the information, like the Bureau of Reclamation, the Corps of Engineers, and the Bonneville Power Administration, to name a few. But allow me to say this: the program owed a great deal of its progress to the strong support and helping hand given to us by the U.S. Forest Service. The Forest Service had ranger stations strategically located on the watersheds, and they were glad to make the services of these people available.

Helms: They were controlling a lot of land where the snow was?

Work: Well, yes, that's true. The high watersheds, from which our summer supplies of water come, are principally managed by the U.S. Forest Service or by the Bureau of Land Management.

Helms: As you got started there, were you seeking their cooperation or were you seeking funds from them? What kind of cooperation were you actually asking them for?

Work: Funds in some cases, but in the majority of cases, services in lieu of funds. We would furnish the equipment and lay out the snow courses, designate their locations, and the times of measurement. Then our cooperators frequently would furnish the manpower to go and get the measurements after their people had been properly instructed.

Helms: From the time you started in 1935, what did you know about how to lay out a snow course, what was the state of the art?

Work: Well, Ash Codd, our former snow survey supervisor in the State of Montana, and myself wrote a tech bulletin about the art—if you want to call it that—of locating new snow courses. Briefly, snow courses were located in sheltered areas at higher elevations where the winter snow would accumulate and not be intercepted by the tree canopy or drift, and measured there usually on a monthly schedule through the winter, beginning in January. The original surveys were made the first of April. Then, as the program expanded and the need became known for even earlier information, the surveys were made in March, February, and January, and nowadays, by means of SNOTEL, all of the time.

Helms: When did you start making survey measurements earlier than April?

Work: We actually always made two. We made one in January and one in April. The one in April was the fixation, the final, the one on which the main forecast would depend, and the January measurement was merely preliminary to give people grounds for a little advance planning on the supply. I can't tell you exactly when we began making the snow surveys in February and March, but it was a long time ago when we filled in the schedule of the measurements.

Helms: So along the way, your cooperators agreed to maintain the snow courses and have their people make the measurements. What about the building of cabins and so on?

Work: Well, the early work in snow surveys was done all together by men traveling on foot, occasionally on horseback. It was only later that we were able to use machines such as over-snow machines, airplanes, and helicopters, and even later on, with the development of the electronic means of snow surveying, the need for men traveling on foot became far less.

Helms: In the early days, you had to locate the cabins so you could get from one to the next, correct?

Work: Yes, a day's journey, we figured, usually was about 16 miles. If the snow was bad, carrying a pack, that's a long haul.

Helms: But you had snow courses along the route?

Work: Yes, the snow courses would be interspersed between the cabins, sometimes quite close to the cabins. In fact, a cabin might even be at the end of the route.

Helms: I know you published one bulletin on a model snow cabin. What sort of an accumulation of knowledge was there throughout the years on how to build cabins?

Work: I dare say we didn't build cabins quite as good as the old pioneers who came out West, but we built them small to be easily heated. They usually housed only two men. It didn't have to be very large. We stocked them in the fall, after the hunters had gone home. Sometimes we had to go up through quite a bit of snow to stock the cabins. But we stocked them with all kinds of staples that the men would need in the wintertime.

Helms: Did your staff do that or the cooperators?

Work: We did that, the SCS [Soil Conservation Service]. We stocked the cabins.

Helms: Did you maintain the snow courses?

Work: We maintained the snow courses. We marked the snow courses, we maintained them, we mapped them, and we kept all of the records.

Helms: That would keep you busy through the summertime?

Work: In the summertime, there were always repairs to be made and new cabins to be built. Snow courses had to be cleared from brush and fallen trees and so forth. We kept busy all year round.

Helms: When was the big growth in the number of snow courses, the late 1930s? Or did you keep adding more each year? Do you have any general ideas on that point?

Work: I would say rather steadily as new needs came into being and as improved forecasting methods were developed. Originally, the forecasts issued by the Bureau of Agricultural Engineering and by SCS were for streamflow through the period April to September. Then, on many streams, there was a need for knowing in advance when the flow of that stream would reach a certain minimum point because that affected the water rights of irrigation districts and of many individuals, and so there came into being the forecasting of the date for low flow. Low flow might be any number of cubic feet per second—whatever the situation on that particular river demanded. Although we never claimed to be flood forecasters or responsible for the forecasting of floods, we did have some formulas that enabled us to predict extremely high flows in certain streams.

Helms: When did this other compilation, the low flow, start?

Work: I think we started low-flow forecasting about 1950.

Helms: You mentioned the formulas. Could you give me, in a nutshell, some of the highlights of the development of the mathematics of figuring water supply?

Work: Yes. In an elementary sort of way, if you were to plot the maximum water equivalent of the snowpack at some given snow course on the watershed on one axis and plot the resultant streamflow on the opposing axis over a period years, then you would be able to develop a relationship between the amount of water stored in the snow on the watershed and the resultant streamflow.

Helms: You had to have your snow course records a few years before you really could use the information.

Work: Yes, you needed around 10 years of records before making reasonably reliable forecasts.

Helms: I have the impression, you can correct me, that when you started in 1935, a lot of the forecasts you had were for small watersheds or a particular irrigation district or something. Was there enough information when you started in 1935 to predict, although you were not in the flood forecasting business, the water to go through the Columbia River?

Work: Well, sure, if you add up the flow from a number of principal tributaries to a main stream, you will come up with a product representing the flow of the main stream.

Helms: Then you average for those that you don't know?

Work: No, you have to weigh them; you apply weightings to the areas' inflows.

Helms: Did your budget grow much in the late 1930s? You told me about the paltry amounts you had to begin with.

Work: It was pretty slow. But as the program became better known and widely accepted by water-using agencies, Congress was more liberal, and the SCS itself became more liberal.

Helms: Since you mentioned that, would you care to tell us about the shifting of the program from the Bureau of Agricultural Engineering to the SCS? What were the reasons, as you saw them, at the time?

Work: The Bureau of Agricultural Engineering was engaged in research programs to increase the efficiency of farm operations in various ways, through controlling soil erosion, through improved tillage of land, through greater efficiency in the application of irrigation water, through spreading the benefits of surplus winter runoff, through water spreading programs, and so forth. In other words, the Bureau's program was one to increase the efficiency of farm production by reducing the costs of production. That simply didn't fit with the national policies that came into being with the so-called New Deal, back in the early 1930s. So the Bureau of Agricultural Engineering was simply done away with, and the Division of Irrigation, my employer, fell under the same axe. So the Bureau of Agricultural Engineering was split up. Part was assigned to the Bureau of Plant Industry and part was assigned to a newly created Bureau of Agricultural Chemistry and Soils, as I recall. The snow survey activity was transferred to the SCS. The SCS was created by President Roosevelt in 1935, and the shift of snow surveys to the SCS took place, I believe, in 1939. It has remained with the SCS since that time.

Helms: What immediate effect of that did you see in the field, or did you see any immediate effect?

Work: It gave the snow surveys a lot bigger, wider field of operations and a wider field of application through the soil conservation districts. There were many hundreds in the United States—a great number in the Western United States. It enlarged the cooperative atmosphere; in fact, it made available SCS people to conduct snow surveys.

Helms: So that started growing right off?

Work: Yes, the program expanded rapidly.

Helms: So your recollection was that as that change took place, the administrators at SCS, the State Conservationists, the regional offices, and the SCS people were really enthusiastic about starting to participate? Or did they think that they had more important things to do?

Work: The snow survey activity in the SCS always met with top-level support: First from Dr. Hugh Bennett and second from Don Williams, the long-time chief of the Service, and even later with people who succeeded Don Williams. I can remember some of the top people on the Washington staff that provided very strong support to snow surveys. In addition to Don Williams and J.C. Dykes, there was Harold Tower, Western States representative of the administrator; Verna Mohagen, head of personnel; Carl Dorny in fiscal matters; Frank Harper in public relations; Bob Branstead in photography; Chester Francis, a former chief engineer; and Carl Brown, a former chief engineer. I just can't name all of the people who supported and strengthened the snow survey program.

Helms: Did World War II have much effect on the program?

Work: Yes, it did. It hurt the financing, and it hurt the personnel. It made it more difficult to find people to do the job. As a matter of fact, we gave up some work in some areas. We moved out of northern California when World War II broke open and turned all that programming over to the State of California.

Helms: That brings us to the point that California operated its own program. Has the cooperation always been pretty good?

Work: California operates its own snow survey program and always has. British Columbia operates its own snow survey program and always has. They have their own programs. But in the Western United States, the programs in all the States are integrated, correlated, and coordinated by the SCS, with the exception of the State of California. The cooperation between SCS and the State of California has always been good.

Helms: When you started coordinating their work in 1935, some of the bureaus had their own snow courses. Their people, I guess, were making projections about water supply. The change was that information from the snow courses started coming to your group, and you released the information. Is that how it worked?

Work: Yes. Several of the agencies relied upon their own personnel to make water supply forecasts for their own purposes, notably the Bureau of Reclamation and the Corps of Engineers. But we always enjoyed the closest kind of cooperation with those agencies because they needed the snow survey information as a foundation for their own forecasting procedures.

There's an illustration of this. The Bureau of Reclamation wanted some snow surveys established on the watershed of a river feeding one of their power plants in Alaska. So Will Reedy, an engineer from the Bureau office in Denver, and I flew up to Alaska. We established and made the first snow survey ever made in Alaska, on the head of Eklutna Lake. I don't recall what year that was; it was in the early 1950s. Now, of course, the snow survey program in Alaska is a major program with many, many uses.

Helms: Did it work out that eventually the others, the Corps of Engineers and the Bureau of Reclamation, made surveys? Did they not also contribute money to the SCS operation?

Work: Yes. We entered into a series of formal agreements with the various regions of the Bureau of Reclamation. Jesse Honnald, a Bureau of Reclamation engineer, and I flew together one winter to all the Bureau offices in working out this overall major agreement, and as far as I know, those agreements are still in effect. We were never successful in getting an overall agreement with the Corps of Engineers. There's a little personal history that goes into that. A high-level officer in the U.S. Weather Bureau came up to Medford in 1938 and asked me if I would like to become affiliated with the Weather Bureau in a capacity and on an assignment that could be determined. I told this gentleman that I was happy with my employer and I was happy with the work I was doing, so thanks but no thanks. Many years later, when attempting to get this overall agreement with the Corps of Engineers, it appeared that that particular gentleman and a highly placed civilian engineer in the Corps of Engineers were close friends. I was told that, "Work, you will never get that agreement," and we never did. But we did have, and I imagine the Service still continues to have, splendid working relations with the district offices of the Corps in Seattle, in Portland, in Omaha, and in California. I don't know if you are going to want to put that in your record. Just a little piece of history.

Helms: You mentioned earlier the good cooperative working arrangements with the Bureau of Reclamation and the Corps of Engineers. Could you tell us a little bit about your relationship with the Weather Bureau?

Work: To put it succinctly, those relationships were a little rocky. I told you a few moments ago about the action by Congress, assigning the snow surveys to the Bureau of Agricultural Engineering. Following the action by Congress, we soon ran into conflict with the U.S. Weather Bureau, which had initiated a rival, but less accurate, forecasting system based on analyses of valley rainfall records. Forecasts of the two agencies were often in conflict. I mentioned to you a classic example, the 1948 great flood of the Columbia. All of that conflict hampered support for the snow survey activities.

Helms: Issuing differing forecasts?

Work: The conflict was completely unwarranted. During the 1935 Senate hearings, the representative of the Weather Bureau conceded that the activity was one for engineers, and withdrew itself from congressional consideration. I mentioned the cooperation, the offer of cooperation made at that time by the U.S. Forest Service. The Weather Bureau, on the other hand, failed to support its position of 1935. Nor did it honor subsequent pledges and agreements to cease its wasteful and less accurate duplication of public water supply forecasting—at least so long as I was connected with the officially sanctioned snow survey program.

Helms: Could you discuss the incident you mentioned earlier about going to Washington in the 1950s?

Work: Yes. Along in about 1954, a Weather Bureau Office in Arizona issued a river flow forecast. It caused serious problems for the Salt River Valley Water Users Association. Arizona's senior senator, Senator Hayden, added a rider to the Weather Bureau's appropriation bill for that year. The rider stated briefly that none of these funds should be expended for the forecasting of water supplies. As powerful as Senator Hayden was, Eastern States' senators, who really held the power, didn't accept the amendment, so it didn't hold up. It was always pretty clear to me that the Salt River Valley Water Users Association, who were always very strong snow survey supporters—still are, I hope—were responsible for that action.

Along in the 1950s, due to some similar situation to the one I just described in Arizona, Don Williams, then chief of SCS, called me to Washington. He and Carl Brown, who was the chief engineer of the SCS, and I went as a delegation over to the Weather Bureau offices where we met with Commander Reichelderfer, the chief of the then U.S. Weather Bureau. Commander Reichelderfer was accompanied by two members of his staff. We met for a short time, I think it was less than an hour, and Don Williams made a proposal to the commander. He said, “Commander, your agency is responsible for forecasting floods. Our agency is responsible for forecasting water supplies. Our agency will assist you in any way that it can to carry out your responsibility. We will furnish data of snow surveys in the mountains to you. We will furnish any formula which we might have for forecasting peak flows. We will furnish advice if you request it. All this if you will reciprocate in our assigned field of water supply forecasting.” I distinctly remember Commander Reichelderfer’s reply. He said, “Williams, let’s do it.” But it never was done.

Helms: Do you know why?

Work: I assumed that Reichelderfer’s staff simply wouldn’t back him up. I guess it was that simple. There was no reason for the SCS to proceed unilaterally with its end of what was a good proposition, a good solution to the problem. Even years later, these difficulties persisted.

Years and years later, a series of events led the Service and the Weather Bureau again to make an effort to resolve this problem. A representative of the Weather Bureau, A.J. “Tony” Polos, and I were designated to represent our respective agencies in reaching an agreement to solve this long-standing difficulty. Any agreement that Tony Polos and I might reach would be binding on our parent agencies. Tony Polos and I went into the field in the Western States. We contacted water-using agencies, many of them, to get their views. I remember one time I was surprised at a statement made to the two of us by the chief operating officer of a western utility. That gentleman said, “Well, in my opinion and in the opinion of my company, the SCS should not only conduct all of its own activities west of the Mississippi River, but should also conduct those currently conducted by the Weather Bureau.” I don’t know which of us was more surprised. But at any rate, Tony Polos and I, after making all of these examinations, went back to Portland, and we sat down and wrote a joint agreement between the Weather Bureau and SCS. This agreement provided substantially the same things that Chief Williams and Commander Reichelderfer had agreed to years before. The SCS accepted our joint report. The Weather Bureau repudiated it—refused to accept it.

Helms: About what time was that?

Work: That was in the 1960s. Well, Tony passed away years ago, so he can't verify this, but that's a matter of history.

Helms: Is there anything else that comes to mind, particularly? Were there any other particular differences over the prediction of floods?

Work: I'll give you a little piece of history that is just simply not known because all of the participants, except myself, have passed on. In about 1938, we were having difficulty pursuing the snow survey activity because of the rivalry that had been created by the Weather Bureau. So Ralph Parshall, Lou Jessup, Jim Marr, and I all met in a little log cabin motel in Moran, Wyoming. We met for the purpose of deciding among ourselves if we would continue to try to improve the snow survey program and the water supply forecast, or if we would give way to what some people considered superior fire power. We decided after a couple of days of discussions and deliberations that we would all go back to our stations and continue to strengthen the snow survey program in any way that we possibly could to improve its accuracy and its usefulness to the water users.

Helms: That was not very long after the function was assigned to you.

Work: I think we were still in the Bureau of Agricultural Engineering at the time.

Helms: You mentioned the research and so on, could you give us some of the background on the things you wanted to do to mechanize and automate the snow survey? I know there are a lot of facets to it.

Work: You will find quite a bit about mechanized snow travel in what I have written. I touch on the origination of SNOTEL and the laboratory we set up on the southwest flank of Mount Hood. But of course SNOTEL, since my retirement in 1965, has just gone all out. Really successful. At the time of my retirement, it was still a little baby. We were just on the verge of a very practical development.

I guess, in talking to some of the people, maybe this is the way it should be—a close connection between research and operations. The people running the operations were working on new devices and improvements.

The original work on SNOTEL was all done by our own SCS engineers. These are the men that received that award in 1968.

Helms: Who were they?

Work: Homer Stockwell is now deceased. Bob Beaumont has retired, and the last I heard, he's in Greece. Ted Freeman has retired and lives in Alaska. Manes Barton, of course you well know, is deceased. Bill Shannon is also dead, and finally, myself. Those were the six. These men were all snow surveyors. There weren't academics. They were snow surveying people.

Subsequent to my retirement, Manes Barton and his group went into this big electronics program with Western Union. Early on, we had two former Boeing engineers that worked up there in the snow lab on Mount Hood. I don't remember their names now. They were electronic engineers. These people had an idea that they could, by electronic means, gauge the water equivalent of the snowpack as it built up. It just never worked. SCS had a contract with these people.

Helms: I guess since you had radios, you had the idea of using them from the beginning of the program, didn't you?

Work: We began using shortwave radios in 1938. We had quite a network.

Helms: For just communicating with one another, or for collecting information?

Work: Collecting information. In fact, in 1938, skiing was becoming a pretty popular recreational activity. The red network of the National Broadcasting Company asked the snow surveyors to produce a program each Friday of each winter week to describe the snow conditions, the weather conditions, and the road conditions at western ski resorts. We called that program *Snowcasts*. We continued that program until the war broke out. We discontinued it in 1942.

Helms: Why didn't you get back into it again?

114G–ORE–40170 National Archives, College Park, Maryland

4.1 Arch Work at transmitter and receiver of Station KBEI (Soil Conservation Service) at Medford, Oregon, March 1942

Work: Never did. Turned it over to the Weather Bureau.

Helms: There was a fair amount of competition on the over-snow vehicles. The design of them and so on.

Work: I've gone into that in quite a little detail.

There again, several of your snow surveyors were involved. Codd, Nelson, George Peak, and myself were involved in working on machines.

Helms: Did you have one machine that the whole Service was going to purchase, or could each operations unit select its own? I've seen some of these records on getting together and having tests.

Work: Yes, we sure did. We were looking for the most satisfactory over-snow machine that snow surveyors could find. For that reason, the field was pretty broad. The first machine that we ever used in snow surveys was called the Eliason Motor Toboggan. The Eliason Motor Toboggan was powered with an Indian motorcycle engine in a frame that rested on skis and propelled itself by a belt actuated by this motorcycle engine. Jim Marr bought one of those machines in about 1936, maybe 1937. Jim used it over in Idaho. It had a lot of limitations. I remember one time Jim came to an open stream. He couldn't get across it with this machine, so he had to get his skis off and go and take care of his mission. When he got back, the porcupines had eaten all the insulation off the wires. He had to ski home.

Then in 1938, I bought an air-propelled machine. That's an airplane engine with a propeller and a very light, aluminum frame body on three skis—two supporting skis and a steering ski. It was sure a lot of fun to run that number. On its trial run on Jackson Lake, it did 120 miles an hour.

Helms: With you operating it?

Work: I didn't operate it on its test run. But I drove it for a good long time after that. It was tricky. The prop created a lot of torque. If you climbed a side hill in the wrong direction, down the hill you'd go. The torque would roll you over. It wouldn't slide in sticky snow. I remember one day Clyde Houston and I were going somewhere in that machine. We just had to sit by a fire for 5 hours 'till the sun went down, 'till we could get going. Well, then Tucker came along with his Sno-Cat in about 1942. That's mentioned in LaLande's narrative. Tucker was a local family. We bought the second Sno-Cat that was ever built, paid $3,500 for it. Nowadays, if you want a big Sno-Cat like they use in the Arctic, man, you get started at $100,000. But at any rate, that Sno-Cat was the first successful over-snow machine that came into our experience.

During the war, the Army built the Weasel, and they built the M–7. The Weasel was pretty useless for snow survey work. The M–7 was a pretty good little machine, but went out of production. We had one or two or three M–7s that we kept cannibalizing to keep what was left going. Then the people in Utah built the snowmobile—quite a successful machine. The patents for that machine were taken over by Thiokol Chemical. Thiokol bought the patents that the engineer, Ross Eskelson, had developed.

Helms: He worked with the University?

114H–NEV–859 National Archives, College Park, Maryland

4.2 Dale Palmquist, 2 miles southwest of Slide Mountain, Nevada, driving Tucker Sno-Cat to snow course, Spring 1961

Work: Utah State at Logan, Utah. That's how I became familiar with the machine, through the University, Utah State. That machine became known as the Trackmaster. It's pretty widely used at ski resorts and so forth. Then came the Idaho Sno-ball, Morlan's development. That machine had a lot of torque. You get a rear-drive machine and you get quite a lot of torque, your machine begins to ascend, assume this position. So if you might have had half a pound per square inch here, you got a pound and a half. Down she goes, just like an elevator. That killed the Sno-ball—torque.

Bill Schomers came along with a side-hilling machine. You shift the center of gravity of that machine by just pushing a lever, pretty good machine. We bought a couple of those. We'd buy these machines and test them. Bill's machine never got into production. He was a flier in the National Guard, the Air Guard. Bill flew into a railroad embankment over there in Wyoming one day, and that ended that.

Then the Polaris people, headquartered in Roseau, Wisconsin, came along with the machine your people are using now, only it isn't a Polaris. You are probably using one of these Japanese-built machines. But anyway, Polaris came out with this first machine that we know of that is similar to the modern day little one- or two-man machines. I went to Roseau and went through their factory. They were a well-financed, well-run operation. We were really interested in that machine. Well, later, I've been told that there are 40 manufacturers of that little one-man, two-man machine. I know snow surveyors used quite a bunch of them. But anyway, when it really came to tough traveling, bad snow, in my day we always relied on Sno-Cat machines.

Helms: I guess the reason for aircraft was because you wanted to do surveys higher in the mountains, is that correct?

Work: An aircraft could cover in a matter of minutes the same territory it would take the men on foot hours and hours and hours to cover. We started using ski-equipped aircraft at the very start of the 1940s. I remember that at one of our snow survey meetings, we invited one of these contract operators to come and talk to the men. This flier built his own airplanes. I remember one of the fellows in the audience, one of the snow surveyors, asked this man, "Well, how do you decide what instruments to put on your plane?" "Oh," he said, "that's easy, you just hold it out and open your hand. If it drops, you don't put it on." That man was later killed on a snow survey.

Helms: Was that the fellow from Idaho?

Work: Yes. One of Morlan's contract fliers. I don't remember his name.

Helms: Did you decide to go with contracting rather than hiring people on and buying the aircraft?

Work: Yes. Bob Beaumont was a Navy aircraft fighter pilot. Jack Washichek was a flier. Some of our men flew. But all of that work was contracted. Then, of course, when we started using helicopters, that's when we began running into trouble with these environmentalists. There wouldn't be a living soul within 50 miles of a snow surveyor and a helicopter. You couldn't possibly hear that machine, yet these people were complaining.

They complained about building landing pads in wilderness areas. That became very restricted, you know. Then, like Bob said, they wanted the aerial markers set up out of sight, in the trees somewhere. Well, big deal. All of this led to the development of SNOTEL. It just had to. We just had to find some way of getting these records without sending these men in machines or in airplanes or on foot up to get them. I have certainly been pleased at the way the program developed.

Helms: When you started out, you said that there were four of you working, generally under McLaughlin, who was head of the Division of Irrigation.

Work: Yes.

Helms: Now how did the shift come where you eventually ended up with general supervision for the West?

Work: I think it might be 1944.

Helms: They had a reorganization, and you were generally put in charge, is that right?

Work: Well, Parshall was dead. Jim Marr was getting ready to retire. Lou Jessup was dead. I just fell into the job.

Helms: So you hired people like Morlan and a few others?

Work: Yes. I could tell you about the day we hired Tommy George. He had a little 3-year-old daughter, and she sat on my knee while I interviewed Tommy. If you see Tommy, you can tell him that it was his little daughter that was responsible for his getting the job.

Helms: The guys in the different States were in charge of issuing releases, dealing with the news media, and so on in their area, for these forecasts?

Work: Yes. We were pretty highly decentralized. I understand perfectly the need to centralize snow survey work under SNOTEL. I understand that perfectly. But in those early days, we believed it was more practical and more profitable in terms of public relations to decentralize. Give each snow survey supervisor lots of latitude. I think it was a profitable position to take because they weren't restricted by, you know, regulations superimposed upon them by someone who didn't know very much about the business.

That was something I always liked about SCS. SCS gave us enough rope to hang ourselves.

Helms: You mentioned the program that you were doing on the snow forecasts for recreational skiing. What other sort of major landmarks do you remember in terms of the expansion of uses of the snow survey from water forecasts?

Work: The snow survey data began after about 20 years of accumulation. It began to be sought after by architects and builders for the information it provided in snowload analysis on building. Tommy George knows quite a bit about that. If I recall correctly, Tommy George put out a bulletin on snowload, a paper on snowload policies. Snow survey records are widely used in projecting or developing ideas of how much snowload a building might have to carry in mountainous areas. That was one thing. Snow surveys were indirectly involved in cloud seeding activities way back in the early days.

Helms: When you say indirectly involved, what do you mean?

Work: By not conducting cloud seeding, but conducting analysis of the success or failure of some particular cloud seeding operation. Way back in the early days, there was a cloud seeding project undertaken right here at Medford [Oregon]. A couple of fliers dispensed dry ice. Now, you have to admire those men because they only flew when most pilots would rather be on the ground, when conditions, they thought, were suitable for seeding. It was stormy—the old black clouds up there. Then these men would go up there in their airplanes. They did have one crash. But at any rate, Bob Beaumont was on our staff here at Medford. The irrigation district asked us to analyze the project to tell the district whether it was a success or otherwise. So Bob Beaumont performed that analysis. It was Bob's conclusion, and I certainly supported it, that the cloud seeding was successful, but they missed their target area by 100 miles. The cloud seeding succeeded in increasing the snow cover over around Bend, Oregon, more than would be expected statistically. That was all gravy for the water users at Bend. But it didn't help the local irrigation district, so that project was discontinued.

Helms: Who was financing that?

Work: The irrigation district. Cloud seeding is still practiced at Medford for the dissipation of fog at the airport. It does work well in dispersion of the fog. It coalesces those little particles.

Helms: It's highly dependent upon the temperature for rain or snow to fall.

Work: On a typical cloud seeding project for the purpose of increasing precipitation, yes. That's one of the problems.

Helms: You said Gregory Pearson got involved in that somewhat?

Work: Yes, there were a lot of sidelights to the snow survey. That's right.

Helms: Any recollections of the fisheries people becoming interested in the data, when the water was going to be high?

Work: No, I don't. But we know they do. But I can't give you any specific illustrations. We know they do.

Helms: Any other uses that come to mind?

Work: Let's take a look at Oregon's water supply outlook for April 1, 1989. Run your eyeball down the list of cooperators. Power companies, irrigation districts, soil conservation districts, you name it, they are there.

Helms: How did that work with Bonneville Power over the years?

Work: You would have to talk to one of their staff up at Portland. But that Columbia River system has become so complicated now. With reservoirs on the main Columbia and reservoirs up on the Snake, it is very complicated. There is a grouping of people who have to operate that river.

Also, Bonneville Power is in the game. I can't tell you if they do their own forecasting—it would not surprise me if they do. But it's an interagency, a multiple-agency deal. The Corps of Engineers, Bonneville Power, Bureau of Reclamation, the International Boundary Commission—they are all concerned with it.

Helms: You mentioned a couple of personalities. You mentioned Homer Stockwell. I know you hate to leave anybody out—are there certain personalities you'd like to mention and their contribution to the program?

Work: Yes. Let me mention Ashton Codd. Ash Codd was a graduate mining engineer from the University of Nevada. Ash made snow surveys for Doc Church—way back when Church was sending his men up on Mount Rose. Then Ash joined forces with the Weather Bureau, and he began work with J. Cecil Alter, the meteorologist for the Weather Bureau, back at Salt Lake City. They were trying to develop a rain gauge, a precipitation gauge that would work in high country. Ash even took this gauge up to Alaska. Actually, the only successful gauge ever found for use in Alaska was the one George Peak of SCS developed, the Wyoming gauge. Our snow survey supervisor in Wyoming developed that gauge. Anyway, Ash came over, and he accepted an appointment in snow surveys.

James E. Church Papers, Special Collection, University of Nevada Library, Reno

4.3 Edgar Boardman (left) and Ashton Codd having lunch during snow survey. Grant peak, west of Verdi, Nevada, Spring 1923

Ash was the one who promoted application of electronic computers to snow survey computation. He was the snow survey supervisor in Montana, stationed on the campus of the Montana State University in Bozeman. He had access to a computer on that campus. When Ash discovered the versatility of that computer and its usefulness in his program, he naturally wanted to share that with all his colleagues. So we held a school on the campus of Montana State University.

Helms: About what time?

Work: It must have been about the mid-1960s. Well, I will tell you. This school lasted several days, and those snow survey supervisors, they just took to that like a bunch of ducks to water. So from there on, we began to use computers in snow surveys instead of slide rules and schoolboy arithmetic. That was only one of Ash's contributions.

There was another contribution that Ash made to the program. As the forest canopy grows, it can and does affect the snow catch on the snow course, depending on where they are located. Ash developed what he called the pin-hole camera. It was just a $5 box camera, and he modified it so that it would take a 360-degree picture. So Ash began making these canopy measurements. He developed a little apparatus for gauging the encroachment of canopies. When this camera was held at the very same spot and oriented exactly the same way, he was able to keep track of canopy encroachment on a snow course. It was pretty darned important if you happened to have a snow course that had a canopy problem. So Ash began making these cameras and furnishing them to his colleagues, and he developed their film for them. Using his canopyometer device would give them a numerical reading for canopy coverage at every point on the snow course. After he retired, he set up a darkroom in his home in Pacific Grove, California, and continued developing the film and the readings for the snow survey supervisors.

He was that kind of fellow, Ash. Well, the snow survey supervisors were a real bunch of individuals. That's about the way I'd put it, a real bunch of individuals. It would be pretty hard to put another group together like that. They all had different backgrounds. We welcomed that. We liked it. Beaumont was a meteorologist. He graduated from the University of

Washington. Stockwell was an agricultural engineer. Codd was a mining engineer. Jack Frost was a biologist. Jack Wilson was a graduate in forestry, and so it went. A group of men with diverse training and diverse backgrounds, but always with a common objective and a common love for their job.

Helms: Were you trying to collect different people, or did it just sort of happen?

Work: I hired some of them. But in some cases, the State Conservationist or the State staff would select somebody. But very few men left the program, very few. A few did. I hope they improved themselves—I'm sure they did.

Helms: Were you generally pleased with your support from the State Conservationists? You mentioned earlier that the people from the national headquarters supported the program. Did you generally have good relationships with various State Conservationists?

Work: In general, yes. I suppose there were some personalities.

Helms: The snow surveyors and supervisors in the Western Snow Conference were at one time with the American Geophysical Union. Could you tell us why you split off?

Work: Well, when the Western Snow Conference originated and held its first meeting in Reno, the name of the conference was the Western Interstate Snow Survey Conference. It was hosted by Dr. Church, and the proceedings were published of that first meeting. That was in 1933. Those proceedings are in our little library up there. It will give you some excellent historical information about the people who were there at that formative meeting.

Later on, the Western Snow Conference began to flower and mature a little. It had grown considerably. We had been closely associated with the American Geophysical Union [AGU]. We were not technically as advanced as the AGU, but many of us that belonged to the Western Snow Conference also belonged to AGU—kissing cousins, you might say. I can't tell you the exact year, but later on, the AGU became perhaps a little more professional in its acceptance of papers and information for the meetings. The people who made up the body of Western Snow Conference were practitioners, they weren't theorists. So it wasn't exactly a schism, but the people in the Western Snow Conference decided that they would go their way and split off from AGU and let AGU go as it would, and that's how the division occurred. Then the Snow Conference became more technical, too. So it started the publication of a little booklet called the *Snow Surveyors Forum*. The *Snow Surveyors Forum* was open ground for the snow surveyors themselves, the men who went on their skis or snowshoes way up there to get the records. All kinds of interesting personal reminiscences appeared in that *Forum*.

Helms: Were there ever any differences of opinion over how to do things between your snow surveyors in the field and those of you who were collecting the information?

Work: Aside from matters of policy, no, I don't recall any. We were a team.

Helms: We didn't get into the matter of your research on Mount Hood. You used the term lab. Was there physically a lab or just an open area where you did your work?

Work: We had a special use permit from the Forest Service to conduct experiments in that area. The area was a forest opening so located that we could get to it in the summertime with a pickup truck, and we could get to it in the wintertime with a snow machine. We had this idea that a snow course has weight. If we could weigh the snow in places, it might give us a tool as a substitute for making these long trips to measure the snow. I remember quite well the first apparatus that we built. It was a big platform, about 10 feet square, that rested on two of these big butyl rubber farm fertilizer pillows. From that we realized that we could weigh the snow. But the platform idea wasn't too practical. We thought we would get exactly the same result from a butyl pillow. Bob Beaumont arranged with some commercial company to build a butyl pillow. It was about 10 feet in diameter. We prepared a bed for that pillow by leveling the ground, and we covered it with sawdust. We put the pillow on the sawdust, and we connected the pillow to glass nanometer tubes nailed to a tree. The pillow, when filled with glycol, was about 4 inches thick.

Later, we built a shelter house because we went from the nanometer tubes to a recorder. The recorders, of course, recorded everything that happened on that pillow. We began determining when snow fell, when there was snowmelt, the snow water equivalent, and so forth from the recorders. Then we got hold of a pressure transducer and hooked that in to the pressure line from the pillow, and the transducer converted pressure readings into electrical impulses. We sent those by radio direct line-of-sight down to Portland. We put an aerial up on the Post Office building, and we picked up the transmissions. We transmitted originally by shortwave radio from the site on Mount Hood down to the office in Portland.

Then we expanded that the next year to, as I recall, some different sizes of pillows. I think it was after my time that the boys went to metal pillows; although, I am not too sure about that. We might have had a metal pillow or two up there in 1964. But anyway, that's the way it developed. It was after my retirement that the snow surveys really got into this fantastic meteor-burst telemetry.

Helms: I am wondering, it sounds like I'm jumping around, why is it that the soil moisture monitoring never quite panned out?

Work: I thought it did. That was one of Homer Stockwell's brainchildren. We made wide use of those thermocouples in gauging soil moisture. Because the moisture content of the watershed soil mantle has a great deal to do with the amount of water that the snowpack delivers to the streams. In other words, if the soil mantle is dry, it can hold quite a bit of moisture. That moisture is going to be held in the soil now. It won't go into the streams. It does become necessary to assess the condition of the watershed soils.

Helms: I think what I was referring to was not that it wasn't valuable, but that some of the other fellows have been explaining the difficulties they had with the equipment and the maintenance of the equipment to do the monitoring.

Work: Yes, it's just like if you drive an automobile, you may have some problems. You don't have to be a mechanic to run an automobile, but sometimes it sure helps.

Helms: This is a general sort of question covering a long timespan. You got started in 1935 working on coordinating things, with very few people. Can you give us some examples of the growth with respect to the information provided? A maturing of the program?

Work: Yes. Let me offer you a specific example of cause and effect in that snow survey program. Along about 1945, give or take a year or so, we received a phone call from Laselle Coles, the manager of the Ochoco Irrigation District in central Oregon. There was an inordinately heavy snowpack on the snow course at Ochoco Meadows. Laselle was concerned about the safety of his dam and spillway. Now, the board of directors of the Ochoco Irrigation District had, more years than not, failed to see that reservoir filled. Laselle wanted to start draining water out of the reservoir, and the board of directors said, "Nothing doing." The reservoir doesn't fill very often. Laselle called us and asked us for any advice we might be able to give. We only had 6 or 7 years of records of the snowpack at Ochoco Meadows above the reservoir. Jack Frost and I were working together. We made an analysis. Our analysis showed the reservoir would unquestionably overfill. There was no doubt about it, even with our limited data. So we sent our analysis and our recommendations over to Laselle, and it was then that his board of directors, maybe reluctantly, said, "Okay, you can reduce the contents of the reservoir." So Laselle opened the outflow gate, and something broke in the gates, in the outflow system. The water level in the reservoir could not be lowered except by a dribble. Well, Mother Nature dealt the cards. That reservoir overfilled, and the excess water started rushing down the spillway. It started eroding the ends of the spillway, and big hunks of concrete started falling off in the spillway. Charlie Stricklin, who was then State Engineer of Oregon and had police power on all Oregon dams, ordered a 24-hour guard be established on that dam, which took place.

The flow finally subsided, and the spillway stopped being eaten away. So the situation finally solved itself. Laselle Coles later became the president of the National Reclamation Association, and the National Reclamation

Association supported snow surveys through thick and thin, high water and low water.

Helms: Anybody in particular that comes to mind that maybe deserved more credit than they received in the origins of snow surveys?

Work: Dr. Church is generally considered, and rightfully so, the father of snow surveys. But there was an engineer who worked in Dr. Church's shadow, so to speak, H.P. Boardman, head of the Engineering Department at the University of Nevada, who I have always believed was entitled to quite a large share of the credit for the early pioneering in snow surveys.

Helms: What were his contributions?

Work: Well, I think he developed the forecast formulae and so forth. Dr. Church was the visionary.

The foregoing material was reviewed by R.A. Work on October 25, 1989.

R.A. "Arch" Work
October 1981

by
Jeffrey LaLande
Forest Archaeologist of the Rogue River National Forest
(now the Rogue River-Siskiyou National Forest, Forest Service)

Jeffrey LaLande: Would you tell me something of your early life, where you were born and raised, and where you were educated.

Arch Work: I was born in Denton, Texas, in 1904. My father was the founding president of what is now the Texas Woman's University, a very large institution.[1] We came to California when I was a young boy. I went through high school in California and graduated from the University of California in irrigation in 1927. It took me several years to graduate because I worked my way through. I dropped out occasionally to work.

LaLande: At Berkeley?

Work: Yes, I graduated from Berkeley, but I spent much of my time at what was called the cow college, at Davis. After graduation, my first employment was with the Miller and Lux Cattle Company, the huge western land and cattle operation. At that time, I think it was the largest cattle producer in the United States. That was the Double H brand. I left them after 2 years and accepted employment with the Division of Irrigation of the Bureau of Agricultural Engineering, in the Department of Public Roads, as an assistant irrigation engineer. I was sent to Medford, Oregon, on my first assignment to make a drainage survey of the Rogue River Valley.

LaLande: What year was that?

Work: It was in 1929. I've resided in the Valley, except for a period of 13 years when I was in Portland, since that time. We initiated some irrigation experiments in connection with some of the drainage problems that we

1 Cree T. Work was president of the Girls Industrial College of Texas, 1903–10.

found. We established the Medford Irrigation Experiment Station in 1931. My colleague was Dr. W.W. Aldrich. Now in 1934, we had a very severe drought in the Rogue River Valley and elsewhere. As I recall, water ran out on the 4th of July on the main canal of the Medford Irrigation District. No more water for irrigating after the 4th of July.

LaLande: So Fish Lake was dry?

Work: Oh yes, there was no further source for irrigation water. The reservoirs were drained. Well, there was considerable economic loss, to the fruit industry particularly, that year. Now we had heard of the science of snow survey, which is the practical means of the measurement of the actual amount of water stored in the mountain snowpack, relative to the subsequent discharge of the streams. That program in Nevada was initiated by Dr. J.E. Church, who was the Professor of Romance Languages at the University of Nevada. But this was a hobby of Church's. He made his first snow survey, we're told, in 1911. We'd heard of his work.

LaLande: Was this really the first snow survey to have ever been done anywhere, that we know about?

Work: No, the very first snow survey was done by an engineer named Charles Mixer in one of the New England States in about 1904. It was for the purpose of utilizing the water supply by the paper mills [for pulp-log drives].

LaLande: So the idea of the snow survey is definitely a 20th century, American development?

Work: That's right; as far as I know, the snow survey originated in this country. Well, so we people at the Experiment Station decided that we would initiate some snow surveys for this Valley. Well, the State Engineer of Oregon, Charlie Stricklin, did initiate some snow surveys in 1933, by the Corps of State Water Masters. But, no snow surveys were made in 1934. In 1935, a congressional committee, actually a senate committee, in response to requests from western water users, decided that some Federal agency should be assigned the responsibilities for coordinating the snow surveys that were then being made in Oregon, Wyoming, Nevada, Utah, Montana, and California, on many interstate rivers. So they called in the Forest Service, also what was then the U.S. Weather Bureau, and the Bureau of Agricultural Engineering [BAE] to decide which of these three agencies should carry this responsibility. This effort was initiated by then Senator Steiwer of Oregon. The gentleman from the Forest Service was the Acting Chief Forester, Mr. Clapp. I don't recall who represented the Weather Bureau, but the gentleman from the Weather Bureau said, "We believe that this is an activity for engineers," and Mr. Clapp said, "If this responsibility is assigned to the BAE, the Forest Service will support that agency in this activity." So on July 1, 1935, this became a responsibility of the BAE, in the Department of Agriculture, and I'd like to say, Mr. La-Lande, that without this cooperation and the unremitting support of the Forest Service, I doubt if this project would ever have been as successful as it has proved to be. That cooperation extends right down to the present time, and it was all on the basis of a handshake in 1935.

Well, I initiated snow surveys in the Rogue River Valley prior to the time we were given that responsibility. I recall making a ski trip from Fort Klamath into Crater Lake National Park on the 5th day of January 1935, to make a snow survey at Crater Lake. Subsequently, I made trips, some-

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4.4 Snow survey research station at Crater Lake National Park, March 1942

times alone or with a companion, into the Seven Lakes Basin [Sky Lakes Wilderness, Rogue River National Forest], over into the Siskiyous and so forth. Well, at any rate, we gradually established a system for this Valley of measuring the mountain snow in order to predict the water supply that would be available for agricultural, domestic, municipal, and power-generating interests. Bill Childreth and Jack Miller made many of those early-day surveys.

LaLande: How did you decide where the best places were to put a snow course?

