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COMPARISON OF RUNOFF FROM A CATCHMENT SNOW PILLOW AND A SMALL FORESTED WATERSHED

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ABSTRACT

Comparison of runoff from a catchment snow pillow
and a small forested watershed

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A 12-by-12-foot square pressure pillow was modified by the addition of drains to collect the snowmelt from the pillow. This meltwater was collected in tanks and monitored by stage recorders. The daily runoff amounts from the catchment pillow was compared with the mean daily runoff from a 1580-acre watershed and one of approximately 80 acres. The runoff from the pillow provided a good measure of the timing of runoff from the two watersheds. A time lag of one day was found for the small watershed and 2 to 3 days for the latter watershed.

COMPARISON OF RUNOFF FROM A CATCHMENT SNOW PILLOW AND A SMALL FORESTED WATERSHED

INTRODUCTION:

The general history of the snow pressure pillow is too well known to require repeating here. Suffice it to say that it has proven itself to be a very useful tool in water supply forecasting. The purpose of this report is to report on an improvement in this pillow and indicate how this pillow may be used in water supply forecasting.

A continuous reading of the snow water equivalent is a necessity especially as regards the critical spring snowmelt period. The timing of runoff from the snowpack as it appears as runoff is one of the critical factors missing in forecast. If a reliable device is available to monitor the melt at the bottom of the pack, it would be a step forward.

LYSIMETER STUDIES:

The cooperative snow investigations unit made extensive use of lysimeters (Corps of Engineers, 1955) for measuring melt from the bottom of the snowpack. Pysklywec and others (1968) carried out an extensive experiment modeled after these lysimeter studies. They used the data to compare calculations of snowmelt made by three methods: the degree-day method, Corps of Engineers equations, and multiple linear regressions. They concluded the regression technique offered very good possibilities of predicting point snowmelt rates with the possibility of extrapolating this to an entire watershed. Haupt (1969) describes a simple snowmelt lysimeter but cites the disadvantage that weekly maintenance is required.

CATCHMENT PILLOW STUDIES:

The measurement of runoff directly from a weighing device such as a snow pillow has been attempted only recently. Cox and Hamon (1969) describe a precipitation gauge which simultaneously weighs the snow on a platform and collects the melt water from the pack above it. Tollan (1970) describes the use of snow pillows in Norway. He attempted to measure snowmelt runoff water from the pillow. He did not have a great deal of success, but did indicate the method showed great promise.

In 1967, a catchment pressure pillow was installed at the Moscow Mountain snow hydrology site. The full construction details are given by Webb (1969). It is basically a 4 x 8 foot rectangular galvanized pan with a rubber cover and filled with 1:1 water-methanol mixture (Figure 1). A rim height of 1 1/2 inches, and two drains complete the pillow itself. Another 12 x 12 foot pillow was also modified by addition of two drains (Figure 2). This pillow has both a rubber top and bottom. The data reported in this paper are from the 12 x 12 foot pillow. In addition to these two pillows there is another square pillow and a 12-foot diameter round pillow which was installed at this site in 1963. From the catchment pillow the water runs to a tank where the level is monitored by a water stage recorder. A 12 VDC bilge pump empties the tanks when the water level reaches the top of the tank. This water is then pumped into a drain field. A copy of the resulting trace of water level in the sump tanks is shown in Figure 3.

There is in addition to the usual instruments for a snow station meteorological data collection devices such as a hygrothermograph, a shielded rain gauge, and, for portions of the time, a pyranometer and anemometer.

The Felton Creek weir is a simple 90-degree V-notch wier with a water stage recorder and hygrothermograph. The drainage area is approximately 80 acres and is totally forested. It has about 600 feet of relief and is basically at the top of a divide and faces south.

Crumerine Creek basin is a 1580-acre watershed ranging in elevation from 2800 to 4980 feet. This is a south-facing watershed and is all forested. A limited amount of timber harvesting has taken place.

