THE WATER CYCLE ON A WATERSHED IN THE PALOUSE REGION OF IDAHO

By

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and

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Abstract

The distribution of water in the hydrologic cycle within the Palouse region of Idaho is becoming a concern of the people in the region. A few investigations have been made to determine the distribution of water, but most of these have come up with only very rough estimates.

During the 1969-70 water-year a rough water balance was made. It was determined that 25 inches of total precipitation was distributed 20% to runoff, 64% to evapotranspiration, and 16% to deep percolation. Some of the data used in this water balance were estimated or transposed rather than directly measured at the watershed. For this reason, the results obtained are considered an approximation of the distribution of water.

During the 1970-71 water-year a better water balance was made. It was found that 27.5 inches of total precipitation was distributed 23% to surface runoff, 56% to evapotranspiration, 18 1/2% to deep percolation,

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and 2 1/2% to an increase in soil moisture. All of these values are based on data collected at the watershed and are, therefore, considered a good representation of the distribution of water at the watershed.

Introduction

The Palouse region of Idaho-Washington is one of the largest producers of wheat, dried peas, and lentils in the world. In this dryland farming area, the moisture supply consists principally of winter precipitation in the form of snow and gentle rains. During the growing season, the crops draw upon the moisture stored in the soil. The area is also one of falling groundwater levels. A knowledge of the movement and distribution of water, particularly soil moisture depletion and deep percolation, is essential to proper management of the water resource in the Palouse region.

The Palouse region and the adjacent mountains supply a part of the water resources of the Columbia Basin. Demand for this water is increasing both within the region and from outside the region. To supply the increasing demand it will be necessary to improve the efficiency of utilization of the available water resources. Before effective utilization can be achieved, however, it will be necessary to determine the exact distribution of water in the hydrologic cycle within the Palouse country. Determination must be made of how much of the precipitation falling in the region will be used by crops and natural vegetation (evapotranspiration), how much will percolate to recharge the groundwater supply (deep percolation) and how much will run off in the streams (surface runoff).

During the last 15 years several water balance studies have been made in the Moscow basin of the Palouse region (Bloomsburg, 1959; Liu, 1967). Most of these studies were little more than an attempt to get a rough estimate of the amount of recharge into the groundwater supply.

Bloomsburg (1959) conducted a detailed water balance in 1958 for a forested area on the north side of the South Fork Palouse River basin. The study showed that for this watershed the precipitation is distributed approximately 25% to surface runoff in streams, 58% to evapotranspiration by the forest cover, and 17% to deep percolation for recharge of the groundwater supply. It was also shown that considerable variability existed in these percentages. As precipitation increased the percentages for deep percolation and surface runoff increased while that for evapotranspiration decreased.

The purpose of the present study is to present the results of a water balance study on a small agricultural watershed in the Palouse region of Idaho. The data presented are from the years 1970 and 1971.

Instrumentation and Procedure

The water balance equation used at the watershed can be written:

$$P = RO + ET + DP + SS + SM + ERR$$

Precipitation (P) is the only inflow term. Runoff (RO), evapotranspiration (ET) and deep percolation (DP) are the outflow terms. Storage can occur either above the surface as snow storage (SS) or below the surface as soil moisture (SM). The final term (ERR) is used to collect the residual of the combined errors for all the components so that the equation will balance. By including this term it is possible to use the measured or calculated values for each of the water balance components. Therefore, it is easier to analyze each component for probable error and accuracy. The final objective of a water balance study is to reduce ERR to the smallest value possible and to achieve maximum confidence in the other components of the equation.

Precipitation was measured using a standard 8-inch precipitation gauge. Since the area of the watershed is only 8 acres it was felt that a single gauge would provide reasonable accuracy.

Surface runoff was measured by a drop-box weir mounted on a cutoff wall at the outlet of the watershed (Johnson and others, 1966). The design of the weir allows sediment to pass through thus maintaining a constant relationship between stage and discharge. A Stevens water level recorder was used to provide a continuous record of water level. The cutoff wall is used to block the lateral movement of subsurface flow so that it will come to the surface for measurement.