Work: Well, that's kind of technical. Let me put it this way, in the Western States, approximately 85 percent of the summer irrigation supply originates in the high-mountain snowpack. Now, the mountain snowpack is concentrated at the highest elevations, but those places were often fairly inaccessible. So we developed motorized transportation; we used helicopters; we used conventional ski-equipped airplanes to get to many of these places, but through most of the early years, the job was done the hard way, by tough men on skis and snowshoes. So we had to provide shelter facilities for these people. We usually tried to place these cabins about 16 miles from where you had to start skiing, on the trails. Because a man on skis with a loaded pack, and when the snow conditions aren't good, does well to make 16 miles in a day.

LaLande: All the measuring equipment and so on had to be packed in with you?

Work: Yes, the surveyor carried his measuring equipment, a little emergency rations, usually a long-handled axe, and generally a candle or pitch, some pliers, some bailing wire, maybe a poncho, whatever you need for a cross-country trip.

LaLande: You spoke of the cabins just now. That brings up a subject I'd like to hear more about—the snow survey cabins here on the Rogue River National Forest. To my knowledge, there were only four, no five, Soil Conservation Service [SCS] snow survey cabins on the Rogue: the log one at South Lake in Seven Lakes Basin, the log one which replaced it at Honeymoon Creek, the log cabin at Whaleback Mountain on the Rogue-Umpqua

Divide, and the shake-and-pole cabins at Wrangle Camp and Grayback Mountain on the Applegate.

Work: Yes, that's right, but I don't know anything about the Grayback cabin because that was built after I transferred to Portland.

LaLande: What year was that?

Work: Well, I was put in charge of the snow surveys for the Western United States, back in about 1938, and we moved our headquarters to Portland a few years later [ca. 1942], in order to be in closer contact with the other Government agencies we cooperated with.

LaLande: Before that, was the headquarters of the entire Western States' snow survey program here in Medford?

Work: Yes, it was for several years.

LaLande: I had no idea. Where was your office in Medford?

Work: At the Experiment Station, on the old Billy Budge orchard, a couple of miles south of the Medford city limits, south of Stewart Avenue and east of King's Highway. We used a shortwave radio to keep in touch with some of our people. Well, as to these cabins you mentioned, the first one we built was on the north shore of South Lake [Seven Lakes Basin]. A gentlemen by the name of Alvin Copeland and I went in there to do the snow survey the first January following the time the cabin was built [1935]. We skied about 16 miles that day and got into the cabin site a little before dark, but we couldn't find the log cabin. We knew where the cabin was supposed to be, and we feared that maybe some hunters had burned it down. But, at any rate, we got our snow tubes out, and we went to where we believed the cabin to be and started sounding. Sure enough, we hit wood. We kept sounding until we came over the ridge pole of the cabin roof; then we sounded out the ridge pole until we ran out of ridge pole. Then we started digging, with our skis and with our hand axe. We had a little door up in the gable. We dug a hole down 11 feet to get into that cabin., and, after we got into the cabin, of course, we couldn't start a fire. We had put on top of the roof jack a metal plate to keep the snow out. I happened to have an old .38 pistol with me. So I shot some holes in that metal plate and then jammed the snow sampler up through it, clear to the surface. Well, then we were able to start a fire, and we laid down on the floor because it was pretty smoky. But eventually, the heat from the fire got a pretty good draft going, and we were well insulated. The upshot was, the next year we put a chimney entrance [an enclosed tower] on the cabin, and then could climb down the ladder through the wooden chimney into the cabin, underneath the snowdrifts.

LaLande: Was that what they called the Santa Claus chimney?

Work: Yes, that was it.

LaLande: You were personally responsible for inventing that particular innovation?

Work: Yes, as far as I know, that one at South Lake was the first such cabin that had a Santa Claus chimney. We built several others like it later.

LaLande: Yes, I know Whaleback cabin has a wooden snow tower like that.

Work: Yes, we built several of them. We built the cabin at South Lake in the fall of 1935. Then the next one was at Wrangle Gap. There was a CCC [Civilian Conservation Corps] camp there. I think the cabin at Whaleback was built about 1937–38.

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4.5 Arch Work on a Santa Claus chimney entrance, Crater Lake National Park, 1945

LaLande: I've been inside the Whaleback cabin, and there's a penciled inscription on one of the wall logs that reads, "October 28, 1937." I had to climb down the chimney because the main door was locked.

Work: Yes, then that must have been the year we built it. The thing about that cabin was this: We used to buy wood stoves for these cabins from the California-Oregon Power Company. I remember they'd sell us a dandy wood stove for $5. So when we built that cabin, there was an unusually large stove that wouldn't go through the door. So after we laid three rounds of logs, we set the stove into the cabin and hung canvas over it to keep the dirt and grit out of the cook's preparations, and then we built the cabin around the stove.

LaLande: Well, I guess it's the same stove still sitting there—a pretty good way to prevent someone making off with it. The Wrangle cabin, that one is lumber frame with shakes.

Work: Well, sure, 'cause we had a road we could bring the stuff in on.

LaLande: But you didn't feel the need for a Santa Claus chimney at Wrangle?

Work: No, it was kind of a high structure, you know. We had a little door in the gable [near the peak of the roof]; we didn't really need a chimney there.

LaLande: So the reason some cabins have the chimney and others don't is simply the varying conditions, the lay of the land?

Work: Yes, where the snowpack was deep, we put on the chimneys; where it wasn't so deep, we tried to get away without it. We just put in the little gable-end doors near the roof.

LaLande: So Wrangle cabin was definitely built the same year that the Civilian Conservation Corps [CCC] was building the big community kitchen shelter up there?

Work: Yes, very definitely, because I remember the Three-C boys were working all around us up there. These lads were from New Jersey. "New Joizy," you know. I remember that some of my men and I were cutting some boards, and I overheard one of these CCC boys say to another, talking about me, "Gheez, look at dem guys woik!" and the other says, "Dat guy's name is Woik." [laughs]

LaLande: So these Civilian Conservation Corps fellows were definitely new to the area, but they seemed to do a good job on building the community kitchen shelter up there.

Work: Oh yes, they did nice work. Many of them were good workmen. They were enthusiastic. I think that it was a great program.

LaLande: Yes, it's rare to find that quality of work, craftsmanship, out in the woods anymore. Do you know anything about the background of the Honeymoon cabin up in Seven Lakes Basin?

Work: Yes, I do. I didn't recognize the name. Jack Frost, Dwight Houghton, my 11-year-old son Bob, one other person, and I built that cabin, somewhere around 1943.

LaLande: Was Jack Frost really his name?

Work: No, his real name is Wilfred T. Frost [laughs], but he was known as Jack. He was the snow survey supervisor for Oregon after I left to supervise the westernwide survey activities. He came from the National Park

Courtesy of Jeffrey LaLande, Forest Service

4.6 Snow survey shelter sign at Honeymoon Creek, Rouge River, Siskiyou National Forest, Oregon

Service as a ranger. I hired Jack away from the Park Service in, I think, about 1942. Jack's been retired for several years now. But he and his wife Hope visited my wife Jane and me just a week or so ago. He looks well.

LaLande: Were there any other snow survey cabins in the Rogue drainage besides those we talked about?

Work: Well, there was an old cabin called the swamp cabin, on the east side of the Cascades, about two-thirds of the way into Seven Lakes.

LaLande: Would that have been at Seven Mile Marsh?

Work: Yes, it was an old trapper's cabin. We called it the swamp cabin. It was near the trail, but maybe there's a road there now. Well, we built a lot of cabins in this State and, of course, in other States, too.

LaLande: Did they follow a similar plan or standard design? In fact, I've got the original plans with me for the South Lake cabin. Let me get them for you.

Work [looking at copy of blueprint]: Well, sure enough. George Michealson drew those plans. It was a small cabin, but it was a lot easier to heat that way—12 1/2 feet long and about 10 feet wide.

LaLande: I noticed that the Whaleback cabin has exactly the same floor plan and dimensions. The stove, bunks, and table are in the same place. The windows and door are all in the same location as these plans. So I just wondered if this was a standard plan that the BAE followed.

Work: No, it just happened that way in this case. We'd just build them out of our heads, more or less, depending on what material we had, how many men we had, whether we had horses to haul the logs, or if we had to haul them ourselves. But we did build them small, just for two men. That's all the men a snow survey usually involved. They're a lot easier to heat when they're small and a lot easier to build. I remember a local Boy Scout troop was given the project of tearing down the old South Lake cabin a while back [ca. 1960s]. One of them was the son of a friend of mine, and he brought back a piece of one of the logs with my name written on it. I'd left my name the second year [inscription reads "Arch Work, Andrus Smith, Jan. 4, 1936, Blizzard;" the other names on the log fragment include Dwight Houghton, Vie Sisson]. Vie Sisson and Harry Kallandar from the Klamath side, we hired some fellows from the Klamath side that had a dog team to go in there and measure the snow some years, sled dogs.

LaLande: That's a really nice keepsake.

Work: Yes, I keep it in a drawer, but it's kind of nice to have. It's all that's left of that old cabin. I'd been down that chimney more than once.

LaLande: When you arrived at these places in the winter, would you find that some four-legged critter had taken up residence inside?

Work: No, never did, except pack rats. We built a cabin on Buck Mountain, down near Medicine Lake, California. We had a bear that kept coming there every year. The son of a gun would tear off the shakes, but he never got into the cabin. So we finally put up corner boards with sharp nails sticking out, and that kind of discouraged him [laughs], for 2 or 3 years.

LaLande: That brings up another question, personal reminiscences of your snow survey experiences. There must have been a fair number of interesting stories that were told—people getting lost or stranded. Were there occurrences like that which you recall?

Work: Well, anybody that has personally made snow surveys—and I made a great many, in Utah, Montana, Wyoming, Colorado, Arizona, Alaska, Turkey, and Iraq—you're bound to have some experiences, if you lived to tell of them. I think one of the most tragic incidents that I had any personal knowledge of was the death of District Ranger Wilhelm in the Humboldt Forest. He and his companion were trapped by an avalanche. Wilhelm was killed; his companion, Dale Rodies, was very severely injured. But he did make his way out to get a rescue party in there. I investigated the site a year or two later. There have been a few deaths in the snow survey activity, but we always stressed safety, and we gave training programs to our people. We gave programs regionwide and State by State. Our men were trained in survival, they were trained in first aid, and they were very particularly trained in avalanches. The man that trained our people in that particular activity was Monte Atwater. Monte was the former Forest Service avalanche ranger at Alta, Utah. He was a very close friend of mine, a great guy. There was one time period in which our surveyors traveled 1,000,000 miles, mostly by ski or snowshoe, without a single death. I recall a number of rescues and so forth [laughs]. I remember this one man up at Diamond Lake. George Howard was running the Diamond Lake Resort at that time. We got a radio call from our man that he was feeling real sick and had to be taken out. George said, "Yes, we'd better go get that guy." So we took George Howard with us in our Sno-Cat, went in there and got the man.

LaLande: Was this pretty much the same piece of equipment as today's Tucker Sno-Cat?

Work: Yes, it was an early model, of course. I bought the second Sno-Cat that Tucker ever built.

LaLande: The Tuckers were a local family, weren't they?

Work: Well, yes, they were a local family, and they were real individuals. Nice people, but the elder Tucker got mad at somebody in Medford, so he moved his shop to Grass Valley, California. It was at Grass Valley that I bought this Sno-Cat. It was a remarkable machine. We named that Sno-Cat "Chinook," the word for "snow eater." I drove it in Montana, Wyoming, Arizona, all over Oregon in the wintertime. In fact, that's the machine that we used on that National Geographic trip, where we went from the summit of Green Springs [near the California-Oregon border] to the Columbia River one winter, in 1948.

LaLande: That was a winter trip, along the route of what is now the Pacific Crest Trail, the crest of the Cascades?

Work: Yes. We left the Siskiyou Summit on the 15th of March 1948; and I told the boys, "This is a good time of year to go. The heavy snowfall's over," and, gosh, I couldn't have been more wrong. It snowed 10 feet on us on that trip—took us 23 days.

LaLande: This was sponsored by the National Geographic Society?

Work: Not really, but the National Geographic sent a photographer and writer along. It came out as an article the next year. What led up to that was that National Geographic sent a writer to Medford in 1946, a writer by the name of Borah, a relative of the Idaho senator [William Borah]. He got a hold of me and asked me to take him to Crater Lake. I did. I took him up there in the Sno-Cat. Of course, he was impressed to no end by the beauty and solitude of Crater Lake in the middle of winter. They didn't keep the roads open in those days. That was what led to National Geographic's interest in this trip. Well, I wanted to make the trip to see if it was practical to survey our snow courses all as part of one trip. We had snow courses scattered along the whole crest of the Cascades, and we sent men on up these side drainages from the east or west, from the valleys below. I kind of speculated and wondered if a Sno-Cat team could just go along the crest and measure all those courses. But it took too much time. Snow surveys have to be made within a certain time period. Well, that's all beside the point.

LaLande: No, it's fascinating.

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4.7 Snow surveyor utilizing Tucker Sno-Cat in Crater Lake National Park, Oregon, April 1945

Work: Well, anyway, getting back to this story about George Howard at Diamond Lake. We thought the caretaker was sick, so we hauled him out. The guy was later down in town, at the barbershop the next day, bragging about how he'd been able to get us to bring all his winter furs out. He'd done some trapping and stuffed the pelts down inside his clothes and gear [laughs]. Well, we felt a little stupid after that, but, after all, when you get a call for help ….

LaLande: Whom did you hire? What kind of people did you hire to do your surveys? Were they just anybody with some backwoods experience? Or was it someone who actually worked regularly for the BAE or SCS?

Work: The Forest Service furnished many of our snow surveyors. The Forest Service made many of the surveys because they had people located at a ranger station and so on, near to the snow courses. Those were competent, capable people. We were delighted when we could find a Forest Service employee that would do the job. But we did employ a lot of private people—ranchers and so on. The power companies furnished some people and so did irrigation districts throughout the West. It was a physical job, believe me. We hired people where we weren't able to find a cooperator who was able and willing to send somebody up to do the survey.

LaLande: What was the pay?

Work: Four dollars a day, and a day seldom exceeded 16 hours [laughs], and all they could eat at the cabin.

LaLande: Who supplied the food in the cabin? The Forest Service?

Work: No, we did. We stocked them each fall, after the hunters went home.

LaLande: Did you use horse teams?

Work: Well, I remember in the case of the Shasta National Forest [California], we used to borrow the Forest Service pack string. They had the slickest pack string of mules: Hattie, Pattie, Battie, Mattie, and Mike. Five mules. Mike was the jack, and the rest were jennies. That damned Mike

114G–ORE–40170 National Archives, College Park, Maryland

4.8 Pack train carrying supplies to shelter passes the Upper Seven Lakes Basin Snow Course Marker, South Umpqua River, Oregon

could pack 300 pounds. They could get a little fractious, you know. You had to show them who was running the show. That was a Forest Service pack string. But, otherwise, we would use private packers.

LaLande: What were the general duties of someone during the snow survey? What kind of things were done on a typical snow survey—tools and what not?

Work: Well, the snow surveyor carried a snow sampling set with him. These snow sampling sets, for areas of deep snow, consisted of six sections of tubing, each section 30 inches long, and they had couplings so that they could be screwed together. They had a scale which weighed in ounces. The first section of tubing has a very sharp, serrated, tempered-steel cutting point that will cut through ice. The inner diameter of that has to be very precise: 1.4865 inches, as I recall. If you cut a core of water of that diameter, each inch of water will weigh 1 ounce. Hence, when they cut a column of snow with this tube and then weigh it, the difference between the empty weight of the tube and its full weight with its snow core, in ounces, equals the number of inches of water in the snow at that point. It was the water equivalent of the snow that counted, not the depth as such. It's the amount of water in that snowpack. You can have a deep snowpack, but with a relatively low water equivalent.

LaLande: Now, when you say an inch of water, you mean …?

Work: A surface inch, an inch of water on the land surface.

LaLande: So it wasn't anything like a miner's inch or a specific irrigation measurement?

Work: No, no. It was actual surface inches. Let's illustrate it this way. Suppose we had a snowpack 20 feet deep, and we measured it with our tubes, and we found 40 inches of water in that snowpack, which, by the way, would be mighty light snow. In 20 feet of snow, it would usually be more like 10 feet of water, which would be a 120 inches. In other words, if that snowpack, by some Mount St. Helen's explosion or an A-bomb or something, were to instantaneously melt, you'd have 120 inches of water there, going to go somewhere downhill.

LaLande: So they'd take a section of tubing and pound it into the snow?

Work: They had a clamp handle that went on it. In quite deep snow, one man would put his hands on his companion's shoulders and balance himself, so he wouldn't bend the tube. He'd get those handles under his feet and push it down. It was a pretty small-diameter tube. It penetrated quite well.

LaLande: So the basic measuring was done with tubes and by weighing it. It was as simple as that, basically?

Work: No, not really. Sometimes you ran into situations that were hard to handle. For instance, I went into that Seven Lakes snow course one time, and I happened to be measuring it alone. My companion was sick, and I'd left him down in the cabin, and I only had six sections of tubing. That's a 108 inches and, by golly, I couldn't get to the ground with it. So what to do? I measured the upper 4 feet of snow, the water equivalent in that, and put the tube back down the hole, went back to the cabin and got a shovel. I then dug a hole 4 feet deep and got down in the hole, and then I had enough tubing to get to the ground. Took me all day to take six samples there. Normally, we'd take 10, but I just didn't have the time.

LaLande: How were the samples distributed?

Work: Well, on the usual snow courses, they're either 50 feet apart or 100 feet apart. The average snow course has 10 sample points, and the end points, and sometimes the midpoint, are marked by a steel pole. You've seen them probably.

LaLande: With the USDA SCS shield symbol on the top?

Work: Yes, that's it. Set in concrete. The surveyor either tapes the 100-foot distance from one point to the next or, if he marks his skis appropriately, he can use his skis. So these samples are taken the same time every year, at the exact same points, within the diameter of a circle of about so [approximately 20 inches], virtually the same spot every time a survey's made.

LaLande: So are they taking a compass line from one of these poles?

Work: Well, if you just head straight on skis, you're going to do pretty good. Often, there are three poles, one at the midpoint, that keeps you right on line, that always gives you two to line up on. Then, there is summer maintenance work on the courses. Got to cut out the vine maple and keep all the points cleared of brush and take care of shelters. Well, of course, we took soil samples, too. The moisture content of the soil has a great deal to do with the amount of the snowpack that the mountain soil will retain. We did that electronically, with sensor units buried at foot intervals.

LaLande: When did you begin doing that electronically?

Work: Oh, we began that about 1946 or so. Several years after that we established a snow laboratory on Mount Hood, which led to the development of the electronic snow survey. The men don't always have to go up there anymore.

LaLande: The SNOTEL?

Work: Yes, the SNOTEL, with a snow pillow with a pressure transducer on it and a radio which sends an electronic signal to a meteor burst that is then reflected to a station in Ogden, Utah, or in Boise, Idaho. Those things keep sending out information, and you can even interrogate them. They've got about 400 of those operating in the Western States now. We were silver medal winners on that one—some colleagues and myself.

LaLande: I've been to the SNOTEL at Wrangle.

Work: Yes, they've also got one at Hyatt Lake and several other locations.

LaLande: When did that electronic snow survey idea first become developed? Which ones were put on the ground first?

Work: Well, the first one we developed was at Mount Hood. At first, we didn't measure that one electronically. The first measurements we made were in a glass tube. We measured the height to which the methanol would reach when snow fell on the pillow. Later, we put in a recorder to keep a constant record. Later yet, we put in a radio and sent signals into Portland. That was in the mid-1950s.

LaLande: Now the SNOTELS are all over the countryside.

Work: Yes, there're sure a bunch of them.

LaLande: Did you have any problem with vandalism on those?

Work: No, just the bear, deer, and moose. That is, until they finally fenced them. There was nothing more that a bear would rather do than tear one of those snow pillows up. He'd say, "What's this? I wonder if there are any ants under there." So he pulls the pillow up and, zippo, it's gone. Of course, they make them out of metal now, but the first ones were butyl. But no, I don't think we've had guys shooting the pillows full of holes. But they do have to be fenced—have to keep the wild beasts off of them.

LaLande: When did the Bureau of Agricultural Engineering become part of the Soil Conservation Service?

Work: I believe that was in 1938 or '39.[2]

LaLande: What were some of the other duties of the old BAE, aside from the snow surveys?

Work: They had a great deal of research underway in the water requirements of plants. That's what I was actually working on at the Agricultural Experiment Station in Medford, before I got interested in snow survey. We had another group that developed methods of water measurement, advanced the methods. We had an agricultural economist by the name of Wells Hutchins who was considered premier by all of his peers. Then we had some fellows working on water spreading. Even if I do say it, those men were all leaders in their respective specialties. When Congress assigned BAE responsibility for the snow survey, all they gave us was $15,000 to carry out this program in all the Western States. Well, how are we going to do that? We had to get cooperation. We developed formal agreements with the States. We only had a handshake with the Forest Service, which endured, but we had formal agreements with the State Engineers of almost every Western State. They became cooperators. We had them with almost every agricultural experiment station. We got money from those people, or help, in lieu of funds. That was how the program began to grow, through cooperation. We were real penny pinchers, real poor. But there was a need for the activity, and those State Engineers appreciated it because they were concerned with the States' water through the water-rights system. Later, we found very strong cooperation with the Bureau of Reclamation and the Corps of Engineers, also Bonneville Power.

Not too long ago, the Federal Office of Management and Budget [OMB], under President Carter, undertook an in-depth study of the necessity of these snow surveys. The OMB dedicated $200,000 to the study, I was told, to hold public hearings and so forth, to determine if the activity should be terminated. Well, I happened to attend the public meeting in Medford, and I listened to the representatives of 43 different agencies concerned with

2 The Secretary of Agriculture by Memorandum 799 of December 3, 1938, effective January 2, 1939, designated H.H. Bennett, Chief of the Soil Conservation Service, to have charge of that part of the work of the Divisions of Irrigation and Drainage of the Bureau of Agricultural Engineering relating to investigations, experiments, and demonstrations on the construction and hydrologic phases of farm irrigation and land drainage including snow surveys.

water get up and tell the chairman that "no way" were these snow surveys to be terminated, that they supported them, and that they participated in them. They needed the results and used the results, and of all the Government activities, this was the one they did not want to see abolished. Then the administration accepted letters. I was told that about 99 percent of the correspondence that went back to Washington was affirmative. Well, that's the last we heard of it. It was swept under the rug. The snow survey could have used that 200,000 bucks to good advantage. But, at any rate, they got it off of their chest, and they did find that they did have a real economic, progressive, productive program that the people wanted. I think it's going to continue because water is becoming more scarce and valuable every day. As it becomes more valuable, it has to be managed as profitably and as efficiently as possible. So you have to have those basic tools and knowledge of how much water you're likely to have before you can even plan its management. Water is an asset, just like our forests, and it has to be managed accordingly.

DEED OF GIFT

I, acting for R. A. Work, do hereby give to the Soil Conservation Service the tape recordings and transcripts of his interview of May 12, 1989.

I authorize the Soil Conservation Service to use the tapes and transcripts in such a manner as may best serve the educational and historical objectives of their oral history program. I also approve the deposit of the transcripts at the National Agricultural Library and any other institution which the Soil Conservation Service may deem appropriate. In making this gift, I voluntarily convey ownership of the tapes and transcripts to the public domain.

Jane WORK
Name
JANE WORK

Jane Work
Signature

July 13, 1993
Date

4.9 R.A. Work Deed of Gift

Gregory Pearson
Salt Lake City, Utah
May 5, 1989

by
Douglas Helms
National Historian, U.S. Department of Agriculture,
Soil Conservation Service
(now the Natural Resources Conservation Service)

Douglas Helms: Just to start out, Mr. Pearson, could you tell us where you were born and raised, something about your early education through your college years, and your career in the snow survey?

Gregory Pearson: Well, I was born here in Salt Lake on October 26, 1915. I lived here just a few years, and then my family moved from here to Vernal, Price, and Sunnyside, Utah, then back to Salt Lake and up to Idaho Falls, Idaho, where I did most of my growing up, graduating from high school there in 1934. Then I went 1 year to the University of Utah, following which in 1935, I went on a mission for the LDS [Latter Day Saints] Church. When I came back from that in 1937, I worked for a short while and then went to Utah State.

At the end of the summer of 1940, I didn't have quite enough money to go back to school, and it just happened that the preceding spring quarter when I was at Utah State, I had taken a class in meteorology. At the end of the quarter, there was a Civil Service Commission examination for a junior observer in meteorology with the Weather Bureau, now the National Weather Service. I took the exam and forgot about it and worked during the summer on an extra gang on the railroad, across Nevada. Near the end of summer, I could see I wasn't going to have money enough to go back to school, so I came back into Salt Lake and got a job. Just before school started, the Weather Bureau called me up and asked me if I would go to work for them as a Junior Observer in meteorology in a little three-man weather station down in southwestern Utah. I was glad to take the job since it gave me money enough to get married. That was in 1940 and 1941.

At the end of 1942, I decided I had better go back to school because the war had started. I went back to Utah State University and then signed up to be an officer candidate in the Army Air Corps. At the end of that fall quarter, I was called up to report for duty. In February of 1943, I reported for basic training at Boca Raton, Florida. From there I went to Yale University, where I stayed and got my officer's commission. From Yale I went to a replacement depot and was sent to Abilene, Texas. In Abilene, we trained fighter pilots until the war was over in Europe. Then we were sent to La Junta, Colorado, to form a unit to go to Japan. When I was home on leave before shipping out, walking down the street one day, somebody's radio blared out the window that the war was over in Japan. I went back to La Junta and waited there until discharged. I returned to Utah, did some work at a bank and with the State road commission on a survey crew, then decided it was time I went back to school. So I went back up to Utah State, got my bachelor's degree in agricultural engineering, then my master's degree in civil engineering. When I received my master's degree, I was offered a chance to go to the University of Idaho in Moscow to teach, or to go work for the Bureau of Reclamation over in Oregon. While I was considering these offers, I received a phone call from the then Chief of the Division of Irrigation Research of SCS, George D. Clyde, who had formerly been Dean of the School of Engineering at Logan, Utah State University. He offered me the job of going to work in the snow survey program. I was happy to unpack things and stay where we were. That's how I got into snow surveys.

Helms: George Clyde was at that time in charge of research?

Pearson: He was in charge of the Division of Irrigation Research for the whole United States. Later he became Governor. I had a chance to work with him at various times, relative to snow. George D. Clyde was the one who started the snow surveys in Utah.

Helms: Can you tell me a bit about his becoming interested in snow surveys and in getting Utah involved?

Pearson: It was back when he was in the Experiment Station at Utah State that he became interested in snow surveys. He knew Dr. James E. Church when he [Church] first started to work over in Nevada. Clyde began the network here and made the first surveys in Utah. The first courses were laid out on the Logan River in 1923 and then measured the following winter. Clyde was the one who designed the snow cutter head still being used today. He was a moving force in the whole western snow survey program.

James E. Church Papers, Special Collection, University of Nevada Library, Reno

4.10 Western Snow Conference, 27th annual meeting, April 21–23, 1959, Reno, Nevada. Seated: James E. Church; standing: left to right) W.W. McLaughlin, George D. Clyde, and H.P. Boardman

Helms: What was unique about the cutter head?

Pearson: The cutter head formerly was a larger size. Clyde designed the size of the cutter head so that what would be an inch deep of water over the area of the cutter would weigh 1 ounce. So that made it very simple in measurement to determine what the water content of the snow core was—just weigh it in ounces, and it was automatically in inches of water. This was a much simpler method than they had before.

Helms: Which was?

Pearson: Just a different sized cutter head. I don't recall all the details, but formerly you had to have specially calibrated scales to determine the water content of the snow core samples.

Helms: What did you start doing when you came to work? Could you give us something of the flavor of the day-to-day work of snow survey specialists?

Pearson: The man ahead of me had only worked for 1 year. His wife didn't like all the traveling he had to do, so she talked him into quitting and going to California and getting a job there. The snow survey job required a lot of travel in both summer and winter, but particularly in the winter.

At the time I started, there was much more interest in water and the pressures that were coming on water supplies. It was obvious that those pressures were going to get greater as time went on and that we needed to expand both the snow course network and also increase the frequency of measurements. The basic need was to keep an inventory as we went through the winter season so that the water managers and users could make plans during the winter and not have to wait until the first of April, when most surveys were made, to know what the water supply was going to be.

Many things depended on having advance information. For example, all the farm implement companies needed to do their own planning. If it was going to be a drought year, they could tell that the farmers weren't going to have as much money to spend, and that the farm implement companies wouldn't be needing to build as many machines as usual to sell. It was obvious that a similar impact would be felt all across our society, such as we see in today's water supply. The water managers needed to know for electric power production. They needed to know the way dams should be operated. If it was going to be a flood year, they needed to draw the reservoirs down to handle the water, or if it was going to be a drought year, they needed to hold every bit of water they could. All aspects of this society, as you know, depend on water supply. It was at this time when we began to realize that we did have to have a continuing inventory as we went through the season.

Helms: So the number of people who recognized the value of having that information was expanding?

Pearson: That's correct, and so we had to start making more frequent readings and expanding the network. One of the first things I was asked to do when I started was....

Helms: When you came to work, you were in charge of the program for the State, right?

Pearson: The man ahead of me had given sufficient notice that when I started to work, he was able to give me 1 week of indoctrination, and then it was mine. So that week we spent together, he took me around the

State. We talked to some of the cooperators we had in the snow survey program and then he was gone, and it was mine.

Helms: I'll let you get back to your original line of thought.

Pearson: When I started, the only ones the snow survey supervisor had to help him, in addition to a few forest rangers, were a few water commissioners on some of the rivers and streams. There were Forest Service people who had jobs that took them into the mountains on other work throughout the winter, who also measured snow courses monthly. Forest rangers made surveys on April 1 only. So there was a need to expand the program.

When we started at Logan, there was a recognition that before we could do a great deal more to expand the networks; we had to have more equipment, more over-snow machines. There had been efforts for a number of years working to develop adequate snow machines that could get into the mountains and back out. For example, the need for them was demonstrated on the upper Provo River where Cardy Clegg from Heber City would go in the Trail Lake, Lost Lake area once a year. He'd take a day to snowshoe in part way, another day to go up to the farthest snow course he had to measure, and then the third day he would come back out. Well, when you need men to go into remote areas like this, you're not going to get lot of volunteers. There are a minimum number of men that want to go out and do that kind of thing. So to meet the need for obtaining the necessary snow data, various people tried to develop over-snow equipment.

A lot of this work had been going on at Utah State and it continued while I was there. There was a real development with the over-snow equipment. There was one machine built up in Oregon, the Tucker Sno-Cat. Arch Work can tell you more about that, because he was associated with the people who built it. The machine they had there was good for all snow country, but in a lot of the West, you have to have a machine that not only will travel on the snow, but at times has to travel some distances on bare ground. The machine that was developed at Utah State was one that would travel both on snow and bare ground. Some of the early experimental machines taught those who built them a lot about what was needed.

The over-snow equipment that I inherited when I started was only used 1 year. It had a half track and a couple of skis out in front with a couple of little wheels by the skis that would drop down when you got to the mud. It had bogie wheels to carry a long track, something like a tank. The first winter I ran that was 1949–1950. In May 1950, the Bureau of Reclamation asked us to expand our network on the Ogden and Weber rivers. While we were on Chalk Creek on the upper Weber, we reached a long stretch of road that had quite a bit of mud we had to run through with the snow machines. It was fortunate USGS [U.S. Geological Survey] wanted to go with us. That way the little experimental machine they had could also be used. After we got part way across the mud, I could see that the bogie wheels that were carrying the track on our snow machine were trying to drop off, ‘cause mud was getting in them. So we took it back and finished with the USGS machine and that was the end of our machine. On a steep hillside that particular machine would throw off its tracks and you would have to get out and work to get the tracks back on. But with further redesign, Thiokol ended up with a real good machine. It’s built now by Thiokol up at Logan. After the research and development was over, it went to them and they sell them. They use it in nearly all the ski resorts for packing their snow.

Helms: Before we get back, what are the things that made it desirable over the other competitors?

Pearson: It got to the point that we got rid of the half-track. It’s a full-track machine now, no longer the half track with the problems that it had. In January 1955 we held some over-snow machine tests. All the snow machines in the country we could get to come were there at Yellowstone, including the Thiokol machine we had. There should be records in Portland about all the tests results. The Tucker Sno-Cat could actually outclimb us just a little. But we had a faster machine and wanted one that would travel on both mud and snow. The Tucker didn’t do well in the mud. It had problems. So the Logan machine was a more versatile one for our work. We were able to carry equipment that we needed in it better as well. It became the machine that most of the surveyors had, except for some places in Oregon and elsewhere where machines didn't run into that much mud.

Helms: But you took the machine from one snow course route to another by a truck or something, correct?

Pearson: Yes, we would carry it by truck, as other machines were also carried. As a matter of fact, that was difficult. I had no assistant or anyone, and we only had the one snow machine. I had to drive it from the Logan River headwaters in Idaho clear down to southern Utah, out to the Uintah Basin in northeastern Utah and to all the courses in between. In those early years, 1949 to 1953, many times I would work 40 to 44 hours without a break and maybe get 4 hours sleep and then go back and work another 40 hours. Many times, as I was finishing my work I'd drive to my home in Logan and suddenly realized that I couldn't remember coming through Salt Lake or Ogden or Brigham City. When I got in my own yard at home I sat there thinking, "Boy this wasn't very safe, you know." But, we began to work to try to get the operations people in SCS to help in expanding the work program. One day I pulled into Coalville east of here at about midnight. The local SCS people had gone to a hotel there to wait for me, and they'd gone to bed about 10 o'clock. Well, I pulled in at about midnight and I got them up at 5 o'clock, and we were on our way. The area conservationist afterwards wrote a letter to the State Conservationist about the unsafe conditions I was working under. In fact, they wrote a letter to my office up in Logan, and our operations officer wrote a letter back. I saw it and said, "Well, when certain things had to be done on the job there is no other way except work the way it was." So I continued until 1953.

Helms: But this one incident you were talking about—getting them up at 5—was that to send everybody out to do surveys?

Pearson: That was to go with me on the surveys. You see, I had to have somebody to go with me on the surveys, 'cause I couldn't do it all alone up there in the mountain. Everywhere I stopped, I had to get somebody locally to go with me. Because we were expanding the network, we had to have more people involved. In most cases, it was in service areas which were the concerns of the local Soil Conservation Service personnel and the local irrigation district.

Helms: One thing I'd like to ask you. In the early times, the pressure to expand your network had been from the Bureau of Reclamation?

Pearson: Mostly from local water users.

Helms: One question of a technical nature is, how did you know how to lay out the snow course? Did you have any particular experience?

Pearson: Well, it depends on the characteristics of watershed, that is, the elevation distribution of the watershed, and what elevation produces most of the water. In general, you try to put the snow courses in different elevations to find out what snow is there, so that you can get a good picture of the snow distribution. Some watersheds produce their water mostly from high elevations, others from intermediate, some actually from low elevations. It makes a difference as to where and when the high water potential is going to occur. You have to take a look at what your watershed is and then what type of an area you need to locate your snow courses in so that the different sections of the watershed will be represented.

Helms: Is there any guide to that?

Pearson: Well, we have it written in the handbook. As a result of all our combined experiences we developed criteria and that ended up in the snow survey section of the National Engineering Handbook.

In 1953, you probably know the snow surveys were transferred from the Research Division of SCS to the Operations Division. I originally worked with the Research Division, and so my office was transferred from Logan to the SCS State Office in Salt Lake City. That helped in a lot of ways. We were able to get more help from field personnel of the Operations Division and to look toward getting some money so we could buy more snow machines.

Helms: It was easier to operate on the action side than on the research side?

Pearson: On the research side, it was slow, and I was not able to give them any assistance. In January 1958, we had a Westwide Snow Survey Training School up in Jackson, Wyoming. Some of my men, some of our SCS people, were going up there for training. I was to meet one of them in Logan to pick up a new snow machine for him to use at Jackson and later in his local area. At the same time my wife was in the hospital and I wasn't able to go to that training school. So I met them up in Logan and got the machine, which was being built there, and turned it over to him. Coming back to Salt Lake that night, as I left Cache Valley, some young man going to a basketball game over at Utah State had stopped along the way and got himself liquored up. As he came down and out of what they call the Sardine Canyon into Cache Valley, it was foggy. He had spent too long in the beer joint along the way, he was late, so he tried to pass a car in the fog and hit me head on. That laid me up for 7 months, but it brought to a head the issue that some of our snow survey supervisors needed an assistant. Meanwhile I was off for 7 months, and they had to bring Bob Beaumont from the RTSC [Regional Technical Service Center] in Portland, Oregon, down to do my work.

Bill Anderson, who used to be the snow survey supervisor in Arizona, was with the Colorado River watershed planning party, at that time located here in Salt Lake in a building right next to us. The two of them carried the program for the rest of that winter, because this was in January. It resulted in my getting an assistant. Also, some of the other States that didn't have an assistant were able to get one. It brought the point home that someone was needed as a backup who knew what was going on. So my accident did accomplish a good purpose and got some help.

During the early parts of the program here in Utah, my main effort was directed first to getting additional snow courses put in many areas of the State where we needed them and in getting expanded measurement schedules on them.

Helms: Originally, you just did it once in April?

Pearson: Originally, the man ahead of me that one year started just a little, and I carried it on, continuing to expand the network.

Another thing was very obvious as I started. One of the first things that I was asked to do was prepare a bulletin. Since we were working part-time, cooperating with the Experiment Station, I was supposed to get a bulletin out on water supply forecasts. But as I looked at the situation, we didn't have the data we needed to do it. One of the principle things we needed was something that would tell us what the soil moisture was when the snowpack began to accumulate, because of course the drier the soil is, the more water it's going to take out of the snowpack to charge it before you get any run off. If it's real wet you're not going to lose much, but if it's real dry you lose quite a bit depending on the watershed. So something was needed to indicate what the soil moisture was, and also for refined forecasts after the first of April. As you go through May and June, the weather conditions can make a major difference—a dry spring or a wet spring is critical. For example, in a flood year if you already have a flood potential and you get a real wet spring on top of it that has a real detrimental impact.

Helms: You mean the tendency was to cut the last survey off too soon?

Pearson: That's correct. There were a few surveys being made on the first of May, but no way near as many as needed. A survey on the first of May doesn't always tell you what you want to know, because generally there has been snow melting during the month. You really can't tell whether it was a cold month and you'd had mostly snow, or if it was a warm, wet month. If a lot of rain would come on the snowpack, it would go on through the snow. We didn't have a handle on that, so we had to have something to measure precipitation during the rest of the snowmelt season. Information on snowmelt season precipitation was also needed for late-season runoff forecasts of recession flow in July, August, and September to aid in caring for late crops. Sometimes precipitation during the summer was needed, as well.

Because of this, one of the first things I did was to start a rain gauge network. I'd had experience in the Weather Bureau. At the time, very frankly, there had been much competition between SCS and the National Weather Service over water supply forecasts. The National Weather Service had no use for snow surveys and some of our snow survey people had no use for a rain gauge. Although they had some experience with it, they hadn't studied it enough to know what modifications can be made and how to meet problems with it, because sometimes a rain gauge can give poor data if it's not built properly, if it's not shielded properly, or if it's not deep enough. There were a lot of problems associated with it that needed to be met. I started immediately developing rain gauges and getting some background and stands that would hold them.

The National Weather Service people locally didn't think much of my idea of putting some rain gauges up in the mountains since they didn't think the snow courses were needed up there in the first place. They felt that they could do their job from data collected down in the valley, but they couldn't. As I first began to try to use some rain gauges in the mountains as an index for both fall and spring precipitation, it showed that rain gauges in the valleys wouldn't help a bit. The Weather Bureau had a few stations at some of the ski resorts and used that data. It would help there, but in many areas there was nothing that could give us any information. So I started building rain gauges and after a few years had collected enough data that I was able to demonstrate to some of our SCS people that they could be a real help to us.

Also at that time, Morlan Nelson in Idaho started working with soil moisture. He was a soil scientist before he had gone into snow surveys. Soil moisture measuring equipment could electrically see what the soil moisture was. I don't know what's going on with that now, but I put a lot of my effort into developing rain gauges that were needed.

Helms: You said the bureaucratic competition between the Weather Bureau and SCS hurt the cooperation on trying to do something on this?

Pearson: Tremendous competition.

Helms: Did you have any instances when there was a flood or the irrigation water was short where accuracy became an issue?

Pearson: In the forecast?

Helms: Yes. Or conflicting forecasts by the Weather Bureau and whatever?

Pearson: There were problems over that. I'll always remember a meeting at the State Engineer's Office. At that time the office was a cooperator in the snow survey program. This would have been probably in the fifties. The local Weather Bureau man had a very different idea of how much water was going to come off of one of the streams in southern Utah. It just happened that the State Engineer at that time was Wayne Criddle who used to work for SCS, who at one time had been in snow surveys. Because of the differing forecasts, he asked us to come and talk with him. When we went up, the Weather Bureau man was insistent that we were going to get a whole lot more water than I said there was going to be. It just happened that Wayne Criddle knew the area of the watershed and he knew the snow course. All I had to say to him was, "Well Wayne, there's no snow left on the snow course, now how much water do you think you're going to get off of that [laughing]?" Well, he took our forecast real quick. We did have things like that happen, where there was a very different opinion of what the water should be and that was confusing. That was the kind of thing that contributed to some of the conferences that we held back in Washington that ended up getting some cooperation.

Helms: So before, each agency sort of put out its own forecast?

Pearson: They put out a forecast and we put out a forecast. Back in 1955, we did have a meeting with Bill Shannon, Arch Work, Morlan Nelson, the Weather Bureau people and me back in Washington to try and eliminate or minimize some of the confusing reports going to the public when they had data that said one thing and we had data that said something else. We were able to begin to get some coordination and at least tried to minimize some of the problems of the competition between what their data in the valleys said and what our data in the mountains said.