1969-70 SNOW SEASON:

Although there is data available from three past snow seasons (including 1970-71) this presentation will mention only the 1969-70 season. Primary data of runoff from the pillow, snow water equivalent, precipitation, Felton Creek runoff and Crumerine Creek runoff are shown in Figures 4, 5, and 6. Because some periods of record during this time are missing, mathematical correlations of volume runoff are not attempted here. However, past records have shown that good correlations do exist among air temperature, snow water equivalent, basin runoff volume and pillow runoff volume for the Crumerine Creek watershed. An examination of Figures 5 and 6 will show some interesting comparisons. One period to observe is March 26-28 when pillow runoff was 3, 7, and 10 units for 0.04, 0.08, and 0.10 inches of meltwater respectively. The Felton Creek discharge showed a single sharp peak on the 28th following two days of increased pillow runoff (Figure 5). Crumerine Creek (Figure 6) shows a more leisurely response two days later, as would be expected, because it is a larger basin, has more relief and heavy snow only on the upper ridges. Other periods of interest in observing the lag factor for Crumerine Creek are the dates of April 5 to 10, and May 15 through 19. The runoff on these dates also exhibits a lag in mean daily discharge to pillow runoff of three to four days. There appears to be some correlation between pillow runoff, time lag, snow water equivalent, air temperature, and the runoff for the two or three days following the pillow runoff. Once more complete data are available, serial correlations can be obtained, and if they appear to be reasonably good, some type of mathematical runoff model will be attempted for next year's work.

FUTURE WORK:

A catchment pillow will be installed on a larger watershed of 3.15 square miles, gauged drainage which is within a 41.6 square mile gauged drainage, both of which are in the Clearwater River drainage area of North Idaho.

One of the most important characteristics of this device is its ability to show the rate at which water leaves the snow pack. Given enough instrumentation, one should be able to do a complete water balance on the snow above the pillow. In order to check point snowmelt equations an energy balance could be made using measured or computed values of energy input. In addition, changes in snow pillow readings will give the loss of water for the snow pack due to drainage and evaporation. The actual drainage from the snow pack is monitored by the recorder on the catchment drain tank. This gives a total of three different numbers to compare and should enable an engineer to choose correct values of coefficients for point melt equations.

ADVANTAGES AND DISADVANTAGES OF THE CATCHMENT PILLOW:

Several advantages for use of this type of pillow may be cited. First, and most valuable, the forecaster obtains a knowledge of current actual runoff at a point in the watershed. One use of this was demonstrated previously. Another advantage of this pillow is that any presently used pillow could be converted to measure runoff in the same manner. A round pillow would present some problems especially if it is one of the type of pillows kept very full with fluid with a total thickness of the pillow of six or eight inches. Another advantage is that any water stage recorder used on the melt water tank is very easily adapted to telemetering.

Disadvantages include the need for a drain field and meltwater collection device. These must be either well insulated or buried and must be below the level of the pillow. The flush mechanism, be it mechanical or electrical, is one more item available for malfunction. The size of the meltwater tanks is also a factor because if the station is interrogated twice per day, the tank must be large enough so they would not flush more than once between the interrogations or one complete tank of meltwater would be missed.

There is also the problem of estimating the difference that may exist between melt from the pack above the pillow and melt in a pack above soil. It is this factor which would make it very difficult to use the results from this pillow in estimating the amount of soil priming which takes place.

CONCLUSIONS:

The catchment pressure pillow has proven itself to be a useful device to measure the meltwater in the snowpack and the snow water equivalent simultaneously. This has enabled an analysis of runoff timing for two forested watersheds and should also be useful on larger watersheds.

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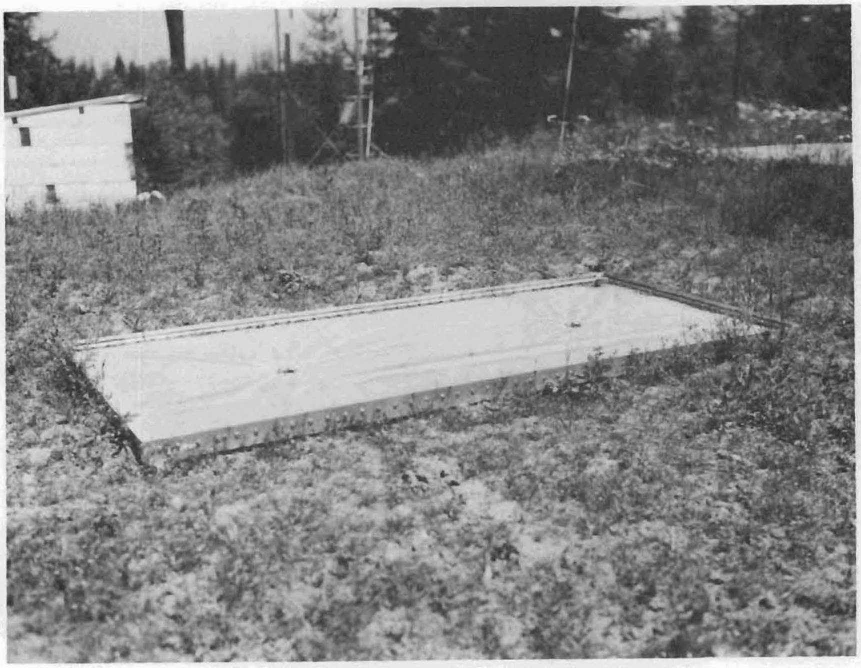

