CALIFORNIA FEDERAL-STATE SNOW SENSOR INVESTIGATIONS

PROBLEMS AND REWARDS

By

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One of the biggest problems that besets the river forecaster is his lack of real time knowledge of changes in snow pack water equivalent. In an endeavor to determine the usefulness of snow pillows for this purpose, the U. S. Weather Bureau River Forecast Center in Sacramento, in conjunction with the California Department of Water Resources, conducted a series of investigations using a variety of sizes of rubber pillows, metal disks, and platforms. These, in turn, were installed in a number of differing exposures at a fairly broad range of elevations from 5000 to 8200 feet in the Central Sierra Nevada Range.

The initial installation involving both organizations was at Twin Lakes, elevation 8200 feet. Here a 20-foot house was built, seven 4-inch standpipe manometers were installed, and six were connected to snow pillows. The seventh standpipe was partially filled with alcohol to measure the diurnal fluctuations of temperature and the daily loss of liquid due to evaporation in the standpipe itself.

The snow pack during the first season was quite homogeneous with no prolonged periods of clear weather to form ice layers and no rain on the snow pack.

The dam tender, a PG&E employee, took weekly snow surveys and tended the instruments.

Several goals were set prior to installation, as to what we were seeking to find from this setup. Because previous investigators had reported variations between pillow sizes in the amount of water equivalent indicated, several sizes were tested (5, 8, and 12 feet). In order to check whether the way the pillow was exposed had anything to do with the overweighing, the 12-foot pillows were installed several different ways:

#1, 12-ft: installed below ground with 2-inch layer of sawdust and dirt covering entire surface.

#2, 12-ft: installed flush with surface.

#3, 12-ft: installed on surface.

#4, 12-ft: installed on surface with 3/4" plywood cover 12 feet in diameter.

#5, 8-ft. pillow on surface.

#6, 5-ft. pillow on surface.

The only apparent difference in readings between exposures was that normally expected between locations in a large meadow. Certainly the differences were no greater than the range encountered in the snow survey (see Fig. 1). At the time of maximum water-equivalent there was only 7% difference between high and low values. At the same time, the 8-foot pillow was reading 13% higher than the average of the three 12-foot pillows.

The 5-foot pillow had burst earlier in the season (with 21 inches of water accumulated). At that time it was reading 14% higher than the 12-foot pillows.

The 12-foot pillow mounted flush with the ground developed several pinpoint leaks and measured several inches of water too low through most of the season. In March, the recorder indicated a dramatic drop of 8.3 inches (Fig. II). This was followed by a slow recovery of 4.8 inches. It never did fully recover before the melt season set in. This rapid