Evapotranspiration was calculated for the growing season using a version of the Penman equation developed in southern Idaho by Jensen and others (1970). For the period following the growing season, when this method of determining evapotranspiration was not expected to give good results, a simplified water balance involving the upper two feet of soil was used. It was assumed that evapotranspiration would be zero during the remainder of the year because of low temperature and high humidity. Any error arising from this assumption should be smaller than errors of measurement for the other factors in the water balance.

Deep percolation could not be measured directly but was estimated from limited data. The moisture content remained nearly constant during most of the year in the lower soil mantle, between the depths of 4 and 7 feet (Figures 1 and 2). This would indicate a fairly constant flow out of the bottom of the soil mantle except during October through January. Unsaturated permeability tests were made on a single soil sample obtained from the upper soil mantle on the watershed. These tests indicated that a flow of 0.010 to 0.015 inches per day would result with the soil moisture content existing during most of the year in the lower soil mantle. From this it was assumed that a value of 0.02 inches per day (a probable peak value for deep percolation) would be reasonable for use in the water balance equation. During the period between October 3 and January 28, the soil moisture content in the lower soil mantle was significantly less than during the remainder of the year. Therefore, it was assumed that deep percolation would be very close to zero during this time.

Snow storage was determined by measuring the depth of snow at several points on the watershed and the density at one location. Some error resulted from extrapolation of a single density measurement over the entire watershed. However, such an error would not result in values greatly different than those shown in the water balance.

Soil moisture storage was measured using a neutron probe and scaler once each month during the winter and once each week during the summer. Measurements were made at 6-inch intervals in the upper 3 1/2 feet and at 12-inch intervals for an additional 3 feet of depth. Six locations on the watershed were used for these measurements and their average was used in the water balance (Figures 1 and 2).

Water balance results

A rough water balance was made for the 1969-70 water year and the results are shown in Table 1. Surface runoff was the only parameter for which complete data was available at the watershed. The value of evapotranspiration is the average for barley in this region, as estimated by Sutter and Corey (1970). Little reliable precipitation data was available for the watershed during this water year. Therefore, it was decided to interpolate data from another location. Originally it was assumed that the precipitation would be about 10% greater than that measured at the USWB gauge 3 miles south of the watershed (Bloomsburg, 1959) due to the watershed being at a higher elevation. However, regression analysis of data collected during the 1970-71 water year indicates that precipitation at the watershed is about 10% lower than that at the USWB guage. This corrected value is used in Table 1. The equation was then balanced to obtain the value shown for deep percolation. The deep percolation term, therefore, includes the cumulative error from the other terms as well as the actual deep percolation.

Table 1
Water Balance at the Thompson Watershed
near Moscow, Idaho during 1969-70

Parameter	Inches
Surface runoff	5
Evapotranspiration	16
Deep percolation	4
Precipitation	25

During the 1970-71 water year most of the components of the water balance could either be measured directly or calculated using data obtained at the watershed. Precipitation, surface runoff, snow storage and soil moisture storage were all measured. Evapotranspiration was calculated using the Penman equation and a simplified water balance. Deep percolation was estimated and is, therefore, the term that offers the least confidence.

Table 2 lists the water balances for the 1970-71 water year. Of the 19 water balances there are 14 with residual errors (ERR) of less than 0.3 inches. This indicates that the assumptions made for the assignment of values to each component of the water balance equation were reasonable. The residual errors for the other 5 water balances are all greater than 0.5 inches. The much greater error for these indicates significant, though not consistent, errors in one or more of the components of the corresponding water balance.

Precipitation occurs during the fall, winter and spring when moist air masses move in from the Pacific Ocean. Runoff occurs primarily during the winter when rain is falling on snow or nearly saturated bare soil. Evapotranspiration is greatest during the warm, dry summers and continues into the fall as evaporation from the rain moistened soil surface. Deep percolation occurs during most of the year at a relatively steady rate. Snow storage occurs during the late fall and winter when mean daily temperatures remain below freezing. Soil moisture storage is continually fluctuating due to the constantly varying inflow and outflow components acting on the soil mantle.

