MODERNIZATION OF THE HYDROLOGIC DATA TELEMETRY NETWORK IN CALIFORNIA*

661-79

By

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California's Mediterranean-like climate produces a maldistribution of water in both time and location. It has also favored growth of an extensive agricultural development and a large urban population. Each consumes impressive quantities of water. The State has put major effort into controlling its water to meet these uses and to the prevention of flood damage. This management requires good water data.

The California Department of Water Resources over many years and in cooperation with many other agencies has developed an extensive hydrologic data collection system. This discussion is limited to that portion of the system where data collection by telemetry is justified because of frequency of interrogation or requirement for the data to be available on a real-time basis.

Data are routinely telemetered on water stage; precipitation, including snow water content; water quality; and more recently, fire weather data. These data are used for many purposes, including flood forecasting, operation of reservoirs, water quality control, water supply forecasting, water recreation, and fire suppression.

This paper discusses the history of the State's program for hydrologic data telemetry, the improvements presently under way in instrumentation of the system and future expansions of the system, with particular emphasis on the role of satellites in telemetry of the data.

In 1931, Mr. I. Ingerson, an employee of the State of California, installed a radio-reporting water stage gauge, which he had designed and built, on a reservoir to transmit the stage information to an office. The radio signal consisted of a sequence of beeps that indicated the reading at the gauge. The transmission was triggered by a clock. It was an interrupted continuous wave modulated by a rotary commutator. In 1932, stations using Ingerson's equipment were installed on the three largest rivers in the Sacramento Valley to assist in forecasting the time and stage of river peaks at Sacramento and the lower Sacramento Valley.

Similar commercial equipment was soon developed for both radio and telephone transmission of data.

In 1958, the State and National Weather Service (NWS) entered into a formal arrangement for coordination of their flood forecasting efforts, which led to the NWS establishing its River Forecast Center in office facilities provided by the State. This cooperative arrangement is still in effect.

The network of data stations was extended steadily to encompass most of the Sacramento and San Joaquin Valley watersheds and the North Coast basins. Watersheds added later included the Napa and Salinas Rivers and most recently the Big Sur area in Monterey County and Sespe Creek watershed in Ventura County.

Radio and telephone quick-call instruments were used until about 1964. At that time the State, in cooperation with the NWS, began flood forecasting service on the North Coast. The telemetry system installed for that area uses a hard-wired controller driven by a program on paper tape to interrogate the individual stations. This system transmits the data in a high-speed code which is automatically decoded. A hard copy is produced on a teletype printer. The signal originating at the remote data station is transmitted by VHF radio to mountain top stations, then over the State's microwave system to the central station. The operator can manually interrogate a single station or a whole group of stations. Interrogations can also be triggered automatically at various intervals using a system clock.

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* Presented at the Western Snow Conference, April 19, 1979 in Sparks, Nevada.

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For some time, we had a mix of quick-call and automatic equipment. In 1973, we began to replace radio quick calls and telephone callup stations in the Central Valley and to add more stations. The new system differs from the North Coast system by its use of solid state electronics and the use of a mini-computer as a controller. In 1976, we added still more stations to the Central Valley system and reprogrammed the mini-computer so that the data received is directly fed into computer storage on disk files where it can be used in further processing. This gives efficient access to the data for river forecasting and simplifies daily, weekly, and monthly reports for archiving. This equipment also reduces the opportunity for manual error.

The interface of fresh and brackish water in the Sacramento-San Joaquin Delta is monitored for salt content of the water at several stations which report to the same computer.

New equipment will be installed at North Coast Stations this year and a few new stations will be added. These stations will be controlled by micro-processors. The low power requirements of the newer equipment permits use of batteries recharged by solar panels at remote locations. Upon completion of our current plans, the central station in Sacramento will receive data from 180 data stations, many with more than one sensor.

The Department of Water Resources installed its first automatic snow sensor in 1965. It was a 3.7-metre- (12-foot-) diameter rubber pillow placed on top of the ground and filled with about 1 100 litres (300 gallons) of alcohol. Snow loading (weight of water) on the pillow was measured by change in fluid level in a standpipe. There are now about 59 snow sensors in California, 45 of them transmitting data by radio. Rubber pillows are still used at about 1/3 of the sites, but replacements and new sites use a set of four four-by-five-foot steel pressure tanks.

