EVALUATION OF SNOTEL DATA DURING JANUARY 9-16, 1980 STORM IN THE TAHOE-TRUCKEE BASINS

by

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INTRODUCTION

This paper covers the operation of SNOTEL data sites during the severe storm period January 9 to 16, 1980, in the Tahoe-Truckee Basins of California and Nevada. These sites are part of the Soil Conservation Service's (SCS) SNOTEL (SNOw TELemetry) data collection system--the world's largest scale application of meteor burst technology.

Papers covering many aspects of the SNOTEL operation have been presented to many professional societies: Barton and Burke (1977) describe the overall system specification and design criteria; locations of sites, measurements-purposes-capabilities of installed equipment (snow pillows, precipitation gages and transducers), and the expected transmission results; Brown (1976) and Bartee (1978) demonstrate the accuracy of the properly installed and maintained snow pillow in measuring snow water content in the snowpack; Shafer (1980) assesses problems associated with the snow pillow (bridging, ice layers, registration lag) and the need for sensors with added capabilities (i.e., identifying measurements of rain-on-snow events); Barton and Crook (1980) document reliability and timeliness of SNOTEL site reports on scheduled and unscheduled polling; and Farnes (1978) and George (1980) explain some uses of and interpretations from collected SNOTEL data. Very little has been reported on the performance of the system and data sites during a winter/spring season or a prolonged, intense storm event.

JANUARY STORMS

The first major storms of the season in the Tahoe-Truckee Basins (Figure 1) occurred about Christmas and again on New Years Day. After a week of little activity, vigorous storms hit California and Nevada. Precipitation over the basins was almost continuous from the 9th through the 16th of January. Warm air temperatures and torrential rain removed most of the mountain snowpack below the 1,830 meter elevation, increased the average density of the snow in the 1,800 to 2,000 meter zones, and increased the snow water and densities at higher elevations.

According to National Oceanic and Atmospheric Administration-National Environmental Satellite Service data, snow covered areas were reduced from 68 percent on December 27, 1979 to 30 percent on January 29, 1980, in the Tahoe-Truckee Basins (Figure 2). The total basin area is 933,380 hectares according to the Central Lahontan Basin 1975 report. This means about 354,684 hectares lost all snow during the month, mainly from the January 9-16 event. The same event reduced snow cover on the adjacent Carson Basin from 31 to 15 percent, and the Walker Basin from 67 to 25 percent.

The distribution of snowpack resulted in a below normal snow water at lower elevations and above normal snow water at higher elevations. Although snow covered areas were fewer, the average water in the remaining high elevation snowpack increased from 85 percent on December 21, 1979, to 150 percent by the end of January.

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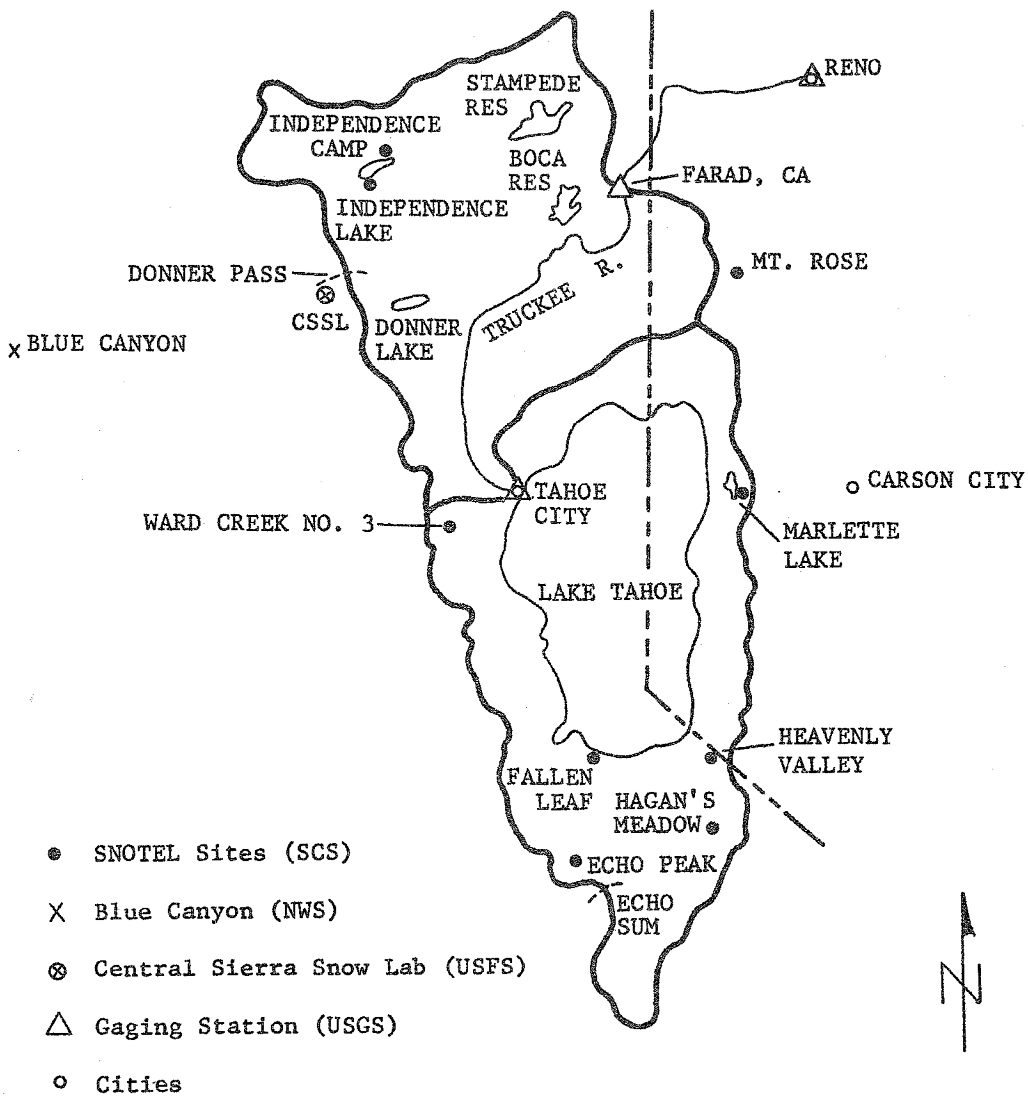

