NATURAL WATER LOSS
IN SELECTED DRAINAGE BASINS

BY
G. R. WILLIAMS AND OTHERS

Prepared in cooperation with the
RESEARCH AND STATISTICAL DIVISION OF THE
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NATURAL WATER LOSS IN SELECTED DRAINAGE BASINS

By G. R. WILLIAMS and others

ABSTRACT

Determinations of areal rainfall, run-off, and water loss, comprising largely evaporation from land surfaces and transpiration by vegetation, are essential in indicating the hydrologic characteristics of river basins.

This report is primarily a statistical study that presents the results of computations of annual water loss, or annual rainfall minus annual run-off, for river basins in the humid or semiarid regions east of the Rocky Mountains. The basic period for which the computations are made is the water year, or year ending September 30.

As it is impractical to present all the basic data used in arriving at the results, only sample computations are given. The various steps in the computations and the probable accuracy of the results are discussed.

The drainage areas for which data are presented are those above river-measuring stations that have records for 3 years or more. For each area there are determinations of annual rainfall, annual run-off, and annual water loss for each year of record as well as the means for the period of record. Results are given for about 200 drainage areas with an aggregate period of record of more than 2,000 years. As an illustration of the magnitude involved, the annual water loss from the eastern streams draining directly into the Atlantic Ocean varies more or less closely with latitude from about 20 inches as an average in northern New England to about 30 inches in Georgia.

As the annual water loss from a basin is affected by the temperature, a supplemental study was made of the relation between water loss and temperature. For 28 drainage areas selected in various parts of eastern and central United States, average temperatures were computed for each year of the period shown in table 1. The results indicate a relation between average annual water loss and average annual temperature.

INTRODUCTION

ADMINISTRATION AND SUPERVISION

A project for studies of floods and other hydrologic phenomena was undertaken in November 1935 by the Research and Statistical Division of the Works Progress Administration for New York City. The project was sponsored by the College of Engineering, New York University. Technical direction and guidance were furnished by the Geological Survey, United States Department of the Interior, and the Soil Conservation Service, United States Department of Agriculture, the Survey furnishing supervisory personnel. The project was terminated June 30, 1936.
The Works Progress Administration for New York City operated during this project under the general direction of V. F. Ridder, administrator. Thorndike Saville, Dean of the College of Engineering, New York University, director, and G. R. Williams, of the Geological Survey, vice director of the project, supervised the research and investigation. Mr. Williams maintained close and continuous contact with the project under the general direction of N. C. Grover, chief hydraulic engineer, and R. W. Davenport, chief of the division of water utilization, Geological Survey.

The material presented in this report constitutes the results of one of the items of this project, which included a study of natural water loss for drainage basins selected with a view to the sufficiency of rainfall and run-off records to produce reasonably reliable results. The word "basin" is used at many places in this report to refer to the area upstream from the gaging station at which the run-off is measured. Therefore, under this usage the reference is to the entire basin of any given stream only when the gaging station is located near the mouth.

The results of the original computations were later summarized and arranged for publication together with explanatory text. The study of the relation between water loss and temperature was not part of the original project but was made in the Washington office by the division of water utilization in 1937.

It should be emphasized that this report is primarily a statistical study and that no attempt has been made to include a comprehensive discussion or analysis of the results.

ACKNOWLEDGMENTS

Members of the staff of the Water Resources Committee of the National Resources Committee arranged for the participation in the project by the Geological Survey and the Soil Conservation Service. Thorndike Saville, dean of the College of Engineering, New York University, maintained a stimulating and sympathetic relationship in the supervision of the project. C. S. Jarvis, hydraulic engineer, Soil Conservation Service, served as a consultant and from the background of his extensive knowledge of hydrology rendered valuable assistance.

The success of the project was due in large part to the cooperative attitude of the administrative officials of the Works Progress Administration, and especially of R. C. Urban, the administrative project supervisor.

Acknowledgment is due the technical and clerical personnel for its help and cooperation.