Helms: How did you do that?

Pearson: We sat down and had a lot of very strong discussions [laughs].

Helms: Was there some schedule that said we'll sit down before the report goes out and talk?

Pearson: It worked like that.

Helms: You needed some sort of official memorandum of understanding or something?

Pearson: They should be on file back there in D.C., I would think. Probably some of that old stuff is there. Bob Rallison's office should have it.

Helms: The idea of the forecast was to try to negotiate a little.

Pearson: We finally got it where it was an agreed-upon forecast with joint names going on it.

Helms: These came out about once every first of the month?

Pearson: Once a month. Those were some interesting times.

Helms: Was it different points of view or were there personalities involved?

Pearson: Well, in different ways they would interpret what the data said. They didn't understand some of the things. They honestly did not understand what a tremendous variability you can get at times. I remember one year, and I don't remember what the year was, down in the center of the State on the steams that drain into the Colorado River. We had made a snow survey and made a forecast. A storm came through over the mountain range. In the valley north of these mountains, there was a lot of rain. I felt that I'd better get some more readings, and so I got permission to have some extra readings made, although it was only about a week after the regular readings. By golly, it was in an area where the water outlook was real poor, nearly facing drought, but during that week, a 2 months supply of snow hit the mountain up there. It hadn't gotten into the valley west of the mountain at all, but it did hit the mountain. Well, you add two months supply in one week and you have really got a different picture [laughter]. But they had no indication of it at all because it didn't hit their valley stations. So that kind of thing, when you get variability like that in the mountains, again pointed to the need again for the telemetry system because when you hit those kinds of conditions you need to notify people quickly. In one year it could mean a change from drought to a real good water supply. For another year it could mean, if you already have a lot of water there that you're going to have floods. So that's another reason why we had to have the telemetry system.

The importance of water and the good publicity it provided began to be recognized more fully, because snow surveys were always a good publicity factor here in the State and all over the West. When they saw that, they sent out some people and said we'd better get back into it.

Helms: Summarize the different points of view and the historical problems. At this time, the Weather Bureau had moved from the Department of Agriculture to Commerce.

Pearson: Actually, up to the time the move was made, the snow surveys were associated with the Weather Bureau, but they didn't want any part of it when they moved out of Agriculture. They didn't think it was worth it, and they had some people who had a little blindness. They didn't understand how variable the precipitation can be between the mountains and the valleys. Going through the season is the thing that helped me realize this. I did study it, and I was glad that I had the background in both—a little with the Weather Bureau and also in the snow surveys. I did some studying that they ought to have done as well themselves. It helped me realize just how badly we needed both. We couldn't get a total picture without having rain gauges in the mountains as well as snow gauges. If we were going to basically define the hydrology of the mountain watersheds we had to have a lot more data than was being collected, and the valley data wouldn't do it.

Helms: Not only is the snow variable but the rain also.

Pearson: The rain also is variable. You see how a storm can be here in Salt Lake and end up as little or nothing in Provo, and then the way the storm's pattern is compared to some of the mountains. For example, the high Uintah Mountains run east to west. Some storms go east along the north face of the mountains and leave nothing on the south face. Also, some storms go along the south face and not the north face. Other storms from the south hit the eastern part of the mountains and not the western part and vice versa. With so much variability, we had to have rain gauges in the mountains to give us a complete picture.

Helms: What did you need developed in the rain gauge? Why weren't the existing ones sufficient?

Pearson: Well, the Weather Bureau did have some rain gauges put in during those years. I believe they had some before I started in the mountains, big ones, but they were only read once a year in the summertime. They had to be drained out and you couldn't read them during the winter time, because where they drained out was well under the snow. If you drained it, you'd have to start all over again. So we needed something that we could measure and be above the snow. We had to have a stand to hold a rain gauge above the snow.

If there's a heavy snow storm, the snow will fill the can up. If you don't have a deep enough can, then it will blow off the top, and you don't get a full catch. So we had to learn what sizes of rain gauges to make, and locations where each size could be used. We determined this by noting the maximum snow depths at the various locations where we had to have a rain gauge. We had to have the rain can itself within a stand an appropriate size.

We had the problem of what kind of antifreeze solution we were going to use in the rain gauges in the winter. We finally got that resolved. First we tried Prestone, then ethylene glycol, and then calcium chloride. But their density as compared to the snowmelt water is such that the water will sit on top of the antifreeze, and then the water would freeze. In others words, it's going to fall in as a snow flake, melt and freeze, and then you'll have a block of ice on top of the antifreeze, the ice extending to the sides of the can. Then we ended up finding a suitable mixture of ethylene glycol and methanol, that is, methyl alcohol. The specific gravity was such that it was between the density of ice and density of water. When water would go in, it would mix with antifreeze on the way to the bottom. Any snow would sit on top of the oil. You would have to have oil on top of the solution for summertime so the water wouldn't evaporate. Then, the snow would build up enough to push it down where it would get through the oil into the antifreeze. Any snow or ice would start to melt.

Ordinarily, if the water collected on top of the oil and if it got through in ice form, it would hit the antifreeze and turn into water. The water then would sink to the bottom and on the way going down it would mix. If it got to the bottom as water and froze again, then it would rise to the top, and on the way it would mix. So it was a self-mixing solution, which helped to resolve the problem.

Helms: These rain gauges actually collected all the water and held it there until somebody came along and measured it?

Pearson: We had the men go in and measure every month. This had to be done if we were to expand our data collection program. We built rain gauges of a size that would hold anything that would fall between the measurement schedules, so that they were able to take care of that. Anyway we got a good network and I was able to show and convince some of our people that they were worthwhile.

Helms: This was a little bit unusual in that an individual could do his own sort of independent research project.

Pearson: You've maybe seen some of these [photos] from the handbooks. This was a rain gauge that I built. This was another style I built. This is a design for another. This is the one a man in California built. This is one a company here locally thought would do the job and in some places it did.

Helms: What are the strips on the side there for?

Pearson: They're baffles to break up the wind.

Helms: Just for the purposes of our record here. Where are these photos from?

Pearson: Well, those photos were some I presented, and they were put in the snow survey handbook [the snow survey section of the National Engineering Handbook]. I was in Portland when we prepared this. Let's see if I can find it, to demonstrate. This is the kind of thing that basically I did to show our own people the value of rain gauges. They had the idea that the gauges would cap over and we wouldn't get good seasonal readings in April. I showed them that by locating the gauges properly, they would catch as much as you found in the snow. This chart shows the accumulated precipitation of October 1 to April 1, plotted against April 1 water content at the same location. These are snow courses and rain gauge readings—eight of them—varying at 8- 9,000-feet elevation and lower. This shows the October to April precipitation. In fact, all sites show more precipitation than what was in the snow. This chart is one where there had been some snowmelt, and it was even more than shown before. I was trying to convince our people that rain gauges would do a needed job for them. Now this chart is one of a lower elevation with considerable snowmelt. This was one I showed them.

If they [the gauges] were located in windy areas, they had to pay attention to where they placed them. This chart shows one that was not ours but from the Forest Service people. You can see that they had quite a number where the rain gauges were not located properly, it was too windy, so they did not collect as much as was actually in the snow. As I just demonstrated, you have to locate the gages properly. With some of these kinds of things I was able to convince them that the rain gauges were of help to us and of value. I did the same things there, showing them how gauges were to be used for forecasting purposes.

Helms: If you have a little warm spell then you'll get some run off?

Pearson: So actually for a total analysis we needed total precipitation plus something that would show us whether there had been snowmelt. If the water has already gone down the river it's not going to come anymore. So it served more than one purpose.

Helms: A friend of mine who's worked on this a little bit said that Clyde was recognized for working on soil moisture. But, I think you're sort of saying that you had an interest which predated that.

Pearson: There had been some soil moisture work years before I came, in which they used to actually dig down through the snow, dig in the ground, and take soil samples. Eventually, I guess they got an unusual order to bring some soil back, take it into the lab and see how much moisture it had in it. That was done, but it became too laborious, too time consuming.

Helms: You said something about the importance of recognizing the rain in water yield at the end of the season.

Pearson: We used that as well. Most of the time we weren't getting snow collected until late in November, so we could get just October and November precipitation data on most watersheds. By starting the precipitation readings in October, that gave you some estimates of soil moisture—an index. However, lots of times you'd find that you had a real wet September. That has a major impact on a lot of watersheds' soil moisture, and not only in the late season runoff of the preceding year—July, August, and September—particularly September rains. With a rain gauge you could form an index. Rain gauges were tied to soil moisture as well. With the soil moisture, as Morlan Nelson can tell you, they had little electronic units, where they put a little metal interlining, whose resistance would vary with the amount of moisture, into the soil. Then he also did some electronic soil moisture readings.

In watersheds, particularly in areas where there is a lot of wind, you can lose snow back to the atmosphere through evapo-sublimation. George Peak out in Wyoming did most of the work on that, all the preliminary work. For instance, Wyoming has tremendous winds, and that's why he got into it. This chart shows just a straight precipitation index up to June 1. Applying an evaporation index—this is what it does to the forecast. First, this is using the snow precipitation index versus runoff, and this is adding the correction by applying the evaporation index, which shows us how tightly it accounts for it. This is on a major watershed.

This is one of the papers I presented to an irrigation operator workshop here in the State. We were starting to collect data on wind speed and direction, air temperature, humidity, and solar radiation. These are factors that effect evapo-sublimation from snowpacks. I don't know what they're doing with it now, but it is a factor and in some of the watersheds it's a major factor.

Helms: So we went from just the results of the snow surveys to adding the rain gauges and soil moisture, and wind is now important.

Pearson: A lot of factors were not there originally.

Helms: You were going to mention 1955.

Pearson: In January 1955, we got some more snow machines to test at West Yellowstone. Arch Work arranged that and we had some others, but that was the first major one. It was very worthwhile. At that time we were just starting with some of the small snow machines, one-man machines, and that became very important. All the big ones had their place, but we recognized that in many places it would be far cheaper to get the little snow machines, and so we began to get into those. There were some, but not many. But that was another forward step and an economical step. It helped to get more data from more places.

Helms: So practically all these machines were sort of government-sponsored research?

Pearson: In Oregon, Arch Work encouraged the Tucker Sno-Cat people to develop the big Sno-Cat. It's a very useful machine, particularly in the Northwest where they don't get so much mud. We encouraged snow machine development here.

Helms: Here the USDA research station itself was helping?

Pearson: We had a man on the payroll working with them. The small snow machines were pretty much all developed privately. Ski-Doo, Polaris, and others were a help. Of course, in 50 percent of the areas that we couldn't get to, like in wilderness areas where you can't get there on foot in the winter because it's too remote. We did get permission in some of them to put what they call an aerial snow depth marker, where you could fly over and fly low enough that you could look. The markers were so designed that you could look from the airplane and actually spot within 3 inches how deep the snow was. You'd have to apply a density factor from snow somewhere outside the wilderness area to get an estimate of water content.

Helms: Could you tell us about snow pillows?

Pearson: The snow pillows originally were all-rubber pillows filled up with antifreeze. When snowfall came to an area, as the snow accumulated on them, the pillows made it possible to weigh the snow resting on

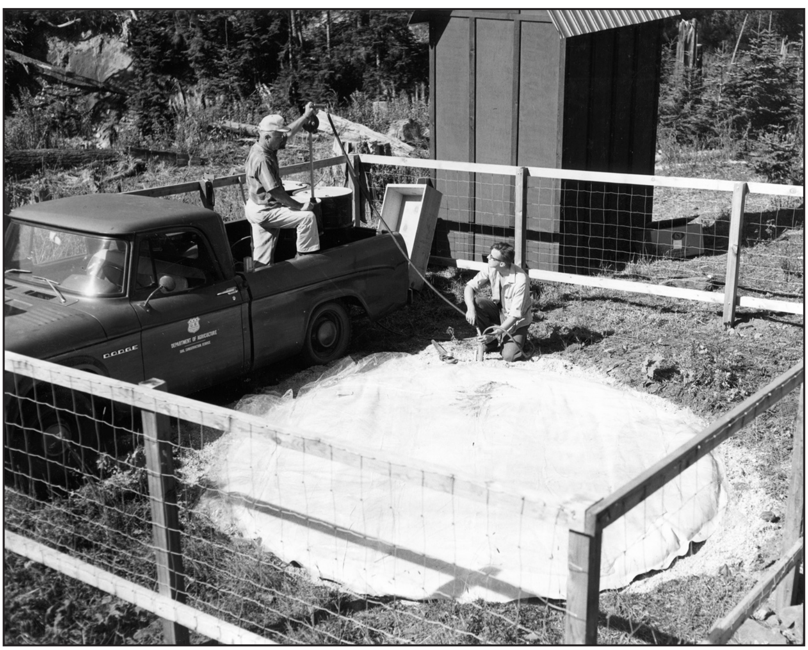
114H–MONT–10173 National Archives, College Park, Maryland

4.11 Ski-Doo snowmobile used in snow surveys in Montana

114H-ARIZ-5479 National Archives, College Park, Maryland

4.12 Aerial snow depth marker south of Humphreys Peak, Arizona

them. The weight could be reported in inches of water in the snow. Lots of times you'll get a tremendous storm coming right after you've made the regular surveys, and you don't really know what the amount of new snow is, so you have to go back again. It was recognized that we needed to get some means for reading the snow data electronically, getting a radio reading from up there, so we started developing the SNOTEL system. The first thing was to build a snow pillow to measure the snow. Originally, it was a rubber pillow up to 6 to 12 feet in diameter, which covers a pretty good area. But we found that we could get smaller ones in many areas just as adequate as a big one, because all we're doing is getting a water pressure on them. First we started having an instrument shelter by them. We would run a tube from the pillow into the instrument shelter and connect it to a vertically placed glass tube with a measuring scale by it. We'd go there and read the liquid level in the glass tube. Next month we'd go back and read again. Of course, each inch of snow water on the pillows caused an inch rise in the standpipe tube when the antifreeze solution had a specific gravity of one, which we had arranged.



114H-WN-90347 National Archives, College Park, Maryland

4.13 Installing snow pillow and instrument shelter at Mill Creek Watershed, Washington

Helms: Could you give a chronology? When did you start using the snow pillows?

Pearson: The snow pillows began with Arch Work up at the Portland office. Experimental work was done up on Mount Hood, before I went there. Arch, Homer Stockwell, Bob Beaumont—there may have been some other work done—but I think basically most of it was started by them. I started to help the operation with some folks in Logan at Utah State University. We decided to try some little metal pillows, with just sheet iron. We developed some of those. We first started with a 4- by 5-foot pillow, and found that they were doing a good job. But we decided that for safety, there were many places with deeper snow where we ought to have more than one. So we ended up in a good share of the places having four 4- by 5-foot pillows interconnected, basically making an 8- by 10-foot pillow. We found that we were doing just as good as with the big rubber pillow.

Helms: What kind of measuring device did you have with the metal pillow?

Pearson: Just the same as with the rubber pillows. The metal pillows gave us all we needed to know and cost a whole lot less for antifreeze than in the big rubber pillows. The metal pillows were only a total thickness of not much more than an inch. So it was much more economical than the big rubber pillows which were about 6 inches deep. The metal pillows were being used most places when I retired. That was what was designed for the SNOTEL system.

Helms: When you started looking at something like that you were thinking in terms of an automatic system?

Pearson: That's correct!

Helms: Because before you had to physically go out and read them.

Pearson: That's correct, but this was just during the experimental stages, trying them out. Then we began to work using a pressure transducer to feed the pressure into the transducer and then it would go into a radio signal which we could read. Originally, those were done through mountaintop repeaters, then the SNOTEL system was designed to use meteor bursts, bouncing radio signals off of meteors as they burn up in the atmosphere. That's the way that came along. We made the contribution of using metal pillows and making them more economical. If somebody's going to come up during hunting season and shoot one of them, you don't loose all the alcohol that you do from the big rubber pillow. Metal pillows are less obvious. As a matter of fact, we even tried burying the rubber pillows, with just a little loose material over the top so they weren't so obvious. The same things can be done with the metal pillows; they still read the pressure of the snow.

Helms: Vandalism is a problem then.

Pearson: Vandalism is a problem sometimes.

Helms: I wanted to ask a question that pertains to the early days when you started in the forties but you can apply it all the way through. Some people, like those on a ranger station, were taking readings.

Pearson: Some of them were themselves extra help for the Forest Service. Some of those ranger stations had men that would go up and could live there. A lot of them would live in the valleys and go up regularly. There were some reservoirs around the West, where the people owning the reservoir and operating it would have somebody stationed there year round. Then they would take some of the surveys.

Helms: There were not a lot of extra seasonal employees for this?

Pearson: No, no. They had a regular job somewhere.

Helms: In the area where they were doing the survey?

Pearson: That's correct.

Helms: But even so, going up in the mountains sometimes was rather dangerous.

Pearson: That's correct; some of them had to travel a long way. Even with the snow machines, some of us traveled a long ways. We had one run over east of here, we took a 3-day run back in, and we were a long ways through those high Uintah Mountains. It takes 3 days to get there and back out even with the snow machine. Oh yes, I've had a break down. The farthest I ever walked out was about 40 miles, but that's a long ways in the winter time [laughs].

Helms: Did you ever lose any people?

Pearson: There was a forest ranger back long before I got into it. He lost his life up here in Farmington Canyon. He ignored snow warning signs. He may not have been as well trained as he needed to be for avalanche dangers and he got caught in an avalanche. In addition to this one in Utah, another ranger over in Nevada lost in life. Basically, it's been an exceptionally safe program. But that was one of the reasons why we started the Westwide Snow Survey Training School. We gave training in avalanche hazards, as well as in all the problems associated with the needs for getting good snow samples and everything else—teaching them how to spend the night out in the snow if they had to, learning that they can. I don't know whether they're still doing it, we used to require that they sleep out.

Helms: They're still doing it. I don't know the particular requirements, but they still have the training course. Of course as part of my little project here, I might take it myself sometime.

Pearson: You'd enjoy it. We had a difficult time getting all the safety equipment we needed and recognition of the fact that it was a hazardous experience. That lasted until 1956, when we had a Westwide Snow Survey Training School here in Utah up at Alta. We had the SCS safety officer from Washington, D.C., out here with us attending that training school. It happen that there was lot of heavy snow—it had come early through December and then into January during the school. Mount Superior up there let go a real good avalanche. It came down and closed the road from Alta down here to Salt Lake [laughs]. The safety officer had to get back to Washington and the road wasn't open. We had to take him out with the snow machine over the top of where the avalanche had come. That helped break the ice. We began to be able to get more safety equipment and more safety consciousness among a lot of our SCS people.

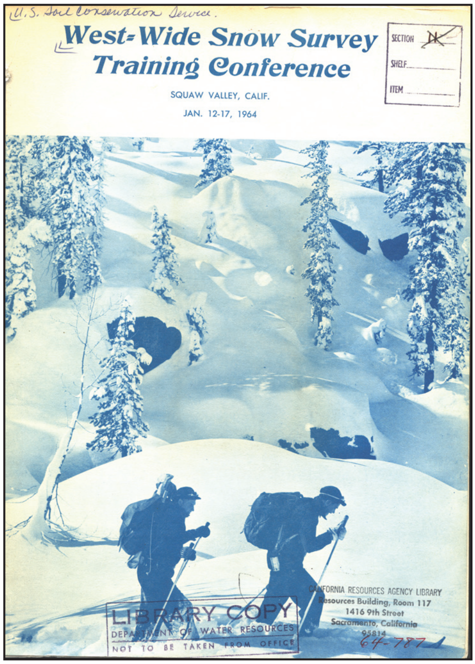
Helms: They didn't understand your unique needs?

Pearson: They didn't understand our unique needs, and that avalanche, as much as anything, helped to break the ice.

Helms: When was that?

Pearson: That was in January of 1956.

Helms: What equipment in particular was it that you needed and couldn't always get?



National Water and Climate Center, Portland, Oregon

4.14 Program of the West-Wide Snow Survey Training Conference, Squaw Valley, California, 1964

Pearson: Winter clothing. A lot of our SCS people didn't have the clothing they needed to get out safely in the winter time. Some of our cooperators didn't have it, and they didn't have the money to get it. We would loan some to them so that they could go and do the job for us. Basically, they were our employees, only they were only part-time. They were employed by us. We needed to be able to train them, which added to our Westwide Snow Survey Training School. We also started holding in-State training schools because there were a lot of people. Some of the cooperators didn't have the money to send some of their people to the schools, so we had to start training them, equipping them safely, getting more over-snow machines, that kind of thing.

Helms: What do they call it, the Nevada Kit, the Reno Kit or something? Is there a standard snow surveyor's kit and who developed it?

Pearson: It started with Dr. Church, but when George Clyde got in and designed the smaller tube, the one where every ounce is an inch of water, we got a different kit. But it is basically the same thing. Jon Werner should be able to show you some of that. There are pictures in the Westwide Handbook.

Helms: We're not a land management agency. I gather that a lot of the snow shelters and snow cabins I see in these photos are on Forest Service land.

Pearson: We had the cooperation of the Forest Service. We made arrangements with them. We always had permission with them to locate where we did. We'd pick a site, and then get clearance from them. We didn't originally, we just went in and put them there, and then it got to the point that we recognized that we were trespassing. We should have gotten clearance with them earlier.

Helms: So those were built out of the funds provided for the snow survey program?

Pearson: Yes.

Helms: You mentioned a little bit of the differences of opinion with the Weather Service. How was the cooperation with the Forest Service, the Bureau of Reclamation, and those other agencies?

Pearson: It was all excellent, we had no problems. Well, sometimes there'd be a little local problem, but basically there were no problems. It was just really excellent cooperation.

Helms: Who else was involved other than the Federal agencies?

Pearson: The State—the State Engineer and the director of the Division of Water Resources here in Utah. They cooperated by putting money into the program. There were some, like Salt Lake City, which cooperated. Various irrigation districts and a part of the Bureau of Reclamation always cooperated. I don't know what the current situation is. Similar cooperation existed in the other States.

Helms: Was this cooperation generally in the way of providing funds or was it in personnel?

Pearson: Sometimes Forest Service people helped with surveys. Salt Lake City people helped with surveys. Bureau of Reclamation always helped and, while I was there, always helped with funds. In some cases, they participated in the surveys, but mostly it was funds. The Corps of Engineers was involved when the Columbia River Basin was involved. They used to be anyway, and I hope that they still are.

Helms: Was there ever any strong disagreement because the field people thought that the people sitting in the offices who want us to do these surveys are making unreasonable demands? Were there differences of opinion over how these things should be done?

Pearson: No, not that I'm aware of. Some of them had not always understood exactly how to meet some of the conditions they would run into in the winter time, and so they didn't get adequate snow samples. Sometimes we had to give them some instruction and ask them to go back. But that was at the minimum. Ordinarily, it would be because when we got their snow notes and went through them, we would find that they had some errors in them. Most of those had to do with snow conditions where the snow would plug in the snow tube and they wouldn't get a full core of the snow. They hadn't understood how to handle some of the situations they encountered. We'd check with them and discuss their problems, and sometimes ask them to go back if it was necessary.

Helms: In fact, all you have is this one tube. All you have to do is read the level and that's it, right?

Pearson: The problem was getting an adequate snow core. Then all they had to do was weigh and record it. Sometimes they made an error in the way they read it. They read the empty weight of the tube first, and then read the weight of each sample. Well, when they read the empty weight of the tube, sometimes they'd make a 5-inch error, that makes a difference of 5 inches of water. Sometimes they would show 5 inches more water and sometimes 5 inches less water than they had. If you check your notes carefully in the office, you can always pick up those kinds of errors.

Helms: You mentioned the problem, in an agency where the snow surveys are small operations, of getting the attention to get the kind of special equipment you needed. Have there been any other problems with this specialized operation in an organization whose functions mostly deal with other things?

Pearson: Yes, there were problems with that. One thing we found after it became evident that we were a good publicity thing was that whenever somebody wanted to cut the budget, we were the ones that were always thrown up to be cut. We were asked more than once to go to our cooperators locally to ask them to write to their Senators and Congressmen to not let us be cut. In some of the other programs which didn't have the same publicity, nothing was ever said about them taking any of the cut.

Helms: When the cut was going to be made they said we're going to cut the snow surveys, because the snow surveys can generate publicity.

Pearson: They can generate political support for us. We saw that more than once.

Helms: That got tiresome?

Pearson: It got tiresome [laughter]. It sure did, but you know that goes with the Government, not just in the Department of Agriculture but everywhere else, isn't that right?

Helms: Yes, it is. The local person wouldn't lay out the snow course. You would go out and do that, is that right?

Pearson: That's right.

Helms: They didn't understand what factors you were looking for. Just a practical thing, who clears the trails and all of that? Who does the maintenance? I guess you have a post at each point where you're supposed to set something up.

Pearson: Yes, something to show. You have a lot of sample points. On the snow course you'd have a post here then another down there. You may take a number of samples between certain intervals. Another thing, when they first started the networks, they took many more samples than were needed. They didn't understand how many were needed, so rather than be on the short side, they went on the long side. We analyzed the snow courses. After you got enough data, you analyzed them to see how many you actually needed, how much consistency there was through them. We developed a procedure to do that. We would cut the courses way back as time went on. Sometimes, some of those old courses had 25 to 50 samples you'd take from the course. Then you'd analyze the thing and find out that you had as much consistency with 5 to 10 samples as you did in 50 samples. We had a lot of work involved in just cutting the snow courses to what was the most consistent.

Helms: Jon Werner, who supervised the work here, thinks that the data base for the SNOTEL is good enough that they won't need as many courses.

Pearson: That's correct. Some of the samples are just as consistent as the old snow courses. Considering their relationship to the whole snow course, you might as well have the one sample. On a lot of the snow courses, you go out and take one good sample and by your analysis you can tell where the consistent samples are. You can take that one sample; it will be as good as always, and that's what the snow course ends up to.

Helms: But you still have to have one each for all the different watersheds for very local usage, I'm sure.

Pearson: That's right.

Helms: I know you do your surveys on a schedule, but did you do special surveys and why did you do those?

Pearson: Well, some of them had to do with the thing I was telling you a minute ago about having the storm. We had reason to think that there may have been a major change in the outlook shortly after our regular surveys. Sometimes the needs were critical and other times people had questions and wanted to have changes, because of a storm or the lack of storms. In that case they wanted extra surveys. That was just under special conditions. There were some made like that.

Helms: Before the law was passed so that the Federal Government could provide coordination for all this, did the various States do their own surveys? After the change, were those who had been doing it previously in this State happy with the way the new coordinated system worked out?

Pearson: Let's say that it stopped the complaints pretty well, because it wasn't confusing the public. The people who were raising objections and were unhappy—at least it stopped those complaints.

Helms: Because you would be in some situations where what's happening in two States would be of importance, is that it? A drainage where the watershed would be in two States?

Pearson: Well, for a while we had basin supervisors. For example, I had the Bear River, which goes through Utah, Wyoming, and Idaho. I made the main stream forecast, but the supervisors in those States made the local forecasts. They'd give their forecasts to me and I'd give them the ones that I had made. It was the same way on the Green River in Wyoming—the supervisor in Wyoming made it, he'd give it to me and then I would use it for the main stream forecast on down the stream. Then we would compare it with the Weather Bureau, but we got things coordinated with no particular problem.

Helms: I'm looking at an issue of the *Snow Surveyors Forum*, which was a combination of articles from the supervisors such as yourself plus the people who actually did the survey. Did it serve a useful function?

Pearson: Yes it did. It served the function of passing on a lot of ideas. Particularly it was designed to help the man in the field understand some of the problems and give him a sense that he wasn't alone out there. A lot of these people locally were the only ones going into the mountains and they didn't have any means of talking to any other surveyors, unless the State snow survey supervisor came around now and again and visited with them. It was just a means of helping them feel part of a big program westwide.

Helms: That's pretty good, it doesn't sound bureaucratic. Well, I'm going to close now. I noticed that you seemed to have enjoyed your get-together annually.

Pearson: Yes, we did.

Helms: Were you around for the beginning of the Western Snow Conference?

Pearson: No, it was going before we came.

Helms: Well, you enjoyed this work obviously.

Pearson: Very much, it had three elements to it that were intriguing. First, you were able to get out. You didn't have to stay in your office either winter or summer; you could get out both winter and summer. You could get up to the beauty of the mountains—you really appreciated it. Second, it was intriguing because you were really doing a lot of research in connection with it, both field research and office research. Third, you were able to interplay with the public, where you could meet with various groups. You could meet with them, get input, and get a larger understanding. You helped them make better use of the data you provided them. It was a totally interesting program.

Helms: Well, thank you very much.

Pearson: It's been very good to talk to you about the snow survey program.

DEED OF GIFT

I, Gregory Pearson, do hereby give to the Soil Conservation Service the tape recordings and transcripts of my interview of May 5, 1989.

I authorize the Soil Conservation Service to use the tapes and transcripts in such a manner as may best serve the educational and historical objectives of their oral history program. I also approve the deposit of the transcripts at the National Agricultural Library and any other institution which the Soil Conservation Service may deem appropriate. In making this gift, I voluntarily convey ownership of the tapes and transcripts to the public domain.

Gregory L. Pearson
Gregory Pearson

14 October 1993
Date

4.15 Gregory Pearson Deed of Gift

Jack Washichek
Fort Collins, Colorado
June 6, 1989

by
Douglas Helms
National Historian, U.S. Department of Agriculture,
Soil Conservation Service
(now the Natural Resources Conservation Service)

The interview commenced with Jack Washicheck's account of his military service in World War II.

Jack Washichek: Of course, the war was in earnest, so I transferred to another new task. I got commissioned in the artillery. Shortly after that, I decided I'd rather be a pilot. I got a pair of wings and flew for the artillery and was sent overseas with the 101st Airborne right after Normandy and stayed with them during the entire war. I was at the Battle of the Bulge

114H–COL–11164 National Archives, College Park, Maryland

4.16 Jack Washichek writes down the measurements as George Peak reads them, Colorado, 1955

and finally got out in 1945. At that time, I went back to school and started as an electrical engineer. I went through 3 years of that and didn't like it particularly, so I went into a field which was a brand new college degree called Light Construction and Marketing. I graduated in 3 years because I went winter and summer. I was anxious, very anxious, to get out of school. In the meantime, I got married.

I got out of school and wanted to be a contractor. My father was a contractor, and I thought that would have been a good field to pursue, so I got that degree here at CSU [Colorado State University]. I had worked for 1 year in construction and had done pretty well at it. We had a lot of houses to build and had built quite a few. When winter came along in 1948, my wife was pregnant, and we had a terrible winter, so I couldn't work on the houses. So I was just loafing around. I heard that there was a job vacancy at the college in snow, and I had been a good skier. I'd liked to ski all my life. I thought that would be a good job. It sounded like it was a ski business, so I went up and applied to Homer J. Stockwell who was, at that time, a snow survey supervisor. Knowing practically nothing about it, I went in and applied to him and got the job. During the next 2 years or year-and-a-half, I was an aide, a GS–5, I believe it was. I liked the work really well and Homer liked me, apparently. About that time the Korean War got heated up, and I was recalled to Korea. So I flew for the 3rd Infantry Division in Korea, got back, and went back to work for the SCS.

Douglas Helms: This was about when?

Washichek: This was, I suppose, 1951 or 1952. They said I could never get anything higher than probably a GS–7 because I didn't have a degree that would warrant it. At that time, the head of the personnel division in Washington was a woman called Verna Mohagen. Verna had talked to me one time when she was out here. She said, "Why don't you go back to school and get a degree in agricultural engineering or something, so you can have a professional rating?" We were located on the CSU campus, by the way and interestingly enough, we were attached with an ARS [Agricultural Research Service] group. Charlie Rowher was one of them. He's the one that designed the Parshall Flume, or helped design the Parshall Measuring Flume, along with Ralph Parshall. Ralph Parshall, Charlie Rowher, Homer Stockwell, myself, and then eventually, a gentleman called

August Robinson, who was also in ARS, were all in the office together. Through the process, I went to the administrative officer of the SCS. He told me that if I would use my leave, they would let me off enough to go back to school. So I went back to school again and got another degree in 1958 in ag. engineering. Upon completion of that, they made me a professional GS–7 [laughs]. That was the start of my career in Colorado.

Early on, Colorado administered all of New Mexico and half of the Colorado Basin in Wyoming, so we had the Green River in Wyoming, as well as the North Platte [River]. We had about half of Wyoming, all of New Mexico, and all of Colorado. We had a really large area, and there were fewer people than there are now. It must have been about a year after that I got a GS–9. Then, about year after that, Homer Stockwell was transferred to Portland and through a lot of craziness, I got to be the snow survey supervisor here in Colorado.

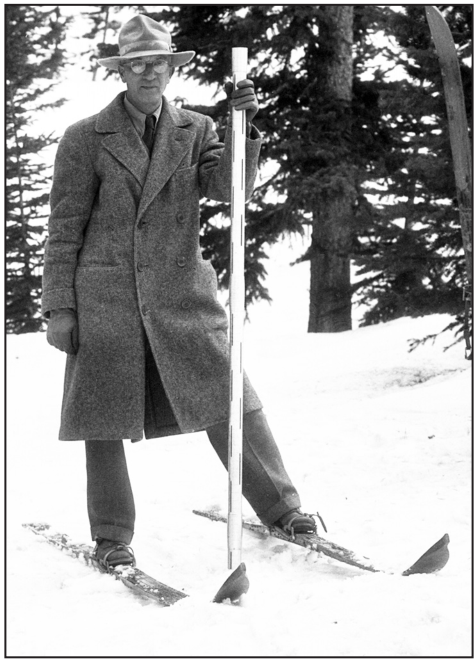
Helms: After not being around all that long in it, huh?

Washichek: No, I wasn't, not too long.

Helms: I don't want to ask you about things you don't have personal knowledge of, but was Stockwell the main person who started the program in Colorado?

Washichek: Probably Parshall was the one that really started it, he's the one that originated it. He laid out a lot of courses and was instrumental in the entire process, but he was also in agricultural research and on the staff at the college here. So he just couldn't do all of it, but he was the main wheel, I would think. If you were going to call somebody the big wheel, he was the one. But as soon as Homer came in, he kind of gave it up and went back to agricultural research. He did a lot of research in trapping sand and measuring water. But in the process, he also designed the cabins that were used at least all over Colorado, Wyoming, New Mexico and, I think, in some of the other places. He had a carpenter here at CSU who went up into the mountains and built those all over this area.

Helms: Who, Parshall did?



4.17 Ralph Parshall

Colorado State University

Washichek: Yes, Parshall did the design, and a carpenter did the work. I can't think what the carpenter's name was. They were one room, very well-built cabins and almost airtight. They had an icebox-type thing up there where you could store your foodstuff for long periods of time. It was mouse proof and rat proof, and you could store canned goods there almost indefinitely. They had an upstairs in them where you could get into the attic of the building through a trap if the lower doors were all snowed in. You could drop down through the attic into the main room. They usually had two to four beds in there and a stove and were fully equipped with wood so you could stay there indefinitely—as long as your food held out, I guess. Most of these were put up in areas where it was at least a 14-mile walk. There were very few surveyors that could walk 20 miles, so we put these at the end of the run. They would walk 8 to 12 miles, stay in the cabins a night or two nights, and then walk back. So we had two of them on the Snowy Range in Wyoming—one on the Snowy Range and the other in Hog Park on the Park Range in Wyoming. This area is above Encampment. We had one above us here near Red Feather Lakes, a couple on Grand Mesa, Colorado, and a couple over in New Mexico. I can't think of any others. Most of them were where there were just really long, long walks.

At that time, the Forest Service was reading them, and we were just administrating. This was kind of a hard thing for the Forest Service to take. They would do all the work, and we would get all the credit [laughs]! Eventually, that changed, of course. We started doing the work ourselves. But that was going on when I got here, and it was still going on in 1956, 1957, or 1958. They read courses for a long time.

Helms: They didn't continue to take the measurements themselves?

Washichek: After 1958, we took them. But before that the Forest Service did most of them.

Helms: Why did you eventually make the change?

Washichek: Well, the SCS didn't have any people in the mountains. We were primarily an agricultural unit, and all Forest Service people were up in the mountains. It might be as much as 50 or 60 miles for our people to go even to find the snow courses, while the Forest Service person was right up there on location. They were the logical ones, and they were still in the Department of Agriculture, so they had made an agreement way back someplace that they would do it. But once the SCS started expanding into the mountain areas, we had people in the same towns that the Forest Service did. But they were still doing the work. So they kind of took a dim view of that, and eventually, we just took over all of their snow courses. Of course, at about that time the Tucker Sno-Cat came into existence, so we had to change the whole thing again.

F–325–4 Water and Climate Center, Portland, Oregon

4.18 Ray Malsor and Dale Palmquis unload the Tucker Sno-Cat up Ward Creek Road, west of Lake Tahoe, 1961

Helms: Can you sort of describe the extent of the operations, which river basins you were doing, the number of snow courses, and anything else you may recall?

Washichek: I would think that there were about 150 in the State of Colorado.

Helms: Snow courses?

Washichek: Yes, and probably 65 or 70 percent of them were put in by Parshall. The old story was that Parshall always took to the mountains on the warmest day of summer and went as far as his car would go, and then rode a horse as far as it would go, then walked as far as he could go, and that's where he always put the snow courses [laughs]. Because they were a long, long way from any place. Man, when you're walking in the winter that changes considerably from that summer trip. That's how come they had to build so many cabins. But surprisingly, a lot of his snow courses are still being read. He had a pretty good idea of what to do and where to go.

I had at that time all the Colorado Basin, all the Platte Basin, and the Rio Grande Basin. We read all the snow courses in Wyoming that involved the North Platte [River], which includes the Laramie River. They flow east into the Mississippi, of course. Then we read all the Green River Basin, which is a subsidiary of the Colorado. Technically, we had all the Colorado Basin. So that involved all the snow courses in Colorado that flow west—everything west of the Continental Divide flows into the Colorado Basin, roughly. Then everything on this side of the Continental Divide, we had, also. That included the Arkansas River, the South Platte River, and the Rio Grande River. Those three divisions were the major rivers, but there were many, many tributaries. Those were more important than the main river itself because the main river didn't supply that much water to the farmland, compared to the smaller basins. We had all the Rio Grande Basin that flows into the Gulf of Mexico through New Mexico and into Mexico itself. We also had the Little Colorado [River] that flows into the Colorado eventually. So we had a really big basin, a big area.

Helms: Who were your main supporters in the States—you can mention a time span—in terms of funds, political support, providing personnel, and doing readings, et cetera?

Washichek: Our primary supporter was the SCS, but others were basically the Forest Service and the Bureau of Reclamation. The Bureau of Reclamation needed the information for dam control, flood control, development techniques for the dam projects, and that sort of thing. They supplied a great deal of money, in fact, probably at that time at least half, whereas the Forest Service provided no money, but supplied lots of assistance to us and did a lot of the readings. Here in Colorado, the State Engineer was very actively involved with the program because they administered the water. Then, almost all of the small irrigation and relatively large irrigation companies contributed in one way or another. They either gave us funds or provided us with personnel to help. The Corps of Engineers helped some, not as much as some of the others. Oh, the Park Service was another one that assisted us quite a bit. Then, of course, we also were involved with the State Engineer in New Mexico.

Helms: It's a powerful group.

Washichek: The New Mexico engineer is still there, too. I was down there last year and went in to see him. He walked in the door, and I said, "My God, is he still here?" and he was, so he's been there forever.

Helms: Who was this?

Washichek: Phil Mutz is the engineer in charge of streamflow and forecasts on the Rio Grande. Steve Reynolds is the State Engineer. I can't even remember who was before him. He must be 85 years old by now. Anyway, he was a great State Engineer. So they supplied some of the funds to us, as well. We had a big list of cooperators, you know. Another big cooperator of ours was CSU, which provided us with housing and all kinds of support. They did all of our publications for years and years and years at practically no expense. They also were the ones that provided us with all kinds of information programs. We did tapes for them on the radio and did TV shows for them when the TV eventually came into existence. So they were really a big, big cooperator.

Helms: From the beginning, when you started on this?

Washichek: Yes, they were involved from the time that Parshall was here because he was attached to the college. Then it just gradually kept continuing until 197l, 1972, or 1973. I was on the campus until that time, and then they transferred me to Denver.

Helms: To the State Office?

Washichek: Yes, from time immemorial ‘til 1973, we were located on the campus here.

Helms: You had your own staff?

Washichek: Yes, we usually had two or three office spaces, and then there were always just three of us, one assistant, the secretary, and myself.

Helms: That little office had to get all the readings in?

Washichek: It did all the readings, did all the calculations, put out the publications, did all the information, the entire thing. We were assisted in whatever the need be from the Portland office. First it was at Logan, Utah, and eventually it got to be in Portland.

Helms: Did you have to do the maintenance on the snow courses?

Washichek: Absolutely, we did all the summer maintenance, did all the readings, did everything.

Helms: What did the maintenance involve?

Washichek: Well, we tried to hit the snow courses once every 3 years at least to clean them out—they had trees growing up in them—and replace the signs. At that time, we were doing some stadia rod work, where we’d read them by airplanes. They had large stadia rods.

Helms: What kind of rods?

Washichek: They're like engineering rods, except they're 3 feet across, so we could fly by in our aircraft and read the depth of the snow. That didn't provide us with the water content, but we used an estimate from other snow courses that were close by. There's a picture of one in there. But usually the elk or something had rubbed against those, knocked off some of the boards, and stuff like that. So we would replace the signs, swamp the course out, and fix the stadia rods.

At about that time, we thought that we had done as much as we could as far as accuracy was concerned with the snow courses. We were at a standstill. So nobody was able to figure out how the accuracy could be improved. Homer Stockwell came up with the idea that probably the soil moisture was important. If it was a really wet soil when it started in the winter, then there would be more runoff because it wouldn't take as much of the snow water to fill the soil mantle. At that time, a wafer came out that would give us how much moisture there was in the soil profile. So we started installing soil moisture stations.

Helms: When was this?