TAHOE-TRUCKEE BASIN LOCATION MAP

Figure 1

SNOW COVER
GOES-3

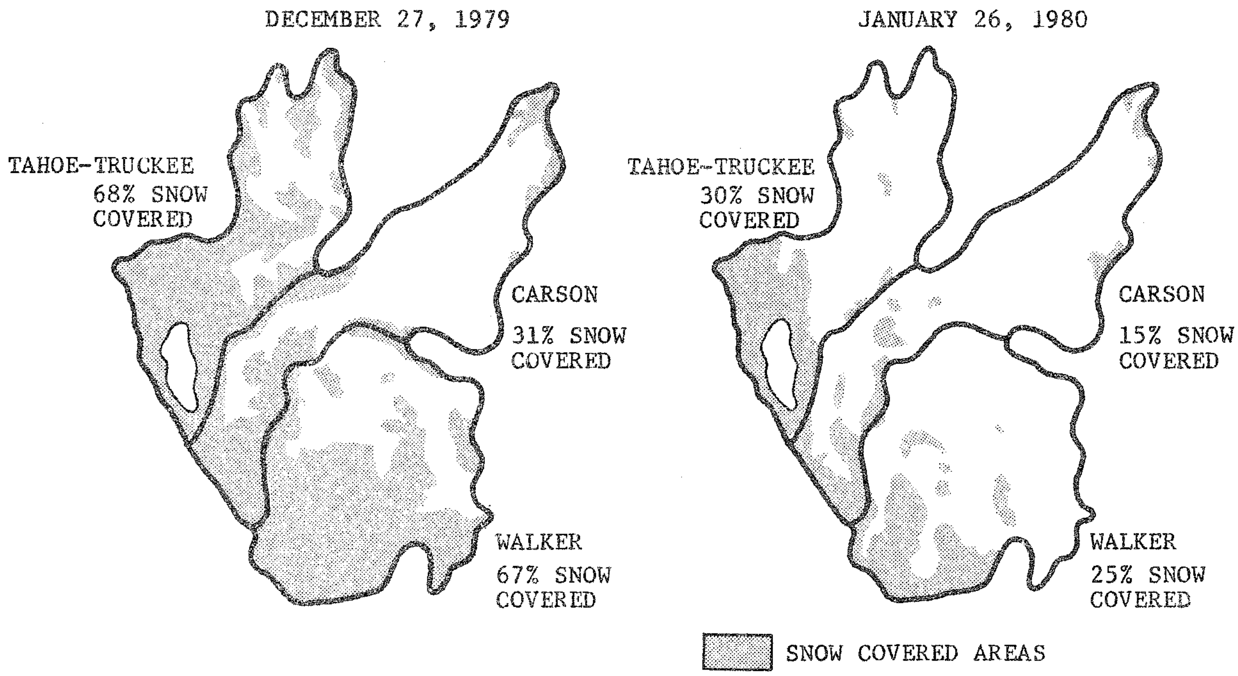

Figure 2

The Central Sierra Snow Laboratory (CSSL) on the west side of Donner Summit at about 2,103 meters elevation, approximately 22 kilometers northwest of Ward Creek No. 3, provided snowpack density profiles useful in analyzing changes in the snow during the subject storm. These were made by a radioactive profiling gage and three are presented just prior, during, and at the end of the storm (Figure 3).

The top chart in Figure 3 shows a pre-storm snowpack depth on January 8 of 106 centimeters containing 35 cenitmeters of water. Principal features are a dense surface layer, one at about 10 centimeters, and one near the ground. On the January 11 chart, the same dense layers appear at almost the same depths, with an additional 72 centimeters of new snow on top--the accumulation prior to the subsequent warm intense rains. Near the end of the storm and after the rains the profile was quite dense below 120 centimeters with layers of new snowfall on the surface. The charts show the tremendous change which took place in the snowpack during the eight days. They indicate the dynamic stresses occurring in the snowpack through the storm.

The storm produced a 158,916 cubic dekameter increase in Lake Tahoe, 14,801 cubic dekameters in Prosser, Stampede and Boca reservoirs, and a flow of 44,405 cubic dekameters in the Truckee River at Farad, California, for a total of nearly 218,122 cubic dekameters of water. The total flow and storage for January showed an increase of 205,129 cubic dekameters over the January average (70,309).

Flood conditions prevailed throughout the area. Peak discharges of 227 cubic meters/second occurred on the Truckee River at Farad, California (1:00 a.m.) January 14 and 244 cubic meter/second at Reno, Nevada (3:00 a.m.). Centimeters of precipitation recorded 24 and 48 hours preceding these peaks measured 16.76 and 27.80 at Ward Creek No. 3 and 16.76 and 29.46 at Blue Canyon. From 6:00 a.m. January 12 to 8:00 a.m. January 14 the precipitation amounts for eight sites were: Echo Peak 26.42; Ward Creek No. 3 24.64; Blue Canyon 23.38; Fallen Leaf 19.56; CSSL 17.60; Independence Lake 12.19; Mt. Rose 11.18; and Heavenly Valley 9.65.