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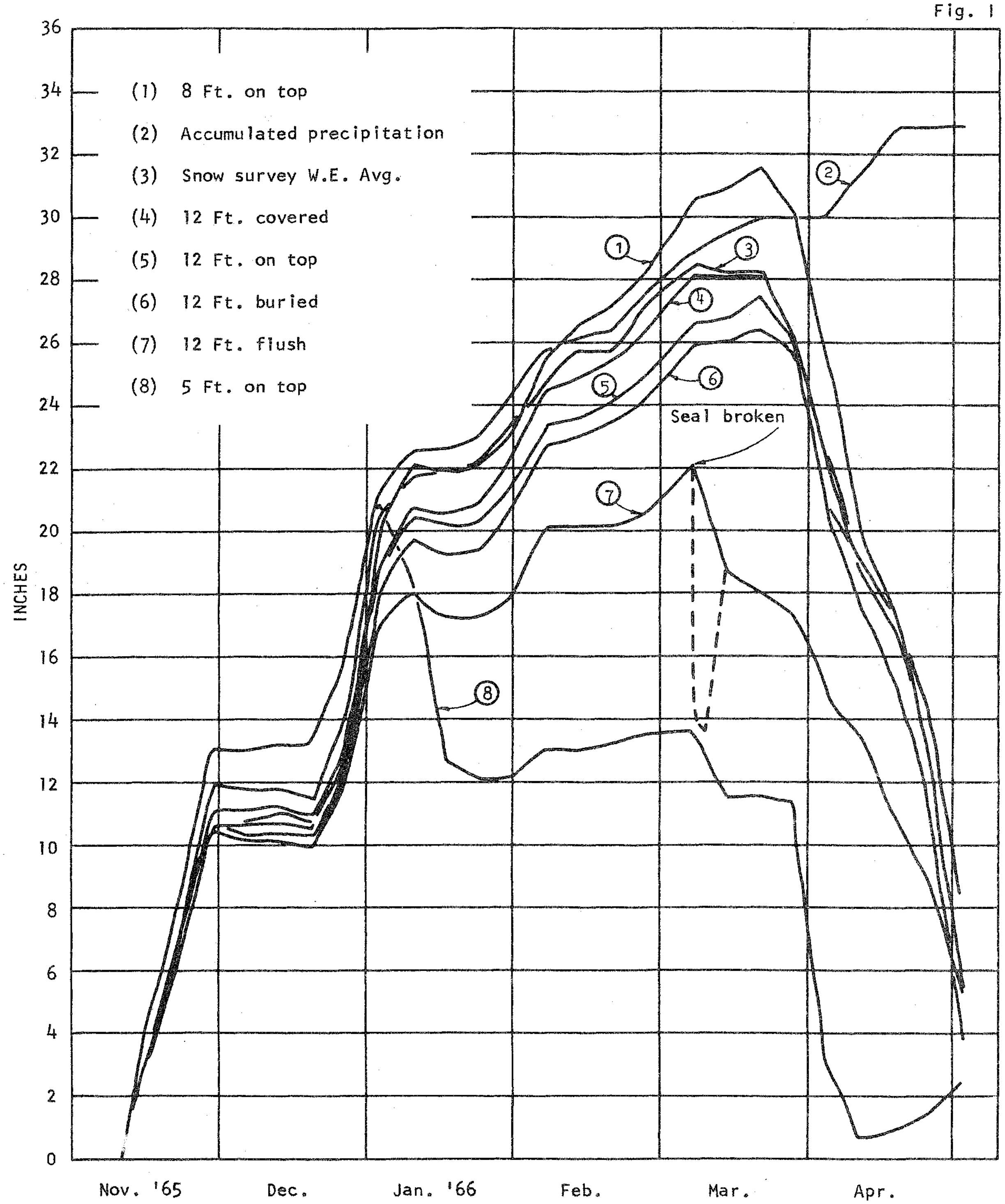
SNOW PILLOW RESEARCH PROJECT
TWIN LAKES, CALIFORNIA BETA SITE

Fig. 1



drop was attributed to breaking of the pressure seal between the snow and the pillow as the result of a cavity being formed in the snow by the alcohol vapor. Similar drops have been noted at other locations under similar circumstances. Digouts have revealed cavities associated with alcohol leaks.

It is interesting to note that diurnal variations in the standpipe were from 2 to 5-tenths of an inch. Expansion and contraction of the gage house itself was about 2/10 inch.

In 1966 the Twin Lakes site was closed and the pillows reinstalled at Cisco (elevation 5700 ft.) and Alpha (elevation 7600 ft.). Additional innertube type pillows were purchased and combinations of 3, 5, and 12-foot pillows with two platforms and three precipitation gages were installed at Cisco Grove. A 5-foot pillow was installed at the Blue Canyon Weather Bureau station. Both Cisco and Blue Canyon encountered a much wider variety of weather conditions than was observed at higher elevation stations. Several very heavy rain periods were experienced at both sites during the 1966-67 season. Complications arose which had never been encountered at the higher elevations. Flush mounted pillows which were thought to have adequate drainage did not drain when rain percolated through the snow. Cold weather and high winds caused the ponded water to freeze. This caused cavities as well as unusual pressure variations on the pillows. Metamorphoses of the snow crystals also gave some rather unique distortions in the readings due to plastic movement within the snowpack.

High winds at the time of low dewpoint temperatures lowered the temperature of the liquid in the pillow, causing a contraction in the alcohol and subsequent sharp lowering of the manometer reading due to the separation of the pillow and disk from the snow. This caused a reduction in pressure similar to that when cavitation occurred. It took several days for both the pillow and disk to recover full pressure (Fig. III) following such conditions. Even using a transducer in place of the standpipe manometer will not entirely prevent loss of pressure if the seal is broken between the snow and pillow surface. The ability of snow to provide a very rigid bridge without collapsing or with very slow vertical movement is well known to anyone crossing a stream in deep snow. This same bridging effect takes place when the interface between the snow and either a rubber or metal sensor is separated. It also takes place if heavy rain falls on the snow and liquid water running along the interface washes a small amount of the snow away. This also caused a loss in pressure which was slow in recovering.