Washichek: It would have been 1955 or somewhere in there, I would assume. We went into all the major basins and had different profiles, 1, 2, 3, 4, and 5 feet down, so we could read how much soil moisture there was in the ground. Eventually, I think all the States put some in, but we had the first bunch in and did the most extensive work on it.

Helms: This was Homer Stockwell?

Washichek: Yes. Finally, after I don't know how many years, it just seemed like it wasn't going to have enough effect to make it worthwhile to read. I think they just gradually phased out the soil moisture readings, so there weren't any more left.

Helms: You decided that the soil moisture content doesn't have as much effect as you originally thought?

Washichek: Yes, so I don't think anybody in the West is reading them anymore. I think it was maybe 5 or 6 years that we did that. But we never could get very much correlation between it and the runoff. You know, it's an expensive project to do because the soil moisture measuring blocks were expensive, and you had to bring them up through a pipe to the top of the snow. So you had a 10-foot pipe sticking out of the ground, and then you had to devise some method to read the thing, which was a little soil moisture meter that you had to put on top. It was quite a complicated procedure. I think over the years it just wasn't worth the effort, so that was kind of abandoned. Then, of course, as I said, the stadia rod seemed to be the way to go. Over the years, that was kind of abandoned, too. Then, of course, when they got the snow pillows, I don't think they ever read any of those anymore. That went by the boards, also. I was trying to think what year it was that Arch Work came up and said to me, "What would you do if you had an unlimited amount of money, and you could do anything that you wanted to as far as the snow survey program was concerned?" At that time, Bob Beaumont had already verified that a pillow would work, that they could measure the snowpack from the pillow.

At that time, CSU was doing some cloud seeding. The cloud seeding project they were doing was at Steamboat Springs, Colorado. I said that if I had all the money I wanted, I'd put in a whole snowpack system on top of the Snowy Range above Steamboat, there on the Park Range in Colorado, and see if we could identify how much the cloud seeding was increasing the snowpack. By gosh, the next year we got the funds and were the first ones to put in any major amount of pillows. I think we put seven on top of the Park Range over a span of 18 miles. We put a repeater station up on top, and it transmitted back down to Steamboat Springs. I think that was the first system of any kind that ever went in with snow pillows. The contractor who did it for us was in Denver, and guy who worked for us was a guy by the name of Barney Swedbury. I'm sure it was a division of Leupold Stevens out of Portland.

Helms: Leupold Stevens?

Washichek: I think it was part of the Stevens company that did that for us. So we had that done.

Helms: About what time?

Washichek: I would say it was probably 1967 or somewhere around there.

Helms: I was going ask you—you mentioned Ralph Parshall putting the snow courses in, some of them far out of the way. When you did your maintenance, did you have to go in on horseback pretty much?

Washichek: Well, by the time I came aboard we had vehicles that could get up pretty close. We had to walk 3 or 4 miles in the summertime, but we could get closer then.

Helms: Did you have to furnish the snow cabins for the Forest Service?

Washichek: Oh yes, we furnished them. We did everything for them; all they did was stay in them.

Helms: You had a list of what kind of medicines, how much food, and various other things were required?

Washichek: Yes. Normally, they would say that they needed such and such to go up for the winter. They'd just haul it in on the first trip or before the snow flew. But those up on the Park Ranges have very high snowpacks, 10 to 12 feet, one of the biggest in Colorado. The radios sat up in a little house. It was 12 feet above the ground, had an aerial above that, and then they had a repeater site. We had a terrible time getting some of those in there. We had horseback and used donkeys. They tore some stuff up. They threw it off pretty consistently. They didn't like to carry that stuff [laughs]. Some of the sites were in wilderness areas, so then we couldn't even take vehicles in there at all. It became quite a pain. But we had a Tucker Sno-Cat that went in every 15 days and read all of the courses just so that they could verify the data we were getting out through our system. That became about a 60-mile round trip, which is a long ways to haul a Cat [Sno-Cat]. A guy by the name of Manes Barton read those for us for years. He worked for the SCS in Steamboat Springs and eventually, went to work for the Forest Service in Steamboat. He just retired a little short time ago.

Helms: He had another regular job?

Washichek: Yes, he worked for the SCS there in Steamboat. He was an engineering aide. We did have a survival cabin up on top of the Park Range, as well, that they could get to. They, theoretically, could walk to it from anyplace. It was almost in the middle of the sector, so the farthest they had to walk would be 7 or 8 miles. The Cat broke down, and they had to walk out several times. It could be a long ways.

Helms: When did you start using the over-snow vehicles, and which ones did you use? I guess each State had a little bit of leeway in what you used?

Washichek: Each State thought they had a unique thing happening, you know. You'd have to have some unique vehicle. I think that probably the Tucker Sno-Cat was one that was chosen more than anything else early on because it was big and heavy and did the work. We didn't have any trouble with it, particularly. I saw those in operation first in maybe 1954 or 1955 at some school. It was at Sun Valley, Idaho, as a matter of fact. George Peak was the snow survey supervisor of Wyoming. He got one to use. Wyoming SCS eventually took over the Green River Basin and the North Platte Basin in Wyoming. He had one that went up in and read the North French Creek Basin and Old Battle snow courses, where the two cabins were previously. We didn't really have that many in Colorado because we were a little bit closer than normal, or we had a cabin. So we only had one Tucker, then eventually we got a bunch of little Sno-Cat machines. But Bill Schomers, he had one at Littleton, Colorado. He called it the Ber-Kat, I believe.

Helms: Who was the inventor of this?

Washichek: Bill Schomers was his name. It had a unique leveling device with different tilting and skis parallel to the slope. He had originally done a snow plane and then, eventually, came out with a tracked vehicle. He was trying to promote, and he did use some of those. As a matter of fact, there's one on the highway as you go into Laramie, right now. I saw it the other day for sale. So that's really old. That thing really worked pretty well, but it was very small, a tiny thing. One time, Bill was going to demonstrate that to us up on the Snowy Range above Laramie. George came

Water and Climate Center, Portland, Oregon

4.19 KRISTI Ber-Kat being demonstrated at the Snow Survey Training School, January 1960

down from Wyoming and Doc Jenkins, the photographer out of Washington, came out to take pictures, and Bill Somers and I came.

We had George's Tucker and that machine together. We went up over the top of Snowy Range, and that's awful deep snowpack country there, too. We didn't think we would have time to get back, so we stayed in the cabin that night. Neither Schomers nor Jenkins had ever stayed over night out there in a cabin like that, and they were a little nervous. When we got up there the whole north end of the cabin was completely covered. The door was free of snow because it was in the lee of the wind. The whole rest of the cabin was covered. We went, had dinner, and then went to bed early. It was hot because those were so airtight that you'd start a fire and in 5 minutes, you could hardly stand it. So George and I kept opening the door, and every time we'd get the door open a little ways, one of those guys would go close it. So all night long, we were opening and closing that dumb door [laughs]. The next day, we went out and tried these machines out. There was probably 10 or 12 feet of snow.

When Jenkins got back, he sent us copies of the pictures he'd taken. When the Cat tipped, he would just shoot it straight out so all the trees were laying at a severe angle, and this was a professional photographer out of the Washington office [laughs]. We laughed and laughed and laughed. But he got some good ones, too. So when he retired, I sent him a couple of those pictures to remind him of us. The camera was straight up and down, but the trees were all lying over, he had a funny angle on those. Bill Schomers made maybe 30 or 40 of these machines. He was a Marine jet pilot. He was on Reserve when he killed himself on maneuvers one year, and that ended that machine. There weren't too many machines built. I think probably Morley told you that they had built one up there in Idaho.

Helms: He mentioned a little bit about it.

Washichek: Of course, the Tucker was the primary one built. Medford, Oregon, that was where Arch was. Arch liked the Tucker. Well, I did too. I thought it was the best machine they had. But it was very expensive. It was $15,000, $20,000 then, and that was a long time ago. But they did have several other littler machines, and then they tried innumerable machines using jeeps with tracks on them and all kinds of stuff. When the little Sno-Cat and Ski-Doo machines and all that started, everybody had them.

Helms: At some point, it became obvious that, commercially, some sort of vehicle like that would have a lot of sales.

Washichek: Originally, it was not a recreational vehicle. Then, when the people thought they could make some money out of this as a recreational vehicle, of course, everybody got into the business. Then they started improving the vehicle materially. SCS wasn't putting any money into development, and trying to keep it going, it was very difficult. Ash Codd built the forerunner of the small, over-snow machine. He worked for years with no money to get one that worked.

Helms: You mentioned the snow pillow, and I guess you'll mention the SNOTEL a little later on. What other sorts of technical innovations or equipment came from the snow survey work?

Washichek: Surprisingly, the snow tubes they're still using today are the ones they used originally. They never could improve on the snow tube.

They did eventually improve somewhat on the scales because they had originally used a dial scale. This froze up something fierce. You know, many times it would be 20 below up there, the wind was blowing like crazy, it was wet, and everything else, so a dial just didn't cut it. They ended up making a tube scale so it wouldn't freeze. Aside from that, that's the same exact tube they are using today. There's been no improvement, frankly, in that system at all, which is really amazing. That was designed by Church. In fact, the first one in the world was his invention.

4.20 Snow-Survey Sampling Guide

Helms: Clyde redid it, didn't he?

Washichek: Yeah, he made a little improvement on it, but it basically all came out of Doc Church's research lab down there. The only thing we did in Colorado was we eventually got the Government to furnish parkas for the surveyors and some clothes. Originally, you just had to be on your own. We had so many guys who were engineering aides who didn't have any money. You know, if you were a GS–5, and you were expected to go out and get gloves and parkas and all that, then work was really a hardship. So we eventually talked the Government into financing it.

Helms: You got them parkas, gloves, and anything else?

Washichek: Parkas, gloves, and a lot of times a hat of some kind. You know, a helmet or something.

Helms: You provided the skis or the snow shoes, too?

Washichek: Right. They were provided all the time. But most of the people took snow shoes, 'cause if you weren't a skier, skis were useless. One time after the war, there were tons and tons of snow shoes from the 10th Mountain Division, and those wide white skis. The 10th Mountain was here in Colorado, you know, up in Leadville, so they were available to us

Water and Climate Center, Portland, Oregon

4.21 Skiing lessons at the West-Wide Snow Survey Training Conference, Winter Park, Colorado, January 14–19, 1962

by the hundreds, literally. So that, for a long time, was our source of supplies for over-snow equipment. The 10th Mountain Division of the Army trained at Camp Hale, just above Leadville, in mountain survival and travel. They saw combat in Italy. As a matter of fact, Morlan Nelson was a member of the 10th Mountain. They were supplied with white parkas that were two way—they'd turn them inside-out in the summer and use them. So we got a lot of those parkas originally, and a heck of a lot of the gloves and snow shoes. They were really good snow shoes, some of the best that ever were made. But the skis were really tough. If you couldn't ski, you would have a terrible time. They were about 7 feet long and heavy. They weren't primarily cross-country either, even though the 10th Mountain used them as cross-country skis. The people in the 10th were all skiers, 'cause that was what they did, trained in skiing everyday. Of course, most of our people never even knew what the heck was going on. So except for the training schools—we had one every other year—they practically didn't get any instruction in skiing.

Helms: Could you give me some examples of uses of the information when you predicted a flood or a drought? I'm sure that a few instances come to mind.

Washichek: One of the biggest ones that really comes to mind was in New Mexico.

Helms: Do you remember the time?

Washichek: Homer Stockwell was still here, so it would have been before 1958. It would have been 1956 or some time around that. We had been forecasting inflow into the Navajo Reservoir. They called us up and said that they were building a coffer dam before they built the dam itself. A coffer stops the river so that they could build the major structure. The coffer just keeps the water there until they can get the major dam built. So they had built the coffer dam, stopping the flow in the San Juan River, and they were building the dam. A guy called from the Corps of Engineers and said they were having a lot of runoff from the snowpack, and he wondered how much water they were going to get down there. He said, "We have got to know because if that overflows the coffer dam, it will also take the dam out." At that time, they were a third or maybe half finished, so if the coffer dam failed, then the whole dam would have failed, and they would have had to start all over again, and it might have done a lot of damage below. The man in charge of the project called us up about every day and said, "Now, what are your forecasts, and how close to the original forecasts are we coming?" They had designed the coffer dam according to what we thought the runoff would be that year in that river. He said, "Does that still hold, are you still forecasting that?" and, of course, by that time, he said, "Well, you know this is only going to be about $5 million if it's not right!" So we hated to take on their responsibility. Even though we probably would not have been held responsible, it would have been quite a shock to our prestige and everything else if we'd been wrong.

He called every other day for about 2 weeks, and it just kept getting higher and higher and higher, and we kept saying, "Well, as far as we can tell, it's still pretty close to what it should be." So finally he called one day and he said, "Boy, we are now within a foot of the top of the coffer. What do you suggest we do? Should we go ahead and try and build the dam up higher, quack like a duck, or what?" So we said, "It should be over with. The flow should go down. You shouldn't get anymore." They could release a certain amount, and we said, "You ought to be able to release as fast as it's coming in." So about three days later that happened. He called us up and sent us a letter of congratulations. He said that they got within six inches of the top of the coffer dam before they could keep up with the water. He said, "Woo, was that ever close!" So those were the kinds of things that were not the everyday problems.

Of course, the everyday usage is much more important than the little individual cases. But the little individual cases were the ones you sweated out because with the others, if you make a 10 or 20 percent error, it probably is not going to have a terrible effect. If you make that big error on a little project, then you have got a big, big problem. So there were quite a few of those over the years that have happened. Two or three times down through the Rio Grande, we had forecast high water. It's difficult to forecast floods because it panics everybody, whereas you could say, "It's going to be very high water." We've had a number of times in Colorado where we thought it could do damage. So we would alert the Corps of Engineers. The Corps of Engineers in Colorado was in charge of flood control, so we would have our meetings in Denver about every 2 or 3 days and discuss who was going to get flooded out or how much and so on. Their flood control committee would get together and put out warnings to various people and various places so they could get down sand bags or protect whatever they had to.

Helms: About what time was this?

Washichek: This would have been maybe 20 years ago, in the mid-1970s. On the White River at Meeker, Colorado, they had a sewage disposal plant real close to the river. We told them that the river might get up to such and such a height, and they said that would be higher than the disposal plant. So that was going to wreck everything. They went out and sand-bagged the disposal plant. If it hadn't been for the sand bags, it would have done a job on them. So these incidents are the ones that you remember most, but they were probably not the most important ones.

I think the drought periods were as much or more important than the wet periods. When Governor [Richard D.] Lamm was still the Governor here in 1978 or so, we met every day for a month trying to figure out how little water we were going to get from various rivers so that they could make some adjustments for the drought period. The drought committee met at the Governor's house. All the scientists from Boulder, NASA, the Weather Bureau, and the SCS met every 2 or 3 days to see how close we were to the estimates we made, what could be done, and all that sort of thing. Through these operations, they were able to make some adjustments in planning, rearrange the water to go here and there, tell which areas weren't going to get any water so they didn't plan to plant crops. I think those kinds of times were probably just as important, maybe more important, than the flood times.

Helms: That was mostly concerned over water for agriculture, or was it municipal uses, as well?

Washichek: Some municipal. But what they did in the municipal was just say, "You can't water your lawn." It was pretty difficult to tell a farmer he couldn't water his crop, 'cause that means his lifeblood. That was part of the project, too. When we met with Governor Lamm, they put out ways to conserve water in the city of Denver. Then they restricted the irrigation of lawns. It was a big pamphlet. As a matter of fact, we put out one in every *Snow Survey Bulletin*. We put out a reminder of how to conserve water. I'm sure you can find them in some of the back issues. So those kinds of things were as least as helpful as the flood predictions.

Helms: This was the late 1970s?

Washichek: It would have been probably in the middle or late 1970s. I retired in 1980, so that would have been in that zone someplace. About that time, NASA called me up and asked if I would consider doing a research project. At that time, they were mapping the amount of snow through their satellite photography—the white areas of the whole world. They could actually map the amount of snow there was on the mountains in various ranges. There had to be some correlation, obviously, between the amount of snow that they could map and the amount of runoff there would be. However, it wasn't always the case, 'cause after a big storm, you could have just a little tiny bit of snow over everything, but the whole thing looked white. Of course, that obviously wasn't going to be the way it would run off. But by restricting the periods when you could, it . . .

Helms: You mean the periods when you took photographs?

Washichek: Well, they took photographs once a day or so. If you had waited until the snowpack had decreased to a point where you had permanent pack and then say, "Now is the time," then you could do it. So I went back to school in Iowa, and we hired a couple of guys. I went out to the Bureau of Reclamation and used their equipment to map the snow basins. Eventually, we got to a point where we could estimate runoff from that. In conjunction with the snowpack, it would have done something really good, and of course, they're still working on that to some extent. Anything you can do, theoretically, might improve your accuracy. I think, basically, they got down to a point with the snowpack where they just couldn't do it any better without some additional help. So that's when some of these other things started to come in to play.

Helms: They had already been using their imagery to try to estimate the snowpack, is that it?

Washichek: No, they had done it for many other things they had been mapping. They could map the snow, so they thought maybe it would be worthwhile to go ahead and see if it would assist us in estimating the snowpack. Of course, it also would give them a little advantage in procuring more money for their next project. The one at that time who was in charge of the project was Al Rango back in Washington. I guess we did that for maybe 3 or 4 years. I think satellite imagery eventually could help, and it also did a lot of other things for the SCS. They counted the number of pivot sprinklers in a district, as you can see them very easily from the satellite pictures. Of course, they also were using infrared, where you could get all kinds of vegetation analysis. Not only did it help us to some extent, but it also improved some of the other projects that the SCS was working on, and it also gave NASA a little kick to ask for more money.

Helms: You wouldn't have known the depth of the snow; I mean, did you have to sort of average the depth?

Washichek: No. See, what happened was we were already reading the depth, so we knew what that was. We just didn't know the extent. There was no way that we could go from where we were measuring it to measuring all of the snow. So this gave us a chance to measure all of it. We could measure down to 200 yards—the extent of how far down the mountain the snow came. They sent pictures down to me by overnight mail from Washington. So I'd get one every other day at 8 o'clock in the morning. We didn't have the equipment to analyze the photographs, but the Bureau of Reclamation or the State Engineer usually had the equipment. They also assisted on this operation. The State Engineer had a stereoscope optical reader, and the Bureau of Reclamation had a guy that could do it. We eventually trained one of the SCS summer assistants to read it too. He'd go out there and plot the snow. He could also tell the extent of the new snowpack when it arrived. You read them every 2 days. So it's all very interesting.

Helms: Was this data used in our forecasts?

Washichek: They did put it into a model that was part of a forecast. It was used in research for several years. I'm not sure what they've done with it now. It's just another tool; if they needed it, they could have it.

Helms: Most of those other guys have commented on their relations with the Weather Bureau. I guess I ought to ask you how they were here in Colorado?

Washichek: We didn't really have any trouble. We were one of the few that didn't, I guess. I don't know why. They just never particularly had anybody who was ambitious enough to push us, or they thought we were so good that they couldn't push us [laughs]. But we were never challenged in the newspapers. We were never challenged anyplace. We really didn't have any trouble at all. The only one who ever gave us any trouble was Gene Peck, and he was out in the Salt Lake office. Greg Pearson kept him so busy over there that he hardly ever even got over to worry about us. I think primarily—I'm saying this tongue in cheek—a lot of times they were mad that the Weather Bureau scooped them in the newspapers. Maybe they would be right, or maybe they would be wrong, but it was always a feather in your cap if you got the news out to the media first, regardless of what happened. Maybe, also, we had a little better shot at the news people; we knew them a little better than the Weather Bureau did, probably. We did a lot of work through CSU, and of course, you didn't touch CSU.

Helms: They were more willing to work cooperatively with you?

Washichek: No, they just worked with us, period. When we had meetings, of course, that was a favorite topic of conversation—Weather Bureau and SCS relations. But we never really had that much trouble. That was the least of our problems.

Helms: But if you thought there was going to be flooding somewhere, you went ahead and let the newspapers know?

Washichek: Oh, yeah. A lot of times, if it was critical, we would confer with the Weather Bureau. Well, we wouldn't necessarily, but the Corps of Engineers would. They'd call all the representatives together that had anything to do with it and pick everybody's brains. So it just wasn't one person's input or one agency's input, everybody contributed something—as much as they knew.

If you were talking about snowmelt runoff in Colorado, you would practically never have a flood from a snowmelt runoff exclusively, 'cause the mountains are too high, and it gets too cold at night. When it starts to melt, it builds up during the day and by 10:30 or 11 o'clock at night, it hits a peak because that's when the major part of it is coming from way the hell up in the mountain. By that time, it's 20 below up there, and it quit melting, so that's the end of the flood. Then it doesn't start to run off the next day until 10 o'clock in the morning when it gets warm enough to melt. Consequently, we would never have a snowmelt runoff flood unless you had extremely low snow, really way down, or unless you got a hell of rain storm on top of it. Even then it was really a minimal chance. So what the Weather Bureau contributed along these lines was saying what the potential was for precip at low levels and all that sort of thing. If you get a big snow storm at 6,000 or 8,000 feet during the spring, then you have got real problems. But if you get it at 10,000, it's snow; it isn't rain at all anymore, 'cause it's so cold. In our mountains, you see, we got about 47 peaks at about 14,000 feet, so we're way up there compared to most of the States. In New Mexico for instance, if you got rain on their snowpack, you got real trouble right away because it will come off, and the same with Arizona. So we had a little advantage here that some of the other States didn't have. But it was nice to have some other input from the Weather Bureau on the possibility of some rain during the day and that sort of thing.

Helms: For your operations in portions of New Mexico and Wyoming, you didn't have people stationed there, did you?

Washichek: Our SCS people were in there, also. We just worked with the State Conservationist in New Mexico.

Helms: But not snow survey people. You did have snow survey people?

Washichek: Well, the snow survey people were actually Soil Conservation Service people that we used. We had those in New Mexico, as well. I was considered to be on the staff of the State of New Mexico SCS office, as well as here. So I went down there and conferred with them on whatever need be. We hired guys and trained guys out of their office and did everything just the same as they did here.

Helms: Did you generally have good support from the State Conservationist?

Washichek: Yes. I hope this never gets back [laughs]. Most of them didn't know that much about it, to be frank—the snow survey part of it. They just generally relied on the snow survey supervisor to keep abreast of what was going on, and that was about the extent of it. So as long as the operation ran smoothly and you didn't have any trouble, they didn't harass you much. There were a few of the State Conservationists who eventually decided on their own that they would like to know. But most of them were so busy doing other things that they considered more important that they didn't brother us at all. But they always liked the publicity, 'cause they got more publicity through our office than any other office. As long as it was good, why, that was fine [laughs]. I never did have any trouble with any of the State Conservationists at all. Of course, the only money involved normally was our salaries. At one time, over 50 percent of the money we spent, including all the hired people, came through other sources, the Bureau of Reclamation or somebody. It seems to me that we had, at one time, $48,000 coming in from the Bureau of Reclamation alone. So it was quite a bit of money coming to the SCS.

Helms: During your time, did you have lots of requests to establish additional snow courses?

Washichek: There were maybe 150 snow courses when I first started, and I think when I retired, there were 200 and something. So we never expanded much. There were a few people who would ask, and some of the agencies, like the Bureau of Reclamation, requested specific locations 'cause they wanted to see if it was worthwhile to build the dam there or if there was a lot of snow there. Some of them also wanted additional information so they could better operate their program or their project. From that standpoint, we helped them out whenever we could.

Helms: Particularly since they were supplying the funds?

Washichek: [laughs] Right, since they requested you to do it! The State Engineer's Office occasionally requested a specific place. Once in a while, some irrigation company did, also. If it was at all possible, we did it for them because that was really good public relations. We felt that was who we were doing it for—for them. But we never expanded the system a great deal. The only time we expanded was if we couldn't forecast the stream worth a damn. If we had just struggled and struggled to forecast it and it never would forecast, then we went and put in additional snow courses. The only problem was that it takes 8 years of reading the snow courses before you could tell if they are any good. You couldn't get any correlation until you had 8 years or so of corresponding data. So you had 8 years of work in the thing, and it might not have been any good at all. Sometimes the snow course would prove worthless, but if it had been requested, the agency or persons wouldn't let us drop it. We didn't think some of these snow courses were worthwhile, but they would say, "Yeah, we use that all the time."

Helms: But what factors would cause the snow courses to give you the information that wasn't useful?

Washichek: It might just be in a poor location, where the wind blew off the top of the mountain and drifted the snow into that little valley more than in any other place. As an example, the Snowy Range goes up 12,000 feet and is completely barren on top. There's nothing up there, just a few little scraggly trees. We know they get 10 feet of snow on the other side, so you have to get a lot of snow there. But if it's barren all winter, then all that snow has got to blow into the parks below. So it's not representative of the snowpack if it's all full of snow that blew off the top. You're measuring too much snow for the runoff, so then you have to adjust that some way. By the same token, it may be a spot where the trees are prohibiting the snow from falling equally in the valley. There are a number of factors of terrain that effect correlation. Maybe it just didn't correlate, you know? Maybe that wasn't the area where the water came from.

The Colorado Basin extends from the Green River way the hell up into Wyoming and clear down through New Mexico. If you're forecasting the Colorado River, where do you start to measure the snow? Of course, we did it by measuring all the tributaries and then adding them up. These basins—like the Green, San Juan, Colorado, Animas, Little Colorado, Roaring Fork—are tremendously big basins. You've got to figure out where the water is coming from. It's hard to say, so you just try to stay relatively close to the main stream and hope to get one that identifies the amount of snow coming in or the amount of water coming off of each basin. Also, if it isn't high enough, then you're not measuring enough snow to get the critical amount that is supposed to run off. If it's too high, then you're getting too much. We tried normally to get three or four snow courses at various places—high, medium, and low. You've got to add these all together to see if that will work. Before computers came into the world, we spent literally half to three-quarters of our time trying to figure out what correlated with what, why it didn't, why it should, or what percentage should be used. In longhand, that takes forever! That correlation work is just an infinite amount of work if you do it longhand, whereas the computer can do it in a split second.

Helms: You were doing regressions?

Washichek: Regression analysis longhand is a long damn procedure. If you make one mistake through the thing then it's all wrong, and you've got to do it over again. It's really a long time. Then you would say, "Well, gosh, I wonder if this snow course will work with maybe half of these courses, or maybe two-thirds?" We used to have a factor of two Aprils plus May. We were saying that the April reading was twice as effective as the May reading, so we used two Aprils and one May. Or you could use two Mays and one April or three Aprils. There are an infinite number of possibilities. We usually spent hours and hours and hours on those regression analyses until the computer came along. Then, of course, you could do it so fast that it took a lot of the fun out of it [laughs].

I guess it was Ash Codd that really was the one who got started on the computer business up in Montana. When it was decided that they should go ahead and work with computers, I went over to CSU and took a course in computers. I went into that room at CSU, and it had one computer in it, and we worked with that thing. That one computer has now been replaced by a Hewlett Packard, which you can hold in your hand. They have one of the biggest ones in the world over here now. So over the years, the computer has changed the whole system just incredibly. It's nothing compared to what it was at that time. My God, we literally had file cabinets that occupied acres of floor area in the hydraulics lab. If you had 150 snow courses, and you read them five times a year, then over the period of years, you ended up with a hell of a lot of paper. They started microfilming and microfiching. You know, the computer just changed the world for us. It's one of the biggest changes, I think, that ever happened.

Helms: When did you first decide you should use computers?

Washichek: Ash Codd I'm sure is the one. He was stationed in Montana State University up there like we were here. At their campus, he and his assistants were looking at that, and they decided at that time it would save so much on notes, 'cause they could do it so much faster. I think it took them 2 or 3 years to convince everybody that was what we should do. We started using the computer in 1954, and at that time, we were the only agency in the whole Department of Agriculture using a computer. It was a gigantic damn computer. There still weren't very many computers when I retired in 1980. There were very few. The snow survey program really advanced that system by leaps and bounds. There was quite a bit of money devoted to getting our notes, regressions, and forecast formulas on the computer. At that time, we were still just using it for data checks and not so much for analysis. It was just to get the data all summarized, then gradually it became advantageous to use it for forecasting. Of course, that's all they do now. All the people in the field just do the maintenance and some snow reading and then let the computer do forecasting for you. It has been a change, that's for sure.

Helms: To what extent did you use airplanes and helicopters?

Washichek: The only time we used them was when reading stadia rods.

Helms: Your planes didn't land, they only did aerial readings?

Washichek: No, they just flew down. We used one helicopter down in New Mexico to read for just 2 years when we were putting some pillows in down there and wanted to get a good reading on that area. We read them up here for about 6 or 7 years. That was a pretty hairy operation here in Colorado. It was so damn high.

I remember at that time we were reading the stadia rod on Elk Mountain. I have to tell you, Elk Mountain in Wyoming was a very prominent peak that sits way up north. I don't know if you have ever been by it or not. When you take the highway from Laramie across to Rawlins, it's a gigantic peak that just sticks up. It's just a big knob. During the war, I don't how many planes crashed into that because it sticks out there by itself. I think there was 10 or 12 Navy Corsairs that have hit that peak. You don't think it should be that high, way out there, 'cause the Continental Divide is only like 8 to 9,000 feet. Here that thing is, 12,000 feet right next to the road practically, whereas the Continental Divide is only 8. Anyway, we had never been able to get up there onto that mountain, and we weren't sure how much it was contributing to the runoff, but we thought it must be contributing something, 'cause it was a big peak. So we decided we'd put a stadia rod up there. Homer Stockwell was still the supervisor there. He and I went up there one summer. They had a logging road that went up to the top. We got about three-quarters of the way up there into an old logging mill area that they kind of cleaned up and put a stadia rod in there. We hired a guy out of Laramie to read that for us. It had been the practice that after you had read the snow course by air to go read it by ground and also see what the snow water content was, so that in the future, you'd have some idea of how close you were, and you'd read the snow course to see if the stadia rod was in the right place 'cause it might not correspond to the snow course at all. It might be in a little shallow place. We put the stadia in there; the next winter we were going to read it. We were going to read it in March, then fly it in March, April, or May.

We took the Tucker Sno-Cat up there, and while we were unloading—I can't remember whether we ran over his foot or the tail piece fell on his foot—anyway, we broke Homer's toe, so he couldn't go on. I said, "Well there's no sense doing that, I'll just walk up." I put my snow shoes on and started up that road. I was probably 2 1/2 to 3 miles up there, about three-quarters of the way. I don't know if you ever had the feeling that you weren't alone. I couldn't have been making that much noise, but I sensed something was there. I turned around, and there was a bobcat following up in my tracks. Of course, I didn't think the bobcat would attack. He's pretty small; he's just a little cat. So I turned around and went, "Get out of here!" I went up the road a little ways, and every time I turned around, he was right on my tracks. I thought that maybe he hadn't anything to eat. So I took the snow tube out. I don't know if you've ever seen a snow tube, but it has an extremely sharp end on it. I thought if he came at me, he was going to get his nose cut off. I carried that thing and went on up, and after about a mile, he diverted and left. I read the snow course, came back down, and told Homer. I said, "Well, I was just about mauled by a bobcat [laughs]!"

We got him [Homer] to the doctor and took the Sno-Cat on into Saratoga. I left it out all night, and the track froze. They won't go with the track frozen. If you make it go, you're gonna break something, so we had to take it to the county shed there, and they steamed it all out for us. By the time we got back to Laramie, it was 2 days later. I said, "My gosh, we'd better check that snow course right away." We went out to check with the guy who was going to fly it for us. We jumped into an airplane and flew up there. We were flying out parallel to the mountains, so we were actually 3 to 4,000 feet above the terrain. But we were level with the mountains. We would fly back and forth parallel to where the stadia should be.

I couldn't see the stadia rod, it was so far away. I said, "You've got to get closer," and he said, "Boy, you know it could be really turbulent when you get close to that mountain." I said, "We can't see it from here." So we kept getting a little closer and a little closer and a little closer. Finally I said, "Well, I think if we make one more pass a little tiny bit closer, I'll be able to see it." We made one more pass and I said, "There it is!" I got the reading. He turned to get away from the mountain, and all of the sudden, the plane just started to go! "Whoosh." I had an ashtray—everybody smoked at that time—sitting on the dash board and a whole bunch of maps. All of it was flying all over the cockpit. We were dropping about a thousand feet, 2,000 feet a minute. He had the airplane standing on its tail—full throttle—we were still going down. I had been a pilot in the military, so I said, "Well, we may get a chance to find out if there really is a cushion when we hit!" 'cause they always said that you would eventually stop before you hit the ground.

Helms: Who said that?

Washichek: The wind starts down when it comes over the mountain, and when it gets near the ground it blows out on the prairie so that when you get to that point your airplane will stop falling. But that has never been proven to me. So I felt that we were going to find out in about another minute and a half. It did stop. I don't know whether he stopped it or what, but anyway, it stopped. By that time, we had cigarette butts in our ears and noses and maps thrown all over the cockpit. He said, "Well, I hate to tell you this, but that's my last reading of that. I'm not reading them anymore." So we had to abandon that one; we never could get a better reading.

We spent maybe a week all total putting it up, finding the course, and reading it. Then we couldn't get an aerial reading. We sent another guy up there once from CSU from the Fort Collins Flying Service. He started to get close, and then he wouldn't go in either, so we just said, "The hell with this, just abandon it."

You get a lot of turbulence. When you get where it's relatively flat, it's rolling 8,000 feet out there. You can just go from Laramie to Salt Lake City, and the land just rolls. When you got that kind of flow of wind, and it all of a sudden hits a mountain that's 5,000 feet higher than the plains, you got all kinds of weird things. Wind is always blowing in Wyoming. It's a kind of steady day and night flow of 12 knots all the time. So you can imagine when it's blowing up there what it's like. When that occurs, that big bump up there creates all kinds of problems. I think that's another reason why so many of the military planes crashed up there. They didn't know what they were doing. They would come around and then, all of the sudden, hit that downdraft or updraft or whatever it happened to be at the very end. They didn't know what to do or what was happening. So that happened to us a few times. We wasted our taxpayers' money for about a week for nothing. But I guess we had to take the bitter with the better.

Helms: No other close calls come to mind?

Washichek: Oh, we had a lot of them. George Peak and I would go to survival school every other year, where we taught not only survival, but also how to read snow courses, safety, and just general snow survey subjects. We also taught how to ski and how to snowshoe. We put students out in the field at night in the snow in a sleeping bag so they could prove to themselves that they could stay out there if they had to. They went out and built shelters and snow caves or whatever. We had demonstrations of how to build various shelters. That was their choice. They had the old buddy system where two of them would build a cave or something together. I think we were at Jackson Hole, Wyoming. We always sent out at least two instructors, sometimes four, from the snow surveys staff to stay with them at night just in case something happened. So George Peak and I were going up to stay with them one night. If it got lower than 20 below, then we pulled them in, it was too cold to use sleeping bags. We had the old army surplus mummy bags. Below 20 below, we couldn't stay there. Well, we could have, but it would have been so uncomfortable that they wouldn't have gained any knowledge from it.

I woke up George—it was nearly 8 a.m.—and we got out of there as quickly as we could. The students usually left the bivwac area by 6 or 7 a.m. We had a car, so we jumped in and went back to Jackson Hole. By the time we got there, the school thought we had succumbed to the weather, and they were already getting a rescue squad ready to go. Oh, it was embarrassing [laughs]! We had a system where they had a little metal tag with your number on it. Each time they went out, each one of them took this little metal disk with them. They reported in the morning; if all the little metal disks weren't there, they knew somebody was lost, and they'd go out and find them. Of course, neither George's nor my disk was on the board, so they assumed that we had gotten frozen or something. We had a very difficult time explaining this to the troops [laughs].

At that same school, I had taught skiing. I was one of the ski instructors, and we had a little tiny bunny hill. We told all these people every day, "Now, don't do anything until the instructor tells you, and do so and so, or you're going to get hurt." We never did really have anybody hurt. The reason that we didn't was because we made them stay right with us. Then one day, we got on top of the slope—it couldn't have been 80 feet high, all total. Our trainees were from all over the Western United States. They weren't anybody we knew, necessarily. They were just some group of snow surveyors. All of the sudden, I turned around and saw this guy in the back. He turned his skis downhill, and he headed right straight down and just zoom and he was gone—Oh, my God! So I jump turned and skied down. I got there almost before he did. He crashed something fierce, he really crashed. Before I even got there, I could see that his leg was broken. You could see it all twisted badly. I ran over to him, and I did read him off! I was so mad at him. I thought, "They'll really get us for this." Here we broke the guy's leg, he'll be out for I don't know how long, and we've lost his use to the SCS or wherever he was working. I was mad at him, and I really told him what I thought about it. He just sat there moaning, and pretty soon, the Ski Patrol came over to assist. I reported that we had somebody who broke his leg. They said, "Who was it?" I said, "I don't even know!" I was so mad at him. He was in the hospital, so we went over to the hospital to see who it was. It turned out he was a tourist from Texas [laughs]! He just happened to be there. He said he watched us for a long time and thought, "That looks pretty easy!" So he just got in line with us. He said, "I wondered why you were giving me so much trouble." So I had to apologize, and we saw him at dinner a couple of nights later. He and the rest of his family stayed there, and he just put a cast on it [his leg]. He said, "My God, I'm afraid to even get out there anymore for fear that somebody will grab me [laughs]!" I bet he'll never come out here again.

Helms: Well I guess, considering that you have the really high mountains, the SNOTEL was a good development?

Washichek: Absolutely, certainly. The only trouble we had when we were originally doing this was that it was going to be a local system. That was before they had any satellite imagery or satellite microwave. We were trying to do it from remote to remote to remote, and that just drove us crazy. We couldn't get from mountain to mountain to mountain. They were so high that it would have just been impossible. You would have never been able to work that system, I don't think.

Helms: You mean for the whole West or just for Colorado?

Washichek: No, just for Colorado. For a lot of them, the repeater sites would have to have been right on top of the very highest peaks. The maintenance up there was almost impossible. We got AT&T [American Telephone and Telegraph], or some of those that can afford $50 million for a site, to work with us with our 8,065 bucks. It was pretty tough, but we tried it. In fact, we tried to get one from Steamboat Springs into Denver. We had a repeater at the top of the Park Range, and it transmitted down into Steamboat Springs. From Steamboat, we tried to go to Mines Peak, which is on the Berthoud Pass, and from the Berthoud Pass to Fort Collins. Mines Peak is the top-most peak in that area, and that's where AT&T, all the highway patrols, and the railroad had transmitters or repeater sites. We could never get through. We just didn't have powerful enough equipment to do it. We had tried innumerable other sites. We just couldn't have done it; it would have been impossible without a lot more money than we had. So

4.22 Repeater at Park Range transmits data to base station at Steamboat Springs, Colorado

114H–COL–11280 National Archives, College Park, Maryland until they got that transmission by the particles in space, we were just sunk. When they got that, it was really the answer to the prayers around here.

You know there are just too many peaks between here and there. Now, the Forest Service has many restrictions. It has to be declared a microwave installation site or you can't do anything. You can't put it on just any peak. A lot of them you couldn't get to even if you wanted to. It has to be a designated area. It just never would have worked. So what we did up in Steamboat was, when they got the data, they just called us on the phone. It was just a kind of research thing anyway. It wasn't that important, we weren't using it as operational data.

Helms: You still continued manually measuring many of the SNOTELs?

Washichek: Yeah, I think they read a third of them. I'm not sure, but I suppose they still check to be sure that some of them are still reading right. The rest of them are automatic. As long as they work, they work fine, I guess. The maintenance is incredible, I'm sure.

Helms: You mentioned a few developments or contributions of people. Does anything else come to mind on that? I guess Arch Work pretty much had leadership?

Washichek: Surprisingly, when I was in the prime of the manual measurements, they were pretty much individuals, and they pretty much ran their own systems. They took a kind of dim view of outsiders coming in to tell them, even Arch. Arch was more of an advisor. He technically didn't have anything to do with us except in an advisory capacity. We were directly responsible to the State Conservationist and certainly not to Arch Work, except in a technical advisory capacity. So he would come down and see us, and we always appreciated that. When he showed up, he'd tell us about some new developments from other States or what was going on. If we had any problems or if there were new developments on equipment or anything, he helped us procure money. Aside from that, it was pretty much everybody on their own.

You know, now it's so highly technical that it's a different atmosphere. The guys at that time worked hard as hell, and they played hard as hell.

They were really a pretty wild bunch, to be frank. They spent a lot time out in the field. Even all the supervisors went out at least every month and maybe stayed out 2 or 3 days. We tried to go out with everybody in the State over a period of 3 years, so you're going into 50 snow courses a year. There was a lot of work involved and a lot of walking involved, so you had to stay in pretty good shape. I think there were some pretty big drinkers in the group, and they played pretty hard.

Now the atmosphere has entirely changed 'cause there aren't any workers, as such. They don't spend that much time in the field. They may work as hard, but it just isn't that type of a deal anymore. A lot of them have Sno-Cat machines to get there; they don't have to walk anywhere, just a half mile or 50 yards. Now it's highly technical, compared to what it was at that time. The stories you got then were about people crashing and burning and getting caught in avalanches and all that sort of thing. Now, the talk is "My God, we've got to get a microchip that's a little faster!"—this sort of thing. So it's more of a technical program.

Helms: So it's now much more accurate?

Washichek: Well, I don't think it is, to be frank, 'cause I think we were just about as far as we were going to go. At the last one I did, we had an accuracy of 85 percent. I don't think it's a lot better now, and it's probably just as expensive.

Helms: You mean 85 percent before you went to SNOTEL?

Washichek: Yeah, when we were making manual measurements and doing our own forecasting, we had 85 percent accuracy. I don't think it's much better than that now—an average accuracy of about 85 percent. It depends on the river. Of course that was the big, big deal with the Weather Bureau. We were always tying to prove that we were more accurate than they were and versa visa. If we made a big bust on some stream someplace and they didn't, then they had a big to-do. That was primarily the reason that we had technicians in Portland come out, check accuracy, and assist us. The technicians in Portland tried to improve the system or help to improve the accuracy. We kept those records for ever and ever and ever. Every year, the first thing you did was check your accuracy when the season was over to see what was wrong because that was the base for all your next year's work.