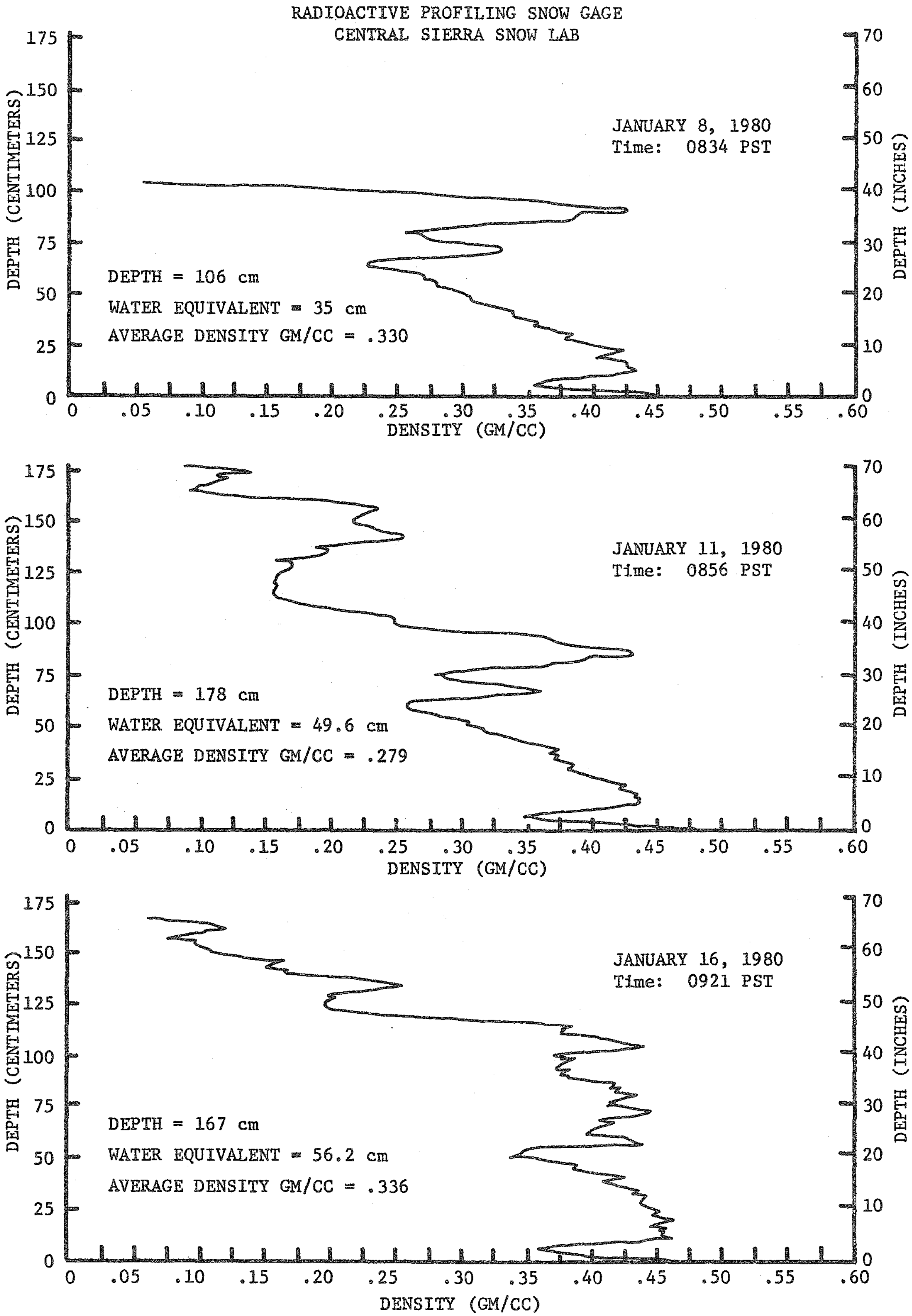
RADIOACTIVE PROFILING SNOW GAGE
CENTRAL SIERRA SNOW LAB
JANUARY 8, 1980
Time: 0834 PST
DEPTH = 106 cm
WATER EQUIVALENT = 35 cm
AVERAGE DENSITY GM/CC = .330
DEPTH (CENTIMETERS)
DEPTH (INCHES)
DENSITY (GM/CC)
JANUARY 11, 1980
Time: 0856 PST
DEPTH = 178 cm
WATER EQUIVALENT = 49.6 cm
AVERAGE DENSITY GM/CC = .279
DEPTH (CENTIMETERS)
DEPTH (INCHES)
DENSITY (GM/CC)
JANUARY 16, 1980
Time: 0921 PST
DEPTH = 167 cm
WATER EQUIVALENT = 56.2 cm
AVERAGE DENSITY GM/CC = .336
DEPTH (CENTIMETERS)
DEPTH (INCHES)
DENSITY (GM/CC)

Figure 3

SNOTEL STORM DATA

The nine SNOTEL sites in the Tahoe-Truckee Basins shown in Figure 1 and four sites in the adjacent Carson-Walker Basins were the only near real time data collection sites functioning in these basins during the January 9-16 event.

The SCS systemwide central computer in Portland polled twice daily during the 1979-80 season: 5:00 a.m. for three hours, and again at 2:00 p.m. for one hour. In addition, in December 1979 Nevada established an ad hoc poll for 1:00 a.m. on six sites in the Tahoe-Truckee Basins.

Four SNOTEL sites--Ward Creek No. 3, Independence Lake, Fallen Leaf, and Marlette Lake--all with different average annual precipitation patterns, provided snowpack snow water, precipitation, and temperature information to help interpret what was happening during the entire January 9-16 event.

Ward Creek No. 3, on the east side of the Sierra Crest, accumulates large amounts of precipitation for its elevation of 2,057 meters (Figure 4). From January 8 to January 16 the total precipitation collected in the precipitation gage was 53 centimeters, while the snow pillow had a net increase of only 12.9 centimeters. Basically, most (75 percent) of the storm precipitation passed through the snowpack at this location.