Some results of the work of other investigators have been included in this report, and appropriate footnotes have been added to the tables to indicate the sources of the data. H. B. Kinnison, district engineer, Geological Survey, Boston, Mass., furnished results of studies made in
SIGNIFICANCE OF WATER LOSS

his office for drainage areas on the Swift and Westfield Rivers in Massachusetts. The records of rainfall and run-off for river basins in Pennsylvania were taken from the publications of the Pennsylvania Department of Forests and Waters, which since 1921 have presented the mean annual rainfall as well as the mean annual run-off for the tributary basins above all river-measurement stations in the State. The data for river basins in Ohio were obtained from a study of the Miami, Scioto, and Raccoon River Basins by J. C. Prior.\footnote{Prior, J. C., Run-off formulae and methods applied to selected Ohio streams: Ohio State Univ., Eng. Exper. Sta., Bull. 49, 1929.}

The detailed study of the area on West River in Vermont incorporated the results of a study by Barrows.\footnote{Barrows, H. K., Precipitation and run-off and altitude relations for Connecticut River: Am. Geophys. Union, Sec. Hydrology, Trans., pp. 396-406, 1933.} Figures taken from the above reports have been presented to the nearest tenth of an inch in accordance with the degree of refinement used in this study.

SIGNIFICANCE OF WATER LOSS

As used in this study, the water loss of a drainage basin is the difference between the average rainfall over the basin and the run-off from the basin for a given period. The basic period used is in general the water or hydrologic year, which ends September 30. At that time there is over most of the country a smaller quantity of water held in surface-water channels, in ground water, in soil moisture, in lakes, and in the form of ice or snow than at any other time of the year. Obviously, the water loss for a given year determined as indicated above may be affected by the differences in the quantities of water held in the basin in the above-mentioned ways at the beginning and end of the year. By the selection of the general reference date of September 30, these discrepancies are reduced to a minimum, and the water loss is essentially the precipitation that passes into the air through evaporation and transpiration. In this study, the effect of differences in inventories of water held in a drainage basin at the beginning and end of a year is further reduced by using the mean annual water loss of several years.

An additional factor affecting the validity of the calculation of the water loss in the way described relates to the adjustments for the deep movement of water in the ground into and out of drainage basins, without regard to watershed lines. There is little, if any, information on which to base a definite estimate of the magnitude of this factor, other than the certainty that apparently it cannot be generally large in the basins presented in this report. The latter decision is reached because of the widely varying ground formations underlying the basins studied herein. Opportunity is thus afforded for display of the influence of deep ground-water movement in accordance with the magnitudes associated with such varying conditions. The general
uniformity and systematic relations shown by the data, irrespective of such conditions, seem to preclude the effect of deep ground-water movement as a factor of substantial magnitude.

Run-off or stream flow represents the part of the precipitation that remains after the demands of evaporation, transpiration, and deep ground-water flow have been satisfied. Therefore run-off is appropriately considered in the hydrologic cycle a residual component of precipitation rather than a percentage assessment on precipitation.

In this report the term "rainfall" is used to include all forms of precipitation and is interchangeable with the term "precipitation."

The relation between rainfall and water loss and between rainfall and run-off varies from season to season and even from day to day within the same season and is dependent upon rainfall intensity, the condition of the vegetation, soil moisture, temperature, snow cover, relative humidity, and wind velocity. The conception of water loss and stream flow as certain percentages of the rainfall may be seriously misleading.

In hydrologic studies where drainage-basin characteristics are to be examined and compared, water loss and run-off may conveniently be expressed as depth in inches on the basin area. When considering individual storms it is a common practice to compute in percentage the rainfall that appears as run-off, but for monthly, seasonal, or yearly comparisons the run-off and water-loss components of rainfall are preferably expressed in inches.

On the basis of the treatment herein run-off and water loss must together equal the rainfall. In humid or subhumid regions a knowledge of any two of the three elements involved in the relation makes it possible to determine the third. For example, if the run-off from a basin has been measured and the water loss in a region of similar characteristics respecting the occurrence of evaporation and transpiration has been determined the two may be combined to give an indication of the rainfall on the basin.

PREVIOUS STUDIES

Several investigators in the field of hydrology during the past four decades have considered determinations of water loss of major importance and have made studies relating thereto. One of the pioneers in this work was Henry Gannett, of the Geological Survey. Gannett was one of the first to get away from the method of using percentages to express the relative magnitude of rainfall and run-off and to adopt instead the actual magnitudes expressed as depth in inches over an area. He was also one of the first to consider run-off as a residual of rainfall after losses. He prepared maps showing mean annual rain-

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fall and mean annual run-off in the United States and in doing so made use of water-loss and run-off information to determine precipitation in areas where there were few if any rainfall stations. In an unpublished manuscript Gannett wrote that he considered the term "water loss" a misnomer, as the so-called loss really supports vegetation.