Figure 1. Small rectangular catchment pressure pillow in place, Moscow Mountain, June 1968.

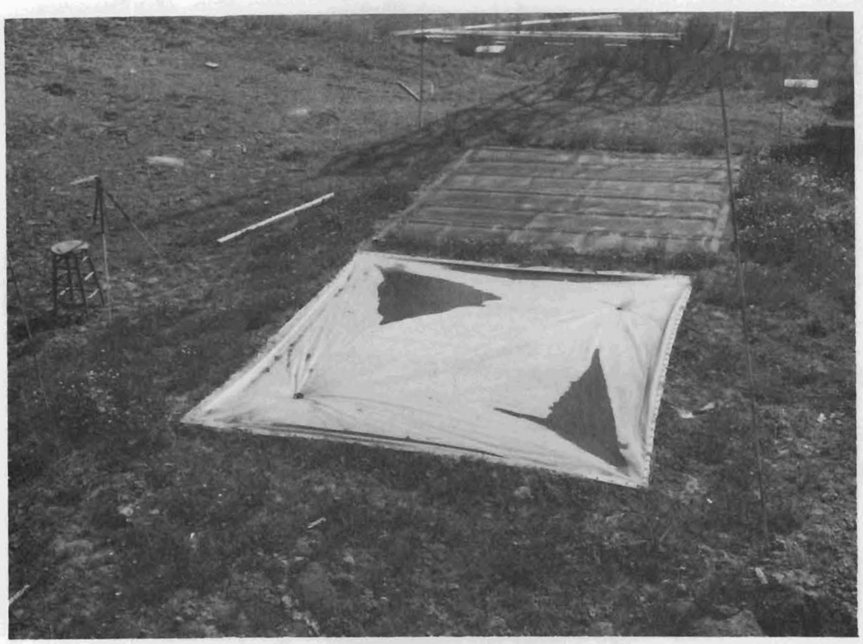

Figure 2. Square catchment pressure pillow in place. Moscow Mountain, June, 1968.