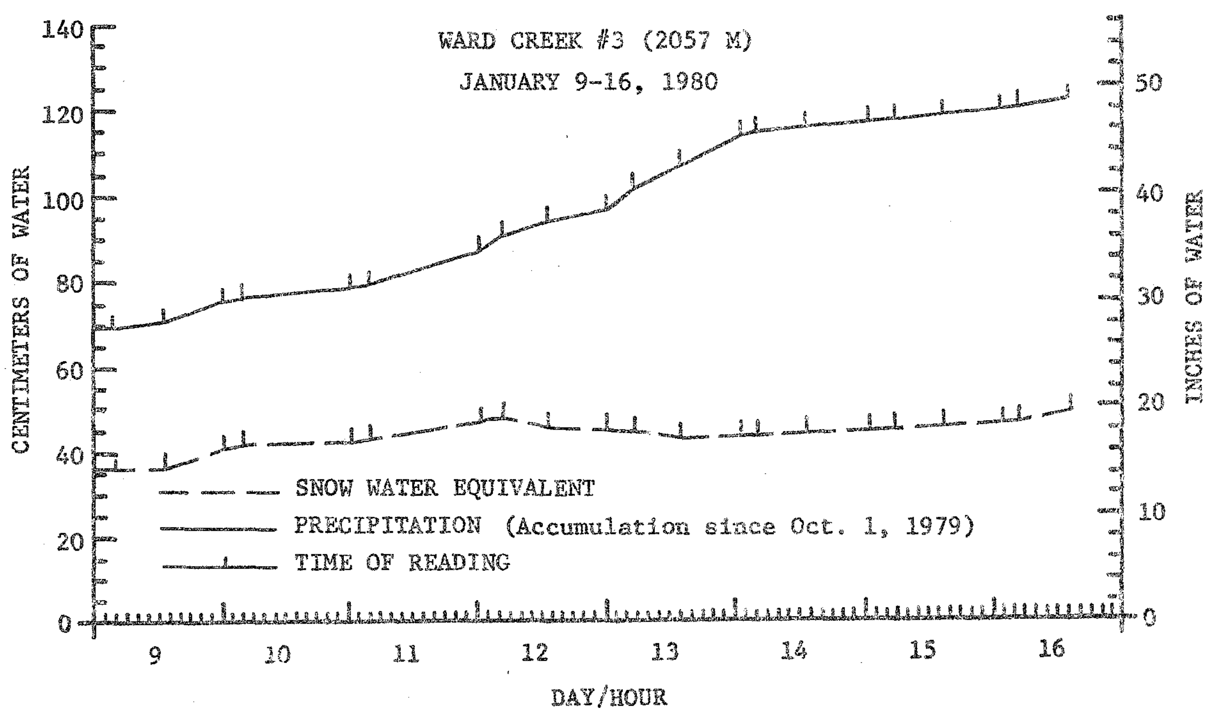

Figure 4

Independence Lake, 13 kilometers north of the CSSL at an elevation of 2,576 meters, is the highest elevation site on or near the Sierra Crest. Both snow pillow and precipitation gage show relatively similar accumulations with little or no water percolation through the snowpack. Total snow water accumulation was 35.7 centimeters and the precipitation gage total was 33.9 centimeters (Figure 5).

Fallen Leaf site, at the south end of Lake Tahoe, elevation 1,920 meters (slightly above Lake Tahoe's surface level) showed a loss of nearly all the snow water from the snow pillow and 32.9 centimeters of water gain in the precipitation gage (Figure 6).