The totals at the bottom of Table 2 list the components of the annual water balance for 1970-71. Table 3 lists the distribution of water as a percentage of precipitation for the 1970-71 and 1969-70 water years at the Thompson agricultural watershed, and the averages for the three years of 1955-58 at the forested watershed about 2 miles

Table 2

Water balance at Thompson Watershed near Moscow, Idaho during 1970-71

Date	P	RO	+ET	+DP	+SS	+SM	+ERR
10-3							
	7.76	0	+ .90	+ 0	+ .69	+6.03	+ .14
12-31							
	3.54	3.04	+ 0	+ 0	- .69	+1.99	- .80
1-28							
	1.83	.82	+ 0	+ .70	+ .42	- .21	+ .10
3-4							
	2.31	2.05	+ 0	+ .58	- .42	+ .18	- .08
4-2							
	1.43	0	+ 0	+ .62	0	+ .28	+ .53
5-3							
	.53	0	+ .47	+ .22	0	-1.48	+1.32
5-14							
	.91	0	+ .88	+ .28	0	+ .85	-1.10
5-28							
	3.31	.38	+1.51	+ .28	0	+1.18	- .04
6-11							
	1.67	0	+3.82	+ .42	0	-2.38	- .19
7-2							
	.08	0	+1.36	+ .14	0	-1.17	- .25
7-9							
	.65	0	+1.43	+ .14	0	- .26	- .66
7-16							
	0	0	+1.39	+ .14	0	-1.61	+ .08
7-23							
	0	0	+1.08	+ .14	0	-1.43	+ .21
7-30							
	.53	0	+ .97	+ .14	0	- .87	+ .29
8-6							
	0	0	+ .50	+ .14	0	- .72	+ .08
8-13							
	0	0	+ .14	+ .14	0	- .58	+ .28
8-20							
	.76	0	+ .31	+ .14	0	+ .38	- .07
8-27							
	1.15	0	+ .45	+ .28	0	+ .29	+ .13
9-10							
	1.00	0	+ .20	+ .56	0	+ .20	+ .04
10-6							
Totals	27.46	6.29	+15.43	+5.06	+ 0	+0.67	+ .01
Percent	100	23	56	18.5		2.5	

north of the Thompson watershed.

Table 3

Annual water balances as a percentage of precipitation for watersheds near Moscow, Idaho.

Parameter	Agricultural 1970-71	Agricultural 1969-70	Forested 1955-58
Surface runoff	23	20	25
Evapotranspiration	56	64	58
Deep percolation	18 1/2	16	17
Soil moisture added	2 1/2	--	--
Precipitation	100	100	100

Table 3 indicates good agreement among all three water balances. The difference between values shown for the two years at the agricultural watershed reflect the lack of certainty in data used for the 1969-70 water year.

Close agreement is indicated in Table 3 between the water balances for the agricultural watershed during 1970-71 and the forested watershed during 1955-58. It must not be concluded from this that agricultural and forested watersheds will always have similar distributions of water. These particular water balances happen to be similar partly due to their common zonal climate and partly due to coincidence. The percentages of percipitation going to surface runoff and deep percolation will increase as the amount of precipitation increases. At the same time the percentage of precipitation going to evapotranspiration will decrease. If the Thompson agricultural watershed received 40 inches of precipitation, as did the forested watersheds during the period of 1955-58, the result would be a much greater surface runoff and slightly higher deep percolation than occurred for 1970-71 with less than 30 inches of precipitation.

Summary

Instrumentation was set up to collect data for a water balance study at the Thompson watershed near Moscow, Idaho. Water balances were made for the water years of 1969-70 and 1970-71. The results of this study indicate that 20% to 25% of the precipitation of the water year will go to surface runoff, 55% to 60% will go to evapotranspiration, and a maximum of 20% to deep percolation. If the amount of precipitation increases, the percentage going to surface runoff will increase, that for evapotranspiration will increase and that for deep percolation will remain nearly constant.