The Department did a substantial amount of development work on snow pillows, much of which led down blind alleys. However, we feel we made a small but significant improvement in the stainless steel tanks, in cooperation with a Sacramento manufacturer, through development of a triangular edge which provides adequate strength with little problem of leakage and minimum difficulty in installation.

We are beginning a cooperative program this year to expand to a network of 120 telemetered snow sensors throughout the snow watersheds of the State. Those stations not in wilderness areas will have precipitation gauges along with the snow sensors.

We also have access to the U. S. Soil Conservation Service Portland Computer to obtain data from 13 of its SNOTEL sites located in eastside Sierra watersheds.

We have experimented over the last two years, in cooperation with NASA, in relaying snow data through geostationary orbiting environmental satellites (GOES).

Satellite telemetry has some very great potential advantages over networks using ground repeaters. We have found the weakest aspect of our line-of-site radio telemetry is the repeaters on mountain tops, because of their exposure to very severe weather conditions. It is both amazing and discouraging to encounter all the problems that severe weather conditions can create with these instruments. It is also discouraging to pay the bills for the time and costs to reach these sites in the winter to restore service.

Snow sensors necessarily are located in areas of severe weather conditions, and attendant mountain top repeaters would be at even higher elevations and subjected to more severe weather conditions. Also it is a lot easier to locate a sensor when terrain obstructions to line of site do not have to be taken into account. Both ground repeater and terrain obstructions are bypassed when the stations transmit the data through a satellite.

We have a site known as Alpha for testing snow equipment at an elevation of 2 300 metres (7,600 feet) west of Lake Tahoe. A snow sensor at this site using a NASA instrument package transmitting through GOES has performed well. We used a buried redwood box for the instrument during the first year's successful test. We had a problem with the instrument this year when we put it in the instrument shelter where it was subjected to the full range of temperature change at the site. We suspect it will be wise to use the buried

redwood box developed by NASA for the instruments to obtain the near 0° celsius (32°F) temperature regime during the winter. Another advantage is to reduce the potential for vandalism.

The State Department of Forestry installed 20 data collection platforms (DCPs) in the North Coast area in California in 1977 and 1978 to transmit fire weather data through the GOES satellite. In 1978, we added tipping bucket rain gages at 10 of these sites. The telemetry worked well, although we had to modify the gage to get a dependable response. The data from the gages reporting through the GOES satellite are stored and reported at three-hour intervals. This time span limits the usefulness of the data for flood forecasting and we regard the 10 rain gages as more of a study device than a real-time aid in forecasting.

There is also an additional time span between reporting by the platforms and receipt of the data at Sacramento. These time spans are acceptable in use of the snow water content data, therefore snow sensors are fully useful when reporting through the satellite.

The Department of Water Resources and the Department of Forestry are cooperating with NASA in expansion of these systems. The Department of Forestry will order 40 additional fire weather platforms in 1979 and the Department of Water Resources will add 6 new sensors with 24 more scheduled through 1983. Forestry plans to continue its program until it has approximately 100 fire weather platforms throughout the State. Water Resources will use satellite telemetry as it expands the snow sensor program in the next few years to the total of 30 telemetered sensors. The other 90 stations will use conventional radio facilities.

A 15-foot disk antenna will soon be installed in Sacramento on the Resources Building to receive data directly from the GOES satellite. It is being funded jointly by the Department of Water Resources and the Department of Forestry. The necessary equipment to store the data in a computer file is included in the program.

Our future "wish list" includes satellite telemetry over which we can have voice communication so that data stations can be debugged and adjusted through conversation between the field and receiving station. This will permit interrogation at will to receive real-time data through the satellite and will enable checking questionable readings. A lingering concern, for those of use who have to attempt to justify budgets, is for the potential day of reckoning when we will have to stand our share of the entire cost of the satellite.

Our experience is that electronic technology moves rapidly and outmoded equipment cannot be maintained because replacement parts are not available. We expect this consideration as well as the advantages of satellite telemetry will result in all stations going through satellites on our next cycle of new instrumentation in 10 or 15 years.