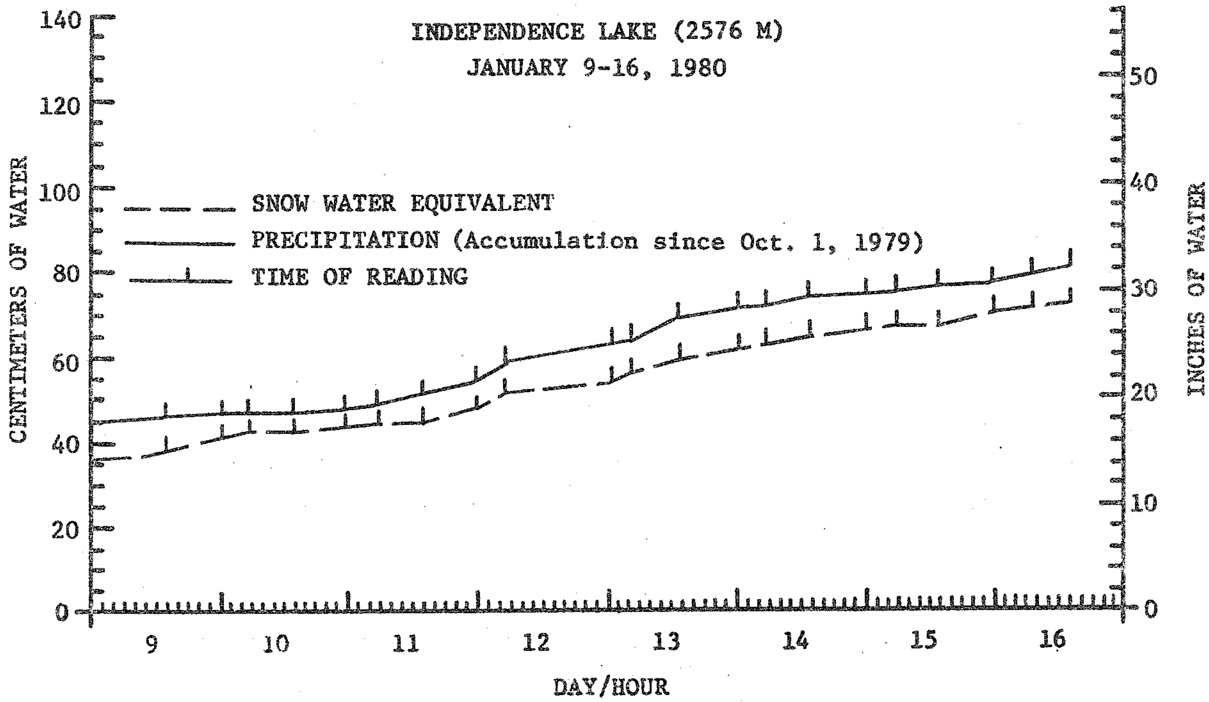

Figure 5

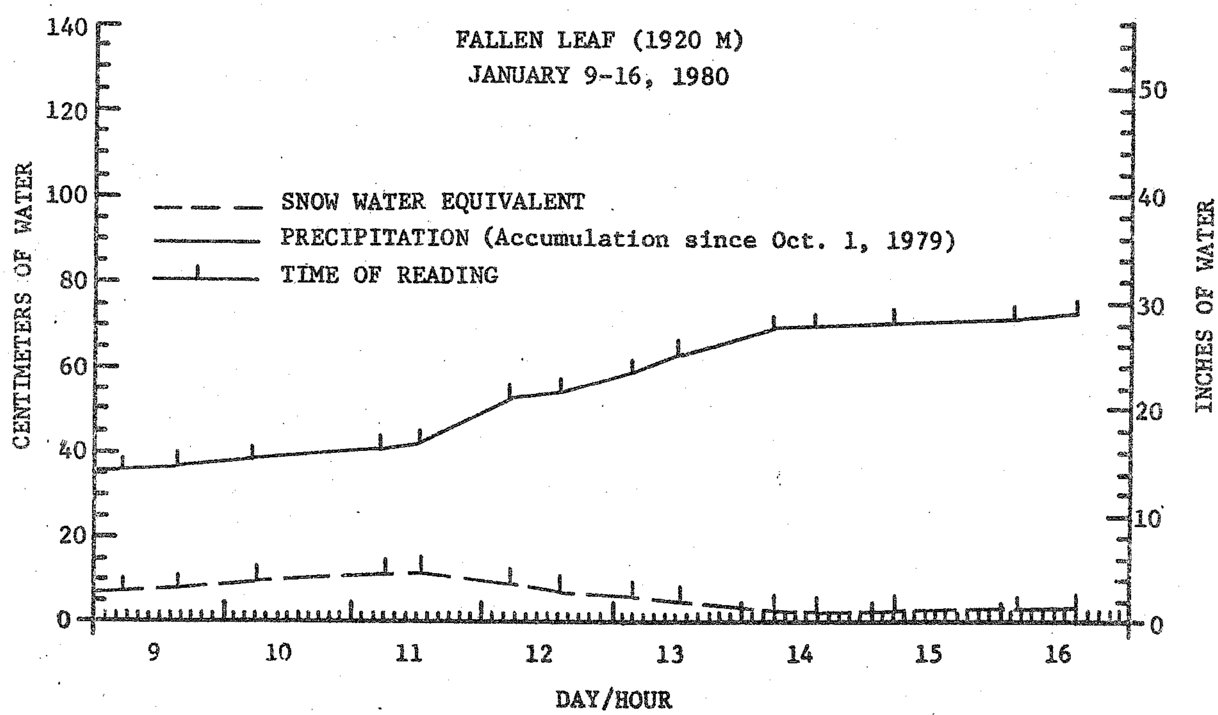

Figure 6

Marlette Lake, east of Lake Tahoe on the Carson Range, at an elevation of 2,438 meters, accumulates less precipitation due to the shadow effect from the Sierra Crest west of the site. During the storm, snow water increased by 14.3 centimeters and the precipitation gage collected 23.2 centimters of water (Figure 7).