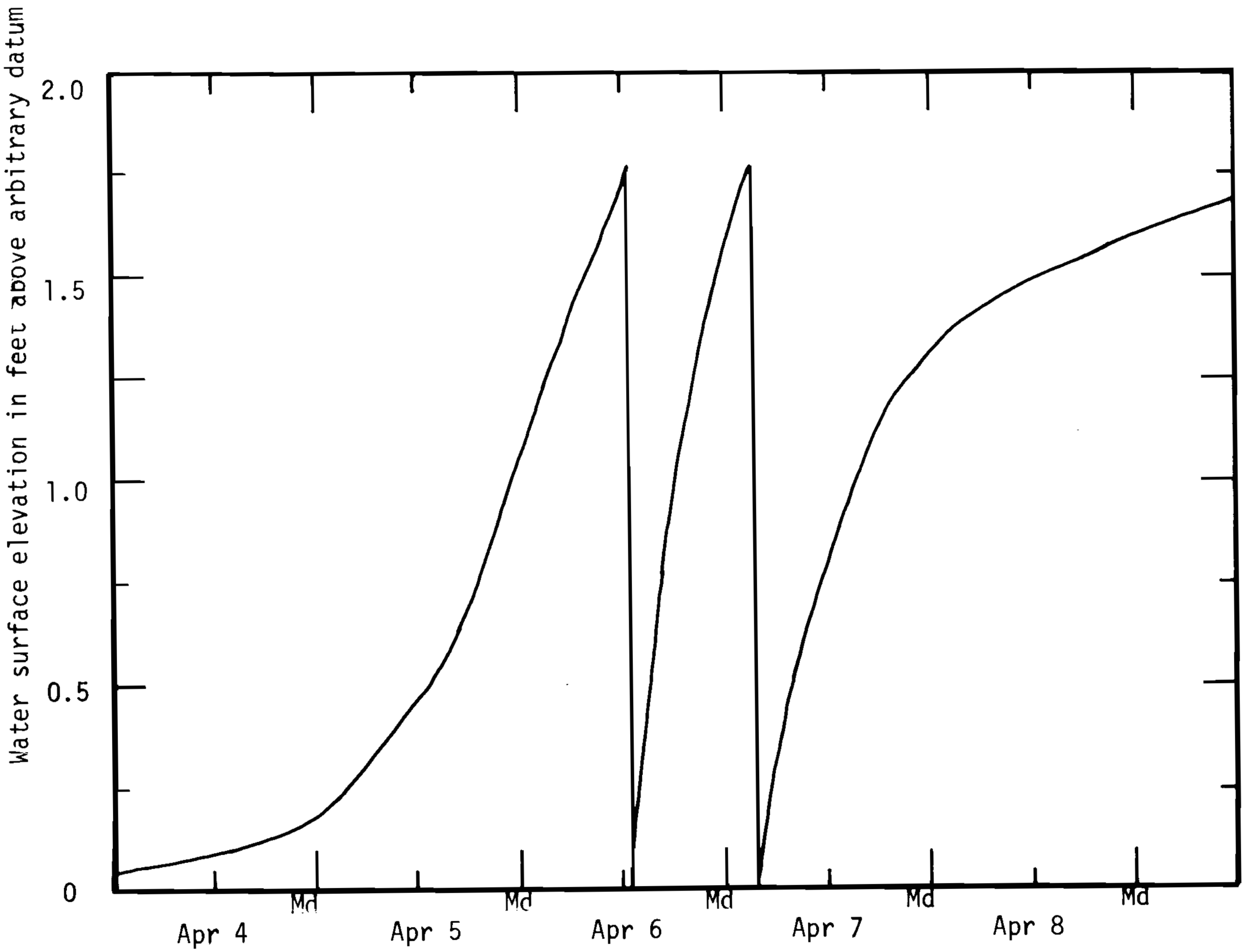

Figure 3. Trace of water surface elevation in the drain tanks for April 4 to 8, 1970.

