SOME COMPARISONS FROM THE USE OF RADIO REPORTING ISOTOPE SNOW GAGES AND THE SNOW PRESSURE PILLOWS

By

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Introduction

The Walla Walla District of the Corps of Engineers has been operating three radio-reporting isotope snow gages in the Clearwater River basin of north-central Idaho since about 1958. In the summer of 1964 a pressure pillow was installed at one of the sites (Hemlock), and in the summer of 1967 a pressure pillow was installed at one of the other sites (Coolwater). These pressure pillows were installed to obtain comparative information on the operation of the two types of gages. Storage-type precipitation gages also were installed at these two sites. Although we have been plagued with considerable operational difficulties, some information has been accumulated which may be of interest. However, this report must be considered preliminary, because, as yet, adequate data for a complete analysis has not been obtained.

Location of Gages

The gages are part of a radio-reporting hydrologic network for the Clearwater River basin drainage area of 9,640 square miles. This network is operated by the Walla Walla District of the Corps of Engineers, and furnishes valuable data as a basis for forecasting flood flows of the Clearwater River. The information is used not only by the Walla Walla District but is furnished to the Corps of Engineers and Weather Bureau River Forecast Center in Portland and to other agencies. A primary purpose is to obtain basic hydrologic data for the operation of Dworshak Dam and Reservoir now under construction by the Corps of Engineers on the North Fork of the Clearwater River. Drainage area at Dworshak Dam is 2,440 square miles.

The location of the network is shown on figure 1. Radioactive snow gages are located at Hemlock Butte, elevation 6,000; Coolwater Mt., elevation 6,000; and at Orogrande Mt., elevation 7,800. Pressure pillow gages are located at Hemlock, Coolwater, and Hoodoo Creek, elevation 6,000. Canyon, Lowell and Fenn are stream gaging stations. Radio communication to the base station at Walla Walla is through relay stations at Black Mt. and Cottonwood Mt., as shown. Distances between stations range from 40 to 90 miles.

Installation

a. Radioactive isotope snow gage. The water equivalent of the snowpack is measured by determining the amount by which gamma rays passing through a snowpack are attenuated. A cobalt 60 radioactive source in a lead collimator is mounted on a steel cross beam 15 feet above the ground surface. The detector unit is installed in a weatherproof metal box buried just below the ground surface, and is accurately positioned in the center of the collimated beam of gamma rays. Electrical pulses from the detector, which correspond to the cobalt radiations arriving at the detector, are transmitted by radio from the gage site through relay stations to the base station at Walla Walla. Details of the theory design and specifications for the radioactive isotope snow gage are given in a report prepared by the Engineering Experiment Station of the University of Idaho, under a contract with the Walla Walla District of the Corps of Engineers. Loan copies of that report are available from the University of Idaho or from the Walla Walla District, Corps of Engineers.

b. Pressure pillow snow gage. The pressure pillow gage which we installed is composed of a circular 12-foot butyl rubber pillow, a float well and counterweight well, a Fisher-Porter analog to digital recorder, and a Fisher-Porter binary to digital transmitter. The rubber pillow is filled with 300 gallons of methanol which inflates to about 4 inches. The pillow is connected to the float well by means of rubber hose. The float well and counterweight tube are 4-inch aluminum irrigation pipes clamped to the tower leg. The level of methanol in the float well is recorded by the float well recorder on aluminum tape, once each hour. At the time the float level is recorded on the tape, the same reading is stored in memory of the binary to digital transmitter. Upon receiving a signal from the base station, the scanning unit of the transmitter interrogates the memory unit and sends the last recorded level to the base station at Walla Walla as a series of tones. These tones are read manually and recorded. Power for the pressure pillow system at the gage site is supplied by nickel cadmium batteries. Solar cells attached to steel towers are used to keep the batteries charged.

c. Precipitation gages. Remote recording precipitation gages were installed at Hemlock and Coolwater. These gages are of the type developed by the Sacramento District of the Corps of Engineers, and consist of a 30-inch diameter storage tank and a 48-inch long conical transition section with a 12-inch diameter collector ring. This gage has been described by Glenn Castle in a previous meeting of the Western Snow Conference. Although it was realized before installation of these precipitation gages that the exposure was not the best for an accurate catch, it was considered that usable information could be obtained.

A sketch showing the relative location of the instruments and facilities at the site is shown in figure 2.