The smaller the pillow the longer it takes to transmit all of the added weight of water equivalent (Fig. IV). With five-foot pillows, it has taken up to ten days to reach equilibrium (45 inches of snow depth). The twelve-foot pillows responded more readily, but even so, they may have up to five hours delay, though this is rare.

If data are needed on a real time basis as to the gain or loss of water equivalent, any delay in obtaining a correct incremental value may be critical.

Much additional investigation will be required before we can advocate a sensor which can be depended upon to provide real time information for short-term river and flood forecasting purposes. However, our experience with a flush mounted, plywood covered 12-foot diameter, two layered pillow has proven to be the best under widely varying conditions.

Fig. III

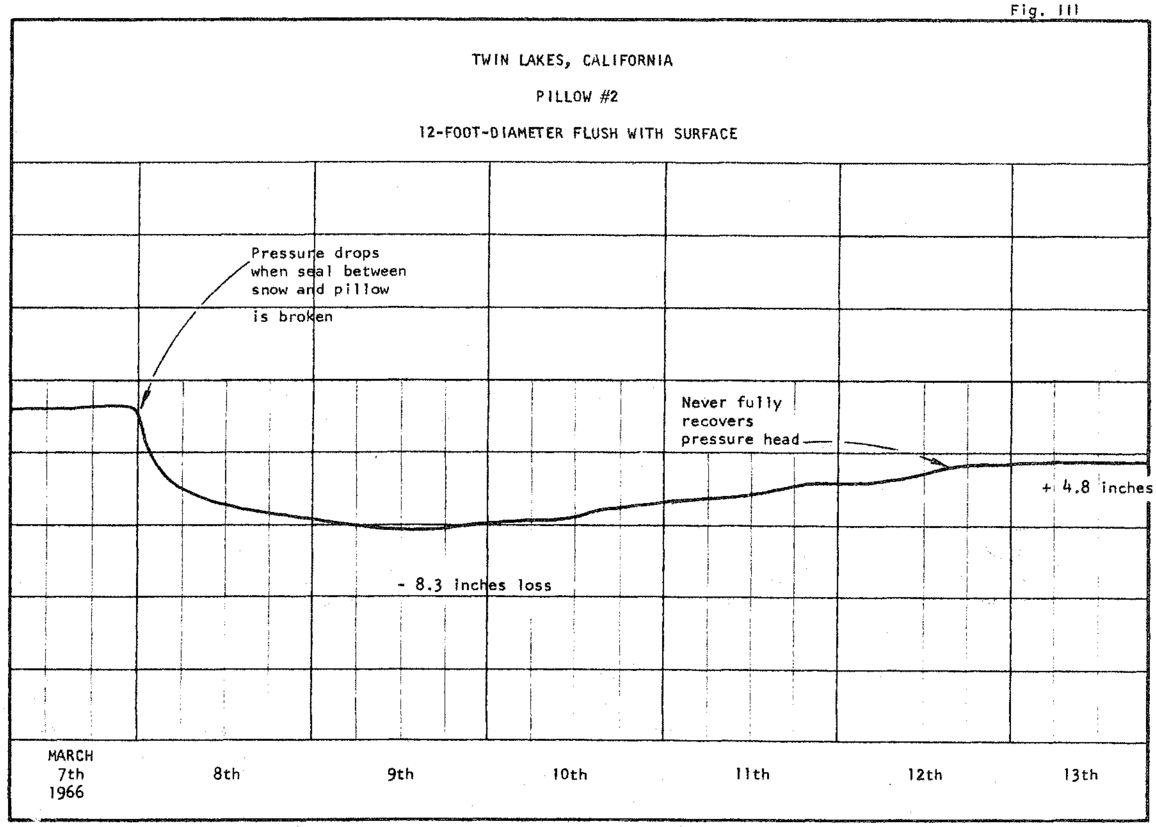


Fig. II