Acknowledgment

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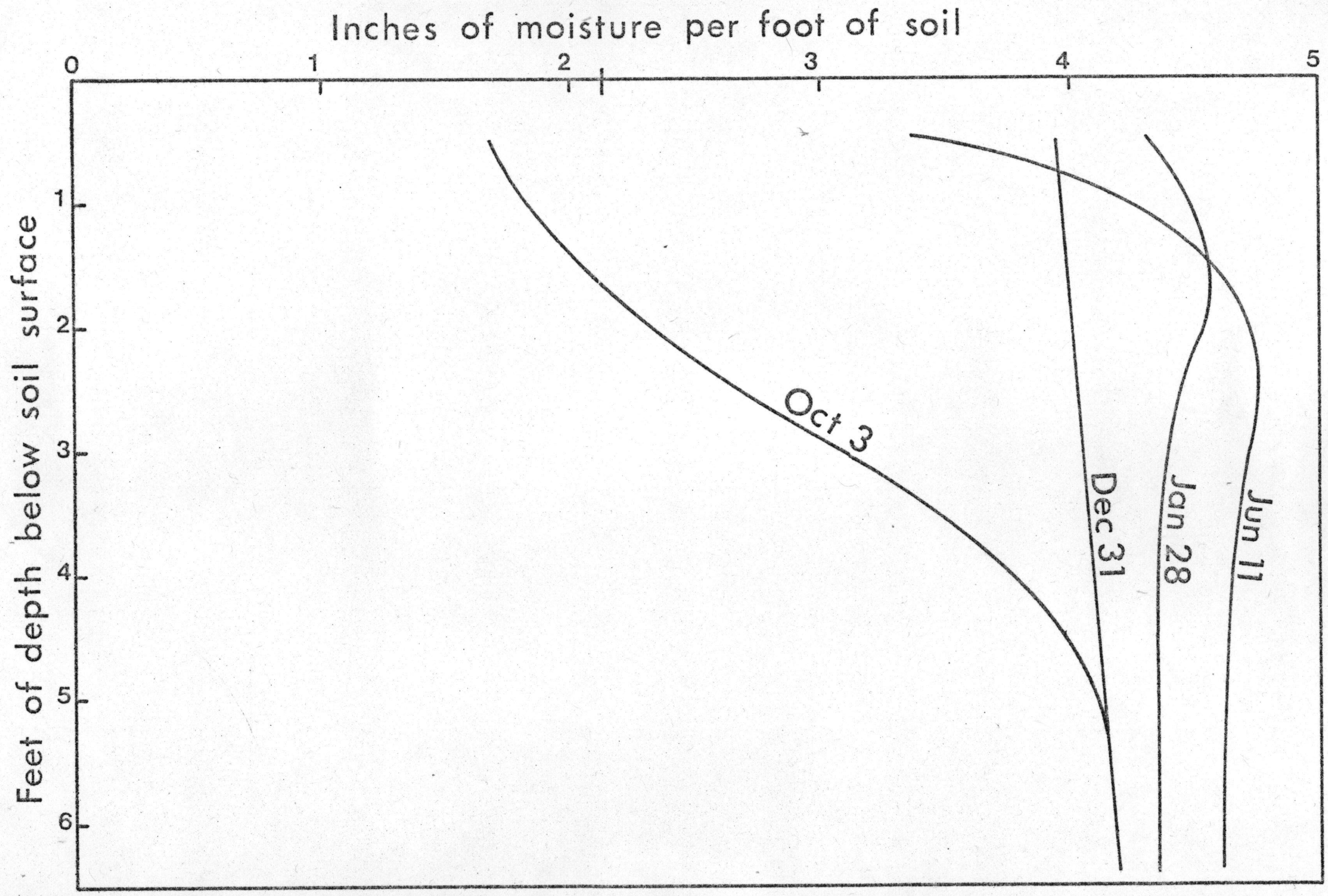

FIGURE 1: Soil moisture profiles during recharge.
Thompson watershed, 1970-1971 wateryear.