The radio network in which Coolwater and Hemlock stations operate is an on-call tone-controlled data and voice communication system designed to operate unattended for 9 months (so far that degree of dependability has not been attained). Radio equipment is solid-state type and consists of Motorola FM Lookout Radio, operating in the 170 MC band with 3 watts RF output of power; a Motorola type-FSK data encoder for isotope gage; two-tone decoder for four functions; encoder for telemark: corner reflector-type antenna for receiving; and a unipole antenna for transmitting.

(Photographs were shown of various views showing conditions at the sites, equipment as installed, and snow accumulation).

Collection of Data and Operation Experience

Beginning with the start of the snow accumulation season, about 1 November, the gages are interrogated from the Base Station at Walla Walla each morning about 8:00 a.m. Water equivalent and precipitation amounts are tabulated and plotted.

Unfortunately, as previously indicated, collection of records has been interrupted by some failures and malfunctioning of equipment. For the first season that the pillow was in Hemlock (1964-65), records were good until about the end of December, when the timing clock in the Fisher-Porter equipment stopped. The clock was replaced by making a helicopter trip to the site. A few days later a leak developed in the pillow, and no further records on the pillow for the season were obtained.

During the 1965-66 season, low batteries caused an interruption in the record for the isotope gage for about 4 weeks in January and February. Thereafter, good records were obtained until the end of April, when the snow surveyors got off course and punched a hole in the snow pillow, which ended the records of that gage for the season.

A complete season's record was obtained for the 1966-67 season except for about 2 weeks in May when low batteries caused an interruption of records from the isotope gage.

So far in the 1967-68 season, continuous records have been maintained except for several short-time interruptions.

During each season it has been necessary to make several trips to the sites mostly by helicopter to keep equipment operating. Most of the recent problems have been associated with the communication of the system. They have not been peculiar to either the radioisotope gage or the pressure pillow gage. Maintenance has been much higher than considered desirable. It is hoped this can be reduced in the future.

Comparison of Measurements

Because of the failure of the Hemlock pressure pillow in 1964-65, no comparative information is available for that season.

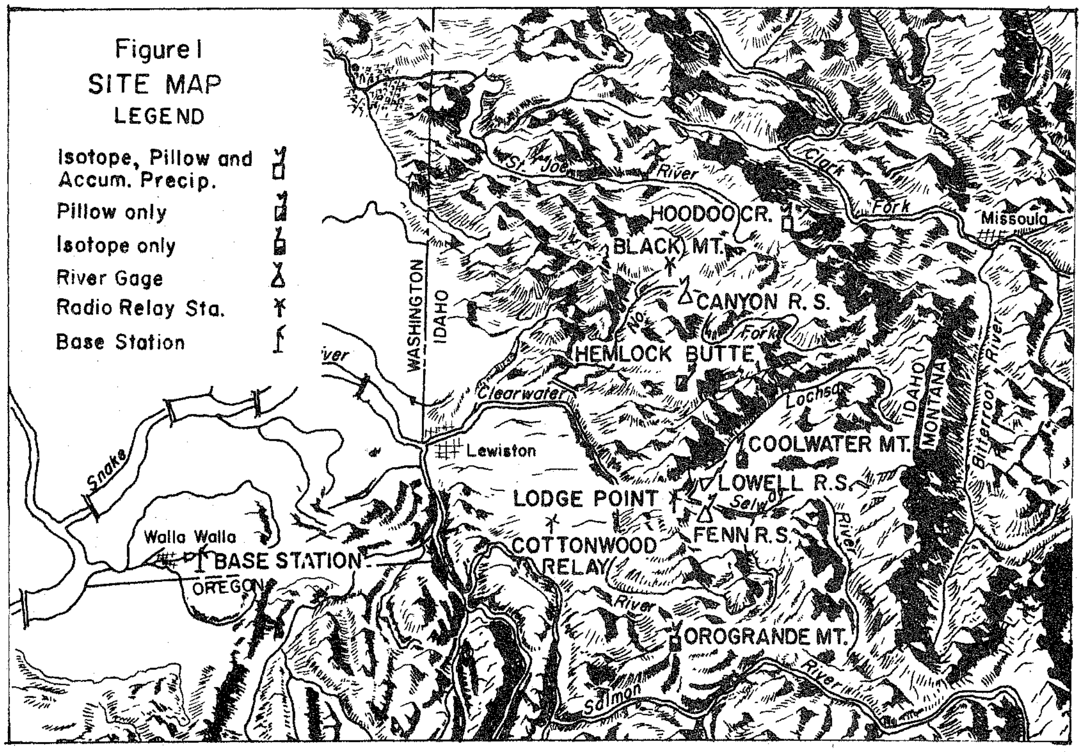
Figure I
SITE MAP
LEGEND
Isotope, Pillow and Accum. Precip.
Pillow only
Isotope only
River Gage
Radio Relay Sta.
Base Station
HOODOO CR.
BLACK MT.
CANYON R. S.
HEMLOCK BUTTE
COOLWATER MT.
LOWELL R.S.
LODGE POINT
FENN R.S.
COTTONWOOD RELAY
OROGRANDE MT.
Lewiston
Walla Walla
BASE STATION
OREGON
WASHINGTON
IDAHO
MONTANA
Missoula
St. Joe
River
Clark Fork
Clearwater
Lochsa
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Salmon
Snake
Bitterroot River