Helms: If one was proving to be pretty accurate, you could forget about it and work on the ones that had problems?

Washichek: When you get lower runoff, like in the New Mexico area, or you get comparatively low flows, then you have a lot worse chance. If you get down around 50 or 60 percent, you're doing well on the real small flows at the lower snows. A lot of times, you get only couple feet of snow down there.

Helms: You can check this by the USGS [U.S. Geological Survey] station?

Washichek: Yeah, as soon as the flow figures came in, they were immediately forwarded to us so we could figure it out. It was an April to September forecast period. So by the end of October, they almost always had those records ready for you. You could immediately go down and get those and see how good the forecasts were. That was the big deal, checking that out.

Helms: You told me about some of the cases that proved right. Were there any ones where there was big criticism of the forecasting?

Washichek: Yes, I'm sure of that. I would guess that the biggest errors that we made were in New Mexico, and they [New Mexico] were the biggest complainer. Phil Mutz was the deputy State Engineer in New Mexico. At one time, he was an engineer with the Bureau of Reclamation when they built the Platoro Dam and Reservoir on Conjeos Creek in the Rio Grand Basin. When the Bureau of Reclamation finished building something, some of the employees on the project were terminated. When they finished the reservoir, Phil transferred to New Mexico, to the State Engineer's Office. He knew a lot about the snow survey program, unfortunately, and knew me from a long ways back. So he really put the pressure on us down there to get the accuracy down, and a lot of times, we just couldn't improve. It got to the point, I can't even think of when it was, when we missed a couple or three of those 2 or 3 years in a row.

They had to supply Texas with a certain amount of water every year according to their compact. Colorado, New Mexico, and Texas have a compact on the water flowing out of Colorado into New Mexico and Texas. If we missed the forecast, then they had problems. We would say, “You should get 100,000 acre-feet.” Then the State Engineer of New Mexico would say, “We’re getting 100,000, and your share of this is 30 percent.” So they released 30,000 to Texas. Then if they only got 60, that meant that they only got half of the water they should have had, and you know who got hell for that! They really put us over the rack a few times when we missed a forecast like that. Oh boy, they did pressure us! But there wasn’t a lot we could do about it. Those times, we would show them the records. But Phil used to come up here and meet with us quite regularly and rap us around, drag us over the coals a little bit. It was too bad, of course, but we couldn’t help it. The Bureau of Reclamation would say, “You’re allotted so much for some project.” Then they only got 20 percent of that. So it was highly hazardous to your health from that standpoint. But officially, they couldn’t prosecute. If you had a hard skin, you were in a pretty good shape ‘cause they couldn’t do anything to you officially. There was just your word after all, your best guess.

Helms: They didn’t have much of an alternative, did they?

Washichek: No, but it did make you feel kind of bad.

DEED OF GIFT

I, Jack Washichek, do hereby give to the Soil Conservation Service the tape recordings and transcripts of my interview of June 6, 1989.

I authorize the Soil Conservation Service to use the tapes and transcripts in such a manner as may best serve the educational and historical objectives of their oral history program. I also approve the deposit of the transcripts at the National Agricultural Library and any other institution which the Soil Conservation Service may deem appropriate. In making this gift, I voluntarily convey ownership of the tapes and transcripts to the public domain.

Jack M Washichek

Jack Washichek

10/8/92

Date

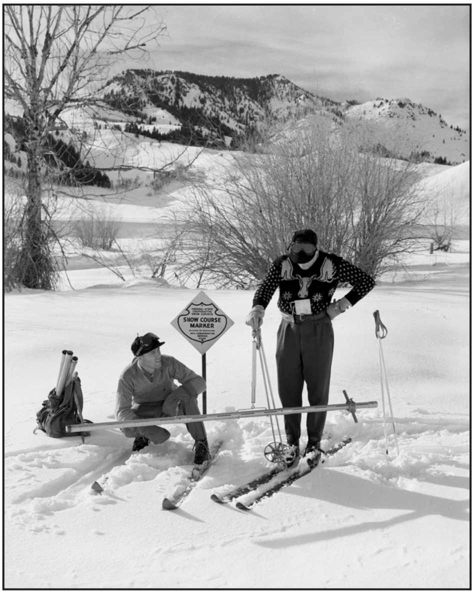
4.23 Jack Washichek Deed of Gift

Morlan W. Nelson
Boise, Idaho
May 9, 1989

by

Douglas Helms
National Historian, U.S. Department of Agriculture,
Soil Conservation Service
(now the Natural Resources Conservation Service)

Douglas Helms: To begin, let me ask you about where you were born and grew up. Tell me something about your education leading up to the point where you got involved in snow survey work.



114G–IDA–35065 National Archives, College Park, Maryland

4.24 Morlan Nelson (left) and Glen Brado, Forest Service, 1950

Morlan Nelson: Well, I was born in Munich, North Dakota, but we lived on a ranch between Finley and Cooperstown, North Dakota. My grandfather was a homesteader, and I grew up on that ranch. I roped horses, herded cows, plowed with the horses, seeded wheat, and shoveled manure and hay, and had a very physical beginning as far as agriculture was concerned. From 5:30 every morning till 9:30 every night we were doing something, and I loved it. I liked the horses and everything—even the hawk that I eventually took out on the range. I couldn't believe that I got a hawk that could catch a flying duck. Training it was just like training a wild colt. I said that to my dad and that concept followed me through my life, as well as the scientific part of it. I still have both of my ranches in North Dakota that were my grandfather's homesteads. Partly it's my problem at the moment [laughs].

When I grew up, I went to my grandfather and my father, Norwegians, who used to say a thing I've never ever forgotten, which is true to this day. They said there is one thing they can not take away from you, and that is your education. When you hear that the first time you think, "Brother, nothing truer that has ever been said in this world." I'm a classic example of that because everything that I ever learned in college I've used over and over—way beyond what I ever dreamt that I would at the time I was studying. They were encouraging my brother and me to go to the university, as my father had been coached by my grandfather, Steen Nelson, to go to college. They had come over from Norway, and they thought that was the biggest deal—they were very very proud of their education, and rightfully so, because they were damn fine students.

By the time I got to college, I had a zest for learning second to none. I had completed a doctor's degree by time I was 29 years old, except I never did go and write the final thing that you had to do. I had taken the two languages and all the things we had to do to get a doctor's degree at that time. I took 23 hours of math, sciences, and soils. I took nuclear chemistry. Because of soil science, I went all through physical chemistry and civil engineering, and then as a side interest I had biology. I was always interested in hawks and of course that developed into the whole field of ornithology, but that was just a side issue. The "ologies" were the ones that I liked. Pedology, agrostology, and geology—all these things I loved. When I came out of there, soil science was the place where there was a growing need because of the Dust Bowl. So even though I had all this chemistry, all this engineering, and all these other things, I just went ahead and plowed more into soil science and ended up with that work. I loved the physical sciences and the chemical sciences.

Helms: Could you tell me where you went to college?

Nelson: North Dakota State University. When I got out of that, I went to work in 1938 for soil surveys. The work was out of Albuquerque, New Mexico, as a soil scientist along the Rio Grande and in parts right near the Rio Grande, out of Las Cruces. I was a party chief in the mobile survey at the time. They shipped you all over. They shipped you way north in the summer—way up in Colorado, Utah, Arizona, and New Mexico—and then to the Mexican border in the winter on what they called mobile parties. I was trying to figure out what the major soil types were and what the major problems were. I worked on the Indian reservations trying to help them in the same way, on a research project. I then went up to Tremonton, Utah, as a soil scientist, doing soil surveys and working with the Utah State University on soil problems.

Then the war came along. I went to war for 5 years and enduring a year with a fragment and bullet holes, I was down all together. My first assignment was at the Desert Training Center with General George Patton. As a part of the assignment, I laid out the Desert Training Center as an engineer. It's still there at Indigo. My work was on his general staff because they had to know about desert soils, water, and survival. They wanted me to teach the desert infantry. But I didn't like that situation and thought General Patton was a limited-minded militarist. My problem is with militarism, and he was a pure militarist.

Then the para-ski troopers, or mountain infantry, was formed, and I had all the background in mountains, skiing, and engineering. They wanted people, and I had experience climbing cliffs to get eagles and falcons, so they shipped me to the ski troops, which was then the 87th Mountain Infantry. This was against General Patton's wishes, but he was ordered to send me off.

I had a great deal of experience in high elevations, sleeping in the snow, working in the snow, and with avalanches. We were controlling avalanches with explosives in the war. As a scientist, I was already struggling with that, and not worrying about water content. I was worrying about sleeping there and keeping warm and digging a hole in the snow to sleep and all that. We went against the Japanese in the Aleutian Islands in Kiska. Then we came back and formed the 10th Mountain Division and went to Italy and fought all the way to Yugoslavia up to the Brenner Pass. I got shot and hit with fragments the last time 5 days before the war ended.

After returning, I went to work at Salt Lake City as a soil scientist. At the time, I was still in the hospital and still in the Army. My rank was captain on rehabilitation leave. I couldn't walk so good—one part of a nerve was shot off, and I had two draining wounds. Once I started to get over it, my recovery went real well. It was possible to start skiing, ski jumping and flying falcons.

Besides the soil and engineering and the nuclear business, I also had the mathematics that provided forecasting ability. This turned out to be good background for a snow survey supervisor. When I got over the wounds, they asked me if I would come up and be the snow survey supervisor for the Columbia Basin. That was a move from Salt Lake to Boise. I came up to Boise and saw the Boise River and seven pairs of falcons in the canyon. Boise was on the western edge of the time zone, so I could fly my falcons after work. The terrain and mountain work fit me better than Salt Lake City.

Helms: So this was about 1946?

Nelson: I came up here in 1948.

Helms: That was because of your background during the war?

Nelson: They were interested in me as a snow survey supervisor. They said the guy goes on skis, lives in the snow, and has studied the mountains, and he's an engineer and a soil scientist. So they offered me the job to be the snow survey supervisor for the Columbia Basin in Boise. The SCS didn't start the snow survey, but they were associated with it. George Clyde, then the Governor of Utah, was a highly educated man. He was the head of the snow survey research. He was the man who hired me to come up here to be the snow survey supervisor for the Columbia Basin. Jack Frost was in Oregon. We picked up a snow surveyor in Wyoming, then we got others in Washington, Montana, and throughout the West. Then they moved the snow survey supervisor for the Columbia Basin to Portland. I did not want to go to Portland, and so I still served as the supervisor and worked with Arch Work, the head of the snow survey and water supply forecasters. Arch Work was a great man. Arch Work didn't look down the same key hole with me, but boy, when I saw something, he just said, "I don't know, but let's give it a try." He was a tremendous man in his ability to assimilate and understand the wide range of variables which are necessary in this kind of work, compared to just soil science or engineering. It's a combination of all of it.

Then we got our own money, but we were still in research. I got the money from everybody including a certain amount from the SCS. But mostly we got our budget from the State, mining interests, the Corps of Engineers, the Bureau of Reclamation, private industries, Idaho Power, and others.

Helms: So you think you got more money from them than you did from the SCS?

Nelson: The USDA funded a big part of the cost. At the time, in research it was also the Corps of Engineers, Idaho Power, the Bureau of Reclamation, and others. All of these people came in with money because of their broad interest in the water supply business. SCS finally said, "Well, wait a minute, we're going take this into the regular SCS." Then they begin putting in the money and putting in snow survey supervisors in other States over a period of years.

Helms: What kind of network existed?

Nelson: I forget. I don't know how many snow courses I posted in Idaho, but it is in the records. I may have posted 30 or 40. Anyhow, they had just a few snow courses. They had one of the first ones that were pretty far out, such as the Moores Creek Summit. But they didn't have Atlanta Summit or some of the others until after that. Then I went out and put in the ones that were further out—up on the other rivers—and even in Wyoming. Other snow survey supervisors started putting them in after we became a part of the SCS.

What I just had to smile at was that when working, I always took my sleeping bag. Even though we went partway in the snow machine, if you get 40 miles out and you can't ski out at night, you're going to sleep in the snow. It was easy to do, like we did in the war. They had a cabin on South Mountain where you could sleep like a gentleman. They had cabins up here in the high mountains, in many places, as survival cabins.

Helms: Who was this? The Forest Service?

Nelson: The Forest Service, the SCS, and the Fish and Wildlife Service's predator control people had them. But if you got in a storm, you could never get to the cabins anyhow. To start with, I said, "This is silly as hell."

All you had to do was get some G.I. sleeping bags, show the men how to drill a snow cave and a lean-to, and teach them survival. Then, forget all about these cabins. Of course, the snow machines were getting better. The first training school we had was over here in Sun Valley. We went out and slept in the snow.

Helms: When was this?

Nelson: Oh, it was maybe 1950. I was the guy who was all into survival—digging the snow cave and sleeping in the lean-to, rather than going to a survival cabin, which was a lot of times 10 to 20 miles up the mountain. So we had a training school which trained men in snow survival. That was a great success. All the young people said, "Well God, I'd rather carry a sleeping bag!" If you know how to sleep and put your blanket down, either build a snow cave or build a lean-to. In the war, we did that all the time and that was the only way to go, it was the only way you could live. Those techniques turned out to be great for snow survey people wherever they were. Canada was interested in that, so they came down as part of Columbia Basin and participated with us.

Helms: So you're saying that before, the snow courses were limited to areas where they were putting cabins. If you don't depend on the cabins, then you can expand the number of courses?

Nelson: That's exactly the way I looked at it. I said you can't be limited by the cabins. It was obvious, the places where I wanted to go weren't up there at 12,000 to 14,000 feet all the time. Nor were they down here at 6,000 feet, but somewhere between 6 and 10, 11, and 12,000 feet is where you wanted to be for the top course, which is the most important for the late streamflow. Furthermore, the snow machines got better. So we could go further on the snow machines and then only walk a few miles. I set the snow course up there at Trail Creek Summit up above Sun Valley. There was a man killed on it by an avalanche, and they had to quit that one. He was skiing and didn't know anything about avalanches. But we used to go up there. I knew that avalanches were there.

For some of these snow courses that I was putting in, you had to go by some bad avalanches. Atlanta Summit is another one, where you come up through the middle fork there are three avalanches that are very dangerous. We just quit that and went to helicopters and to other things for coming in.

Helms: Would you say there's a way to predict an avalanche?

Nelson: Always. On the mountains, there are avalanche paths. You can tell them by the way they clear everything, the angle of the snow, and the direction of the wind. Monte Atwater, who was another ski troop officer, and I started out with avalanche research for the snow surveyors. As we did in the war, we skied with the rope on top of the mountain. One guy put an ice axe in up there, and then the other guy skied over the cornice. One guy put an ice axe in up there, and then the other guy, secured by a safety rope, skied onto the cornice. The intent was to break off the cornice and trigger an avalanche below. I did this all the time. Monte wasn't a good skier, but he was a good scientist. I would ski that, and then I would trip the avalanche and go down. All of this was done over in Utah. We damn near took out the lodge at Alta one time with an avalanche that we had set for research.

Helms: Who was Monte Atwater?

Nelson: Monte Atwater was the man who started avalanche research for the Forest Service at Alta, Utah. He was a ski troop officer with me in the 10th Mountain Division. He was also a captain, we were both in the Mountain Training Group. We had these interests and knowledge of each other as ski troopers. Those that lived through it to this day meet once a year or more often. It's a very close-knit group of men.

The avalanche control program was more appropriate to the ski resorts than to the snow surveyors, in some cases. In other words, there were more problems with skiers than there were with guys making snow surveys. A lot of times if there was an avalanche problem or too great a distance to travel, we'd change over to our 'copter. Which we still do, no doubt.

But the knowledge of this fits in with other things. The insulating quality of the snow is one of the amazing things. We started digging down through the snowpack. This was why I wanted to put the first soil moisture unit in the soil for snow surveyors. When you did avalanche research through the snowpack, if the snow is deeper than 3 feet, the soil is not frozen. This year [1989] is a classic example of that. It can rain and the rain goes right through the snowpack and into the soil. All at once, the soil won't take as much rain as we thought it would this year from the snowpack because it had been raining like hell, and a lot of it got through the snow. I'm talking about the days when we had big snows and we had floods right here in town.

A part of our work was research. I went over to the Arco, Idaho, area where there was a tremendous snowpack, down 3 and 4 feet. Everybody was saying that we were going to have a big flood down low. I said, "I don't think so, as long as you got 4 feet of snow." I went over there and dug down through the 4 feet and found the soil unfrozen. I knew then that it would absorb a lot of water. If they had a warm spell in March, then they'd have flooded that place like you couldn't believe—with the soil frozen. But with 4 feet of snow and 2 weeks of time when the snowmelt started, the soil took its piece out of it, and it didn't flood. This was one of the things that we found out.

Helms: How did you manage to work that into forecasting?

Nelson: The Weather Bureau was supposed to be making the flood forecasts; they were talking flood, and I was not. I was always fighting with the newspaper here. Because I never agreed with what the Weather Bureau was doing—measuring the water down in Boise and telling us what was going on 10,000 feet up in the mountains. That just wasn't working. We fought over that at the Columbia Basin forecast meeting in 1949. Remember, in 1948 they flooded Portland. Come 1949, they had more snow than they had in 1948 at one time. But they had completely dry soil underneath it. The Columbia Basin forecast man, Arch Work, and I were there, and some of my own men were there. They were saying, "We're going to flood." I said, "Guys, it's way, way down! The lower elevation snow is all gone, the higher elevation snow is an altogether different thing. We haven't got a flood potential in 1949, even though we got a tremendous amount of snow." So sure enough it didn't flood in 1949, it did just exactly what we said it was going to do.

In 1948, when I was starting it, and Arch agrees with this, I came up with the point that we have got to have a soil moisture factor. It was written up in the Proceedings of the Western Snow Conference. They published a paper on snow moisture's effect on forecasts. I was measuring with electrodes the water holding capacity of the soil. I was saying that it was going to take 10, 12 inches of water from the snowpack to saturate the soil underneath it. But there was no way then we could get enough soil moisture electrodes in the soil to do this. Then I went for the thing which is still one of the best ways of getting it, and that's the baseflow of the river. The baseflow of the river in the fall and in the spring is a function of the soil moisture beneath the snowpack. So Dr. Hal Wilm, Arch Work, and myself published the first paper on this subject. This was the way they apportioned the water on the Columbia River between the United States and Canada. It was damn good forecasting—.96 was the accuracy. We used the baseflow data and the snow data.

I talked to Arch, and he sent me this letter just this year which said, "I'm proud of the best thing we ever did, which was when we got together and wrote that paper on the forecasting at Columbia which resulted in the international cooperation." That created a real good feeling between Canada and the United States. Both organizations were happy with that, and they have improved on it, no doubt, with all the knowledge that they have now.

The other thing that happened was that we always were arguing with the Weather Bureau about floods because of 1948. Then I designed this flood forecasting thing. Instead of April through September, I went down to April through June and then subtracted the flow in March and April and forecast the correction with precips based on April through June. I could forecast the floods better than the Weather Bureau because I was taking the volume of water for a shorter period of time and correcting it for what had actually flowed down the river and relating it to the snowpack. Then I got the experience on which way it was going to go. They couldn't do that because they were just measuring the rain.

Helms: Did you always make the forecasts whether the ground was frozen or not?

Nelson: The ground was never frozen underneath the snowpack. That just occurred on the lower edges, that's a different problem. In the high mountains when you get 10 feet of snow, you get the vertical hexagonal forms that create avalanches. You get the interface of the moisture and the heat of the earth coming up. This will create cornices right within the snowpack. This is why we were always digging all the way through. If there was 10 feet of snow, we took the stratigraphy of the snow all the way to the ground. On a dangerous avalanche, it was a function of the relationship between the soil, the snowpack on top of it, and the angle of the soil. So if we had all these factors, then we could forecast an avalanche.

The other kind of avalanches are where you've got 10 feet of snow and the snow comes over and forms a cornice, a slab. That's different. One kind of avalanche is where the sun hits the snow and creates a hard surface. Then comes powdered snow on top of that. A little wind blows, and you get a cornice up here. When a little piece of this cornice takes off, then the whole damn thing goes. But it doesn't go to the ground, it only goes to the surface of the snow. But when you're doing this other thing, you can tell the time it is going to go when the whole thing goes all the way to the ground.

Helms: You were discussing soil moisture and improving your relationship with Canada.

Nelson: Hal Wilm was a beginning computer man you know. He said, "Well, Nelson, you got all these things. Do you want to put them in multiple regression equations?" I said, "Can you do it longhand?" That's the way we were going. You can imagine the mathematics that I'm talking about over a 40-year or a 20-year period. Plus subtracting the actual flow and relating this all out. But once you did it from the future on, you had a real forecast—a billion dollars of wheat weighed on what I said at one time. A billion-dollar shipment of wheat because I was forecasting that the ports were going under in Portland, where they load their wheat. The Weather Bureau said no.

Helms: What year was this?

Nelson: I don't know. It happened every year I thought. What happened was, they were going take the carloads of wheat down, but then they had to get them in the boats at the loading docks in Portland Harbor. If the water was too high, they would be flooded out. Well, this is why all this was so important. Then you had the reservoirs that could hold only so much water—a hell of a multiple regression equation was required. Anyway, I got all this put together. First we did just one, where we put all this together. I was the junior officer on it. Then I was the senior officer on all these other ones that we put together. Hal Wilm was the man who trained us in computer statistics and multiple regression equations and all that. You're talking about way back in 1950 or 1951. That ended up in the SCS. Arch Work became the head of the Columbia Basin Committee as a result of the strength of the snow survey program.

We were better than the Weather Bureau—whether you were talking about flood forecasting or total water supply forecasting. We fought for years over that, and to this day, I say we should never have backed off. But in the long run we had to. The Weather Bureau had such a powerful thing on us there. The SCS was in a tough position with the Department of Agriculture.

Helms: You thought that you should have had the authority to predict floods, is that what happened?

Nelson: You bet your life. We can do a better job to this day than the Weather Bureau can, insofar as snow is concerned, and with snow and soil and the water, if you wanted to go that way. In the SCS, there are soil scientists and soil conservationists talking about some high-powered hydrological problems that had no bearing on what the Service was set up to do—the Dust Bowl and all the rest of it. So we were a little out of our field, but not really. I think in the SCS was where they belonged.

The other point was, it just wasn't right to have the Bureau of Reclamation forecasting the flow of their own reservoirs, or the Corps of Engineers. This was the political argument that went up to the very highest echelons. But all that worked out. I used to go to Portland once a week for years when all of this was going on because we were just setting up the snow survey program in the total picture. Industry, power, agriculture, business, and the whole West was geared to it.

Just like last year when I got Roger Cares out here because of the drought. I just called up Roger Cares and said, “Roger, this is going to be low water.” It was the same thing. You see, the snowpack is a real powerful thing, and we have yet to learn a lot over and above where we are. Humanity is going to have to go back and research some of the things that have been done so well in order to keep up with what humanity is demanding.

But one other thing that happened that was funny, just to put something funny in all of this high-powered business. One of the things that I did started with Walt Disney at about this time.

Helms: About what time was that?

Nelson: In 1952, with The Living Desert. Everybody was shooting my eagles and my hawks when I tried to fly them. They asked me if I could train a hawk to catch rattlesnakes. I said it happened every day, no problem. That was in The Living Desert. That changed the whole world. They said that the film was run behind the Iron Curtain without Federal tax, because they wanted the people to see it. Walt Disney made $9 million a month on that alone. I was in on the deal when this was going on. But that wasn’t what got me. The whole world said, “You have got to quit shooting those chicken hawks because they kill rattlesnakes!” Well, I never dreamt that there was a conservation message. In this film, when you see the red-tail come down and grab that snake and kill the son of a gun 6 feet from the camera, it was my hawk. The whole world changed—chicken hawks are good, they kill rattlesnakes. The guy that was just shooting hawks for the hell of it got a reason not to shoot them. So many millions of people saw it because it went around the world, even the British Falconers Club. I got letters back saying, “This is great!” All kinds of good things were happening.

This is why we started to do the avalanche film. Walt Disney started with the film “Avalanche Control” at the same time that Atwater and I were doing ours. We shot it for Walt Disney. But then this guy who was an engineer, not an old snow trooper, was assigned from Disney to help us.

He went over to Colorado and set off an avalanche and killed himself and two other people. That stopped the film. They eventually did the film "Avalanche Dog." I tried to make a film with Walt Disney on snow surveys on the lines we're talking about here. It should still be done, we still haven't done this right. They were interested in doing it, but somewhere along the line in Washington, D.C., somebody said, "We have to approve this script." Walt Disney said, "Nobody approves the scripts except me!" Then that was over. I still feel bad about that. I'm not criticizing any individual, I'm criticizing the philosophy of the time, that the Government shouldn't be doing films that enhances its own business, which is still a questionable function in the United States Government—partly right and partly wrong. I'm just telling you what happened now.

Arch had done a beautiful thing in the *National Geographic* magazine with the snow machine going down the top of the Cascades. Arch did a film with National Geographic. He took a snow machine and went down the crest of the Cascades. Snow surveys were a part of it, but we didn't do a film.

Helms: What do you think about the research efforts in snow survey?

Nelson: The thing that is wrong, in my opinion, right now with the snow survey program is that elements of the most basic research have yet to be done. I'm talking about the things that I've already mentioned. They've been touched by the Forest Service, they've been touched by the SCS, and they've been touched by the high-powered scientists. But they have never gotten down to the practical relationships that we're all dealing with. The interface of the soil and the snow needs to be studied. These are the kinds of things that we're going to do in the future in the SCS to compete or to stay ahead of the demand for water.

The other thing that has never been studied that needs to be studied is the angle of the Earth's orbit around the sun. The north and the south slopes are entirely different. What you could do is determine the percentage of the north slopes and the percentage of the south slopes, the east slopes, and the west slopes. Then you'll have a corrective factor that goes way beyond what anybody ever dreamt of. The snow melts twice as fast on the south slopes as it does on the north slopes. It also has a different stratigraphy when you dig through it. It has different avalanches. The south slopes don't have any avalanche problems except at certain times. The north slopes are an entirely different proposition. So the water that comes out of the snow is directly related to the angle of the earth's orbit around the sun.

Helms: When you were with operations side of the snow survey, did the ARS [Argricultural Research Service] do very much in snow research?

Nelson: Everybody stayed with the SCS when we left the research. There were a few guys like Wayne Criddle that went into the water supply and irrigation aspect of engineering. Wayne Criddle dropped from this office here and the other guy retired, I can't remember his name. He was here before I was, a good man and a practical research man. But he, Jack Frost, and myself worked. That's about all it was at the time; there was one or two more.

I could see that there was a life's work in doing the operations work. We already knew more to correct our forecasts in my time than we could get done in the next 20 or 30 years, counting some of these things I'm now talking about. More work is going to have to be done and can be done with this beautiful photography and the outer space business. You can calculate the north slopes and any correction in there that would kick up another 2 or 3 percent in the accuracy of your predition of the flow of rivers. The south slopes have a different effect on the rainfall because of the temperature, the humidity, the vegetation, and the dryness of the period.

Helms: So tell me what happened to you—some of the things you did? The snow courses became higher and higher in elevation, and you expanded the number of them?

Nelson: A lot of them were in the middle, you see. I said we got to have more snow courses at low elevations and more at high elevations. We wanted a greater altitudinal differentiation in the locations of the snow courses. We all put them, rightly or wrongly, in the protected wind sites. Which was fine for what we did; that was the only way we could do it. But it does not give you the answer on the south slopes; it's entirely different.

In addition, I wanted soil moisture stations at the major snow courses to see what was going on with soil moisture beneath the snowpack.

Helms: Did you do that?

Nelson: We had the cost again here. We'd have to have a soil scientist to find the stratigraphy of the soil and the maximum water holding capacity of the soil. We have got to have every electrode geared to that study, which we're going to have to do someday. But we could do it in soil easier than in the snowpacks. Your snow pillow is good, but you're going to end up with an ionic measurement of the water in the soil beneath the snow courses. It will be at more stations than the snow courses. You want to know the amount of alluvium and the amount of fine textures such as clay. When you get to that point, then you've got something that is refined to a point that we don't really need quite yet. But, we need to go out just like we've done the snow surveys.

My part of it was, I wanted to know more about the soil beneath the snowpack all winter. That proved to be most interesting to say the least—

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4.25 Soil Moisture Station at Hoop Creek, Colorado, 1961

Water and Climate Center, Portland, Oregon

4.26 Soil moisture measuring equipment manufactured by the Beckman Instruments Company. Note the map of the snow course on the inside of the case lid.

way beyond what anybody dreamt it would be. I don't think they carry on with it, I don't even know whether we measure with the electrodes at those soil moisture stations now. The electrodes would measure the temperature of the soil and its water-holding capacity.

Helms: Did the other States do this or did you do it on your own?

Nelson: Well, I mostly started this. It was kind of a research proposition on my part. A lot of the other States put them in, some of them didn't. Some of them said they would get the precipitation up there. But that's a mistake, too, because the wind velocity varies the 'precip' capacity to capture water. The transpiration of the trees, the kind of soil—they don't give you the answers that I was looking for. The answer I was looking for was what eventually gets down into the soil, which is different than what comes in the rainfall. If it comes at a tenth of an inch or a quarter of an inch over a half a day, it doesn't do anything to the soil. You can get a certain amount of rainfall and not change the soil moisture capacity one bit. This was the reason I wanted it, technically. When you're talking about a snowpack that melts with 20 inches of water in it, you could lose 10 to the soil. You'd better know that. Now, in some cases, the soil moisture capacity is not much, just rock.

Helms: How did the breaking-up of the regional offices and going to a State basis effect your work?

Nelson: Well, it was a mistake. That's the reason I left the SCS. That made my job tough here because I'd been forecasting the Columbia River and doing a good job of it. They published our record of who was most accurate every year. We were standing way out in front, the SCS was. Furthermore, I went to the soil conservation district meetings and took the soil conservation district supervisors up to the mountains with me. When I forecast, they really farmed according to what we said at that meeting. I'm talking about the Snake River, Salmon Falls Creek, the Payette River, and the Boise River—especially where they had that problem like in Salmon Falls Creek and up in the Teton. I sat there in 1961, at the meeting of the soil conservation district supervisors and the water conservation people, and told them that they were going to get one-quarter of the water they had in every of one the last 20 years.

They saved their farms by not putting all that land in and trying to farm it. The Snake River got nothing but sewage and they had to pump new drinking wells for Twin Falls and Idaho Falls. They couldn't use the water for the cattle or for anything else. They had to drill new wells because the Snake River was so low in 1961, as I had forecast. The University of California came and asked me to lecture. Which I did for 7 years, at the University of California at Berkeley on "Man and His Total Environment."

Helms: Were there many people at Berkeley involved in this?

Nelson: There were two professors. One was a guy who invented using human sewage for making cattle food. There were three others who were with me, who lectured on it. We went all over the Nation, even to Alaska and the Hawaiian Islands, talking about this stuff. I did it on sabbatical leave from the SCS. They wanted to give me a doctor's degree, but I'd have had to move to Berkeley for 3 months, and I couldn't stand that. I said, "No, I'm not moving." They wanted me to get a residency. I got all this stuff published. My doctor's degree was done, as far as they were concerned. It was just a matter of residency someplace and putting it all out.

Helms: You were giving me some good examples of forecasts and how they were used. Do you have any other points which come to mind?

Nelson: Well, this comes up. The farmers didn't want you to empty reservoirs on the basis of what might flood. They wanted them to be full on April 1. For all the water supply forecast meetings of the Bureau of Reclamation and the water supply meetings, I went there with the regional director of the Bureau of Reclamation. We'd go together. I just had dinner at his place the other night, we became very good friends. Then the aluminum companies got in here, the wheat shipping companies got in here, and the people who were selling their crops got in here. The soil conservation district and the range management people started paying attention because the snowpacks that I measured on lower elevations and the precipitation had a bearing on the carrying capacity of the rain. We got into every field of the thing, as far as a plan for the year was concerned. In 1961, I just said, "It's a disaster!" and it was. They saved so much by knowing that. That became a major enterprise—which it is to this day in the "Man and His Total Environment" work at the University of California. It's talking about humanity getting along. Well, they had no forecast of that, but we could have forecasted that.

Now there's another little item. They wanted to set up snow surveys in the East, which the SCS should have done. But nobody with any intelligence or consideration in scientific background was interested enough to go back and do it. Homer Stockwell went back there, but he just wasn't geared for this thing. He didn't believe much in it. He didn't look at it the same way I did, in terms of these elements and what they do. For instance, the flood in North Dakota on my own land this year—it was obvious to me that it was going flood. The soil was frozen, no snow on top of it. There wasn't enough snow, it was a drought, but rivers flooded. That's what the SCS should have been doing in the East and should be doing to this day. Then later, they wanted me to go back to Washington, D.C. I liked the wind in the mountains, the vegetation, the soil, and there was no way that I was going to leave Boise, Idaho. They didn't like me for being that way, I know. We didn't have anybody in the SCS who was willing to go back and take the lead in this work.

The lead is the newspapers, television, and scientists, and then the soil conservation districts. That's the problem, you can't start out with the soil conservation districts, you've got to come the other way. Now, I already had more than I could do and more than I was interested in doing. Arch Work encouraged me to make the news releases on the water supply forecast for the State. I had forecast the flood on the Columbia River 2, 3 months before that.

Helms: What year was that?

Nelson: It was 1949, but it's all a matter of record. It was on the front page. If you look in the Boise paper, you'll see my forecasts on the front page for 30 years.

Helms: This was around the first of the month?

Nelson: It would be about the ninth of the month. There was a guy, down here on February 1, saying that the Kotenai River was going to flood. The State put the National Guard up there and stopped up the dikes and everything. But they had months to do it; when the flood finally came, they stopped it.

Helms: How nervous were they about this? Did they evacuate the town?

Nelson: That's right. They were out on the dikes. When the dikes broke, they fixed them because they were ready for it. This happened several places, several ways, but I remember that one.

I was the guy who convinced them to change the forecast from April through June to April through May. I subtracted from April through June to get the remaining. That's what really did it. You kept correcting the April through June, and then you corrected for what had happened—you get more accurate. That's exactly how I was going to go, whether it was the Columbia or the Boise River or some little creek—a beautiful technique to this day.

Helms: Tell me a little bit about the routine of work on these snow courses. What about rehabilitation in the summer and dealing with all the snow surveyors out there—the operational things?

Nelson: Well, it was an interesting job. It fit my interests and my background beautifully. Because in the summertime, we went back and put our posts in concrete to make our markers. We checked that the wind stopped blowing and that there wasn't something gone. I would take my sons. I'd go for 2 weeks. We go to go up on top of all these mountains and sleep out. We'd do maintenance work. We'd survey and be certain everything was right and talk to the people who went—the Forest Service people, or the soil conservation district people, or the water supply people. I would make arrangements and agreements for money. This went on in parts of Washington, Montana, Wyoming, Utah, Nevada, Idaho, and Oregon. Arch Work went to snow supervisors and other organizations interested and made arrangements for them to come to a training school. There were always new men at my school. They said, "Here's a man in Forest Service that would like to participate. He'd like to go sleep in the

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4.27 Ski training in Idaho

snow and learn all that stuff you're talking about to be a snow surveyor for a few days every year." That was the way we operated. We had to go and clean up if there was some stuff growing or if there'd been a slide.

The idea in locating snow courses that most of us used was essentially the same. We would get out of the wind to the leeward side of the mountain. Now, this was in part a mistake, as I was just telling you before. But for the most accurate, total, simple, and cheap way to get the best forecast, this method was proven to be true. I could look at some snow courses and tell you they ain't going to forecast. I could see others where I said, "I bet you $1,000 they would forecast!" —and they do—by their location in the mountains with respect to prevailing winds, the terrain, the trees, and the soil underneath. This is still true. But the funny part about it is that every one of them has got a use, we just don't exactly know which area they represent. We were doing the ones that would give it the best forecast, not for the least amount of work because a lot of the time, it was more work to go to those places.

Helms: You, just one individual, would go for the summer for the rehabilitation work?

Nelson: Sure, just the snow survey supervisor or, a lot of times, his assistant. The supervisor got an assistant who was a student trainee. Keith Higginson, one of my student assistants, has been the head of the Bureau of Reclamation; now he's the head of Water Resources for Idaho. That's how far back this goes. He's a heck of a good man [laughter]. We took students, for money, who liked adventure and would go with me. A lot of times I'd take a student from BSU [Boise State University] who grew up in my area, that I knew could sleep in the snow and could ski out if he had to. My sons were all good skiers, and they did it, too. I never did pay them, but they came along with me, especially in the summertime.

It fit into the other things that were important because I had to go in the summer and winter through these mountains. I located all the peregrines, all the prairie falcons, and all the golden eagles that lived in the area. This is now a tremendous record and is a part of the Peregrine Recovery Team work. I was on the Peregrine Recovery Team for the Department of Interior, working for the BLM [Bureau of Land Management].

Helms: Did you have any trouble getting enough people to do the snow surveys for you during the winter?

Nelson: Not at all. Because of the publicity and the things that we put in there, I had soil conservation district supervisors standing in line to go along with me. I'd never pay any of those people anything. A lot of these people were interested, like Jerry and I were, in the mountains and in the snow and in what we were doing. A lot of them were former ranch people who just said, "Yeah, I'll show you," and knew a lot about this.

Helms: Did you have to have training meetings for them or were there written instructions?

Nelson: No, we had training. I wouldn't take them unless they could sleep in the snow. Because every time you get up there, you're going to get caught or the damn thing will break down. My famous story is still one that I'm writing a book on, of my life, called The Cool North Wind. I just was thinking about this not too long ago. It was up there on the way to a snow survey beyond Morris Creek Summit. I got about 30, 40 miles out there with somebody, I can't even remember who this was or what year it was.

You know we had the Weasel in the war. It was too heavy in pounds per square inch, so it was not useful for some snow surveys in high elevation, powdered snow. It was hard to keep going, and it had all kinds of problems. We ended up with a better one. The Tucker Sno-Cat was a good one, of course. But it was different from what I thought it should be for powdered snow, and it should have been a lot cheaper. The all metal tracks were going around, and it was hard to keep greased and going. This other system that we use now is better. But we broke the axle and the two trainees that were with me were saying, "Oh, my God, we're 30 miles from home!" and I said, "Yeah, guys, there's no problem at all, nobody's shooting at you!" and they said, "What the hell is the matter with him [laughs]?"

There are people to this day who will go snow surveying with you on the basis of interest. I suppose that's the way snow survey supervisors are—

on the basis of interest, in the first place. They're not afraid to go there, they realize how good it is, and they want to participate.

Helms: There have not been any fatalities in the whole program all through the years, I would think.

Nelson: That's to our credit, there could have been plenty. One time Jack Wilson crashed down here, and I found him in a plane. He went down in the light plane and crashed.

Helms: He was what? Your assistant?

Nelson: He was my assistant snow survey supervisor. He was way down in Owyhee County. I put those snow courses way out there on the Owyhee River. They were so damn hard to get to that we had stakes, and we measured the depth of the snow from the air and then used correlating snow courses to figure out what the water content was, based on the depth. Which was pretty good. I think it's to our credit because everybody drove miles and miles and miles in the winter in the worst possible conditions. If people out there had that on the highways, there'd be 40 million a year die. But we never have had a man killed on the job or die of exposure in the history of snow surveying. Let me tell you, there have been plenty of times I've been along when somebody could have died.

We had everybody take a physical examine before they could go up there, on the basis that they might just have a problem. You know you can do that walking down the street 'cause you eat too much—a lot more than climbing the mountains, actually.

Wait a minute now, one. One guy died of a heart attack in the ski lift up here. One of our own men—he was training, too. I had those guys take their physicals because it was just like the war.

Helms: You had to take a physical?

Nelson: You had to take a physical to be a snow survey surveyor, and this guy had taken one. He went up there and was standing in line at Bogus Basin when we were teaching basic skiing. He keeled over with a heart attack. Arch Work was there, and I was there, too. That was the only one, and that was not related to our work.

I went to Atlanta Summit once, and this avalanche slope that I knew about killed seven deer and a coyote in front of me. I took Atwater with me. I said, “Well, Monte, you ought to come with me, I go over all these places, you ought to come up and see it.” We got there, and he said, “Jesus Christ, Nelson, this is terrible!” I said, “I know that!” We saw the damn avalanche; it killed seven deer and a coyote. Then, of course, we went across it safely. It was right here on the way to Atlanta Summit. We quit that, never did it again from the Atlanta side, always with a helicopter. You still go with a helicopter, don’t you? This was the reason. I went to all these places alone. It’s better to go in a chopper than to risk somebody being killed going there. The Forest Service, they got a man killed in there. I believe I did read about that a long time ago. That was when we were just starting all this work, too. You’re talking about 30 years anyhow. So now our men, they’re not avalanche experts, but they’re aware of the problem.

Helms: Did you get into the use of planes and helicopters before you retired?

Nelson: Oh sure, I flew to all of the places with both airplanes and helicopters. I flew with Laurence Johnson. He killed himself, but not snow surveying. He’d go in, he used to land at 9,100 feet on that snow course I put up. I don’t even know if you’d do that one anymore. That’s the one right over there, Trail Creek Summit.

Helms: Yes. But you still had fixed-wing planes?

Nelson: You had to use them. The mountain comes down like this, and then there’s this flat. This is the spine of the Sawtooth Mountains over here. I went up there and thought that it was a neat place for a snow course. I went up and put that one in there, and then I went in on the ground. That’s dangerous, you know. So he said, “Well, I can land.” Way back, when we first started, I did not fly with him to that snow course. I said, “Laurence Johnson, two of us couldn’t go there.” “That’s right!” he said, “I wouldn’t take two in there at 9,100 feet,” and he’s talking about a Super Cub. He’d land into the face of the mountain on the slope. Then he'd stop there, turn around, and run off. He had 5,000 feet to dive off. It was no problem once he got over the lift. But landing was a son of a bitch [laughter]. I was up there and watched him. Of course, he was a master. He had a big engine—he had a Super Cub, but it was a double Super Cub. That son of a buck would go right like that, and boy, when he gave it the gun, he could get off in 60 feet. I took a movie of that once. He just put the brake on and sat there, he gave her full throttle, pulled her down, and then went up in the air [laughter]. He was a character, a little guy. But he got killed—not doing that though. He got killed flying some old airplane. The motor quit, and he went down.