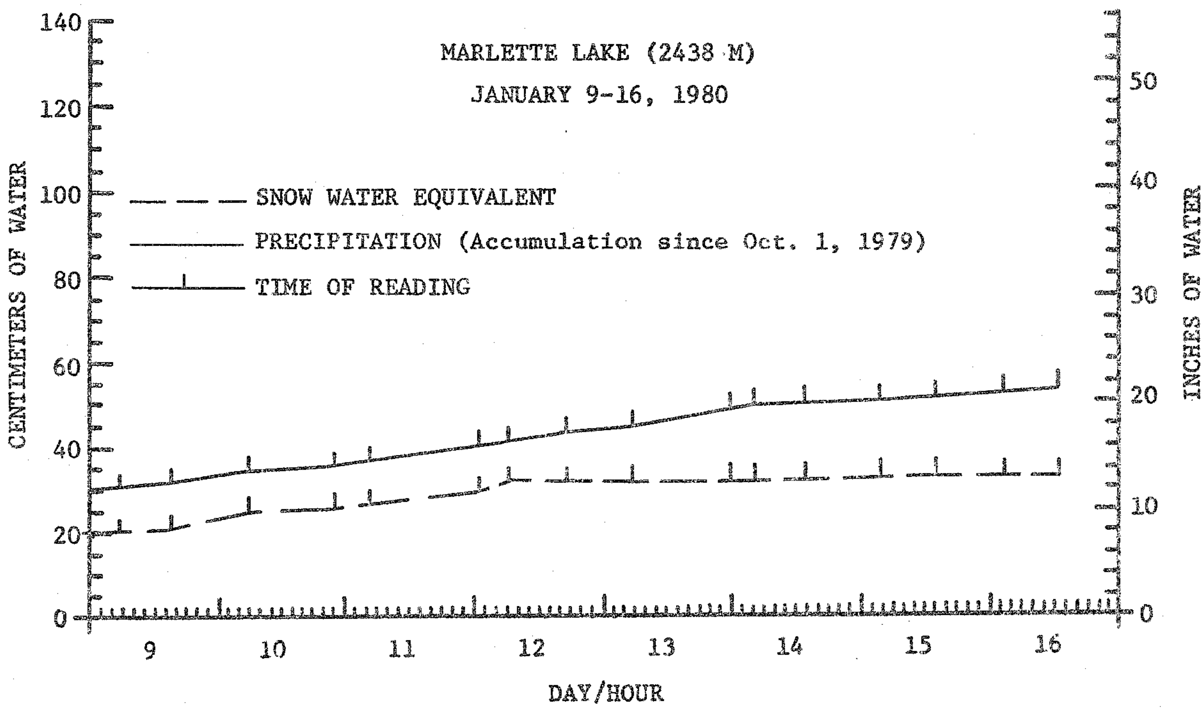

Figure 7

Although snow water loss cannot be detected, the difference of 8.9 centimeters between the snow water and precipitation catch may indicate that water percolated through the snow profile without decreasing snow water.

Table 1 shows snow water increments for the previously discussed four sites plus three additional sites--CSSL, Heavenly Valley, and Independence Camp--and Figure 8 compares snow water values at five sites during January 9-16, 1980. These sites show common similarities in amounts, reactions, and timeliness at each elevation, as expected.

In Table 2 and Figure 9 precipitation data is compared to the CSSL and the Blue Canyon precipitation data. The Blue Canyon gage operated by the National Weather Service (NWS) is located about 45 kilometers west of Ward Creek No. 3 at an elevation of 1,615 meters. It is an event-actuated telemetered station. CSSL is about 22 kilometers northwest of Ward Creek No. 3 at an elevation of 2,103 meters. Both sites are monitored by on-site observers.

Table 2 shows the daily precipitation gage increments and the total for January 9-16 for seven data sites in the study area, plus the Blue Canyon and CSSL sites. The accumulated increments for four of these sites are shown in Figure 9.

Both graphs show a common pattern of increments and/or accumulation between sites except Blue Canyon had larger increments of precipitation on the 12th and 16th and CSSL accumulation slacked off after the 13th.

TABLE 1

Daily Snow Water Increments
(Centimeters)

Site Name & Elev.	Jan 9	Jan 10	Jan 11	Jan 12	Jan 13	Jan 14	Jan 15	Jan 16	Total
Independence Lake (2,576 meters)	4.5	1.3	5.8	5.8	11.4	3.3	1.8	1.8	35.7
CSSL (2,103 meters)	10.16	2.79	2.54	-2.54	-1.01	4.24	3.48	3.56	23.22
Heavenly Valley (2,682 meters)	3.3	2.3	4.6	2.0	5.8	3.3	0.8	1.0	23.1
Independence Camp (2,134 meters)	4.8	1.0	0.8	1.8	7.1	0.3	0.0	0.5	16.3
Marlette Lake (2,438 meters)	5.8	0.3	6.4	0.0	0.5	0.0	0.0	1.3	14.3
Ward Creek No. 3 (2,057 meters)	4.8	0.5	5.1	-2.3	-1.0	1.3	1.5	3.0	12.9
Fallen Leaf (1,920 meters)	1.5	1.5	-0.5	-1.0	-3.6	0.5	0.3	-0.3	-1.6

TABLE 2

Daily Precipitation Increments
(Centimeters)

Site Name & Elev.	Jan 9	Jan 10	Jan 11	Jan 12	Jan 13	Jan 14	Jan 15	Jan 16	Total
Blue Canyon (1,615 meters)	7.32	1.01	11.98	11.54	16.00	8.33	2.24	5.58	64.00
Ward Creek No. 3 (2,057 meters)	6.4	2.0	9.4	10.4	16.7	3.3	1.8	3.0	53.0
CSSL (2,103 meters)	5.08	2.54	7.23	13.05	10.96	3.45	1.30	4.39	48.00
Independence Lake (2,576 meters)	2.0	0.8	4.3	8.6	8.9	3.0	2.0	4.3	33.9
Tahoe City (1,899 meters)	4.62	1.96	8.86	7.76	5.72	1.19	2.23	1.30	33.6
Fallen Leaf (1,920 meters)	3.6	1.8	8.6	9.7	6.4	1.0	0.8	1.0	32.9
Independence Camp (2,134 meters)	3.6	1.3	5.0	8.9	7.1	1.8	1.5	0.8	26.1
Heavenly Valley (2,682 meters)	2.3	1.3	4.0	5.8	5.8	4.6	1.5	0.8	26.1
Marlette Lake (2,438 meters)	3.3	2.0	4.8	2.5	4.8	1.0	2.3	2.5	23.2

