SOIL MOISTURE MEASUREMENT IN

WATER SUPPLY FORECASTING

By

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Introduction

Snow surveyors have long recognized the value of measurements of soil moisture on watersheds. Typical of the papers responsible for this feeling would be Nelson, Wilm and Work (1953). 1/ They cited correlation coefficients for the Columbia River at The Dalles for 1 April as +0.79 without the soil moisture factor and +0.94 with the soil moisture data.

Nelson (1962) 2/ pointed out that soil moisture content of the areas not on the watershed also influenced downstream flow through its influence of this moisture level on upstream diversions for irrigation.

Soil Moisture Determination

Soil moisture for water supply forecasting has been measured by many procedures. Some of the principles of these methods with some of the strong and weak points of each are subsequently enumerated.

1. Neutron Scattering. In this method a thin-walled tube of either aluminum or stainless steel is installed permanently in the soil to the desired depth. When the moisture content measurement is desired, a neutron source is lowered down inside the metal access tube. At predetermined points the concentration of the neutrons, which have been slowed or attenuated by the water in the soil, are measured. The concentration of the slow neutrons may be measured by either a rate meter or counter. The advantage of this method is the ability to sense the moisture content in any concentration. The disadvantages are the necessity for direct access and the difficulty involved in automation. The meters are generally somewhat heavy and fragile so are difficult to use in remote mountain areas. Getting AEC clearance for unattended remote operation of automated equipment is a problem.

2. Resistance Methods. Several resistance methods have been used to measure soil moisture for water supply forecasting. All of the methods utilize the fact that the resistance of a porous medium varies with its moisture content when the resistance is measured with alternating current to prevent polarization interference. Porous media such as nylon, soil, gypsum, and fiberglass have been used, with the use of the latter exceeding the others. The problems with the use of these methods in water supply forecasting are: first, they are point measurements; second, the salt content varies tremendously owing to the decomposition of the organic matter; third, the units do not operate below freezing but do indicate when they are frozen. The use of the units are somewhat limited at the upper end of the moisture range.

Anderson (1955) 3/ developed a "plotting index" to utilize the Colman meter readings directly. He based the index directly on the number of inches of moisture deficiency present in a four foot-soil profile in Arizona. The saturation or zero deficiency point was at a low scale meter reading of 146 or 1100 ohms. Use of this index improved his forecasts measurably.

3. Capacitance Methods. These methods have not been widely used for water supply forecasting but should prove superior to the resistance methods. The principle of operation is based on the fact that the capacitance of a porous medium dielectric is strongly increased by the presence of water. The determination is simple and rapid but is somewhat temperature sensitive. The greatest weakness is that, in common with neutron and resistance method, it is a point sample.

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4. Other Methods. No other methods for measuring soil moisture have been widely used for water supply forecasting, but some other methods may be used. A few of the methods for measuring soil moisture, which at some time may be used, follow:

a. Thermal Radiation Units. The response of these units depends on the resistance of a fine copper wire being sensitive to temperature. A heat pulse is applied to a soil. Wet soil conducts heat away from the heat source better than dry soil. The resistance readings of the fine copper wire at the end of one minute following the heat pulse is an index of the soil moisture content. D. C. Ohmmeters are now available in a quality which would make it possible to automate the method. This is again a point measurement.

b. Gravemetric Sample. This is the old strong arm method. Unless multiple samples are taken the errors are greater on this than any of the other methods.

c. Air Humidity. This method depends on the humidity of the soil air being proportional to the moisture content of the soil. It loses sensitivity in the higher moisture ranges and is sensitive to temperature changes. Some of the newer humidity sensing equipment should make this method effective for point samples.

d. Heat Conductivity. This method depends on the property of the soil water system which makes the time rate of travel of a temperature wave directly proportional to the moisture content. The chief limitation is the depth to which a thermal wave from the sun can reach. This is again a point sample method.

e. Tensiometers. These instruments measure the direct tension on the soil water. The bit limitation is that freezing destroys the instrument. It is also a point sample.

Discussion and Conclusions

The soil profile on a watershed is analogous to a reservoir from a water supply forecasting standpoint. Water can go into it and remain in storage, it can go into the reservoir and out the spillway, or it can go into storage temporarily to be drained after a delay time.

In order to make a streamflow forecast, it is necessary to know the inflow and the changes in storage. One of the large components of this storage is the change in the soil moisture status. The moisture status is a volume concept and yet all of the soil moisture methods merely give the moisture content at a point. It is necessary to assume a constant relationship between the actual moisture volume and the moisture at a point or points.

The need for soil moisture measurements in water supply forecasting is well established. It remains for the people in research to develop an instrument that can measure the integrated moisture in the soil reservoir.

REFERENCES

1/ Nelson, M. W., H. G. Wilm, and R. A. Work. 1953. Soil Priming in Relation to Snow Surveys and Flood Regulation. Trans. AGU 34:240-248.

2/ Nelson, M. W. 1962. Personal communication.

3/ Anderson, W. E. 1955 Personal communication.