Helms: When did you start using airplanes?

Nelson: Well, let me think a minute. Monte Atwater and I started it in the early 1950s. It probably was started by Laurence Johnson. No, it was started in Wyoming. That was the first place we started airplanes, in Wyoming, in the Jackson Hole snow surveys. Flying the airplanes was a fairly reasonable deal. It was a lot better—turn around on skis and get off. So it was started in the 1950s.

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4.28 Laurence Johnson preparing for snow survey flight, 1961

They had some of those snow courses so high, like Vienna Mine and Galena Summit. We had a snow course at Galena where a lady lived. I wanted one on the Galena Summit. We went up on top, that's 8,600 feet. Vienna Mine was just on the other side from there.

Helms: Once you do that, it sort of creates the pressure to the use aircraft, doesn't it?

Nelson: A lot of times. The Vienna Mine was one I set it up knowing you could use aircraft because I didn't like it on the ground. First you've got to go over Galena Summit, which has an avalanche problem. I asked Laurence, and he said he could measure it from the air. So I set some of those snow courses up. I set that up on the Divide the same way, even though I was going in on the ground. I set that up originally, by a few trees, thinking we could use Laurence, but that avalanche was so bad. That avalanche came down between my assistant and me when I went up there. I said, "Well, if you go across here, there's only 40 feet, so you let me go first. I'm going to go up and get a hell of a speed off the top of the mountain. I'm going across that thing wide open." He wasn't that good of a skier. I said, "All right, if I get across and she don't go, then you can go." He was a big fat guy, I can't remember his name. He would go with me, but he was always a mile or two behind. Pat-pat-pat, he'd finally get there. I'd have the snow course measured usually before he ever got there. But if something went wrong, he could go back and get help. I skied across, went down and across that. But before he got there, the avalanche hit [laughs]. That was when we quit. Laurence Johnson surveyed that.

Oh God, what a wild situation! That was when I decided that's the end of that. That was cutting it too damn close, like the war. 'Cause if you couldn't ski that fast, you'd get caught. I didn't get caught 'cause I had a high velocity. I went up and came down that side. Anyhow, that was the end of that. Laurence Johnson did that one ever since. You're still doing it by air, no doubt. That's the only safe way to go. So then the choppers [helicopters] came. We went on the first chopper, and that was really good.

Helms: That was about what time?

Nelson: Let's see, I don't know, that came a little later. I started it, and then Jack Wilson flew the chopper after I left. But I started that. We're talking about the 1960s.

Helms: Did you use those just to measure from the air?

Nelson: Oh, no; we landed and measured the water content.

Helms: You didn't use aerial depth markers?

Nelson: The problem with that was that it wasn't accurate enough with the pressure on us and the value of the forecasts. When you started talking about millions of bushels of wheat hanging on that, plus Kaiser Aluminum deciding whether to open plants or close them—everything was depending on that, you know. It was pretty obvious to us that we had to get snow measurements done right.

Helms: So the depth of the snow without the water content was not good enough?

Nelson: It was not, especially when we had better techniques. There was no mountain or no snow course that we couldn't get to safely, with the knowledge we had. So there just wasn't any reason to fly to a place like that and not have the basic data with it. We started some of them with flying-by and then established it, which is a good technique, probably.

The other thing that I think was important was the Western Snow Conferences. The snow survey supervisors were the heart of the Western Snow Conferences to start with, but they're not anymore. But they gave people around the world a chance to come, and I mean around the world. They came with the idea that what started so well in the Intermountain West could work elsewhere. I had men from New Zealand, from Africa, and from all over Europe here with me. The Snowy Mountain Hydrologic Authority in New Zealand, and all those people have been here, and they learned all that stuff from us. Of course, it works just as well there as it does here.

Helms: You mentioned that the Western Snow Conferences became international.

Nelson: That's one of the problems that we're still having. The Soil Conservation Service's mission in life was not necessarily the snow survey project. Yet if you want to look at it broad enough, that's where it belongs. I think it is where it belongs because of the soil connection. You have the finest soil scientists in the Soil Conservation Service. They're not looking at the things that I'm talking about. But mark my words, the angle of the sun as it hits the mountains and the soil underneath are the things that this nation is going to research if it is to keep its food and fiber in drought years, which are coming again some day.

I've already written to the Department of Agriculture that if the precipitation was the same as it was in 1934 when I was on the ranch, this Nation would not raise enough wheat for its own people. You know why? Because you can't fertilize your wheat when there's no water coming down, and therefore, you just can't grow any wheat. You take the Dakotas and Kansas and all that. In 1934, you know what, I was lucky to grow on my own land? We were lucky if we got 12 bushels to the acre. You know what the average is? It's 44 for the last 20 years. When the precipitation went down last year [1989] you couldn't put on that much fertilizer. If you can't get the water, then you can't put the fertilizer on, and everything goes to zero. The nation has not been alerted to this yet, but they're going to get there. It's a real scary son of a gun.

What I'm talking here, snow surveys, are going to do what saved people in Afghanistan in the drought—tell us what is happening in the 30,000-foot mountains in back of them, not what was happening down below. That can be true here if you want to push it. Now, I realize that I'm talking about a hypothetical situation, but it could come true. When you go to the other places and come back here, you can see it happen. If we got 1961 again, it would be disaster without some of these forecasts. Without the forecasts, it would be the end—it would be terrible. The forecasts save it.

Helms: But isn't all the information collected in the same place?

Nelson: It does come through your office in Portland. That isn't really the problem. The point is that the research and the creative work should be funded like the snow survey was originally funded—by the Bureau of

Reclamation, the Corps of Engineers, and the SCS. That's the way I look at it. Those are the three major ones. The power companies should be put in there. If you take those three units and go to them with a creative research project in the SCS, they're going to fund it. For some of these things I'm talking to you about, they would say, "Damn right! Here's the money. Go do it!" just as they did originally because there's a great deal of information still needed for the future.

Helms: I liked your story about flying the airplane for the survey. Are there any other particular incidents that pop right to mind?

Nelson: I got a thousand wild stories on that kind of thing. One thing that happened was when I flew with Laurence Johnson. My brother was a fighter pilot in the war, and I flew with him, too. The blackout and all that high-priced P–51 Mustang stuff, that's a little different. I'd fly my eagle and knew where every updraft and every downdraft was. I'd say to old Laurence, "Now look out, we're going to hit a downdraft," and he'd say, "What are you talking about?" I'd say, "I've been flying my eagle here, and brother, there's a downdraft here!" and he would hit it [laughs]. Then I'd say, "Laurence, when you get over there, you're going to hit an updraft. You can turn your motor off and go up." We came over top of this mountain, turned the motor off, and went right up with no power on at all. That was a vertical thermal updraft I'm talking about, and, of course, he knew that. I trained Laurence about the way the mountains were shaped from my experiences with the eagles.

He and I had a lot of fun together. I went to courses with him. I never did go to Vienna Mine with him, but did go to all of these other ones in certain kinds of weather. If it was a little hazardous or the snow was too soft, we couldn't go. But Laurence was an eagle, he ended up like one of my eagles. He knew where these things were, and he was a wonderful man.

One day, he pulled a trick on me. It was really funny. He had gotten a new big high-powered airplane. We were taking off from over there in Hailey, Idaho. He said, "Come on, get in. I want to show you my new airplane. She rides good, and I can take off downwind." I said, "Oh, come on now!" There was about a 10-mile an hour wind blowing. "I know you've got enough power. You can go downwind." Well, that ain't exactly the wise thing to do, but he knew what he was doing all along. There was snow on the ground. He scared the living daylights out of me; he never got over it, either. So here we go, he started downwind, and we're going up to this snow course. Well, we just barely get in and he started turning back in the wind, and the right wing hit the snow. I'm sitting in there—Jesus, I didn't like us going downwind and all in the first place. All this boom, boom, blip, blip, blip, blip—we were dragging in the snow! I was so relieved when he pulled it up [laughs]. He looked back, "How'd you like it?" I was sitting there all scared, you know. He was a real good guy, I just had to smile. He seldom smiled, but he looked back with a great big smile and he said, "I scared the pee out of that old boy this day!" He really did, when that wing hit. But he had a little deal out there. It was this soft snow, and it made a lot of noise, but it had a little protection out there on the outer edge of the wing of this new airplane. When it hit the snow, it didn't bother him at all, but it sure as hell bothered me. You can imagine how clean that had to be done. I'll never forget it [laughs]. He sure scared me. He was so proud of that. But I went with him a lot of times, and we had a lot of good things, and he did real good job of snow surveying. I showed him personally, and I told him how important it was, and he came to the water supply meetings a lot of the times, just out of interest.

Helms: Just before we close, I noticed one letter in the files where you were asking if you could do soundings like they do to check sedimentation in lakes and use that for snow surveying. You were going to explore that and some other ideas, I guess.

Nelson: Well, you know, the thing that I was thinking about was radar. It came from the attenuating beam of cesium. What I was thinking might be better than just flying to measure the snow course would be to measure the stratigraphy of the snow from the time you took off to the snow course on a known flight path. In other words, you take off, and you set up a transect from here to Morris Creek Summit, where you know exactly where you are and what the terrain is. You just fly over there with an attenuated radar beam and measure the water content of the snowpack. It's just like we did with the cesium-attenuated beam with a scintilometer. In fact, I was thinking of putting a scintilometer in. I felt it would be better to do it with a 1-foot micropulse radar.

Just before the pressure pillows were tried, the Idaho National Laboratory asked me about using an isotope of cesium to measure snow water content. As a result of studying nuclear science at the University, we established this unit at the Mount Baldy snow course above Sun Valley. The beam of radioactivity was measured as it was changed by the water content of the snow. This was a very accurate way of measuring water content. It was checked by our own snow tube water measurements. The data from this snow course was radioed to my office in Boise using batteries charged by the Sun's energy, just as the data is today from the pressure pillows. This was the beginning whole network that is so important today in both streamflow and flood forecasting.

As usual, this was another point that resulted in problems with Lee Morgan. He decided that my office should be moved from the top floor of the building to the basement. It became another argument that went all the way to the regional office, similar to all the others. The move was impossible because of the radio data coming in from the top of the building. The loss of signal from the top to five stories down was too much.

The results of the work resulted in a meeting in Sun Valley with men and organizations interested in nuclear energy. Dr. Willard F. Libby, the professor from the University of California at Berkeley who received the Nobel Prize, participated[1]. His work with tritium, proving how accurate in time the atom disintegrates, was the reason for the prize. During this meeting, they asked if I could differentiate each storm of the year by studying the stratigraphy of the snowpack. We often did study each storm in forecasting and working with avalanches. My answer was yes, at the snow courses each month while we were snow surveying.

As a result, in cooperation with their personnel, I took samples of the storms they were interested in studying at any time of the month. They were interested only in the very high snow courses along the Sawtooth Mountains, and that is where we took the samples for the Atomic Energy Commission and INL in Idaho. The Idaho National Laboratory is part of

1 Libby was awarded the Nobel Prize in Chemistry in 1960. He specialized in radiochemistry, particularly hot atom chemistry, tracer techniques, and isotope tracer work. He became well known for his work on natural carbon-14 (radiocarbon) and its use in dating archaeological artifacts, and natural tritium, and its use in hydrology and geophysics.

the Department of Energy. The reason for this work was to determine when the Russians set off an atomic bomb because 12 days later we would find one storm with very high readings of radioactive tritium. This was done for several years, and there were times when we got the high readings and Russia said they did not set off a bomb. The data was not published, and we also checked to see if the river below came out with a high reading during the snowmelt. We did not find high readings in the rivers below these snow courses, and the work was discontinued.

Jack Frost and Arch Work were the guys that really got it. Jack was a guy that got down on the ground and started it. Arch was the guy with the wide vision that took off. Arch was an inherent scientist and a wonderful academic man. He wrote all kinds of articles and did all kinds things. His background was the same as mine. He didn't go as wide as nuclear and all that like I did, but he grabbed on to other ideas just as quick as I did. He saw everything. Arch and I looked down the same trail. We worked together for all these years and really had a good relationship. Jack Frost and Arch Work—it was their intimate understanding of this potential that drew men like me into it.

Naturally, every time we put a new man in, he brought a new background of knowledge and research. This was one of the beauties of the Western Snow Conferences—they had a chance to publish what they were finding out. All at once, it has become a wonderful thing to have. Guys like Jerry Beard were saying, "Well, what about this?" You can go back and read about it, and say, "Okay, that's the way it is. I don't have to screw with that. I'll go and do something else." Arch Work was the leader. Then you throw in guys like Jack Washichek and all those who came later and Greg Pearson from down there in Utah and Ash Codd, who was another engineering scientist. Pearson is a good man who picked that up in Utah. He didn't believe in these wild ideas that I was doing at first. He was a steadier guy, not worried so much about some of the side issues as I had been concerned with. When he got on to something, he was a real scientist. There were some men in the water department in California that were the same way that you need to talk to. They had a tremendous interest in California. It's still done mostly by the State of California. It's done very well, but it wasn't developed. It hasn't been necessary until now. Now it is necessary in order to do some of the things in California that the Soil Conservation Service has done—in terms of snow courses, some other ways of thinking, and research. But research here is going to go to all the mountainous terrain of the world.

My work in snow surveys and water supply forecasts and everything related to them is one of the most wonderful opportunities any man could be lucky enough to experience.

DEED OF GIFT

I, Morlan W. Nelson, do hereby give to the Soil Conservation Service the tape recordings and transcripts of my interview of May 9, 1989.

I authorize the Soil Conservation Service to use the tapes and transcripts in such a manner as may best serve the educational and historical objectives of their oral history program. I also approve the deposit of the transcripts at the National Agricultural Library and any other institution which the Soil Conservation Service may deem appropriate. In making this gift, I voluntarily convey ownership of the tapes and transcripts to the public domain.

Morlan W. Nelson

Morlan W. Nelson

Dec. 20, 1993

Date

4.29 Morlan Nelson Deed of Gift

Bob Whaley
Salt lake City, Utah
May 9, 1989

by
Douglas Helms
National Historian, U.S. Department of Agriculture,
Soil Conservation Service
(now the Natural Resources Conservation Service)

Douglas Helms: Could we get started by telling me where you were born, a little bit about your early childhood, going to school, and getting involved in the snow survey work?

Bob Whaley: I was born in Nampa, Idaho, on January 12, 1930. I kind of bounced around southern Idaho and eastern Oregon going to school. I spent 3 years in Cascade, Idaho—my first 3 years of grade school. I graduated from high school in Baker, Oregon. So I've been around southern Idaho and eastern Oregon quite a bit. After I graduated from high school, I was in the Marine Corps for a couple or 3 years in the Korean deal. I then came back and started going to Boise Junior College. I went to work about a year after I started there with Morlan Nelson, part-time, in Snow Surveys. I worked part-time for him until I transferred to the University of Idaho to get an engineering degree and then continued making snow surveys at Moscow, Idaho. While I was going to school, we established some snow courses on Moscow Mountain. I measured those every 2 weeks with some friends from the university. After graduation, I went back to Boise and worked half-time for Morlan in Snow Surveys and half-time field engineering out of the Area Office in Boise. Then I went to Portland as assistant snow survey supervisor under Jack Frost. I was there for 7 years. We established the initial radio network that was used to measure snow surveys.

Helms: Let's talk about when you were working here in Idaho and some of the practical things of the snow surveys. You mentioned that in the early 1950s you already had some over-snow equipment?

Whaley: Yes, we had. Some of the earlier stuff was Second World War surplus, M–7 Sno-Cat machines, which were tracked vehicles that held two people in tandem, one behind the other, and had two skis out front. But it was real heavy, as you might expect for a piece of military equipment. So in soft snow, it didn't go very well. We graduated from that as money became available to some Tucker snow machines, both the old two-ski, two-pontoon type, and then one of the Tucker Kittens that was just two-pontoons which were about 5, 6 feet long with a little cab sitting between them. Morlan probably told you about his part in the development of the Idaho Sno-ball, which was a pretty good idea, I thought. It was an adaptation of a snow machine undercarriage to a small Jeep. Originally, the idea was to make it so a rancher could have a Jeep in the summertime, and in the wintertime he could take the wheels out from under it and hook snow tracks under it and go with that. That was a pretty good rig. But one of the problems that developed with it was that the Service

114G–IDA–45184 National Archives, College Park, Maryland

4.30 Tucker Sno Kitten at Idaho Snow Survey School, McCall, Idaho, 1954

114H–IDA–45279 National Archives, College Park, Maryland

4.31 Sno-ball developed by Morlan Nelson, 1961

wanted to get surplus Jeeps and put the snow tracks on them. We always had problems with the surplus Jeeps falling apart. But the ones they bought a new Jeep for and put the tracks on were real good machines.

Helms: You said you got some new Jeeps and that worked better?

Whaley: Yeah, the new Jeeps that were adapted to the Idaho Sno-ball undercarriage were pretty good rigs. They were lighter and, of course, being a new piece of equipment, they lasted longer. We didn't have nearly as many breakdown problems as we had with some of the old ones. We had some interesting experiences with the older ones. We would get out about 30 or 40 miles into the back country, and they would break down. One time, we took this Idaho Sno-ball machine out, it was one of the ones that was a surplus Jeep. First the track broke on us. We didn't have track splicing material with us to fix it, but we did have an old Forest Service radio in the Sno-Cat. Luckily we were sitting where we could reach the repeater on Shafer Butte up above Boise. We talked back to the Boise Forest Service, and we told them where we were and what our problem was and for them to contact Morlan. So they did, and a little bit later, they called back and said Morlan will have you some track parts, some food, and some gasoline and drop it to you with a Forest Service plane in the morning. They said, "Put an air panel out that they can see." So we did, and luckily, we were about a mile or maybe a half a mile below a cabin where we could stay at night. We stayed there, and the next morning, they air dropped us our stuff that we needed, and we went on. We got up just above this cabin a ways into a deep canyon, and the generator fell apart on this the snow machine. We had to rob a screw out of the radio panel and put the generator brushes back on the generator so we could continue.

When we got back, kind of an amusing thing happened. We started out one morning about 5 o'clock from Boise, and we got back the second night at about midnight. We turned in our report which said how long we had been gone and so forth. The administrative officer here at that time had just come back out here from Washington, D.C. He could not understand why it took us so long to do that survey. So he had me write up a report of why we unloaded the Sno-Cat at Idaho City and why it took us so long to get up there and back. I think I spent 2 days writing up a report, just because he didn't understand why it took us so long to get the job done. But, anyway, there used to be some interesting things happen quite frequently with all of our equipment.

Helms: So you put them on a truck and drove to the nearest location, which might be how far away?

Whaley: About 40 miles from here to Idaho City was as far as the road was plowed at that time. We'd unload the Sno-Cat there and continue on by Sno-Cat another 35 or 40 miles to the snow course.

Helms: What was the difference in the ones you did on skis or snow shoes and what you attempted with over-snow machinery? Or was it just that as the machines became available you used them for everything?

Whaley: Well, yes. Pretty much, except the snow courses that were pretty close to the highway. When we were within maybe 2 or 3 miles of the highway we might go on skies or snowshoes. But if it was this much distance, why, we'd take the Sno-Cat after they became available. Now, back in the days before they had reliable Sno-Cat machines, they used to go on skis and maybe take 4 or 5 days to do a 1-day survey. But they had survival cabins at that time, too.

Helms: You would have to have a cabin for that?

Whaley: Arch Work was involved with designing and building those old cabins back in the 1930s.

Helms: I saw one publication in 1939 on that.

Whaley: Well, there were a lot of those cabins over the West. Probably until the late 1950s or early 1960s, some of them were still maintained. But as we got better snow machines and the cabins weren't needed anymore, we were having too much trouble with vandalism, and people were breaking into them. So they just abandoned the cabins or gave them back to the Forest Service or, in some cases, burned them down to get rid of them.

Helms: When would you use the snow skis or the snowshoes? Depending on the nature of the snow, I guess?

Whaley: Primarily, it was what you were used to traveling on. Now if you had to go very far, not too many people would use snowshoes, because they would work you to death. But if you only had a half a mile to go, or you were gonna jump out of a pickup and just go a couple hundred yards, snowshoes were easier to carry. We used them in Utah in planes and helicopters because they were shorter and easier to carry.

Helms: Would you jump out of a helicopter and go do your survey?

Whaley: Yeah. But if you knew you had to go very far, you took skis every time, because they were much faster and easier on the person to use. Snowshoes would just work you to death.

Helms: The longest you had to go in, either on the skis or in the Sno-Cat, would be about 40 or 50 miles or so?

Whaley: Some of the old trips were that long. But they would be maybe 5, 6 days, you know. Even before my time when they were taking the long surveys, they'd have 2 or 3 nights out, probably in cabins.

Helms: You were going to mention the work you started doing in Portland when you went there.

Whaley: One of the things that we started down there 2 or 3 years before I left and went to Reno was a Radio Telemetry System.

Helms: This was about what time?

Whaley: About the mid-1960s probably. I went down there in 1959. We put in the early radio system, one of the initial radio systems to measure snow water content there.

Helms: How did that work?

Whaley: Well, we got a butyl rubber pillow that held 200 or 300 gallons of alcohol and water. We had that hooked or piped to a standpipe that had a Leupold and Stevens recorder hooked to that. As the snow fell on the pillow and increased the pressure, it pushed the fluid up the tube in the house. We measured the rise and fall of that water level in the house in that tube just as you would on a stream gauge. Then that was adapted and hooked to a radio system, and we measured the position on this wheel of how many inches high the float was. It went well. The device sent out these beeps on the radio. It was all manual at that time, and you counted the beeps. You'd interrogate the site and tell it to answer back, and then count the beeps for feet and inches of water on the pillow.

114H–MONT–10187 National Archives, College Park, Maryland

4.32 Testing metal and butyl snow pillows at Lick Creek, south of Bozeman, Montana

Helms: Before you had the capability to use radios had they already started using snow pillows anyway?

Whaley: Only at the Mount Hood test site. They had some them on recorders there.

Helms: I mean, you've got to get out to read a snow course anyway, so you may as well just measure the tubes, is that right?

Whaley: Yeah, after we determined that it was reliable enough to correlate one with the other. Then you could do that, as they're still doing now. They do take check samples now with their more sophisticated radio gear.

Helms: What was the Mount Hood test site that you mentioned?

Whaley: Well, the Mount Hood test site was an area at the lower end of a ski hill in Mount Hood, Oregon, above Portland. The Forest Service allowed the SCS to put in this pillow test site and we had various different kinds of pillows. The earliest metal snow pillows were developed there by Bob Beaumont and a friend of his from Seattle. We had different sizes of rubber pillows there after they came along and we had different configurations of the metal pillows. We might have two of them connected together. We might have a gang of four of them connected together just to get more area to see if that made a difference.

There is a pretty well-substantiated theory, I think, that a snow pillow over-weighs to a certain extent. Instead of weighing a direct beaker or column of snow, it weighs one that bellies out like a funnel. So we were trying to see if there was a direct relationship that was consistent at all times. We spent many hours up there digging pillows out, replacing pillows, taking snow samples, and testing snow tubes and different types of snow tube cutters. We wanted to see if there were better ones for different types of snow. They have a lot of those records in Portland.

Helms: About when did they start working on that?

Whaley: They started that in the early 1960s, I think, around 1960. Arch Work's office, which Bob Beaumont was in as a statistician, and the State

Office, where I was an assistant snow survey supervisor, worked together. Whenever they needed some help at Mount Hood, I would go over and help them. Somebody had to go up there about once a week to take check samples around those pillows and take the data.

Helms: Morlan mentioned about adding snow courses. All through this period of the 1950s and 1960s, were you adding more and more courses or was it sort of stable?

Whaley: Well, there were some added then, and there still are. As we get a request from some water user group or something like that for a snow measurement, we may have to add one. But there were some added and some dropped that we determined we had no more use for.

There was another development over there. I'm not sure whether soil moisture measurements started in Oregon or in Utah. They may have started in Utah under Greg Pearson. But Oregon, when I was there, had a pretty extensive network of soil moisture stations that we would have to frequent about once a month and take measurements. If not, on snow surveys, then I would take a trip through the State and measure the snow, measure soil moisture, and take soil samples with a King Tube. Then I would bring the soils back to Oregon State University, and they would check them for water content in the lab down there. We were trying to correlate what our electronic reading was with the actual moisture by that method. We had quite a problem with that in that we found that the soils vary so much in just a short distance. If we took our King Tubes samples 10 feet away to protect the site, that was too far to get a consistent reading. So we kind of abandoned that. We weren't really getting enough out of the soil moisture, as far as water supply forecasting was concerned, that we could use in an equation. So we abandoned that, pretty much.

Helms: Did all the States in the West do soil moisture?

Whaley: They had soil moisture sites. But I believe only Oregon was taking the soil samples.

Helms: Well, that was just one problem. I think I heard Morlan mention the problems with the sensors and I guess a number of other things.

Whaley: We had some of the early soil moisture units. The gypsum blocks weren't good in acid-type soil in the timber because they would disintegrate, and you had to replace them yearly. So they came out with the metal wafer. The Coleman unit, they called it. It was developed in California, I think. It was just a little metal wafer about 1/8-inch-thick and 2 inches by 1 inch, I guess. Those worked fairly well; at least they lasted longer if you were careful and got them in right to start with.

Helms: If you stopped taking the soil moisture, then you just had to come up with some average number to use for figuring out what infiltration was going to be?

Whaley: Right, they have an average soil curve, three of them—one for sandy soil, one for medium texture soil, and one for heavy. You would have to make your best estimate of which your soil was and that was only a good guess. We never did get anything that I know of that was reliable enough to use in the statistical equation. So they pretty much abandoned them.

Helms: But it is still something that would be nice if you could do it?

Whaley: Oh yeah, you bet! Then they had what looked like it was going to be a more reliable system, the neutron method. A fellow started out here in Idaho, up at the National Engineering Testing Area over at Arco. He developed a radioactive source that he would bury in the ground and then measure the attenuation between the source and the counter above ground and determines the water content of either snow or soil. That, I think, had some good qualities to it. It worked fairly well. We had it in Utah and it worked fairly well for a while. The problem we had with it was that we didn't have a big enough company to be reliable on maintenance and so forth. If anything went wrong with it, he'd try to fix it or he'd say, "Well, it's your problem. Part of your equipment is faulty." So the actual operation of the thing never did too well.

Helms: Sometimes you'll establish a new course that somebody wants. When you have got several sites on a river basin and you think you have good information for the whole river basin, if there is a tributary to that, then one of the sites doesn't specifically have to be located on it. But if you're going to forecast for that one tributary, then you have to put a course on it. Is that the case?

Whaley: Well, there are two different theories there. One is like you said, if you don't have a course on the watershed, you would like to have one there. It's more reliable and represents that watershed better if it's physically located there. A lot of times we did that, or we were forced to do that by a water user group. The thought was that you had to have something right there. The other way is that, if you have a course that's on an associated basin close by that correlates real well with that basin, you don't have to physically locate one there. So we did both. The water user group a lot of times was willing to pay to put a snow course in. If they were willing to pay for it, maintain it, operate it, and measure snow on it for us, why we put it in.

Helms: That was often part of the deal for putting one in?

Whaley: A lot of times it was. Sometimes if they requested it and put enough pressure on, we had to put it in whether they paid for it or not. You know how that works [laughs]. A lot of times, there were requests from SCD's [soil conservation districts], there were requests from water user groups like irrigation districts, or anybody who worked with us. We'd put in a snow course if it was at all possible, if we didn't have one already there. A lot of the old snow courses were put in as far up the watershed as they could get on skis and snowshoes at that time, and that was as far as they could physically measure them. There were some higher elevation areas where we needed courses, and there are probably a lot of lower elevation courses where we needed snow courses and data sites to help us assist in flood measurements and so forth.

Helms: Right, for that first melt.

Whaley: A lot of our data sites now are primarily pretty high up, from middle to high elevation, because that's where all of our data, our long-term records, were.

Helms: I gather from talking to Morlan that many of the early sites were in the mid-elevations and there was a desire to have it from the higher elevations. I guess as technology advanced and so on.

Whaley: Yeah. As soon as they got snow machines that could get us back in there or helicopters or whatever.

Helms: So in doing that, the lower elevations were sort of neglected and now there is a need for them?

Whaley: Well, that too, but our purpose was primarily forecasting agricultural water and not floods.

Helms: Okay.

Whaley: We were interested in the long-term water that was produced from April 1st through September, and not the first peak that came out.

Helms: Which is often the problem for flooding, is that it?

Whaley: Yes. March, April, and May are possible for flooding, or even mid-winter sometimes, depending on where you are. They have mid-winter floods in Oregon and Arizona in December and January when the weather changes, sometimes. I think that's pretty much true. As we have gotten better equipment installed and radio equipment, we have added higher elevation snow courses farther back to correlate and go along with our mid-elevation stuff.

Now we went, as I said before, from snowshoes and skies to older Sno-Cat to surplus Sno-Cat to good Sno-Cat machines that would get us back in there quite a ways. From that to fixed wing planes and helicopters. When I left Utah, we had contracted out almost all the snow courses in the State to about two helicopter companies. We furnished the snow surveyor, and they furnished the pilot. The pilot assisted with the snow survey on the ground, usually. Sometimes we had to send two guys, but we didn't like to do that because that was too much weight. We were able to get all of our surveys done in the last 5 days of the month with two helicopters, if the weather allowed it.

Helms: You mean even the ones that weren't hard to get to, you flew to. You did all of them?

Whaley: Yeah, we just made a circle. If we flew over a site that was even at the end of a road, we'd set down and measure it to keep some guy from getting in a pickup and driving up there. Now if there was one snow course way out by itself, we'd still measure it on the ground because it was too expensive to go to by helicopter. You were able to make about two big loops and measure most of the State because the mountains run north and south in Utah, except for the Uintah Mountains. We would make two great big loops, north and south loops, and do it all in about 5 or 6 days. It used to take 2 or 3 weeks to get done with snow machines, and maybe 10- to 15- or 22-man crews. So it was pretty efficient, really.

Helms: I'm sure that some the people who used to do the snow surveys had misgivings about that.

Whaley: Well that's true. We got some static from them once in a while. We had some problems once in a while. When a helicopter sat down to measure a course and it was so cold that it wouldn't restart or something like that, we'd have people out overnight. But they all had been to survival school, and generally, there was a cabin close by that they could stay in.

Helms: Providing they knew where it was. I guess if you have been in the helicopter you had seen where it was.

Whaley: You spotted where they were. They were old cattlemen or sheepherder cabins, most of them were.

Helms: You wanted to mention, you went from Portland to where?

Whaley: To Reno, Nevada. After I got to Reno, I took Manes Barton's place as you know.

Helms: You were the supervisor for the State, and you had been an assistant in Portland?

Whaley: Right. Manes Barton had been the assistant in Oregon before I got there, for Jack Frost. I left here and went to take his place in Oregon when he went to Reno. Seven years later, I left Portland and took his place in Nevada as supervisor when he came back to Arch Work's office to take Bob Beaumont's place. Manes had started a radio system in Nevada on the ridge between Nevada and California, part of it was actually in California, and a year or two after we put in that initial one, he got a different company. The original company out of Portland was Motorola. Anyway, we put in two or three sites down there on radio and one repeater to the manual base station. We got that company to come back in and give us another bid on redoing that system, making it more automatic. We had an automatic base station to record the data on a timer and put in another repeater or two and three or four more data sites. I was there 2 years in Reno. Then Greg Pearson left Utah. He was asked to go to Portland to Arch's office to take Homer Stockwell's place. They asked me to go to Utah and work there. I started a radio system there in Utah. Thiokol Chemical was the contractor in Utah when we built the radio system. We had repeaters strung from Salt Lake south to above Beaver. We could cover about two-thirds of the State. We had snow pillows on them, we had precip gauges on them, and we had temperature readout over the system every morning. We could also use them as a backup voice radio system for emergencies.

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4.33 Bob Whaley at radio repeater station, Beaver, Utah

Helms: But you also still checked manually every month, right?

Whaley: Yes. We still checked them once a month manually and kept the data for correlation between the two—manual and electronic. We built up a pretty fair database of manual and electronic data.

Helms: Then when you went to forecast on it, did you use the manual reading or did you use the one that fit closest?

Whaley: Well, you had to use the manual because that was what was in the equation. That was supposed to be used to build the equation. During the middle of the month, we used the electronic data if we updated the forecast. If we needed some other data, we could extrapolate between the first of the month and the middle of the month.

Helms: When you wanted to do something like put in a radio system, it required some money. Did you get that from the State, or did you get it from the snow survey group from Portland? How did you go about that?

Whaley: Well, two or three different ways. One way was to get some budget from the national office through the State Office and down to snow surveys as a part of our budget, and then we also got some donations, if you will, some water user groups would put in some money. Utah had the first system that was cost-shared. There must have been half a dozen different water user groups that cost-shared based on how many different courses they thought they used in their area. In one case, some of them shared money, and some of them provided personnel to build shelters. They built shelters for us and transported them up to the sites.

Helms: That brings up a question. Since you worked in several different States, what differences did you recognize about operating in terms of cooperation with State and Federal agencies, or the importance that it was given in the overall SCS operations in the State?

Whaley: Well, that is a big question. I don't know quite how to answer it. I think in general we had real good cooperation from the local water user groups and the State Engineer's Office in each State, usually, because he was in charge of the water measurements and so forth. We had very good cooperation from those people. In most cases, snow surveys had cooperative funds that were donated by those people. Another interesting thing that hung on for years and years was that those funds that were donated, in most cases, were kept separate from SCS funds by the request of the donating agency. They felt that if they were left in the SCS overall funds, the donated funds would disappear, and in some cases, they did.

Helms: They probably got some inside advice. That, too, occasionally happens.

Whaley: Yeah, they probably did [laughs]. We had real good cooperation from most water user groups and State Engineer's Offices. In some cases, there was much better cooperation. I think here in Idaho there was real good cooperation from soil and water conservation districts. Oregon had good cooperation with the State Engineer's Office and some funds through the State Engineer's Office at Oregon State University where we had our soil samples analyzed. We also had some of the early computer work done down there at Oregon State University on water supply forecasting.

Another thing that Oregon did, and Idaho did, too, was to hold spring water forecast meetings. In Oregon, as soon as we got our March 1st bulletin out, Jack Frost and I would take off and do a series of water supply forecast meetings. We'd meet with the farmers, ranchers, Forest Service, fish and game people, and whoever was interested in water. We'd meet with them and talk to them about their conditions on the sites and conditions on the watershed. Then we would give them our forecast, our best estimate of what was going to come off for that year. I think Oregon probably had some of the best results in doing those water supply forecast meetings. Although they had some real good results here, too, in Idaho. During the dry years of 1959 to 1961, in the third dry year we had the county courtroom filled with people in Vale, Oregon. There was that much interest. I don't know how many people were there. Probably 200 or 300 at least, 'cause they packed that courtroom.

Helms: You went to a lot of different sites around the area?

Whaley: Yes, we'd start right after we got the bulletin out in March, after we analyzed the data by the 5th or 6th of March. We would go to the sites in the areas of the State where the runoff started first. Then in April, right after the April *Bulletin* was out, we would go to several of the rest of them, where the runoff came a little later. A lot of times they were arranged for by either the soil conservation district or by the county extension agent's office. There was real good cooperation there, usually. Now Idaho had, still has I think, a series of water supply forecast meetings for some of their key areas like Twin Falls and Salmon Falls Creek. That's two that I can think of right off. But we used to have real good cooperation with the Owyhee North Board Irrigation District—that's over here on the border between the Idaho and Oregon. If it was in the spring and we needed to go up and maintain a group of aerial markers on the Owyhee, the North Board would furnish vehicles and people to help us. We would go up and do it. It would take about a week to maintain those markers on the Owyhee River.

114G–ORE–40144 National Archives, College Park, Maryland

4.34 Mona Updegraff and her father John, superintendent of the Vale Irrigation District, snow surveying in the Blue Mountains of Oregon

Helms: You had to fly in?

Whaley: Yes, they were fixed wing. The aerial survey sites were located back far enough so that that was the only way we could get any data. You would fly by and read the snow depth and then estimate the water content from the nearest snow course. That was fairly good data. It was better than no data at all. It was fairly efficient; we had several of those loops of aerial snow markers that we flew.

Helms: For several of those years, was there just not enough irrigation water? Has that happened occasionally? Or they might adjust their planning of what crops they were going to plant or something like that?

Whaley: Well, those 3 years that I mentioned were some of the worst years, until more recently. The one that we're into right now, for instance. The last 2 or 3 years have been fairly dry. But 1959, 1960, and 1961 were 3 consecutive dry years that were well below average. Maybe percentage-wise, you might have gotten 20, 25, or 30 percent of average of some rivers. After the second year, their reservoirs were dry, too, and that's what creates the need for the water. To adapt, the farmers would either lay off half their acreage or lay out their worst fields and just use their best soils to raise what they could, or raise crops that didn't require as much water. They would lay off potatoes and sugar beets so they could raise grain—something that would get on and off quickly and didn't take as much water. But that was hard for a lot of people to do, like this group I mentioned over here at Vale, because that was a heavy row crop area. They raised a lot of potatoes and sugar beets and onions and things like that. They just didn't have that much chance to rotate their crops, so it was hard on them. About all they could do was not plant all their acreage.

Helms: Any other differences?

Whaley: Well, one difference. When I got to Utah, they didn't have water supply forecast meetings at all. We got our bulletin out, put advance notice out in the paper and to the irrigation district and so forth. Through the Bureau of Reclamation people and their dams over there along the Wasatch Front, we started a monthly meeting. We provided the forecast. The Bureau people would be there to tell us how they were going to have to operate their reservoir to adapt to those forecasts.

There were small differences, like Phil Farnes up in Montana liked the butyl rubber pillows over the metal pillows, for instance. You know, those kinds of things. But there were some advantages to one and some to the other; it just depended on what conditions you had.

Helms: You were around when the automation was coming along—the decision to do the SNOTEL. What were some of the discussions on the advisability of going that route?

Whaley: Well, the early discussions were that this would give us much more data than we were able to get manually because we could get daily or hourly data on the electronic system and not disturb the snow course at all. Every time you go out and take a manual measurement, you poke holes in your snow course. So if you took them out, you destroy the snow course eventually. If you took a mid-month measurement, you had to be careful that you didn't sample in the same hole that you measured before.

Helms: Or where you step.

Whaley: Right, or where you step, that could effect it, too. But the early discussions, as I recall them, were that we could get so much more data, so much more frequently, and therefore, less costly per data piece. The radio was much more expensive than making manual measurements to start with, but it would last so much longer and hopefully give us so much data—daily and hourly information instead of monthly. I think that was probably the biggest thing. We could see down road where we could eventually do away with a lot of these Sno-Cat machines and stuff, and maybe just have the maintenance crews who maintain the electronics also take the check samples of the snow courses. We could do away with some of the manual labor that we had to put in. It was also much safer to get electronic measurements—no crews in hazardous situations.

Helms: SNOTEL—who were the shakers and movers in that, getting that going, finding what equipment to use, the use of the meteors, and so on?

Whaley: The predecessor of the SNOTEL system as we have it now was actually started on that Mount Hood test site. I guess Beaumont and Arch Work would be the ones that actually got that going because they had a small contract with a Seattle outfit. Now this same Seattle outfit was the predecessor of the people who make the SNOTEL equipment now, if my memory serves me correctly. There were a couple of guys connected with Boeing, and they eventually broke off from Boeing and started this company that makes SNOTEL equipment now. But this initial system was a system that had one data site and one pillow connected to it at the Mount Hood test site. It transmitted by meteor burst, bouncing signals off of meteor trails into Seattle. It worked fairly well; it had a big ungainly antenna and the frequency was probably different than it is now. But it did work pretty well, really. I think that's probably the predecessor to the idea to go with the SNOTEL meteor-burst system.

Helms: What changes have you seen in the expansion and usage of the snow surveys? Give me States and dates as best as possible, if you can.

Whaley: Well, let me think. One of the different uses would be to assist cities with forecasting their city water supply. Flood uses have come into play, too. In the last few years, we've convinced the Weather Bureau that snow data is valuable, and that they'd better use it. The Weather Bureau is using the data now more than they used to for their flood peaks and most of their equations.

Other uses might be for transcontinental highways. The highway departments in a lot of States are using the data from electronic sites to assist in forecasting what kind of equipment they're going to need to keep a highway open or what equipment to send to get a highway open in a area. Maybe avalanche warnings are something that are coming into play, possibly with electronic sites. We don't, in general, have the right kind of equipment, zigzag neutron measuring devices, I guess you call them. They measure the water content between two pipes with neutron sources and counters. Also, they had one that lowered a source and a readout device, in two different pipes. So you can read the water content every inch if you want to. Now that will tell you the layering of the snow and if you had a real dense layer, which they're concerned about in avalanche forecasting. That will tell you where the layer was, how many inches up off the ground, or how many down from the surface of the snowpack it was. We tried those for a couple of years, but they developed too many problems mechanically. They still have some in the research end of it. I think there is still one in Colorado possibly, not with SCS, but with a research group over there.

Helms: It's got to assist the fisheries and so on, also. It's got to affect the numbers.

Whaley: Well, it affects the spawning and so forth. Because if you could tell them when the flood was going to come, the fish and game department would not dump fish out there in the stream and have them washed away. They can do some planning that way. They would know if they were going to have high flood peaks that were going to erode their streams and so forth. There's not much they can do about it except get things back away from the river, I guess. It would assist fisheries and also assist game management people. Knowing how deep the snow is and what kind of a crust it has on it tells whether they're going to lose a lot of the deer, elk, and bird population.