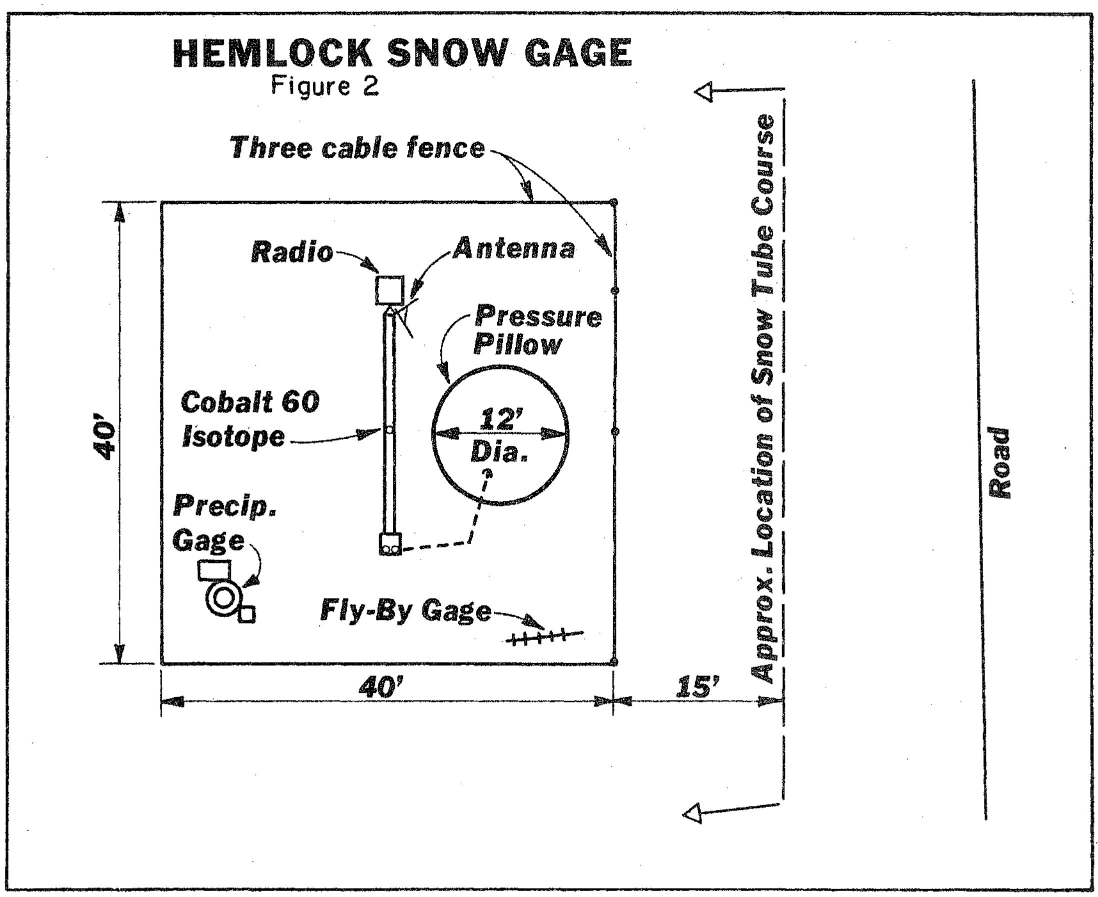
HEMLOCK SNOW GAGE
Figure 2
Three cable fence
Radio
Antenna
Pressure Pillow
Cobalt 60 Isotope
12' Dia.
Precip. Gage
Fly-By Gage
40'
40'
15'
Approx. Location of Snow Tube Course
Road