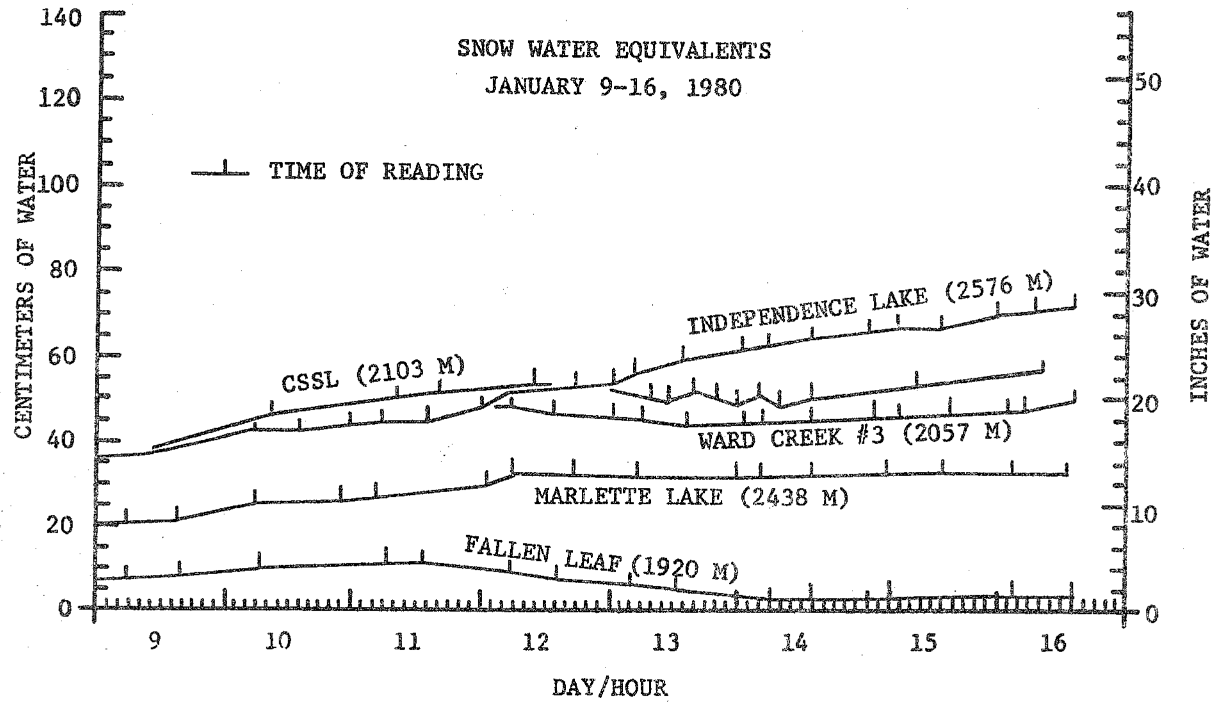

Figure 8

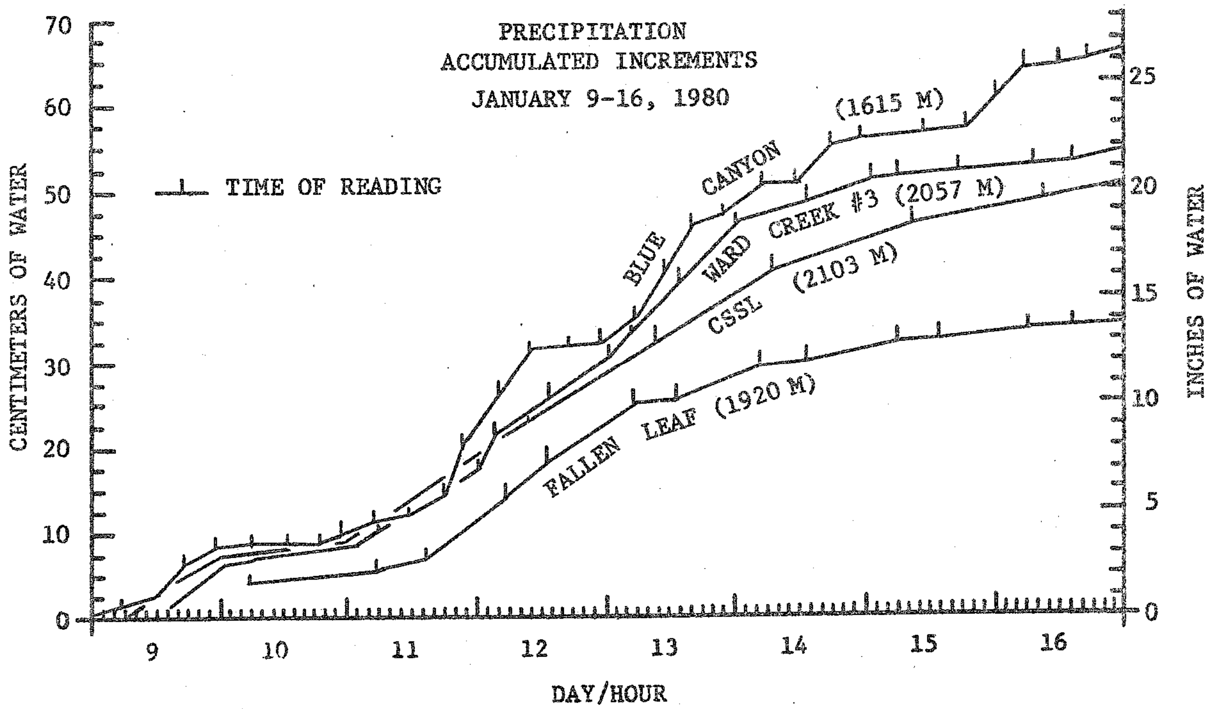

Figure 9

Temperatures at Ward Creek No. 3 are compared to the continuous temperature data at CSSL for January 7-14, 1980, in Figure 10. The instantaneous readings of the Ward Creek No. 3 site are almost identical to those recorded at CSSL. Maximum and minimum temperature readings are very close. Temperatures at Marlette Lake, Fallen Leaf, and Independence Lake are shown in Figure 11. These readings correlate as expected for their respective elevation and location. The temperatures on the 11th are mixed, but this is just prior to the intense rainfall.