Another early study of interest was made by J. C. Hoyt, of the Geological Survey. It contained information on monthly and yearly rainfall, run-off, and water loss for 15 river basins in the northeastern United States. In this study water loss was given in inches as well as in percentages of rainfall.

Other more recent studies containing water-loss computations are available. One of these is a report by W. G. Hoyt and others which contains annual water-loss computations for seven of the longest run-off records in the humid regions of central and eastern United States. Some of the results of that study are presented in this report.

METHOD OF DETERMINATION

The fundamental procedure in making water-loss computations is merely to subtract the known values of run-off from a drainage basin from the known volume of rainfall which fell on the same drainage basin in a corresponding period of time. However, numerous considerations enter into the application of the procedure, and many complications arise. The number of drainage basins which through sufficient basic information and otherwise are suited to water-loss studies is comparatively small. The considerations and processes of treatment that have been applied are described in the following sections.

SELECTION OF SUITABLE DRAINAGE BASIN

An important requisite is to select a river basin for which there are sufficient reliable data to insure the determination of dependable results. If the investigator has the choice of several basins in a given region, as in this study, the problem of satisfying this requisite is simplified.

There must be at least 3 years of run-off records. That condition being met the adequacy of the number and distribution of rainfall observation stations usually determines whether or not a given area is selected for study. It is necessary that the rainfall stations be well distributed over the drainage area, but what is more important in hilly regions is that they be so distributed in altitude that the mean altitude of the rainfall stations approximates the mean altitude

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of the basin, thereby tending to compensate for the variation of rainfall with altitude. Because of the relative scarcity of rainfall stations, the latter requirement practically eliminates from the study all basins in mountainous regions, and accordingly the computations are for the most part confined to basins in rolling country or plains. Exceptions to this are the computations made for one drainage area in Vermont and several in Pennsylvania and northern Georgia.

The period of record for which computations can be made is determined by the years of available run-off records. Therefore, the first step is to determine the location of available stream-gaging stations—points where run-off has been measured. The drainage areas above these stations are then outlined, and the rainfall stations within or adjacent to the area are plotted, on standard Geological Survey base maps on a scale of 1:500,000. The lengths of all records are noted on these maps, as well as the elevations of the rainfall stations.

**SOURCES OF DATA**

In general, the equivalent run-off depths, in inches, for water years were taken directly from the records of surface water supply in the water-supply papers of the Geological Survey. The annual depths of rainfall at individual stations for water years corresponding to the stream-flow records were computed from the monthly totals published by the Weather Bureau.

**COMPUTATION OF AREAL RAINFALL**

After the annual rainfall depths at the available stations within and adjacent to the selected drainage basin were compiled, the average rainfall on the basin for each year was computed. Three methods were available for combining the individual station records into an areal average, (1) computing the arithmetic mean of the rainfall stations; (2) drawing isohyetal lines and computing a weighted average; (3) weighting the rainfalls at individual stations by geometrically constructed areas, commonly known as the Thiessen method. 6

The first method was used where the rainfall observations were of comparatively uniform magnitude, or where the weights of the respective observations would be about equal. In such basins it became evident by inspection that the arithmetic average of the station rainfalls would give practically the same result as a weighted average.

The second or isohyetal method is more laborious than the other methods, is dependent on individual judgment in drawing isohyetal lines, and is no more accurate than the other methods, especially if the data are meager. Consequently it was discarded.

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The third method is quicker than the second and is less dependent on individual judgment. Its application is developed more fully below. Other studies have tended to show that where the rainfall observations are not favorably distributed the isohyetal method may have no advantage in accuracy over the Thiessen method. In this study the basin rainfalls were computed by the Thiessen method or by taking an arithmetic mean of the station rainfalls.

A comparison of the isohyetal method with the Thiessen method was made for the record of the 1933 water year for that part of the West River Basin above the gaging station at Newfane, Vt. The computations by the two methods are given below, and the corresponding diagrams are shown in figures 1 and 2.