Figure 3 shows traces of the isotope and pressure pillow recordings for 1965-66 at Hemlock. Also shown are the accumulated precipitation and snow tube measurements. The isotope consistently showed somewhat greater accumulations of snow. It will be noted that the isotope shows a maximum accumulation near the end of March of 48.0 inches of water equivalent, compared to 42.3 inches for the pressure pillow. Incidentally, the recorded accumulated precipitation was only 38.3 inches at this time. By the end of April, the difference in accumulated amounts was considerably less; the isotope showing a total of 40.6 inches and the pressure pillow 39.1 inches, or only 1.5 inches difference. The snow tube measurement made on this date was 44.5 inches. The isotope and pillow readings are reasonably close, but as yet no detailed analysis has been made as to which might be the more accurate. Daily incremental changes in amounts of water equivalent are also shown on figure 3. Although the patterns of daily changes are somewhat similar, specific amounts usually are quite different. The isotope, generally, tends to show greater daily variation. This is an important aspect since incremental changes during the melt season are very significant in the short-time forecasting of streamflow.

Accumulation of snow for the 1966-67 season was considerably greater than that for 1965-66, as shown on figure 4. Again, during the accumulation period, the isotope and pressure pillow showed reasonably close agreement. In contrast to the 1965-66 season, the pillow generally recorded higher water equivalent. Maximum amounts occurred near the 1st of May and were 70.9 inches for the isotope and 64.6 inches for the pressure pillow. Although this difference is 6.3 inches, the differences in accumulated amounts were generally within 2.0 inches of each other throughout most of the accumulation period. It is interesting to note that snow tube measurements for the 1st of April showed 52.4 inches, compared to isotope reading of 63.2 inches and pressure pillow reading of 62.4 inches. The record for the isotope gage from 6 May to 26 May appears to be in error. At the latter date, the gage ceased to function and a subsequent trip to the site showed the batteries were too low for operation. Again comparison of daily increments show the isotope readings much more erratic than those for the pillow. What is especially disconcerting is the readings showing large daily change but having no justification in having been caused by precipitation or temperature, which was the case for the changes for 29 March and 24-26 April. Because of the above, the pressure pillow daily changes in water equivalent appear to be more reasonable than those of the isotope.

However, as yet we have not had concurrent records from the radioisotope gage and the pillow gage during the melt season. Such records may show better conformity between daily readings.

Snow tube measurements have been made for comparison with isotope and pressure pillow measurements. Figure 5 shows a plot of snow tube measurements vs concurrent isotope and pressure pillow readings. The comparison shows snow gage measurements generally within 10 percent of snow tube measurements but some variation greater than 20 percent for both the isotope and pillow gages. Since individual snow tube measurements often have wide variations among themselves little confidence can be placed in the snow tube measurements as a standard of comparison.

At this time no definite statement can be made as to which snow gage is giving the more accurate reading.

Cost Comparison

Based on our experience with the radioactive snow gage and the pressure pillows, estimated present costs for installations at one site equipped to transmit over a radio network are as follows:

Radioisotope gage

Detector and inclosure	$2,400
Collimator	300
Cobalt 60 - two 40 MC capsules	300
Support structure and antenna	500
Radio and inclosure	1,700
Batteries and solar cell	300
Installation	1,200
Total	$6,700