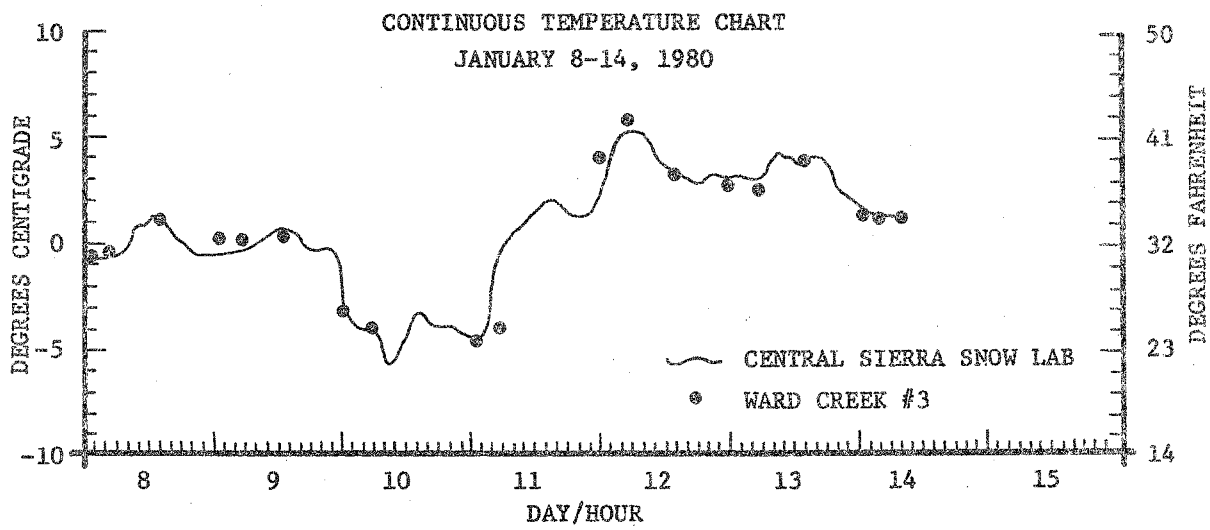

Figure 10

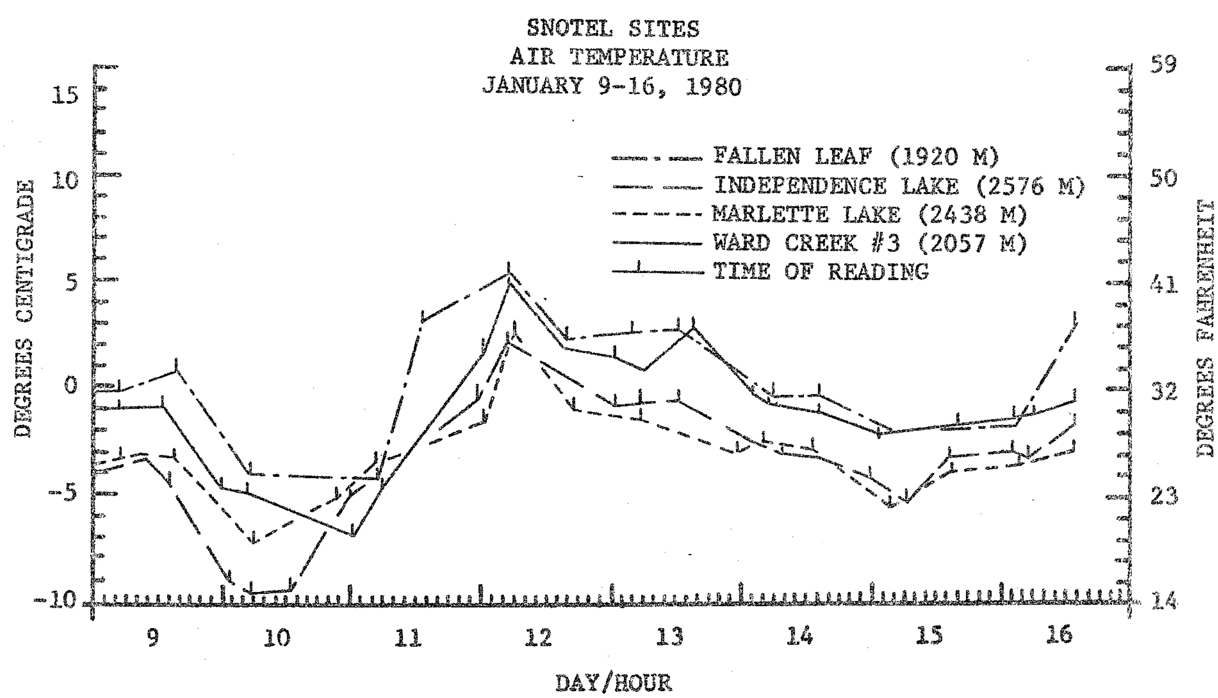

Figure 11

CONCLUSION AND RESULTS

The Federal Watermaster and other concerned officials realized the importance of more frequent accurate data about the storm activity in the watershed--especially rainfall amounts and temperatures--when on January 11 the storm intensity brought the rivers to flood stage. The SNOTEL information gathered was useful to the Watermaster in evaluating the situation. Snow pillows were indicating at what elevations water in the snowpack was being retained and how much rain was falling on the snowpack, and air temperatures helped to determine freezing levels and melt zones.

Data collected at SNOTEL sites during this storm period appears to be quite accurate. Only the Blue Canyon site exceeded SNOTEL sites in frequency of readings. Its data was limited to precipitation amounts on a real time basis. Snow pillow, precipitation gage, and temperature readings during snow periods are comparable. Pillows react during rain-on-snow conditions as anticipated. Precipitation accumulation measured at SNOTEL sites is similar to other gages.

Frequency and timeliness of data can be and should be enhanced during storm events--especially critical events--by implementing additional scheduled polls, adding unscheduled ad hoc polling during SCS off-duty hours, and by providing event-actuated capabilities to certain SNOTEL sites.

SNOTEL's 1981 operation in Nevada and on the east slope of the Sierra has been readied to poll (a minimum of four polls) on weekends and evenings when an intensive storm is predicted. SCS has authorized the polling of nine sites at 2300 hours for additional data for the NWS at Reno to use in weather forecasting until the end of the snowmelt season.

The improved polling process and event-activated capabilities will provide timely information during any precipitation event.

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