**Computation of mean rainfall by Thiessen method**

<table>
<thead>
<tr>
<th>Rainfall station</th>
<th>Measured rainfall (inches)</th>
<th>Area of basin nearest to rainfall station (square miles)</th>
<th>Column 2 times column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavendish</td>
<td>45.90</td>
<td>16.6</td>
<td>762</td>
</tr>
<tr>
<td>Somerset</td>
<td>59.84</td>
<td>19.9</td>
<td>1,491</td>
</tr>
<tr>
<td>Newfane</td>
<td>48.36</td>
<td>225.4</td>
<td>10,840</td>
</tr>
<tr>
<td>South Londonderry</td>
<td>48.99</td>
<td>308.0</td>
<td>15,020</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>202.19</strong></td>
<td><strong>308.0</strong></td>
<td><strong>15,020</strong></td>
</tr>
<tr>
<td><strong>Mean rainfall, in inches</strong></td>
<td><strong>50.55</strong></td>
<td></td>
<td><strong>48.8</strong></td>
</tr>
</tbody>
</table>

**Computation of mean rainfall by isohyetal method**

<table>
<thead>
<tr>
<th>Average rainfall between isohyetals (inches)</th>
<th>Area of basin between isohyetals (square miles)</th>
<th>Column 1 times column 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>43.5</td>
<td>1.9</td>
<td>83</td>
</tr>
<tr>
<td>44.5</td>
<td>18.5</td>
<td>828</td>
</tr>
<tr>
<td>45.5</td>
<td>30.7</td>
<td>1,597</td>
</tr>
<tr>
<td>46.5</td>
<td>35.2</td>
<td>1,637</td>
</tr>
<tr>
<td>47.5</td>
<td>72.3</td>
<td>3,434</td>
</tr>
<tr>
<td>48.5</td>
<td>34.6</td>
<td>1,678</td>
</tr>
<tr>
<td>49.5</td>
<td>28.2</td>
<td>1,926</td>
</tr>
<tr>
<td>50.5</td>
<td>21.5</td>
<td>1,101</td>
</tr>
<tr>
<td>51.5</td>
<td>22.4</td>
<td>1,154</td>
</tr>
<tr>
<td>52.5</td>
<td>19.2</td>
<td>1,008</td>
</tr>
<tr>
<td>53.5</td>
<td>12.2</td>
<td>633</td>
</tr>
<tr>
<td>54.5</td>
<td>7.7</td>
<td>420</td>
</tr>
<tr>
<td>55.5</td>
<td>3.2</td>
<td>178</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>308.0</strong></td>
<td><strong>14,967</strong></td>
</tr>
<tr>
<td><strong>Mean rainfall, in inches</strong></td>
<td></td>
<td><strong>48.6</strong></td>
</tr>
</tbody>
</table>

The result obtained by the isohyetal method was very close to that obtained by the Thiessen method. In this example, partly due to the fact that of the eight basic rainfall stations, only one was within the basin and the other seven were outside of it, the isohyetal lines may not have conformed to the variations associated with the
topography within the basin. For example, according to the iso-
yetal lines shown on figure 2 the rainfall decreases upstream from
South Londonderry. This may be contrary to fact, as the basin
rises in this region to a relatively high altitude, which is usually asso-
ciated with greater rainfall. If an altitude-rainfall relation could
be determined for individual years, the position of the isohyetal
lines might, by the use of a topographic map, be altered to conform

to the changes of rainfall with topography. The Thiessen method
may not have produced greater accuracy in this respect, but it had
the advantage of being less laborious.

ADJUSTMENTS TO COMPUTED RAINFALL

As previously stated it is desirable in computations of the mean
rainfall of a drainage basin in which rainfall varies with altitude that
the mean altitude of the rainfall stations correspond closely to that
of the basin. In mountainous regions this requirement is rarely
satisfied, as the available rainfall stations are usually located at low
METHOD OF DETERMINATION

altitudes—often in the valleys. In order that the computation of average rainfall for a mountainous basin may even approximate actual conditions over the entire area, it is necessary to make adjustments to the rainfall data. Such adjustments have been applied in the study of the area on the West River above Newfane, Vt.

The first step is to derive an altitude-rainfall relation. (See fig. 3.) In many basins this cannot be done with any degree of success, as

![Diagram of West River Basin showing location of adjacent rainfall stations, measured rainfall for the 1933 water year, and isohyetal lines for computing areal rainfall.](image)

the influence of altitude is obscured by that of variable exposure and air currents in different parts of the basin. Moreover, for shorter periods, as a year or less, there may be, in a limited sense, the fortuitous areal distribution characteristic of individual storms. Usually such a relation can be reliable only when determined on the basis of the means over several years.