Helms: For the ranchers, it tells how much moisture there is for the range grass and so on.

Whaley: Yeah, that's all a part of it. How much moisture they're going to have to raise their crops or forage—in the way of grass.

Helms: The people I have talked to all have mentioned the relationship with the Weather Bureau. Since you worked in several States, how was it when you were dealing with them and forecasting floods? What about different ideas of the value of snow surveys?

Whaley: It has been interesting. Back about the time that I first started, they were having some good relationships with the Weather Bureau, depending on the people, and some not so well. But I think Morlan probably told you that they used to have an annual forecast meeting on the Columbia Basin. They went to this meeting in Portland, and practically all the data and everything came from our snow courses. But the Weather Bureau tried to use valley precip and valley temperature and everything else, and that didn't really correlate too well with what was going to come out of the mountain snowpack. So there were some problems between SCS and the Weather Bureau. Our feeling was that they'd better stick with floods, and we would stick with agricultural forecasting, but they weren't willing to do that, they wanted the whole thing. That's about what it amounted to. There has always been the feeling by our people that the Weather Bureau would like to take over the whole thing, except that they didn't have the people that could actually do the mountain work. They were willing to let us do the mountain work, if they could do all the forecasting, which was about the size of it [laughs].

But in some cases in different States, you had just as many differences as there were personalities. You got along with some of them real well, and the others you had to fight for everything you got. We had a pretty good relationship there in Portland, because they had an interagency once-a-month meeting, a hydrology subcommittee if you will. So we knew all those people who were operating the forecasting and dams for the Corps and the Bureau, and we got along pretty well with them. We had a pretty good relationship in Reno, but the guy that was over him in the Sacramento Forecast Office for the Weather Bureau, we didn't get along with so well. We were usually invited to go to the local water supply forecast meetings and give the forecast, but of course he didn't like that because he wasn't invited. They used and relied on our forecasts more than they did his. Unfortunately, he was able to develop new forecast equations in a computerized system faster then we were. That helped his status quite a lot, with the reservoir operators especially.

Helms: That's our not having lots of funds or maybe choosing not to put lots of funds into it?

Whaley: That hurt us back in those days because the Weather Bureau was able to get a lot of money. But one thing that they never did have was local knowledge. They had these river forecast centers, like Portland, Sacramento, and Salt Lake. They gave all their forecasts out of the centers, and the guys at the centers had never been on the ground where the water came from. That helped us greatly, 'cause we could adapt forecasts to local conditions and come out with a more accurate forecast than they could. It was "by the seat of the pants" method, but it still worked.

Helms: There is enough variation in climate that one little valley is going to flood and the next be calm?

Whaley: That's right. Or the southern half of the State may flood and the north half won't or whatever. In Salt Lake, I had to deal with their forecast center out there, and the guy that was the head of the forecast center was a real nut to deal with. His helpers were great guys; you could get along with them anytime, but if you had to deal with Jerry— I don't remember his name now—he was something else to deal with. We had all kinds of problems with him, I'd better not get into that [laughs]. Anyway, it was just a difference of personalities, I think. What he was trying to do was to build his own little domain over there and cut us out with those water users. That wasn't working, 'cause the water users asked us to come to the meetings and give the forecast. Whenever the Governor would hold his big flood forecast meeting, Jerry was there with his flood forecast, but they'd ask us to come and give snow data and so forth, and our analysis of it. Generally at those meetings, they called on the Weather Bureau first, and he would give half of our data and all of his and leave us holding the bag. When it was our turn to get up and give it, the only thing we could do then was... Well, he did that to me, he gave all of our data and his, too, and gave analysis of it, and then asked me if that wasn't right. It wasn't quite right. So I said, "No, it's not. It's not as good as you say. The lower elevation snow was greater, and therefore, I think we've got worse conditions than what you are saying as far as floods are concerned." So we had that kind of riff between us all the time.

Helms: Was there not a joint forecast on the flooding?

Whaley: Well, there's joint forecasting in Portland, but since Portland does all of our forecasting now, it's coordinated right there with the Weather Bureau in the West.

Helms: But you still had leeway for local forecasting that the State still looks at.

Whaley: The only problem with that is that by the time Portland gets through with the data, it's so late that it has to be published. There isn't very much time for local adjustment at all anymore, and that is a problem. We're more now like the Weather Bureau, we have a centralized forecasting system, and the guys in Portland do it. Some of them don't know what the watershed looks like.

Helms: So you think something was lost there?

Whaley: I think we lost a little bit. I think we lost a little in the translation. I think Dave Johnson could still do a lot of that if he'd have his people go out to the State and work with the local people on working up a forecasting procedure or have these people go in to Portland and work with him for a month or so. He does some of that.

Helms: There was something I heard about doing local bulletins up in the mountains. They've got local analysis in the State or something like that from State Offices.

Whaley: They put together on the computer what they did for Portland with local analysis—that's good, if they do more of that. One problem we have that I might mention is that the statewide bulletins that come out now are coming out so late that they are good for nothing except reference libraries. Many of mine that I get from Idaho, Utah, and Colorado arrive a month late.

Helms: I think that's something where they are going to stop sending the printing to outside contractors and start doing the desktop publishing in-house.

Whaley: Yeah, I think that's needed. Do a faster news release-type thing here at the State Office and get it out quicker. It will mean a lot more to the water users, I think, that way.

Helms: What about being equipped for survival and the survival school?

Whaley: Well it had to have started after a helicopter accident at Dodd's Summit after helicopter use first began in the mid- to late fifties. However, they had some minimal survival training before that time. This must have been in either the late 1950s or early 1960s. It was with one of the earlier helicopters, the small ones. There was a pilot and one snow surveyor along, and they thought they were landing up at Dodd's Summit which has a creek down through the middle of a meadow area. There was real deep snow that covered all the willows and everything along the side of the creek. The pilot had set down and lifted to pack this area—you know, lifted and sat down and lifted and sat down to try to pack an area. He thought he was safe, but as soon as he cut the power, he was on a big willow, and it caved on him. It tilted the helicopter over, and then they crashed as a result of it. The pilot didn't have any survival gear at all, or very little. So our fellow had to split his gear with the pilot. He just had a minimal amount, but he had enough to get by. After this, they started really stressing that everybody that goes up, pilot or not, has to have survival gear and training. So we stressed that highly in all the survival courses.

We made all of our fellows plus the pilots be aware that they might have to stay out there. They must take enough food for 5 days and skis or snowshoes, and enough field boots, socks, and so forth for them to get by. In a lot of cases, we also carried radios.

Helms: Is that what started it? You had already had a snow survey training course annually, I guess. But you made survival training more a part of it, is that the idea?

Whaley: Survival became just a real integral part of the snow survey training. It stressed how to survive basically and also how to be able to stay out 4 or 5 days, if necessary.

Helms: We were discussing survival training and the snow courses.

Whaley: One like that was at Aneroid Lake up in northeastern Oregon. That's in a wilderness area, and it's a 7-mile track from Wallowa Lake at the bottom of this canyon to Aneroid Lake at the top. It's a kind of a real glacial canyon with a lot of avalanche paths, a pretty arduous stretch. It's good and steep. Quite often the parties that would measure that would consist of irrigation district people along with SCS people. There might be four, five, or six of them who went in there. They had that survival cabin near the lake and near the snow course where they could stay after they got there. They kept this journal and they said, "Left Wallowa Lake at such and such time. Traveled 10 hours on skis. Had to sleep out in the meadow. Built a snow cave in the meadow because the storm got so severe we couldn't see." Or, "We had to wait out avalanche conditions," or whatever, and they would put in little quips: "Fishing lousy, only caught 30 fish in Aneroid Lake." They always put the snow depth was such and such, the water content was so much. They had this journal that went on. I think they used to only measure on April 1st each year, because it's too dangerous, too hard to get to, because the snow was soft. But they had recorded in that journal from the early 1930s, when the snow course was established, until the 1960s, when I was there. It was very interesting to read that journal; you get a lot of history out of that from those guys.

114G–ORE–40135 National Archives, College Park, Maryland

4.35 Max Wilson, attorney for the Consolidated Ditch Companies, Joseph, Oregon, unlocks the top door of the Aneroid Lake shelter cabin.

114G–ORE–40127 National Archives, College Park, Maryland

4.36 Arch Work (left), Soil Conservation Service snow surveyor, and Max Wilson review snow course data in shelter at Aneroid Lake, Oregon, 1941.

DEED OF GIFT

I, Bob Whaley, do hereby give to the Soil Conservation Service the tape recordings and transcripts of my interview of May 9, 1989.

I authorize the Soil Conservation Service to use the tapes and transcripts in such a manner as may best serve the educational and historical objectives of their oral history program. I also approve the deposit of the transcripts at the National Agricultural Library and any other institution which the Soil Conservation Service may deem appropriate. In making this gift, I voluntarily convey ownership of the tapes and transcripts to the public domain.

Bob L. Whaley
Bob Whaley

10-19-93
Date

4.37 Bob Whaley Deed of Gift

Arthur Crook
Beaverton, Oregon
February 3, 1990

by
Douglas Helms
National Historian, U.S. Department of Agriculture,
Soil Conservation Service
(now the Natural Resources Conservation Service)

Douglas Helms: It's February 3, 1990, in Beaverton, Oregon. Art, will you just tell me where and when you were born and something about your education up to the time you started to work in the snow surveys?

Arthur Crook: I'm vintage 1936, born November 27 in Fort Collins, Colorado. I spent my early childhood and school years in various locations in Colorado. My father was a Soil Conservation Service [SCS] employee in Trinidad, Colorado, and that gave me my first introduction to the Service. I did my college education at Colorado State University; I started at Colorado A&M, and the name was changed while I was there. My major was forest and range management. At the time of my recruitment, Federal agencies were fairly active as recruiters at college campuses, and the SCS people who were recruiting had known my dad, and so there was an entree there which allowed me a little better access to SCS. I joined SCS and was assigned as a range conservationist in Akron, Colorado.

After about 3 years there, I transferred to Salida, Colorado, which is in the Rocky Mountains. That was when I got my introduction to snow surveys. Jack Washichek and Don McAndrew, who were the supervisor and assistant in Colorado at the time, came to Salida and took this green rookie up on Monarch Pass with a pair of snowshoes, and we tromped through the woods and made our first snow surveys.

Helms: No previous training or anything?

Crook: No previous training. The engineering technician that was at Salida was also new and had no previous training. He was sent to the Westwide Snow Survey Training School at Winter Park, perhaps it was in

1962. He came back as the trained person in our two-man team. We did a number of snow courses. We regularly measured four on Monarch Pass, and at periods of the year, went to Fremont Pass and Independence Pass, all located on the headwaters of the Arkansas River.

Helms: Had the courses already been laid out?

Crook: Yes, courses were already established. There had been a lot of work done there in the 1950s to establish some of those snow courses, and so we were simply making measurements at previously established courses. I enjoyed that work very much. I enjoyed the snow. I hadn't previously been a skier or a mountain-oriented person except in the context of hunting and fishing as a recreation-type thing, but I did enjoy that. In 1965, I separated from SCS for a short while, perhaps 18 months, and then after having spent a little time seeking my fortune in private business, I decided to go back. Very fortuitously, I guess, I found an opening for an assistant to the snow survey supervisor in Wyoming. Washichek and McAndrew were located in Fort Collins, Colorado, at the time, where the State Snow Survey Office was headquartered on the CSU [Colorado State University] campus. They were instrumental in getting me introduced to the people in Wyoming, and I spent 4 years in Wyoming as the assistant.

Helms: Who was the supervisor there?

Crook: The supervisor at that point was George Peak. He had come to Wyoming in 1955. They were making a transition from more of a regional river basin-based organization to a statewide organization. Part of Wyoming had previously been handled in the north by Ash Codd, who was located in Bozeman, Montana, and in the south by the Colorado people, and part by, I guess, Ralph Parshall. He was an early snow surveyor there, and then Homer Stockwell was a supervisor for a number of years. Jack Washichek then became the supervisor when Stockwell moved to the headquarters office in Portland. I think Stockwell worked under Arch Work at one time. At any rate, when Stockwell left, Washichek took over there. Colorado handled the North Platte [Basin] and some of those drainages in the southern part of Wyoming while Montana handled the northern part. When they went to the State organization, George Peak moved down from Bozeman to take over Wyoming. I think it was in 1955 or 1956.

He set up a lot of the existing snow course network in Wyoming. It was all relatively new when I got there—only a 10- to 12-year record for most of the snow courses. I was replacing Tommy George who had been the assistant in Wyoming. He transferred to the assistant's job in Oregon, later became a supervisor in Oregon, went to the national headquarters as the national hydrologist, and finally became the director of the Resources Inventory Division. I spent 4 years learning the business as a soil conservationist. While I was there, they reclassified it to a GS–1315 series, hydrologist, so I more or less grandfathered into that job series even though my academic background was in forest and range management.

Helms: What was there to be learned about the job? What were the major things you had to really become proficient at?

Crook: Well, you have to understand hydrology, and I think it's very important that you understand at least the fundamentals of meteorology. You have to have a flair for mathematics, if not a mathematics background, and a certain understanding of statistics. But basically, what we did was try to understand the hydrologic response of the watersheds. We tried to understand the distribution of snow in the watersheds based on snow course measurements, making deductions from those measurements to try to explain the character of each watershed, and then doing a statistical analysis of the accumulation of snowpack versus the spring and summer snowmelt season runoff. Then we used that statistical analysis as the basis for the forecast. Snow makes up on the order of 75 percent of the variability in annual runoff in the Western United States from the mountain areas. That, of course, varies in areas with a little bit more rain influence like the Cascades and the Sierra Nevada. But, in the continental climates of the Rocky Mountains, it certainly explains 75 percent of the annual variability.

Helms: Well, although you didn't work under the system when they did it on the river basin basis rather than having State Offices, do you have an opinion on the reasons for the change?

Crook: I think the reasons for the changes were coincident with the change in all the SCS structure from the regional concept to the State Conservationist. I know that in the 1940s and perhaps into the early

1950s, there were regional offices as opposed to State Offices. I would expect that probably they were staffing up on a statewide basis after the change.

It makes a little bit more sense, I think, to be regionalized on watershed boundaries in hydrology because water doesn't respect political boundaries at all; it simply respects the topography. If you are responsible for forecasting the Colorado River, the Colorado River originates in Colorado, with some tributaries in Wyoming and in Utah, and travels through Colorado, Utah, and into Arizona. Well, if you have Arizonians forecasting the Arizona portion, Utahans forecasting the Utah portion, Coloradans doing the Colorado part, and Wyomingites doing the Wyoming part, you have a fragmentation of perspective, which isn't necessarily unhealthy, but it does cause a little bit of difficulty in coordinating the numbers so that they are all routed into some sort of a reasonable forecasting of downstream points. If one office was responsible for the entire run of the river, then there would be some continuity in procedure and perspective. I think that the State-oriented organization is very good from a local servicing standpoint and helps you to get out and see more of the watershed onsite, but it doesn't necessarily help you understand the full reach of the river.

Helms: Did you get a lot of support in terms of manpower, as well as finances, from other State or Federal agencies in Wyoming?

Crook: There is a really exciting facet or characteristic of the snow survey program in that it's so widely accepted by so many Federal agencies and water-user-oriented groups that the grass roots support is extraordinarily high. Any project or water-user group or other entity that is interested in water has a need to know the forecast to manage their water supplies during the summer. They have always been really very quick to respond to the need for help or finances, if at all possible. Of course, early in the program, finances weren't as difficult as they are now. The Federal budget wasn't as closely managed, or as scrutinized, or as out of control, maybe, as it is now, so we got a lot of funding support from other agencies, and we got lots of manpower contributions. The Forest Service, the National Park Service, and the Bureau of Reclamation made a lot of snow surveys in the cooperative network of snow surveying. All of those snow courses were part of the network. All of those results were quickly reported to our office where we checked the notes and committed the results to the record and used the information in the forecasting procedures. Then we distributed the forecasts back to organizations like the Bureau of Reclamation that had to manage their reservoirs based on those forecasts.

Helms: Could you talk a bit about the people in the snow survey program and their approaches to this work?

Crook: George Peak was a very interesting, unique individual and not without some controversy in the snow survey program. It was a very interesting time because most of the practitioners were the original people in the States. I guess Ash Codd probably had retired at the time, but he was the main man early on in Montana. Morlan Nelson was in Idaho and Homer Stockwell was still in the program, but he left his stamp in Colorado. Greg Pearson was in Utah and, although not the original snow survey supervisor in Utah, he was one of early program fathers. Each of these people had his own unique view of how the program ought to run and what were the really significant parts of the program that needed to put together.

For instance, Greg Pearson in Utah was a proponent of precipitation, wintertime and springtime precipitation gauges. He installed and then operated in Utah a very extensive network of storage gauges that were observed, weighed, and measured at the same time the snow courses were made. He placed perhaps a greater reliance on those data than some of the other States. Soil moisture was the domain of Morlan Nelson in Idaho. He was really very interested in integrating soil moisture observations into the formula and worked harder at that than any other State worked on soil moisture.

In Wyoming, it was evaporation and sublimation from the snowpack. George Peak was strongly committed to the theory that much of our error in forecasting was attributable to the variability year to year in sublimation and evaporation from the high-altitude snowpack. If you travel in the Rocky Mountains during mid-winter, often times on a moderate day—no storms—you'll see plumes and banners of snow being blown off of the high mountain peaks. If you fly over or if you're driving in the mountains, and you look up some of those beautiful peaks 14,000 feet, you'll see these banners of snow being blown from the windward side to the leeward side. That goes on for countless hours and days in that country. We now know that the transport of snow and the exposure of snow to radiation and wind effects introduce a significant loss to the snowpack. It directly sublimates back into the atmosphere, and it can also evaporate back into the atmosphere. So you can lose a lot of what falls on the ground back to the atmosphere without any beneficial effect on the river. As a matter of fact, I think George's work was significant in heightening the awareness of the hydrologic community that those things could really happen. George received a lot of ridicule, certainly a lot of nonsupportive discussion regarding his concepts.

Helms: Among the other snow survey people?

Crook: Yes, and the discipline in general even outside of snow surveys. I remember that for much of my work early on in Wyoming, I'd go to the local locker plant and freeze 1-cubic-foot blocks of ice and store them in plastic bags. We'd take them up and put them on towers where they were exposed to the wind up on bare ridge tops, and we weighed them daily. We observed the wind passage, the relative humidity, the temperature, and the soil radiation. He worked very energetically for many, many years to develop formulas to express the loss to a frozen surface as a function of wind speed, wind direction, temperature, and solar radiation. He wasn't academically as well prepared as he should have been, but he understood what was going on in a practical sense. With a lot of study and hard work and review by some folks who he could rely on who were better physicists and snow scientists—at least in the academic sense—he developed some formulas that ultimately were embraced. Unfortunately, they're still not widely used, if used at all, in the snow survey forecasting. But those same principles are much more widely used now in physical process simulation models used by researchers and in more sophisticated analysis techniques.

Helms: I don't quite understand why they would be used by one and not the other, except that the decision was made not to use them.

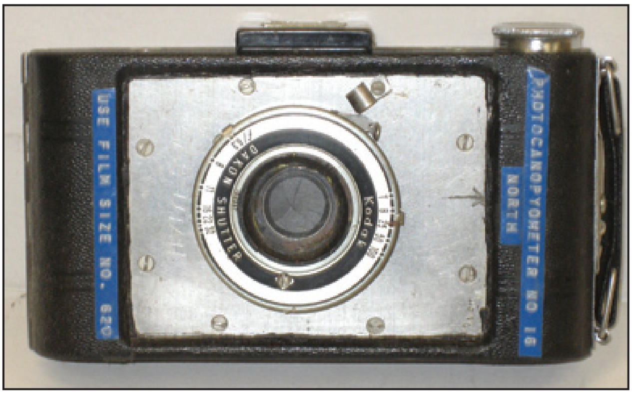
Crook: There's a lot of imprecision I guess, a lot of ability to mask the effects of one parameter with another. Snow surveying is certainly not an exact science. Snow surveys just give you an index of the amount of water that's on the watershed. The surveys are made in generally protected locales, in a forested environment, rather than up on windswept slopes or above timber line where the wind transports the snow so badly that you wouldn't really have a good assessment of how much had fallen and accumulated. It would be more a function of how much wind had blown, and how much sun had shined, and the other things that affected it. It is just an index, and when you're dealing with indexes, you have some error potential. Now to add the calculations to express the losses from sublimation, for instance, is also somewhat subjective. Of course, you can articulate that as an objective mathematical function, but the observations you use to plug in to your formula are kind of shaky to begin with, perhaps. Whether you're introducing more error or whether you're reducing the error by use of that is the question. In other words, it's perhaps a very rigorous exercise to go through, and the potential for refinement in the forecast is relatively small. So I guess you're beyond the point of diminishing returns. Manes Barton used to say that you can achieve 90 percent of your forecast accuracy in the 10 percent of your effort, and if you want to gain that final 10 percent accuracy, it takes 90 percent more of your work.

Helms: You said that George Peak was a controversial personality. Did you just mean his ideas, or did you think more about his personality?

Crook: Well, he was a good personality in his own sense. He was a fun-loving, exuberant sort of independent cuss who wasn't steeped in agency tradition. He had more allegiance to his discipline than he did to his agency, I think. I don't mean that in a detrimental sense, but they were all to one degree or another unique personalities.

Helms: Well two things that strike me talking to you and some of the others are the combination of the survey and the research work and the very limited personnel. It seems now that when we have a research project, we need at least five people, so many thousands of dollars, and these people have their own specialty. Unlike parts of the agency, I guess, those who surveyed retained some of their research functions in snow science, didn't they?

Crook: Well, at least some money could be used either to develop some technology within the discipline or to fund some ARS- [Agricultural Research Service] type research, those sorts of things. We never did have what you'd call a research branch within snow surveys. We just simply devoted some money and some energy to developing the various concepts, even though these were perspectives that might not be shared throughout the program. For example, there was the contribution that Pearson made to precipitation and that Nelson made to soil moisture and that George Peak made to sublimation.



4.38 Kodak camera modified to photograph tree canopies

Equipment at Water and Climate Center, Portland, Oregon

Ash Codd was the innovator of the photocanopy meter, which is a pinhole camera that looked vertically into the sky from the sampling point and by periodic measurements determined the encroachment of the canopy over the sample point. For instance, if you're working with a small natural opening, when you measure the snow, you don't want the surrounding forest canopy to intercept the natural falling snow. You want an accumulation on the ground that is as undisturbed as possible. But in much of that country, particularly in second growth forests, those canopies grew fairly rapidly, particularly the trees around the edges of the openings, which had a little bit more favorable soil moisture conditions, nutrient availability, and that sort of thing. So over a period of perhaps 10 years, you can see a very significant encroachment of the canopy over the sampling point. Well his device, the pinhole camera, gave you a pictorial view of what it looked like vertically from the sampling point. If you compared photograph A with photograph B, which had been taken 10 years later, you'd find that perhaps it was significant and that the measurements that you're taking have been so affected that there needed to be some corrective measures taken.

But each one of these perspectives was developed by individuals, and they all had merit. If the program had assigned each of the people to do all of those things, they would never have been developed because there wouldn't have been enough energy, enough enthusiasm, enough discipline, and enough opportunity for everybody to do everything themselves. Eventually, some of the best of those viewpoints became integrated into the program. One of the ways we did that was through the *Proceedings of the Western Snow Conference* where results were reported in a technical form, and also other technical exchanges. There was relatively little in the way of a bible or procedural bible ever developed for snow surveys; it was more or less knowledge gained in the field and information shared among the States and from the Portland headquarters office out to the States. Everybody learned through those mechanisms. It wasn't until Section 22 of the National Engineering Handbook was finally written in l971 or 1972 that we had the first discipline handbook. It wasn't particularly technical. There were a few things in it that were reasonably technical and timely at the time, but mostly it was a general "how-to" book. Even to this day it remains a compendium of knowledge that people are carrying around with them, rather than a cookbook procedure that anybody can read through, take to the field and adopt, and immediately prosper.

Helms: Tell us a little bit about moving to Alaska, unless there is something else you want to mention about Wyoming.

Crook: One significant thing in my experience in Wyoming was that at the time I was there, we were beginning to develop the first statewide and programwide plans for a massive automated data acquisition system. The idea at that time was that we'd use VHF telemetry. We'd have repeaters on mountain tops, and we would collect data from a number of stations that we had designated. Those data would be transmitted via VHF line-of-sight radio through the repeaters back to our State offices. I spent a lot of time when I was in Wyoming doing radio-path checks. Before I left there, we had written a plan for a Wyoming snow survey network, which uniquely included a number of meteorological data sites. George Peak's perspective was that he had to measure wind passage and radiation and temperature and relative humidity in order to express in his formulas those parameters as corrections to snowpack loss. None of the other States had those because they didn't believe in them that strongly. Utah had a lot more precipitation gauges planned for their network. I expect that if we look at Idaho's plan, they probably had some soil moisture stations that nobody else had. Those unique characteristics were expressed in each of the State's plans.

Helms: Well, was this a network where information they collected was in the State, unlike the SNOTEL where you have a single point collecting data from many States?

Crook: Unlike SNOTEL, that's correct. The first few prototype systems were installed—one was out of Steamboat Springs in Colorado, one was in the upper Snake River Valley up in Jackson Hole Country in Wyoming, and we operated that one out of Casper, Wyoming. There were others in other States, but as we operated them, we learned more and more about the vulnerability of the mountaintop repeaters to the really rigorous conditions up there. Rime ice would develop in the wintertime, and the weight of that rime ice would knock over antenna towers. It's really a very hostile environment to try to operate in. We learned as we went that it would be very, very difficult at best to operate a very extensive network on our kind of budget with our kind of talents. The repeater was the weak link. It would have to pass data for the reports from the data sites, through a repeater to another repeater. If the repeater went down, you would have lost the data; you were unable to get the reports from perhaps a very large number of data sites.

Let me interject in here, because I just remembered a significant thing. History will not record this, and perhaps your documentation may not want to dwell on this, but George Peak was very well acquainted with the director of the Atmospheric Research Group of the University of Wyoming. Dr. Donald Veal was the head of that group, and he is a renowned figure and an expert in hail suppression and in cloud seeding for snowpack augmentation or snowpack enhancement—snowfall increasing. He did a lot of work funded by the Bureau of Reclamation. He did a lot of work in the Elk Mountain and Medicine Bow Ranges of Wyoming. Don Veal and George Peak negotiated an agreement whereby the SCS snow surveyors did a lot of field snowpack measurements that were the validators or the measurements of the results of the snowpack enhancements by cloud seeding. So they developed a good rapport. In their official and social conversations, George talked very much about the need for automated data acquisition systems, and Don understood that and was a proponent of that, as well. Don Veal was a very close friend of the past professor of history at the University of Wyoming, who was elected senator. That was Senator Gale McGee, I believe. Perhaps the records will show Don Veal convinced Gale McGee of the appropriateness and the validity and the necessity of this sort of a program. It was through Gale McGee's work that what became the SNOTEL system's funds were appropriated to the Soil Conservation Service. That was, I think first, done with either the l972 or 1973 budget. But there were impoundments, and I believe, perhaps some diversion of funds in the first year or two that left nothing available for the program. So it wasn't until 1974 or 1975 that the program really got an infusion of money and was able to buy things. It was in 1977 that the first of the SNOTEL system was actually put in the field, and I'm sure you have that well documented. It was, I believe, the direct linkage from George Peak to Don Veal to Senator Gale McGee that was instrumental in getting that through Congress.

Well, in the late 1960s and very early 1970s, we were developing our State plans for our automation and learning how difficult it was going to be to do them the way we thought we wanted to, which was line-of-site in VHF with mountaintop repeaters. Concurrent with that evolved the concept of meteor burst. I'm sure you also have documentation that the group in Seattle that brought it to the awareness of the SCS was out of Boeing.

The group that developed it was within Boeing Electronics. As a matter of fact, they successfully demonstrated it twice in Alaska while I was up there in a summertime and wintertime environment. We subsequently issued an invitation to bid for a master station and four or five data sites in Alaska to try the concept. Their bid was three times the engineering estimate and it was rejected. Everybody went back very much dejected over the fact that we just couldn't afford to acquire the system and try it. Boeing, I think, also became discouraged and decided that they wouldn't try to market it anymore. They arranged some sort of a deal with Western Union where Western Union would market the technology for them. I have no idea what the business dealing was, but I'm assuming that Boeing retained the technology and probably would have made the equipment had Western Union been successful in the marketing.

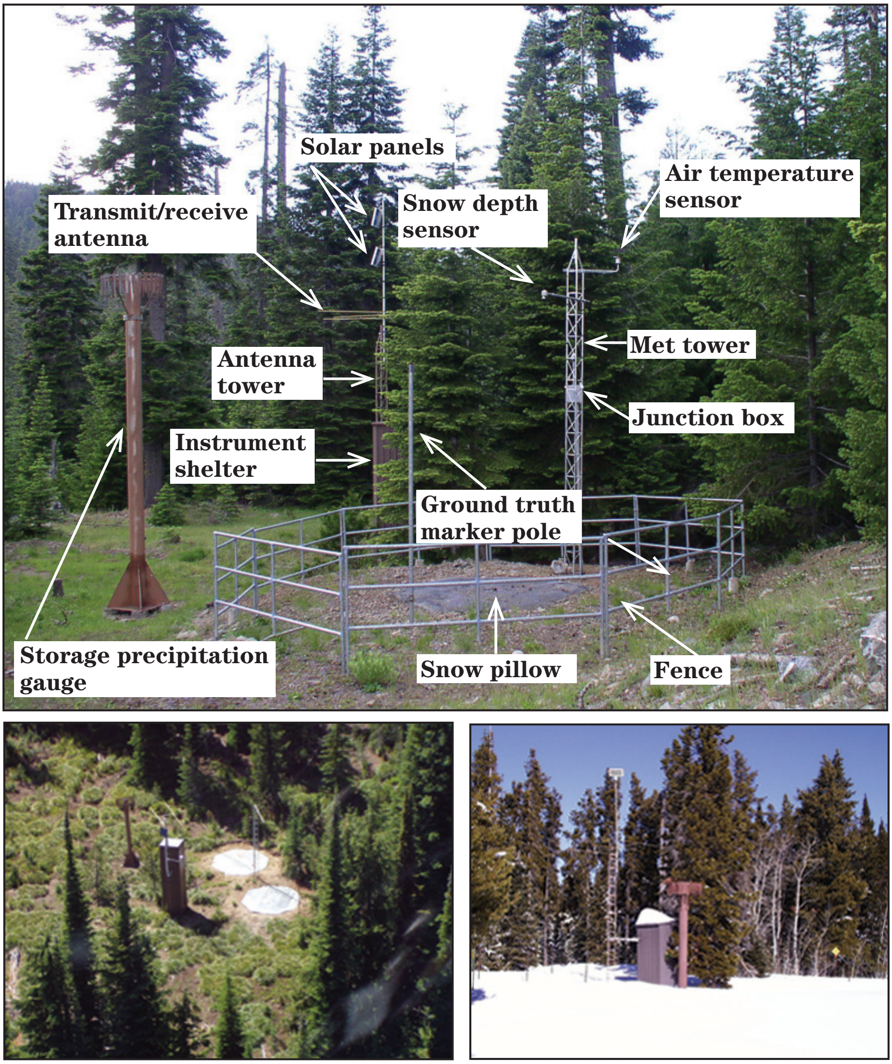
But the five people, who were really instrumental in developing the technology then left Boeing, formed their own company which became Meteor Communications Corporation, and proceeded to try to sell the technology. Through the Freedom of Information Act, Secode Electronics which, I believe, is a subsidiary of Collins Communication Corporation down in Texas, acquired the drawings, the plans, and all of the technology because apparently Boeing had done its original development work under some sort of Government contract. Anyway they wound up with all of the keys to the city down at Secode. Secode and Western Union kind of got together and so when the SNOTEL contract was finally awarded it was awarded to Western Union. They used the Secode Electronics equipment which had its derivation in Boeing. So the trail gets rather convoluted and it all leads back to the same people in Boeing.

Helms: But at the time they bid on this project in Alaska, in 1971 or somewhere thereabout, the technology was not being used for other communication systems already?

Crook: Not commercially anywhere. It was only demonstrated. At least there was no nonclassified use of meteor burst in an operational sense. I think it was 1974 that this bid was issued and rejected. The sole respondent was Boeing and their offer was rejected as being far too high compared to the engineering estimate, which might have been a bit low.

Helms: Let me ask you about going to Alaska, how you ended up going there, and what the program was like. It seems fairly new, but I'll leave it to you to explain.

Crook: Well, in 1952, the first snow courses were installed up there. I believe they were done by Jack Washichek and maybe some others who were asked to come up by the Bureau of Reclamation and set a snow course network to support inflow forecasts into Eklutna Lake. The Bureau of Reclamation was developing a hydroelectric project in the area between Palmer and Anchorage at Eklutna Lake. They turned that opera-



Water and Climate Center, Portland, Oregon

4.39 SNOTEL sites

tion eventually over to the Alaska Power Administration which is something like the TVA [Tennessee Valley Authority] and Bonneville Power. But the Bureau, as I understand it, built that first power plant and in 1952 a few snow courses were put up. Then there were a few more installed for various reasons but in 1964 there was a move to staff the SCS State Office with a snow survey supervisor. Ted Freeman at the time was in the forecasting office in Portland and was selected as the supervisor.

Ted was in the transition period, house hunting, and trying to run a program there while still living in Portland. He was in Anchorage on the day of the Good Friday earthquake in 1964, waiting for an airplane to return to Portland for the Easter weekend. He tells some really very interesting stories about surviving that earthquake and helping the victims. He was within a few yards of the very dramatic land subsidence on Fourth Avenue that's shown in all sorts of pictures of Anchorage during the devastation. He just stepped right outside of this shop that he was in and saw all of these things fall and all of this happen.

But Ted then assumed the job of snow survey supervisor at about that time. In 1971, he was offered an opportunity to become State resource conservationist, a promotion for him with more responsibility and a higher grade. That left a vacancy and I was selected to fill in behind him. So I moved there in 1971 and was there 4 years. I got there in June of 1971 and left in July of 1975 to come down and fill a vacancy in the water supply forecasting staff. That was created by Greg Pearson's retirement. It is a great country, it was very interesting and we were busy beavers. The program grew a lot.

Helms: How many people did you have?

Crook: Well, I really didn't have any when I got there. Ted had a part-time secretary. His office was in Anchorage, and the State Office was in Palmer. I'm not certain that I can tell you exactly why he was separated from the State Office other than as a matter of convenience. There had been some attempts for some time to move this State Office from Palmer to Anchorage because the other agencies that you dealt with were all in Anchorage. That finally became a reality while I was there in the early 1970s. Perhaps as a first entrée into Anchorage, Ted's office was located there. So when

I got there, Ted continued to maintain an office as the State resource conservationist in Anchorage, and I had my office. But together we had something on the order of a half-time secretary and that was it.

I had a few of the SCS people and a few other agency people who were taking snow course measurements in various parts of the State, but I did most of the snow survey measurements. I was making my monthly treks throughout the State. I was measuring as many as 49 different locations where I either made ground measurements with tubes [physical measurements] or fly-by observations of stadia rods. We had one 4-day trip up in the Yukon and Brooks Range, then a 2-day trip through the Matanuska and the Susitna valleys, and then a few local surveys that were made. If the weather was good I was busy for 7 or 8 days straight, doing those measurements to get those 49 locations, or fewer, depending upon the schedule of the month.

Helms: Now in Alaska is the data eventually used for concerns of flooding?

Crook: Well, a lot of it was simply data collection for future uses, and was somewhat speculative. The U.S. Army Corps of Engineers' Corps Regions Research and Engineering Laboratory in Hanover, New Hampshire, supported this substantial network in Yukon and the Tanana Valleys in relation to snow traffic ability. They were looking at the mechanical aspects of snowpack so that they could theorize how their troop movements might go in wintertime, I guess. So we took snow density and snow temperature and snow stratigraphy observations for them, and they supported a substantial network.

We also took measurements in areas of high interest for winter moose range conditions. The Game and Fish Department was very interested in that information. We installed a substantial network along the route of the Alaskan Pipeline which was planned, and some of the earliest construction had begun when I arrived there. Then the environmental concerns and native land claims settlement issue all kind of conspired to shut that down for several years. So there was really no work on the pipeline while I was there. But we did have measurements established along the pipeline with support from the Alyeska Pipeline Service Company and others that were interested. So a lot of what we did was project oriented. Some of what we did was based on the expectation that there would be some need for future data for a variety of reasons.

Helms: Was there a big expansion of the number of courses while you were there?

Crook: Yes, we installed a number of snow courses while we were there. There were a couple of snow pillows already installed when I got there and we put a few more in. We were making a transition toward an automated system, or at least the ability to collect the data on a real-time basis onsite with recorders, but we didn't have transmission facilities when I left. But there's a lot of interest and a lot of awareness that snow is a very significant factor in the lives of the people in Alaska. There were a couple of very interesting things that I did while I was in Alaska. They were unique opportunity, and I really enjoyed having had the chance to be there and to participate.

When the construction began on the bridge over the Yukon River north of Fairbanks along the pipeline route, the construction people came to us and asked us for some sort of an estimate of the summertime flow of the Yukon River at that construction point. They were concerned about the required height of the coffer dams to protect the foundations that they were constructing. Well, forecasting the Yukon River at that point had never been attempted. I would say probably it's the kind of thing that would take several universities, hydrology departments, many professors, and lots of graduate students several careers to really come up with something super good. But in a couple of days, we made an approximation. We used two or three snow courses and tried to draw some conclusions based on some pretty sketchy and certainly not statistically significant analysis. We were pushing the limits of statistical credibility far beyond where we should have but there was nothing else to do. They wanted an answer, and we gave them the best we could and we disclaimed the statistical confidence. We tried to explain to them as best we could that we just didn't really have much to go on, but with what limited resources we could put into it we gave them an estimate. Lo and behold and luckily for us it turned out that it was right. They didn't overtop the coffer dams. They didn't build them any too high but they didn't overtop them.

Helms: Which particular event are you referring to?

Crook: This was the construction of that bridge the following summer. The Yukon River during its spring snowmelt rise didn't endanger the construction project because, based on what we told them, they built coffer dams at sufficient heights, but they didn't build them overly high and spend a lot of extra time, effort, and money doing something that wasn't necessary. I mean it was perhaps more luck than science, but we lucked out. They were so appreciative of that, they came back the next year and asked us for another forecast because they were deploying their barges anchored in the river. They were doing work off the barges. As the river rose during the spring snowmelt period and receded during the summer, they were going to have to schedule the placement of their barges so that they could get the work done before they ran out of water in the shallower areas and could move their barges to the deeper portion as the river level dropped. They didn't want to get the barges stranded, so they wanted to know about how long the river would be at such and such a level. We gave them another forecast and lo and behold again it was sufficient to keep them from getting into trouble. So we had a batting average of 1,000, and we quit at that point.

Helms: This was a construction company that you were dealing with?

Crook: Yes, a part of the pipeline construction effort. There was no bridge across the Yukon River prior to that time, so they went to a locale near Livengood on the Yukon River north of Fairbanks and built this humongous bridge.

Another really interesting study we made was of the snow conditions at the location of the expected new city that would be constructed as a part of the then-approved move of the State capitol from Juneau to a point north of Anchorage. While I was there, there had been many initiatives. The one that passed moved the capitol from Juneau neither to Fairbanks nor to Anchorage but to some area of State-owned land in which they would build a new city, a Brasilia of Alaska, if you will. We received money from the Capitol Relocation Committee to support some intensive surveys and statistical analysis of the data we had been capturing for some time out of there plus the new information. We wrote up the report in which we detailed the expectations of the accumulation of snowpack throughout the winter. They could use that to determine the cost of snow removal and the cost of operating a city through the winter. That wasn't something you got to do very often, so that was a lot of fun. So there were a couple of things that were unique to that assignment that I really enjoyed.

Another side issue with respect to snow surveys: the year that the snow courses along the pipeline were established was my first winter up there, 1971 and 1972. Ted Freeman and I made a trip to Valdez and measured a very, very heavy snowpack in that area that winter. When the construction engineers for the pipeline terminal facilities analyzed those snowpack readings, they found that they had grossly underestimated the snow load requirements. Since they had that information, by their acknowledgment they saved from potential failures caused by underdesigned structures. So whatever we did in Alaska in terms of public good was, I guess, paid for many times over just in the first few measurements we got in Valdez. Tank farms and buildings and all sorts of things would have collapsed if they'd continued with their construction unaware of the potential snow loads that they were going to encounter.

Helms: What about other uses?

Crook: A lot of other uses. I think that it was very legitimate that SCS was involved in that because we had the expertise and we had the cadre of people to support that sort of program. We did that for a variety of other reasons, some of which were agricultural and some not. I think it makes more sense to use SCS people than to have some other entity that's not in the business try to develop some in-house expertise.

Helms: Because it's all the public's money?

Crook: It's all the public's money and I believe that, because of our expertise in the West, we did it more efficiently and more cost effectively than some of the other alternatives probably would have. I was transferred down to Portland to fill the vacancy left by Greg Pearson's retirement in 1975.

I don't know if there is a great deal more to add about Alaska. It was a very interesting place; there were a lot of things happening and a lot of fresh new perspectives. There's a different way of looking at the program in Alaska, every bit as valid, but certainly not oriented toward water supply forecasting for agriculture because there was no surface irrigation. There was very little pump irrigation. We just simply couldn't sustain a snow survey program based on water supply forecasting for agriculture.

Helms: I think you mentioned something about a l977 flood.

Crook: Well, in 1977 we had an extraordinarily dry year throughout most of the Western United States. We were at the Westwide Snow Survey Training School at Lake Tahoe in January of l977, and all of the guys from the different States were assembled there. We compared notes and it was quite clear at that point and time that the snowpack was really low throughout the entire West. Duane Bosworth, then the information specialist in Portland, was there and with his help and our collective concern we developed a strategy to begin to advance an early warning of the potential severity of this situation. The potential was high for a catastrophically dry year, and as it turned out that's basically what happened.