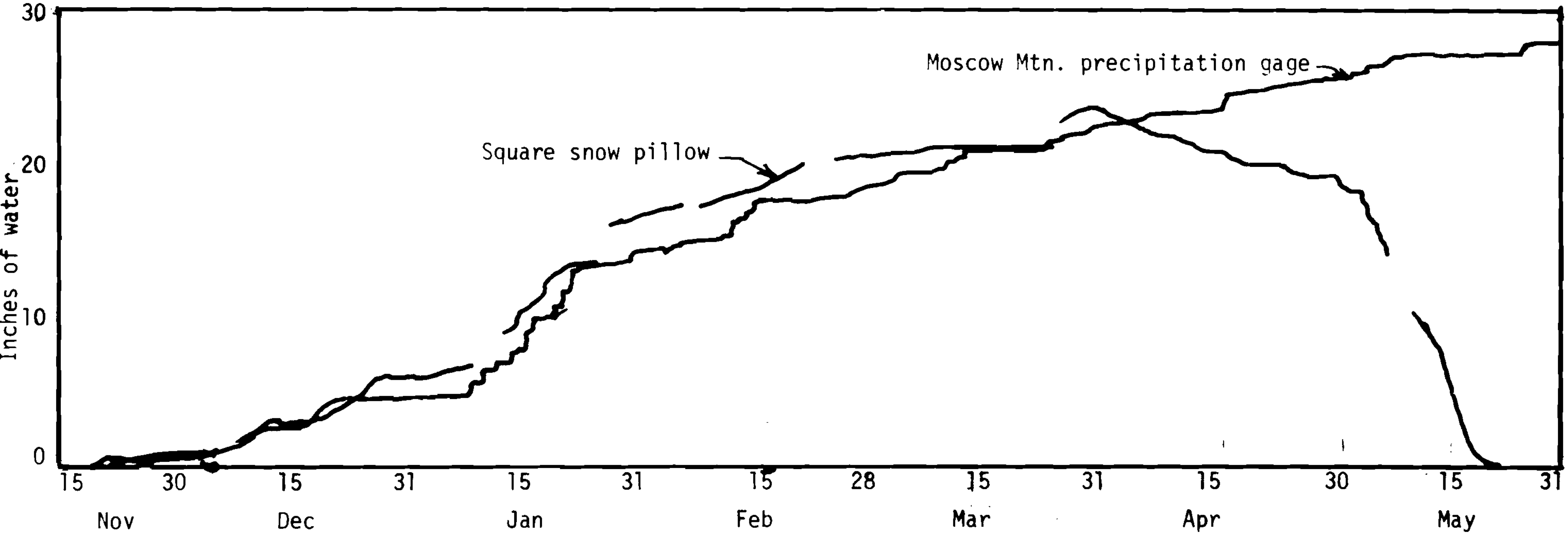

Figure 4. Snow water equivalent and precipitation for the 1969-70 snow season.

NOTE: The precipitation gage was not operated properly during November and December.

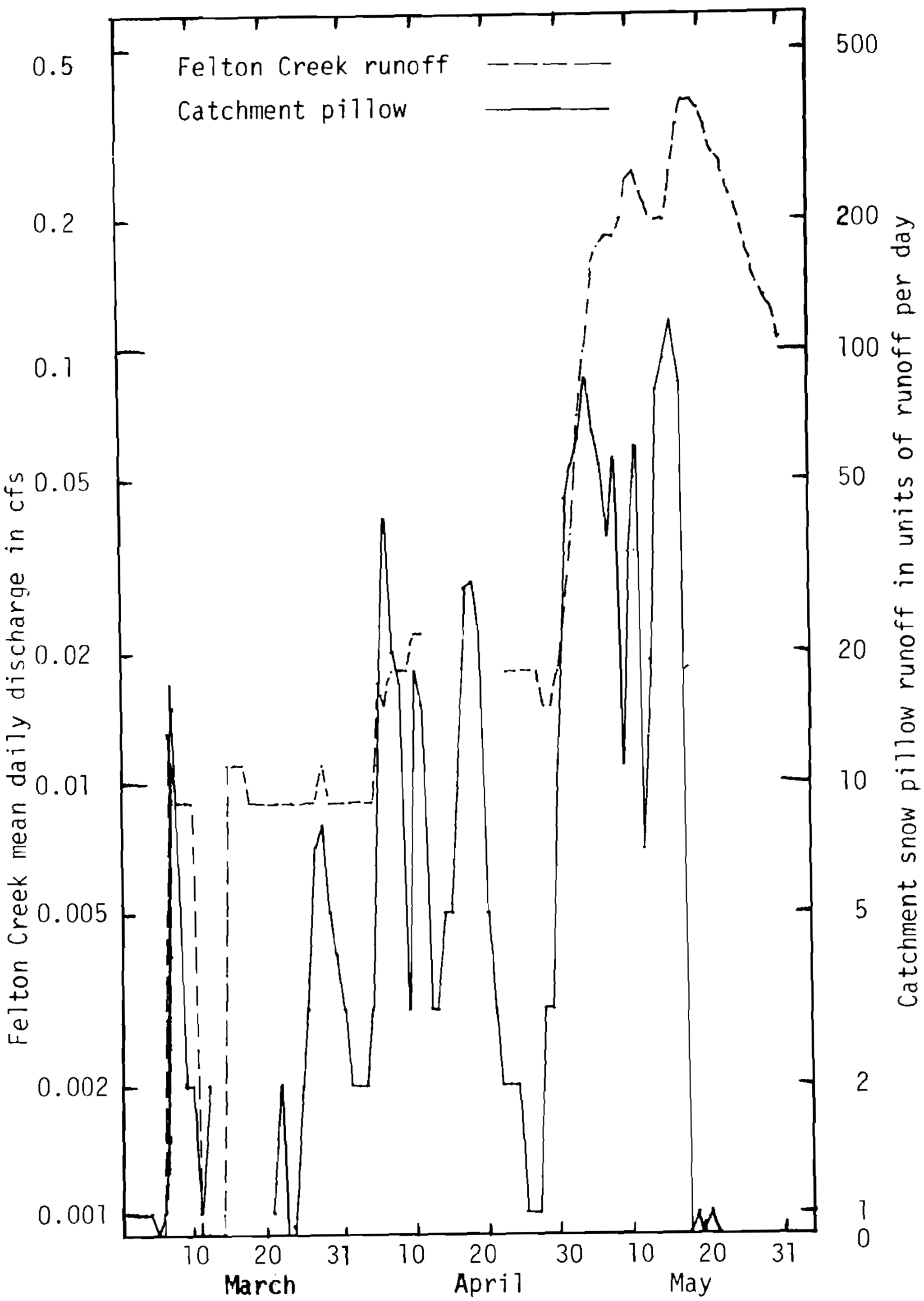

Figure 5. Runoff from the catchment snow pillow and Felton Creek.