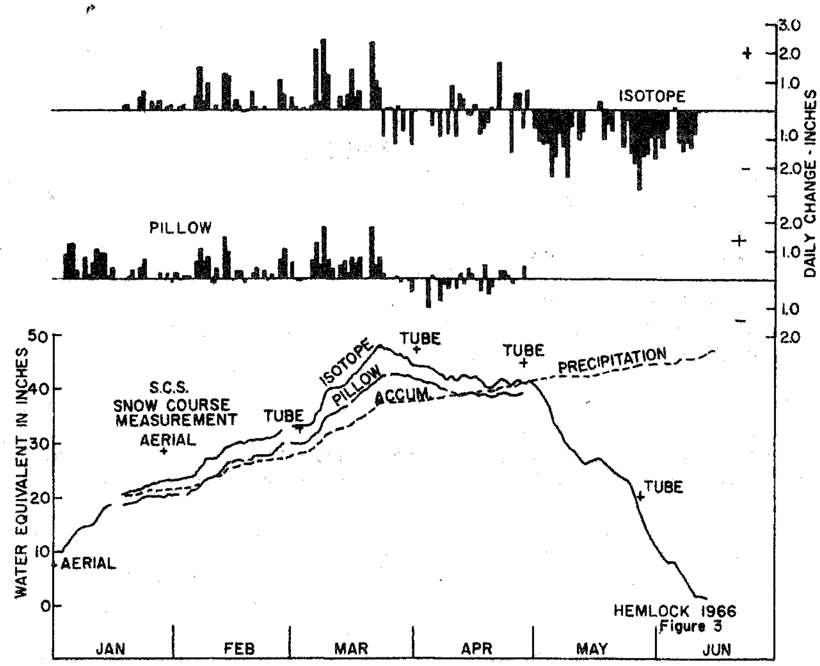

Figure 3

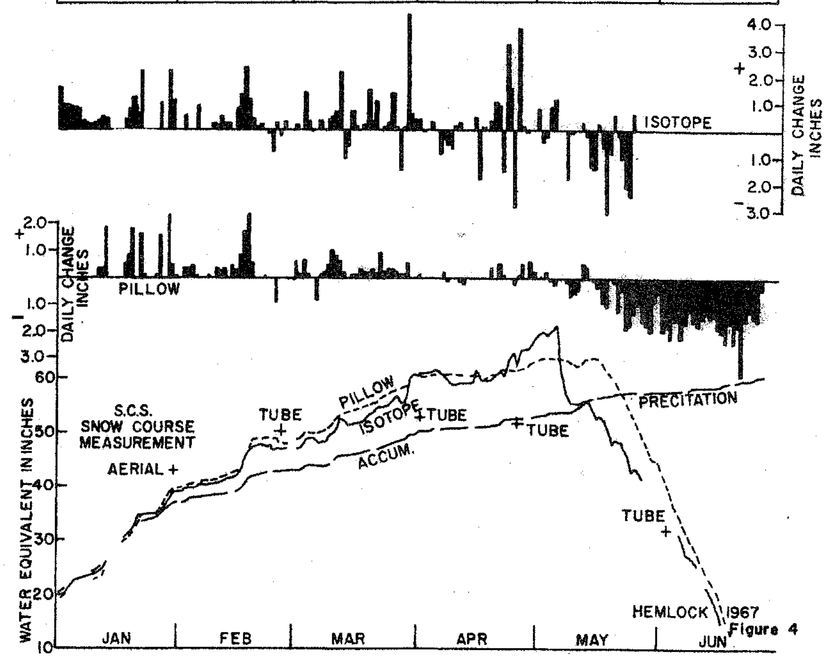

Figure 4

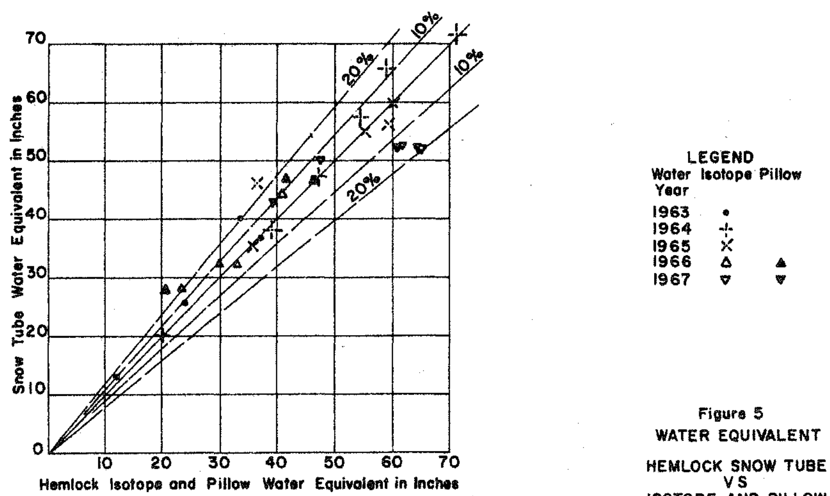

Figure 5
WATER EQUIVALENT

HEMLOCK SNOW TUBE
VS
ISOTOPE AND PILLOW

Pressure pillow gage

Butyl rubber 12-ft. pillow	$ 800
Alcohol, 300 gal.	200
Fisher-Porter ADR & BDT	1,250
Recorder inclosure and standpipe	250
Float, tape and miscellaneous	100
Radio and inclosure	1,700
Batteries and solar cell	300
Installation	800
Total	$5,400

In addition to the above, the radioactive snow gage required a technician or engineer qualified to remove and replace radioactive isotopes and execute tests for leakage.