The SCS was prepared early on with a series of informational tips that were handed out to field offices for water users on how to conserve. The initiative got information to them early enough so that they were able to incorporate that kind of information into their planning process prior to planting crops and casting a die that was perhaps irreversible. They were able to make more intelligent choices, shift to crops with lower water needs, or make other management decisions in a more timely fashion. I think we all felt like we'd really accomplished quite a bit. The agency was able to provide the sort of information and to assemble the agricultural community and the water management community early enough that we could get this all out on the table and understand the severity of it. As a result, we got the word out and we got a lot of news wire press type information out. It was enough to help to alert the general public to the severity of the situation well in advance of the time when the shortage really occurred.

Helms: It wasn't just a problem with agriculture, but also for urban uses, too?

Crook: Yes, in the West, water is the limiting factor for industry and domestic life as well as agriculture, fish and wildlife purposes, and navigation on such rivers as the Columbia. The entire community was really impacted.

Helms: When you said you replaced Pearson, what particular job was that? What was the structure of the snow survey?

Crook: At the time I came to the West Technical Center in 1975, Manes Barton was the leader, the head of the water supply forecasting staff, and Greg Pearson was a staff hydrologist, essentially his assistant. Greg retired and so I came on as a supervisory hydrologist, basically an assistant to the head. We did most of the same things. I did it under his direction. I supported him as a technical overviewer to the field and transferer of information.

DEED OF GIFT

I, Arthur Crook, do hereby give to the Soil Conservation Service the tape recordings and transcripts of my interview of February 3, 1990.

I authorize the Soil Conservation Service to use the tapes and transcripts in such a manner as may best serve the educational and historical objectives of their oral history program. I also approve the deposit of the transcripts at the National Agricultural Library and any other institution which the Soil Conservation Service may deem appropriate. In making this gift, I voluntarily convey ownership of the tapes and transcripts to the public domain.

Arthur Crook

7-12-93
Date

4.40 Arthur Crook Deed of Gift

Phil Farnes
Jackson, Wyoming
April 14, 1992

by

Douglas Helms

National Historian, U.S. Department of Agriculture,

Soil Conservation Service

(now the Natural Resources Conservation Service)

Douglas Helms: Let me ask you where you were born, something about where you grew up and went to college, and how you got interested in snow surveys.

Phil Farnes: I was born in Billings, Montana, in 1934. I pretty much grew up on a farm. I saw some guys from the SCS doing some surveying on our place in my early years and decided that I wanted to be a surveyor.

Helms: Snow surveyor?

Farnes: No, a land surveyor, looking down through a transit. When I finished up with high school in 1952, I went to college in civil engineering. I went 2 years in eastern Montana at Billings, then transferred to Bozeman and signed up in the civil engineering curriculum. I started out working part-time for snow surveys as I was going to college in Bozeman in the fall of 1954. I worked for the SCS in snow surveys part-time from 1954 up until I graduated in 1957. At that time, the SCS created a full-time job and I moved into SCS snow surveys as a civil engineer GS–5 level. About 3 months after that, Uncle Sam came looking for me, and I spent 2 years in the Army. When I came back, I went back into the snow survey program working for Ash Codd, who was then the snow survey supervisor. Ash retired in 1962, and I ended up taking over the program at that particular time. I continued to operate as a snow survey supervisor or data collection office supervisor until 1989. Then they split my job into a data collection office supervisor and a water supply specialist. During that time, I was able to clean up the records, develop a lot of the files, straighten things out over here, and kind of get things in shape. I continued to work for another year after that and retired August 31, 1990. Jerry Beard took the data collection part, while I took the water supply specialist until I retired.

Helms: So were you looking for a job for summer employment while you were in college, or did you definitely want to get into that line of work?

Farnes: No, no, it was strictly by accident. Ash Codd gave a presentation to the Student Chapter of the American Society of Civil Engineers about the first week that I had moved to Bozeman. College was just starting, and I didn't have much to do at that time as far as studies went, so I went down and listened to the presentation. This was like the third or fourth week in October. He made a statement that he was looking for somebody to help out part-time with snow surveys and that he generally hired somebody that was taking engineering. At that time, I didn't have any real money worries, so I kind of let that pass. But along towards Thanksgiving time, I could see that the money I had was not going to last until springtime. So I got to checking around and found out who that old fellow was that gave the talk and was looking for some additional help. About the middle of November, I went down to visit Ash. At that time, the Snow Survey Office was on campus at Montana State. I knocked on the door and asked Mr. Codd if he had hired anybody. He said, "No, nobody's been down here." This was a little over a month after we had the meeting. Just about the time that I introduced myself, another knock came on door, and it was another chap looking for the job. Ash said, "This young chap is interested and he was here first, so I'll give him the job." So it was strictly to get some revenue while I was going through school that I took the job.

Helms: What did that involve?

Farnes: Well, I was doing technical-type work. I started out as a GS–2, I think it was $1.02 an hour, basically doing statistical relationships, tabulating data, drawing maps of snow courses, and these kinds of things.

Helms: You had maps of all the snow courses so somebody who didn't know the area could go?

Farnes: Yes, all the courses had what we called sketch maps that were part of the agreements for the snow surveyors, so they knew where the samples were to be taken, had documentation of the course, what land it was on, how to get there, how many miles it was from known locations for field offices, etc.

Helms: Since he's deceased, maybe you could talk about Ashton Codd in particular. He was one the first people involved in the work to start trying to use computers to do the calculations, is that right?

Farnes: Actually, when I came back out of the service in July of 1959, we were cooperating with the Agriculture Experiment Station in Montana, and one of the chaps working for them by the name of Lynn Johnson was taking college courses in computers. He needed a project as part of his class, and so he was investigating the possibility of doing the forecast with computers. I had just come back from the service, so he and I got together, because he did this for his class project, and then we saw the advantage of using it. Lynn and I put together a lot of forecasts for Montana. Within a year after that, we had a training session to show all the other States what we had done as far as developing the forecasts using the computer. That was in the days of punch cards.

Helms: This was what year?

Farnes: This would have been in 1959 and 1960. We also used a printer. We hardwired a program to print the first snow survey summary using cards and data, then took the output and had it processed at the cartographic units. Montana was one of the first States to utilize computers in processing data.

Helms: Were you doing the same thing, except that the calculations were faster? What were the advantages?

Farnes: Back when I was a youngster first starting out, to develop multiple regression forecast equations, we had a statistical calculator. To do one procedure, it would take about a day and a half to 2 days, just to punch the things in the calculator and come up with all the information you needed to do a multiple regression. Once we got the computers, that took away that long, laborious period. Once we got the data in there, it was much easier, a much shorter time period, to do the same thing as we were doing with the hand calculator.

Helms: Was that a problem when doing timely forecasts?

Farnes: Well, it was definitely a problem to develop forecast procedures. Some of the first ones were developed while I was in the military. They hired a statistician. He was a school teacher; he spent the summer there, and for the whole, entire summer he developed nine forecasting equations. It was just long and laborious, so when we went into computers, we were able to develop many, many forecast procedures in a much, much shorter time, and also, once you had the data on the cards, from there you could generate summaries and other kinds of statistics. If you had done them by hand like we used to, it was all punch it in the calculator and do the laborious statistical calculations.

Helms: What was the process of using computers? These were computers that were available at the university? When did the SCS acquire its own? I guess it varied State to State.

Farnes: When we first started in 1959, we actually started using the one at Montana State. We had what I think was the seventh project number of the computer. Very few people knew how to use them. We were able to utilize them for the forecasts, and when we had the training session, other States went back. Some ended up using university-type computers. I think Idaho had access to Idaho Power's computer. Most everybody found another computer that was available to process the data with. Being a cooperative program, almost all of the States had cooperative relations with other agencies or universities, so it was real easy to get in and utilize their equipment. It was probably in the late 1970s before the SCS actually starting procuring their own equipment, and that was associated with SNOTEL and the transmission of data. We pretty much used other people's computers.

Helms: In the interviews that I have done, I haven't collected a whole lot of information about releasing information to cooperators. Did you, in the late 1950s, have lots of meetings with irrigation districts, or did you mail out the forecasts for the different streams?

Farnes: Early in the season—January, February, March—most of it was handled by mailing and a fair number of telephone calls. For a lot of the agencies, like power companies that really needed the data, we transmitted it by telephone so it was just a manual thing. We would tell them what the data were, and they would copy it down. Snow surveyors would call the data in to us, and we would write it down. In the early stages, a lot of it went in by typewriter. The water supply outlook reports were all typewritten, taken down to the mimeograph, copies made, and then mailed out to the cooperators. We kind of had a deadline in those days that the bulletins would be in the mail by the 10th of the month. So we would gather the data, process the data, type it all up, run it through the printing presses, and, in Montana, we utilized the facilities of Montana State University. We would take it up there, help them collate it, and get it in the mail. That was on the 10th of the month.

As a matter of fact, even with automation and all the computers now, it was earlier then than they're able to do now. I suspect that a lot of them don't come out until the 12th or 13th of each month because of printing requirements. We've lost ground with the modernization in recent years in our ability to get them out in the hard copy.

Also back in that era, almost all of April was taken up with water supply meetings. We had meetings with agencies where we all got together and talked over what the water supply situation was. The Corps of Engineers would come up from Omaha. The Bureau of Reclamation would present its information. We would present all the information and meet with some of the irrigation districts. That April 1st survey was kind of a turning point, pretty much all of the snow was on the ground and decisions had to be made. At that time, there were also meetings on the Columbia, so we traveled to Portland to participate in the Columbia River water management meeting. We generally hosted the Missouri River group, which was primarily Montana, Wyoming, and other downstream States. Montana kind of took the lead on that.

Helms: What was the last thing? The information was collected for the April forecast by March 31st?

Farnes: We tried to have most of the information by the 1st or 2nd of the month. So last snow course reading—we'd try to have it in by the 1st or the 2nd.

Helms: The information you were going to give to the Corps or Reclamation Bureau was the forecast for the total amount of water, is that right?

Farnes: For April 1st through July 31st or through September 13th.

Helms: Then they had programs that could tell them what that meant in terms of operating the reservoirs or whatever?

Farnes: These numbers were taken as input, a lot of times it was just by hand. It told them how they needed to operate the reservoir, whether they needed to fill it at a faster rate than what they were used to, or whether they really had too much in there and needed to release some. In later years, they actually developed programs that helped to do a better job at scheduling. But mostly back then, it was almost an analytical-type approach and not much formal-type programming.

Helms: Do you have any recollections of particular outstanding successes or forecasts that were off that were a problem?

Farnes: Probably one of the first periods that I ran into was in the 1960–1961 era, which were some of the first drought years we'd had since the 1930s, and most of our forecast procedures did not have data for those low water flow years. This was a real problem when we reached the minimum lows with water equivalents. So we did a lot of work, scoured the back records, and tried to find what some of the lower flow were. The first years that we forecasted these low flows, it was not readily accepted because it had been 20-some years since we'd had the previous dry periods. People didn't really believe us, but in reality, that's how we ended up, with quite a low year. That was in 1960. Nineteen sixty-one was also a dry year. We picked up an extremely large following after we had said it was going to be dry in 1960 and it turned out to be that way. In 1961, we saw an awful lot of change in farming activities and reservoir operations. They paid an awful lot more attention. There had been an attitude that the dry years were all over with and would never happen again. So we picked up a lot of agricultural people and reservoir people to go along with the program and believe in the data in the 1960s. Then in the later 1960s, we had some extremely high years, flood event-type deals. Through the 1960s with some real drastic years, I felt that we picked up quite a large following. You don't do it on average years; the extreme years are the ones that really come out, and that was when the program had its greatest benefits, too.

Helms: It seems that those things followed sequences—a series of 2 or 3 dry years followed by 2 or 3 wet ones. Or was that not necessarily the case?

Farnes: A lot of our dry periods in the 1960s and 1970s would be 12 to 18 months. A lot of times they didn't go too long. It was in the 1980s when we started stringing years together like we did in the 1930s. In the 1930s, it wasn't so much that the years were extremely low, it was the fact that there were 4 or 5 dry years back to back. You can always get through that first year fairly comfortably, even though it's down. You've got some residual grass on the grazing lands, and you've got hay that's still in the haystacks. The second year really starts to get in, and you don't have those reserves. If you get a third dry year in a row, then you're down to crunch time. So those periods with 1 or 2 dry years at a time, we were able to sneak through and operate fairly well without any major loss of agricultural revenue. Then we got into the 1980s and started putting those years together; in some places it went as many as 7 and 8 years. Those were the periods when we got an awful lot of attention. People were extremely concerned. Quite frankly, we're still in that period in a lot of places. We've had 1 or 2 half-way decent years, but basically, they've been below-average years.

The other thing that has happened is that water use has been more extensive since the 1960s. Water use has become a lot more critical. Another thing that has taken place is that now the recreationists insist that they'd like to have their fair share. In prior years, if the irrigator dried it up, there wasn't really the environmental movement, the recreation people felt that it was just a fact of life. So competition for water is a lot keener, a lot more critical in more recent years. Again, in Montana this has followed some of the other States. The heavier agriculture States like Idaho and Utah went through a lot of this in earlier phases. Montana got into it more in the 1980s.

Helms: Is there increasing use for industrial and residential, too?

Farnes: Everything. The competition is becoming greater, recreation is becoming big. So now, people who are guiding fisherman expect to have their fair share of water in the rivers, they don't believe that it's right for the irrigators to take it all. Irrigators feel that it's their historical right to come first and take everything and the fishermen get what's left over.

We've had fairly large problems with downstream States, particularly on the Missouri River, in the operation of the Fort Peck Reservoir. When things get to crunch time, should people in Montana have water in Fort Peck that provides good recreation, or should that water be released downstream for barges, hydroelectricity, and other things? There's quite a fight now between upstream and downstream States as to who comes first in a dry situation.

Helms: Before SNOTEL was used, who were most of your snow surveyors in Montana?

Farnes: We had about a hundred individuals who actually went out and measured snow. Of those, there were approximately 25 different Federal, State, and private agencies that participated. Approximately half of those measurements were made by SCS people. The other 50 percent were measured by cooperators. The Forest Service was a large cooperator, National Park Service, U.S. Geological Survey, and then after that Montana Power, Fish and Wildlife Service, Montana State Park Service, and private individuals. There were some Indian tribes involved. Generally, we tried to get those people who had an interest in water to participate in the actual measurements because we felt that their participation would enhance the program more than just giving them the data. Besides, there was a cost and staff problem. We didn't have enough people to do everything ourselves. We asked the cooperators to help get measurements rather than the SCS having to expand itself.

Helms: Where one stream's water flows into a tributary, you're interested in that for what it contributes to the total. But for another stream of the same size, with some immediate use like irrigation, a reservoir, or something, you do a forecast for that tributary for just that local use, right?

Farnes: Actually, in Montana, we would forecast any place that had a U.S. Geological Survey or any other type of stream gauge on it. Normally, if it was an important source of water, it had a stream gauge. So we felt that if it had a stream gauge, then we were kind of obligated to make a forecast for it. There were many different kinds—for reservoir operations or for Montana Power. Maybe they'd have the upstream operations, but again that water was used downstream for the irrigators. In Montana, the water supply is relatively good, so what happened is that over the years, there was no justification for building big irrigation reservoirs. They were pretty much relying on the natural streamflow. When Montana went into a short water supply, it was really hard on the irrigators, as opposed to say, Arizona, where they had large reservoirs that might have a 20-year supply. They got a full supply as long as the reservoir had water. We suffered more in the real dry years because we just didn't have the economics to justify building reservoirs for irrigation when most of the time we had adequate water supply.

Helms: Does that mean that what George Clyde was doing in Utah, looking at the period of low flow, was important?

Farnes: Timing was extremely important in Montana. Through the years, we tried to make forecasts that were residual. How much water was left to come? How low would the water get later in the year, and when would different water rights be cut off? It was very important for the irrigator to know what time his water would be cut off. We would project that he would be out of water on the 15th of July. Then, his best operation was to use that water for one last irrigation, just before he was cut off, not to be sitting there ready to irrigate then find that he's got no water. The other thing that really came into play in a lot of these low water years was that a gentleman with a late water right a lot of times would change cropping patterns, knowing that he only had enough for one or two irrigations. He would put in barley as opposed to some crop that he had to irrigate through the whole season. At least he would bring off some kind of cash crop. In many years, the real dry years, they actually ended up summer fallowing and not spending the money to till the soil, to plant the grain or whatever, and not get any harvest at all. They used that year to summer fallow and do other kinds of conservation practices.

Helms: This was connected to the late water right? You'd only get water early in the season if there was definitely a surplus?

Farnes: The real old water right in Montana was "first in right was first in time." So as the water rights got cut off, the junior rights got cut off first, and then they went back. Pretty soon the first water right was the last person to be cut off. The other thing that was unique about this was that most of the old water rights were low on the tributaries. So as you move upstream, you run into a lot more junior rights 'cause of the way the land was settled. Further downstream were generally the ranches that were settled first. This always presented a problem because the more upstream ranches had poor water rights, but they also had better stealing rights. You get into these conflicts, and it was very difficult when one person's crop was burning up to convince him that he shouldn't try to irrigate. There was a lot of confrontation.

Helms: They had ditch riders to take care of that, right?

Farnes: There were water commissioners who were supposed to, but many of the old-timers who I talked to said if you had a poor water right, you could leave a fifth of whiskey or a six-pack of beer sitting on the headgate. Somehow or another, you'd end up with water when maybe you shouldn't have! There were some things taking place that weren't kosher. Water was extremely critical. A lot of times, that last irrigation made a difference whether the person made a profit or whether he didn't. It's still that way, really.

Helms: I noticed that some of the places tried to do a forecast before April 1st?

Farnes: Oh, yes. Way back, the first one was always put out on March 1. We felt that in Montana at least, March 1 was the earliest date that we could put out a realistic forecast. As you moved farther south, the timing of the season was advanced so that you could do them earlier in the season. Pretty soon, requirements became that we did them on February 1st, and now we're up to the point where we do them on January 1st. Now, January 1st may be a realistic number in more of the southern areas like Utah, New Mexico, or California. But in reality, we really don't know much about what's going on until we get close to February 1st. We kind of hurt ourselves in a way by doing January. We're trying to put everything into one little black box with it all being the same. So we end up doing them on January 1st, when we really shouldn't be. But that's the standard, thou shalt put them out on those five months. The last one we generally put out is on May 1st.

Helms: That was all done in the interest of planning?

Farnes: Reservoir planning; power companies particularly needed that information quite early in the season. For irrigators, March 1st was generally early enough to schedule cropping, buy fertilizer, and those kinds of things, and then they would do a kind of check on April 1st. Most of the farmers had their minds made up on April 1st, and they had to do things. The May 1st ones were more of a confirmation to pick up any anomalies that may have occurred in the previous month. March and April were the two critical months from an agricultural standpoint. January and February were probably more critical from the standpoint of power companies. For reservoir operators, if they didn't have power involved, probably April 1st was when they really needed to have the information for the best management.

Helms: If they had power involved, they could generate more power earlier if they knew there was more water?

Farnes: Right. Most of the major power reservoirs had what they called drawdown curves. So the better the water supply, the further down they could take their reservoir and the more power they could generate. But it was always based on the 95 percent probability of refilling. The earlier they could get that information on those probabilities, then the further down they could go and the more power they could make with the assurance that the reservoir would refill.

Helms: You mentioned the people who helped by collecting the information. Did you have any financial contributors to the snow survey?

Farnes: Yes, we had quite a few of them that chose to participate financially rather than offer in-kind services, then there were some that did both. The Bureau of Reclamation was a large financial contributor.

The Corps of Engineers actually paid us money and contracted or did work with the SCS. Forest Services basically had staff, and they contributed people. A lot of the other agencies, Bonneville Power, Corps of Engineers, and Bureau of Reclamation, were large financial contributors to the program to get the data.

Helms: It sort of went into the general pot of money to run the program or specifically for their area?

Farnes: It was specifically for certain courses, and that money stayed within the snow survey program. In other words, we could bank on those dollars, and we actually spent those same dollars.

Helms: Were these more courses where you had to use airplanes?

Farnes: One of the places that we utilized some of them was first for surveys where we had a contract for airplanes. A lot of them were to pay SCS staff salaries and travel outside of the normal conservation district activities. What happened in many of the cases was that the additional contribution enabled us to put a full-time technician in a field office. Or maybe the conservation district could support a half-a-year staff, and the snow survey could support the other half. Then we could hire somebody on full-time and come out much, much better than if we had just had the revenue to do a half-time person. It enabled us to increase the field office staff and a lot of the snow survey operations.

Helms: How many staff did you have in Montana?

Farnes: There were three of us permanent, full-time staff when I first started in Montana. When I retired, we were up to 14, so there was a considerable expansion of the program, and financially also, at the time I retired, my salary was greater than what it was costing for the whole snow survey program in Montana when I first started in 1954. Of course, that's just part of the economy. Dollars were hard to come by back in those days, too. We had to do everything we could to save dollars, so this cooperative deal was extremely important. If we could find a Forest Service office that could do the snow surveys rather than an SCS person that we had to put on travel, we would do our best then to try to get that local person to do it to minimize the overall cost.

Helms: I guess when you added somebody new it was no great problem. You had a fairly rapid training session?

Farnes: For the permanent staff, we felt that it was probably 2 to 3 years before that person could really operate effectively with all the multitude of locations, the large number of cooperators, and so forth. It wasn't real easy just to go out and hire somebody and then bring them up to full-speed right away. Back in those days, we were real fortunate in that we didn't have this big mobility push. I actually worked under Ash Codd for 7 years before I took over. Many of the people who worked underneath me were there for long periods of time. I signed on in the fall of 1954, and in the summer of 1954, Ash Codd hired our snow survey secretary. In January of 1955, we had a hydrologic technician come on staff by the name of Glenn Herdina. We had worked together for 23 1/2 years, the three of us, before our secretary retired, went off, and got married. Then Glen Herdina continued to work for me some more. It was 27 years that Glen and I worked together. A lot of the technicians we picked up would work with us from 3 to 5 years. It took them a long time to become very proficient at what they were doing.

Helms: Just taking the surveys, or were they doing forecasts, too?

Farnes: A lot of them ended up at least helping with developing the forecasts, tabulating the data, processing the records, summer maintenance, measuring the snowpack, and becoming familiar with the routines and locations so that they could operate independently.

Helms: Were there any instances when there were disagreements over forecasts and information? With the Weather Bureau or others?[1]

Farnes: In the early days, there was a lot of competition between the National Weather Service and the SCS. Each forecasted independently. That was a real major requirement. Arch Work was very adamant that we had better do a better job of forecasting than the National Weather Service, or we would find ourselves in real disagreement with Arch. There was

1 In 1970, the name of the Weather Bureau was changed to the National Weather Service, and the agency became a component of the Department of Commerce's newly created National Oceanic and Atmospheric Administration.

a measure of competition, which I think actually improved the relationship and improved the forecast accuracy. It was a very emotional thing for us to be involved in these. You didn't want to put out a bad number, you wanted to get a good number because you felt obligated from the standpoint of the cooperator and, also, you wanted to beat the Weather Service. In those days, outside of the Weather Service, the competition, everybody looked at the SCS to see what our numbers were. They were very, very interested in our numbers. As time has evolved and the major agencies have picked up computers and have access to our database, we find that a lot of them now are doing their own forecasting and not paying nearly as much attention to what the SCS puts out as they did in the past, before they had some of the capabilities.

Helms: Concerning the Columbia River flood of 1948, wasn't there a suggestion that there should have been more measurements on the lower elevations. Is that something that was areawide or just that one instance?

Farnes: Every time you had an event, it always brought up some shortcomings. The progressive people were really looking to close up those holes so it wouldn't happen again. In some basins, we were short of high elevation data sites, at some basins it was the low elevations, and at some we needed the precip. That's what helped shape the whole program. You were always trying to get data from areas with too few sites. When I first started in Montana, I think there were something like a hundred snow courses. At the time I retired, we were up to 242. Those were locations where we needed additional sites—Public Law 566 projects, ski areas—and different demands for the data.

Helms: For the Public Law 566 projects, would you put those in for planning, or did you want those after they built flood water retarding structures?[2]

Farnes: Both. The first Public Law 566 project in the United States that had irrigation was Lower Willow Creek Reservoir in Montana. Most of them were flood control reservoirs prior to that time. As soon as they

2 Douglas Helms, Small Watersheds and the USDA.: Heritage of the Flood Control Act of 1936, in The Flood Control Challenge: Past, Present, and Future, edited by Howard Rosen and Martin Reuss, pages 67–88 (Chicago: Public Works Historical Society, 1988).

started in on the planning, we put in two snow courses for planning and also for operations after it had been completed. That project is still operational today, and the data sites that were put in the early 1960s for the plan and the operations are still going today.

Helms: I noticed that in the generation that preceded you, they each had particular areas of interest that they researched or technical improvements that they were trying to make. Did you have anything in particular that you worked on?

Farnes: At that time, and Arch was very instrumental in this, each State kind of had a little pet project that was its responsibility to resolve. One of the things was the over-snow machines. We were working on the Snow Bugs in cooperation with the university. We improved the forecasts by utilizing more modern techniques rather than the old graph paper and cross plots to develop forecast equations. Probably our biggest contributions were in the lines of the forecast development and forecasting computation.

Helms: What was the work that you were doing with the university on the Snow Bug?

Farnes: Actually, in about 1945, Montana State University saw a need for good over-snow equipment in order to access a lot of the snow courses. They actually developed and built about five different kinds of snow machines at the university.

Helms: Where did they get their funds from?

Farnes: This was through an agricultural experiment station. I don't think that the SCS actually contributed dollars to those in the early stages. There were grants to land-grant colleges for different projects. That project went up through the late 1950s before it was actually terminated. This was about the time that small commercial snow machines became available. For the first 5 years that I ran snow surveys in Montana, I utilized one of the Montana Snow Bugs and put large numbers of miles on it doing snow surveys. Of course, we also had the Tucker Sno-Cat, which came into being in the 1930s.

Helms: The Snow Bug was a small machine.

Farnes: The Snow Bug was the first small, open air, one- or two-person machine. It was kind of frowned upon by a lot of the other States because at one time, it was felt that you had to have a big machine with an indoor cab with heaters or nobody would go out in them. Of course, the evolution of the small machines actually took off. They were patterned after the machines that were built at Montana State, as opposed to the big Tuckers and Thiokols with heaters and big cabs and that kind of thing.

Helms: I gather from talking to people that there was a lot of regional or State pride in which machine was the best.

Farnes: There was always competition in anything that we did. At the meetings, basically, there were always knock-down, drag-out fights internally on how we were going to do things. But whenever somebody from the outside challenged the program, then everybody seemed to unite against them. But different kinds of snow generated different kinds of equipment. We had a lot of powder, light snow. We had to have a snow machine that had very low psi [pounds per square inch] because a big machine, a heavy machine, would just bog down in that powdery snow. In the Cascades or the Sierras where the snow was harder and denser, they could use heavier or different kinds of machines. We'd have training sessions and, of course, whoever could put the flag first on the hill with the snow machine kind of walked away a little bit prouder than anybody else. This was in all things. There was a lot of competition, a lot of personal desire—hey we're going to do a good job and show these boys!

Helms: You mean the training sessions like the safety training?

Farnes: At the westwide training school. We actually had quite a few over-snow vehicle training schools where all different kinds of machines went through a lot of different kinds of side hills and climbing tests and speed tests to really see how each one of them performed. All of them came together on the same kind of snow.

Helms: Was the westwide training school the same as the snow survey safety training?

Farnes: Yes, they came about in the early 1950s. Jack Wilson, who was the assistant in Idaho, went down three different times in a fixed wing airplane in 1 year, and there'd been some other things that had happened. One of the pilots who had gone down with Jack could see the lights of town and he wanted to walk to town. Jack said, "No, I'm staying right here, and I'm going to set up a camp," and the guy said no, and we almost lost a pilot because he got hypothermia. He finally came back with Jack. At that time, we were sending these people out without any real training. Those kinds of accidents caused us to start the westwide training school. In the early days, they were held every other year. Pretty soon SCS requirements said that the person will have to go through the training school before he can participate in snow surveys. Somebody would leave and a new person would come, but if the training school was going to be held next year, you couldn't really legally put him out on snow surveys. I think it was in the early 1970s, we had a lot of turnover in Montana, and the training schools were scheduled for the next year. So we had one at Big Sky, which was just being developed. I think I had seven or eight people. I was going to do the training with my own staff. At that time, Portland did not want to participate because we were out of the normal 2-year rotation. Other States also had a lot of new people needing training, so we ended up with 97 people at our training session from all over the West. But the NTC [National Technical Center] would not participate because they thought it was an illegal school. Anyway, that was enough to force us into the annual training sessions. The NTC said, "We're not going to let this happen again!" so at that time we went to the annual sessions. That's the only way you can do it with turnover of your staff. You can't wait 2 years and still meet the requirements of having trained people every year.

We've had an awful lot of close calls. There's only been one person that I'm aware of that has ever been killed on snow surveys, and that was the Forest Service person back in 1941 out of Jarbidge, Nevada. It's a pretty enviable safety record, and a lot of it goes back to training schools and the effort that we've made to provide our people with equipment and training.

Helms: With the SNOTEL, you're taking a lot fewer trips, aren't you?

Farnes: I'm not sure that that's true. We take fewer scheduled trips, but a lot more unscheduled trips. We're probably putting more SCS people out in the field, but there probably are fewer cooperators and fewer field office people. Snow survey people, electronic technicians in particular, are spending a lot of time in the field now. Probably more days in the field now than we were in the past.

Helms: Before the time of using meteor-burst technology, what were some of the various things that went into the SNOTEL site and some of the drawbacks and complications? I guess there were years and years of experiments to find out what would or would not work.

Farnes: In the late 1950s and early 1960s, there was a lot of discussion about automating. There were all kinds of problems associated with it. They said, "The snow pillows are going to bridge," or "We are going to automate robots to eventually take the manual samples." There were a lot of discussions of pillows. At that time they decided that the only way we were going to find out was to put a pillow in and try it. Like I said, in the late 1950s and early 1960s, they were starting to be put in out West. The first one, I think, was associated with the University of Idaho out of Moscow. A guy by the name of Cal Warnik put in the first one. It looked like it would do its job. The next year, the SCS put one at Mount Hood; things seemed to work okay there. The next one went in Montana; they were scared that the light, powder snow might not weigh properly. I think that the following one was in Colorado. These were really the first ones that we started getting data on.

To me, it appeared that it was a real feasible way to go, and in 1964, I put out the first plan to automate snow measuring sites. We had approximately 75 sites identified in Montana, and we had line-of-sight communications which we were going to use. Actually, one of the first radio systems was in Portland, Oregon, at Mount Hood. The second one was designed by Montana State University and put on at Lick Creek repeater to bring in Lick Creek and two additional sites in Montana signaling into Bozeman. Those were the first two line-of-sight telemetries. I put together this plan, and Colorado thought this was a good idea, as did a couple of other States. Basically, other people were, you know, "You guys are way off in left field. This will never happen. It will never come about." Then, about

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4.41 Manes Barton at the Mount Hood test site

half of the States had a plan, and about half of them didn't. Manes Barton, at that time, decided it would be good if all of the States had a proposed telemetry plan. So the other States put one together, and we ended up with a westwide automated plan.

Helms: Was this just for snow pillows?

Farnes: Well, at that time we were also starting to look at precipitation gauges. Utah was doing a lot of work in precip. It was bringing out both the snow pillow and precipitation, and maybe temperature. Temperature was really a factor. Snow was first, precip was secondary, and we were starting to look at some of the other parameters. Then after we had this together, we said, "Hey, we need to go after some money to do this." That's when we got into the meeting in Portland, and we had all the plans. We had people out from Washington. The people from SCS in Washington basically said at the meeting, "You guys can come up with all the plans you want, this sucker's never gonna fly. You have to get funding up through the Presidential staff because we're part of the Executive Branch. By

MT–P391–9 *Water and Climate Center, Portland, Oregon*

4.42 Precipitation gauge, instrument shelter, and snow pillow at the Fisher Creek snow pillow site, 8 miles north of Cooke City, Montana, 1965

God, the SCS is never going to put in a dollar for you." The guy had to go back to Washington, and everybody kind of sat around the table.

Helms: Who was that?

Farnes: I can't remember the individual's name; he was probably equivalent to deputy chief or one of those kinds of people.

Helms: They weren't going to ask for the money in the budget process?

Farnes: Basically, what he said was, "We're not gonna ask for it, and you aren't ever gonna get it." So anyway, the guy had to fly back, leaving a lot of the snow survey supervisors—George Peak, Jack Washichek, Bob Davis, myself, Manes Barton, who was kind of head of the unit out there, I think Jack Frost was still around, and Dick Enz from Arizona. One guy says, "Who the hell does this guy think he is, telling us we can't get this money?" We didn't like being told that we couldn't do this, so somebody said, "How are we going to get around this problem?" George Peak, who was snow survey supervisor in Wyoming at that time, said, "An old fraternity buddy of mine is the chief aide for Senator McGee, who is Chairman of the Senate Appropriations Committee. I bet I can get a hold of him, and we'll find out what we can do," and we said, "Hey, that sounds real neat!" So George called up his old fraternity buddy.

Then, when Senator McGee had the budget hearing that year, Ken Grant was the administrator of the SCS. He presented all of this information that the SCS wanted to put forward. Senator McGee said, "Well, don't you have a snow survey program?" Ken Grant said, "I guess we do." He said, "Don't you need some money to put in an automated network?" Ken Grant says, "Well, I suppose we do, sir." He said, "How much money do you need?" Ken said, "I don't have that information with me." So he had to call a recess and go back to the office and get that. In the file was the westwide plan that we had put together with all of the States for 512 sites and all the dollars. He came back and presented this to Senator McGee. Senator McGee said, "Sounds like a real good idea." They put a million dollars in the kitty for a snow survey telemetry system.

Helms: This was about what year?

114H–WYO–10197 National Archives, College Park, Maryland

4.43 George Peak traveling to Alpine site and snow pillow at North French, Wyoming, 1974.

Farnes: It had to be in the late 1960s or 1970 to 1971. In that year, Richard Nixon had basically impounded all of the extra funds, so he impounded the million dollars that McGee had in there for SNOTEL. The next year, Senator McGee got unhappy with the whole system and said, "We're not going to hold hearings this year." But he threw another million in the kitty, which also got impounded, so there's 2 million in the kitty. Then the third year we came along; it had to be around 1972 or 1973, and they threw in another million dollars. We had 3 million sitting on the board waiting to put into the SNOTEL system. At that time, of course, everybody was scrambling trying to get it.

It appeared that there was a shift in attitude at the SCS. Prior to that time, anytime we had wanted money, we'd go to the SCS and they'd basically say, "We don't have it." Then we would go to the cooperators like the Bureau or the Corps, and they would give us the dollars to do what we wanted. From the beginning up through the 1970s, we actually were alienating ourselves from the SCS. If we needed money, we went to our cooperators, and that's where our efforts went. You know, we kept getting further and further from the main SCS. After we picked up the $3 million without anybody in the SCS asking for it, it appeared that there was a little change of sentiments. They said, "Hey, these damn kids can get $3 million, maybe we'd better tag along with them!" At that time, it appeared that the SCS started to get involved, concerned, and interested in SNOTEL. We then became more closely associated with SCS and less with our cooperators.

SNOTEL, as we know it today, would have gone on regardless, but it may have ended up that it was done by the cooperators providing the funds. We may have even been alienated from the SCS. Through this evolution, we actually were able to pick up the funds and get started. That started off the SCS SNOTEL-type deal. Basically, it's been an SCS program since that time and the SCS had been instrumental in getting additional funds to keep it going.

Helms: But originally, it was to be radio communications, right?

Farnes: It was to be manual communications. After we got the $3 million, we let a contract with an outfit called Systems Consultants out in

California. Their charge was to investigate all of the present ways of telemetrying data and to recommend to us the best system. They looked at hard-line communications, and they looked at satellite communications. At that time, meteor burst was just starting to become useful. Actually, the meteor-burst communications was developed between Montana State University, M.I.T. [Massachusetts Institute of Technology], and Stanford under a contract with the Navy to develop nonjammable communications systems. I was involved with it in the early years when they were using it as a communications system. Then, they actually developed satellites, and the Navy backed off of it. The next time it got brought up was they were going to use it as the time sync system.

Helms: What was that?

Farnes: The Navy used to broadcast the precise time. They were going to use meteor burst because of its rapid transmission to broadcast the time. Then about that time, the quartz crystal became one of the things that gave very precise time, so meteor burst got pushed back down. Then Boeing Aircraft was running short on both commercial and military contracts, and a lot of the people who had worked on the meteor burst at Montana State University had gone to work for Boeing Aircraft. They talked Boeing into bringing this thing up and trying to develop a communications system up there. Actually, Boeing bid on the first communications system we had. But the bid came in too high, and it was rejected. Then Boeing dropped it. They started getting more aircraft contracts. That little group that was working on that said, “There must be something here.” So the original guys who organized MCC [Meteor Communications Corporation] quit Boeing and formed Meteor Communications. Then the second contract was let....

Helms: About what time was that?

Farnes: This would be in roughly 1974 or 1975. Actually, the contract went to Western Union. MCC was providing the technical information to Western Union on meteor communications with the idea that they would not compete on the bids with Western Union in the early stages. My understanding was that Western Union got out of it and through that opened up the door for MCC. Then MCC started in to it. This would have been in the late 1970s. Basically, MCC now has been doing the contracting, and we have been working with them. Western Union, when it originally got the bid, was supposed to do the maintenance for 10 years, and there was a fixed price on it.

SCS and Western Union, I understand, had some contractual problems. Western Union had two or three lawsuits against the SCS and vice versa. It was a mutual agreement that if the SCS would let them out of the 10-year maintenance contract, which was really underbid and was really killing them, they'd drop the charges against the SCS. So it was kind of a mutual agreement. At that time, when the maintenance agreement went down the road, that's when we put on our electronic technicians and started doing our own maintenance. Then MCC came in and provided equipment. That's kind of the evolution of SNOTEL up to where we are today.

Helms: Originally, it was just for snow pillows, precipitation, and temperature.

Farnes: Actually, yes. When we got started in the contract, it was those three parameters that were the keys ones. But we still always recognized that there are places we may want to add additional sensors. With SNOTEL came the computers in the field offices. Also with that came reorganization. We recognized that we needed to have a group in Portland that could do some things. One of the things that got us into trouble was that the Chief of SCS was very scared of going in and asking for additional staff for SNOTEL. When all this was presented, he said, "Okay, if you give us all this money, then we'll be able to do this whole thing without any increase in staff." That really killed us out there. You just don't double or triple the size of your program and keep the same number of people. As a net result of this, we had to make some changes. We formed a unit in Portland. There used to be two or three people out there; then that went to the 12 or 14. We reorganized, put things on a D.C.O. [Data Collection Office] basis rather than on a State basis, hired some electronics technicians, made some changes, and basically, that configuration is pretty much existing today. In reality, one of the areas that suffered was our work with cooperators. There just wasn't time to do all of the things that made this program successful. Another thing that has hurt us was SNOTEL was never planned as a fully automated system. It was originally conceived as a combination of manual and automated stations for economy. Then one of the NTC [National Technical Center] directors started using the line that all manual stations would be discontinued when SNOTEL sites were completed. Many administrative types still pursue this path today. In reality, Montana originally proposed 75 or so stations with the idea that the number would be up to 100 before SNOTEL was fully implemented. Even today, some 25 years later, we are not even up to the 75 stations. But the pressure to get rid of the manual sites is becoming a career goal for a couple of administrative types without regard to the needs of our cooperators or the best overall type of program. I think history will show that the decision to eliminate all manual stations was not the best for SCS and its cooperators.

Helms: What are the advantages of having the continuous information over doing it every month?

Farnes: The main advantage is that from the time the snow starts to melt—at least in our country, roughly the first of April toward the middle of April—on through the melt season, we know what's going on every day. We can advise cooperators whether we're picking up melt, whether we're gaining new snow, and whether we're getting precip. From the operational agency's standpoint, it's a lot more data than we ever had when we were doing it on a once a month basis.

Helms: But you only do that if something significant appears, right?

Farnes: When we get to this time of year—the middle of April—on through the runoff season, many of the agencies and even our own people are looking at the data daily. What happens on a mountain today will be reflected in the streamflows tomorrow. So if you're operating a reservoir, that's extremely important information to know. If you get a big precipitation event, you can do things as far as the flood aspects. Before, we used to have to wait until the water got down off the mountain and times were quite short. Now we have those advanced warnings.

Helms: They can access the information sort of instantaneously?

Farnes: Almost every morning at this time of the year, many different agencies get on and find out what has happened in the past 24 hours.

There are even some places, like the St. Marys drainage in Montana, where the Canadians are very interested. Sometimes we will increase the sampling to four times a day because of the flood aspects on the Bow River that comes down through Calgary and causes problems there. If there's a major precipitation event coming through, we'll increase the sampling intervals so we can know what's going on even more frequently. We just can't sit down in the valleys and look up in the mountains and see what is happening. If you're getting an inch in the valley, you don't know whether it's an inch in the mountains, whether it's half an inch, or whether it's 3 inches. When you have these stormy periods and you can't see up in the mountains, you don't have the knowledge. The only knowledge you have is from the SNOTEL. It becomes extremely valuable in the main runoff season.

Helms: Thank you very much.

DEED OF GIFT

I, Phillip E. Farnes, do hereby give to the Soil Conservation Service the tape recordings and transcripts of my interview of April 14, 1992.

I authorize the Soil Conservation Service to use the tapes and transcripts in such a manner as may best serve the educational and historical objectives of their oral history program. I also approve the deposit of the transcripts at the National Agricultural Library and any other institution which the Soil Conservation Service may deem appropriate. In making this gift, I voluntarily convey ownership of the tapes and transcripts to the public domain.

Phillip E. Farnes
Phillip E. Farnes

11/15/93
Date

4.44 Phillip Farnes Deed of Gift

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