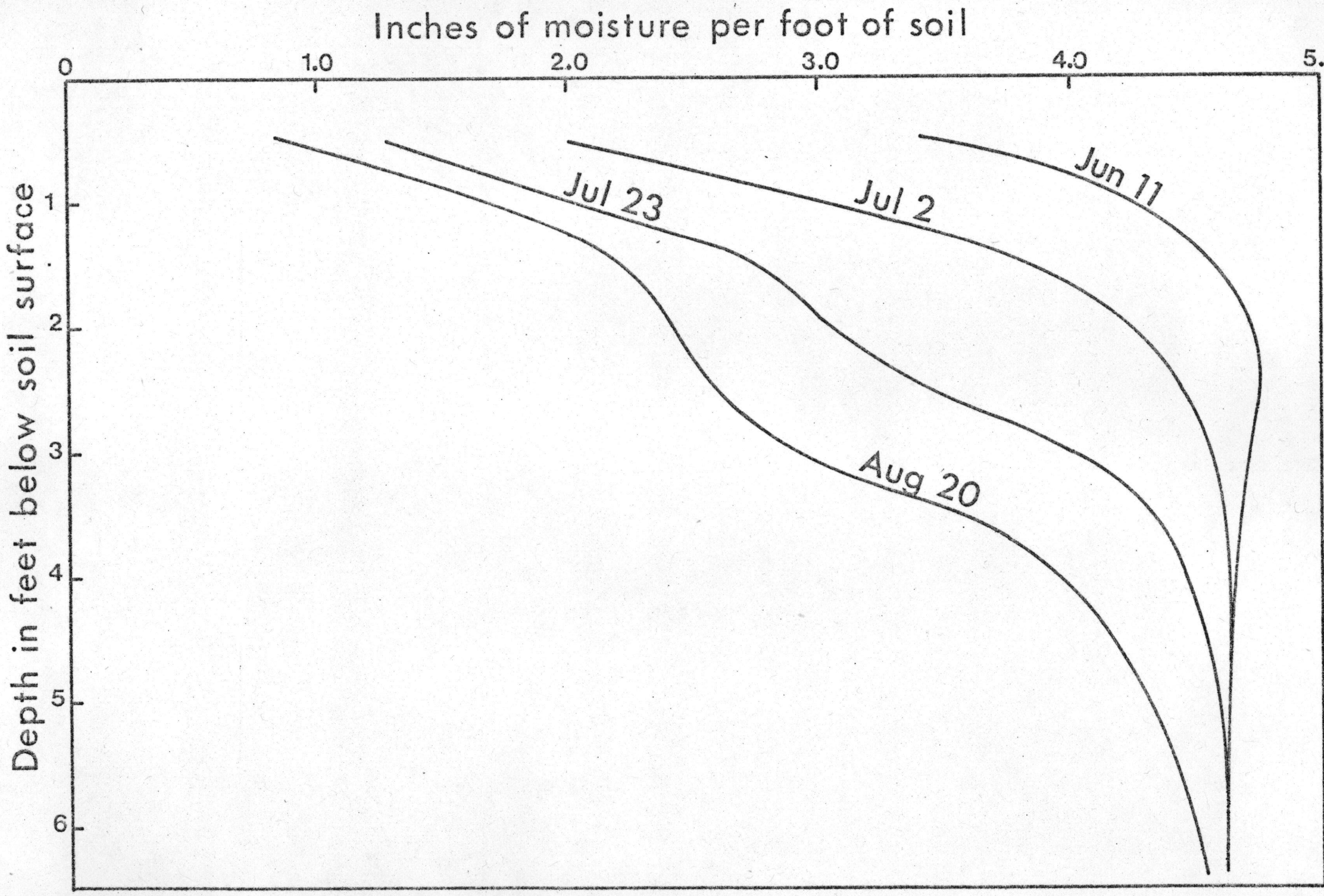

FIGURE 2 :Soil moisture profiles during consumptive use.
Thompson watershed, 1970-1971 wateryear.