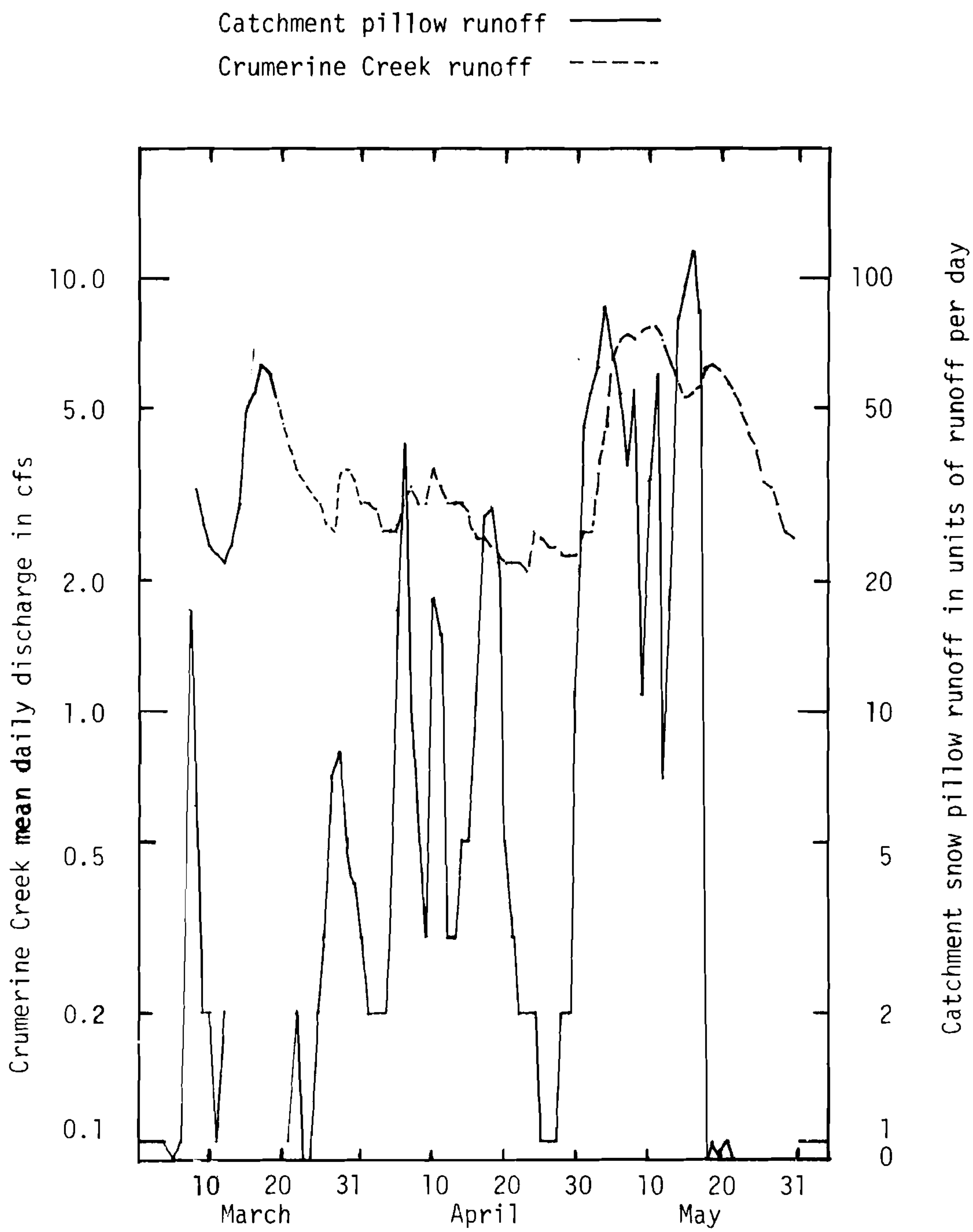

Figure 6. Runoff from the Catchment snow pillow and Crumerine Creek. March-May,1970.