In this example the mean annual rainfall for the stations in and adjacent to the basin for the total period under consideration (1919–23, 1929–33) were plotted against altitude as shown in figure 3. It is
evident that although the mean annual rainfalls at the lower altitudes are somewhat scattered, only one of the station records used in the computations deviated more than 4 percent from the mean curve. The weighted mean altitude of the rainfall stations was taken as 1,020 feet, using weightings obtained by the Thiessen method. The weighted mean altitude of the drainage basin is 1,760 feet. The difference in mean rainfall between these two altitudes was 6.8 inches as indicated by the curve. This figure was applied as a positive correction to the mean rainfall, resulting in an adjustment of 17 percent. The mean water loss for the period was increased 46 percent. These results are illustrative of the errors that may be encoun-

\footnote{Am. Geophys. Union Trans., 1933, p. 402.}
METHOD OF DETERMINATION

ADJUSTMENTS TO COMPUTED WATER LOSS

The purpose of this study is to determine water loss for land areas only. The water loss from a prevalent water surface is, of course, entirely an evaporation loss and in general over periods of time of a year or more, and except under certain conditions favorable for excessive evaporation from vegetation, it is believed to be greater than the combination of losses that occur from land.

Three of the drainage areas selected in Massachusetts include the surfaces of large reservoirs, and it is thought that the computations do not give a reliable figure for the loss from the land area without appropriate adjustment therefor. Accordingly, adjustments to the mean annual water loss were computed. An example of the determination of the adjustment for the drainage area on the South Branch of the Nashua River above Wachusett Dam at Clinton, Mass., is given below.

Drainage area = 108.84 square miles.
Water surface = 4,735 acres = 7.40 square miles.
Mean annual water loss for total area = 22.03 inches.
Approximate mean annual evaporation from water surface = 25 inches.

\[
\begin{align*}
\text{Water loss from total area} &\times (\text{total area}) - (\text{water loss from land area}) \\
&\times (\text{land area}) + (\text{evaporation from water area}) \\
&\times (\text{water area}) \\
\end{align*}
\]

Let \( x = \text{water loss from land area.} \)

\[
\begin{align*}
x &= \frac{(22.03 \times 108.84) - (25 \times 7.4)}{101.44} \\
&= \frac{2,398 - 185}{101.44} \\
&= \frac{2,213}{101.44} \\
&= 21.8 \text{ inches.}
\end{align*}
\]

The mean annual evaporation of 25 inches is not exact but was selected after an examination of the scant information available. This example shows that when the percentage of water area is small and evaporation differs slightly from the water loss from the land area the amount of the adjustment is comparatively negligible. The need for such correction can usually be determined only by trial.

ACCURACY OF RESULTS

From the foregoing it is evident that there are decided practical limitations to the accuracy of results of studies of water loss. Even though refinement is attempted, little faith can be put in the results if the rainfall observations are not adequately distributed. Moreover, rainfall records at individual stations may be unrepresentative owing to exposed or unduly sheltered positions of rain gages, inability to make accurate measurements of snowfall, and shortcomings of the observers. The records of yearly run-off may also be subject to slight

inaccuracy, but it is believed to be relatively negligible compared with the inaccuracy inherent in computations of areal rainfall.

PRESENTATION OF RESULTS

MEAN ANNUAL WATER LOSS

Table 1 (pp. 13–18) presents the mean annual precipitation, mean annual run-off, and mean annual water loss for the years of record covered in this study.

The drainage areas in table 1 are presented in the same geographic order that is followed in the Geological Survey water-supply papers and are grouped according to the following order and arrangement: North Atlantic basins, South Atlantic basins, Ohio River Basin, St. Lawrence River Basin, Hudson Bay Basin, upper Mississippi River Basin, Missouri River Basin, lower Mississippi River Basin, and eastern Gulf of Mexico basins. No computations were made for basins west of the 104th meridian.

The first column in table 1 gives the drainage area, which is designated by the name of the gaging station at which the run-off is measured. A few of the drainage areas represent only that portion of the total drainage area that lies between two or more main-stream or tributary gaging stations. These were selected only if rainfall observations were not available over the entire drainage area. The run-off for such restricted drainage areas is the difference between the run-offs at appropriate groups of the several gaging stations and is, of course, because of accumulated errors in the difference, subject to greater inaccuracy than a single observed record.

The second column gives the period studied in water years, which end September 30. The period does not necessarily represent and should not be confused with the period of available record of run-off at the gaging station. For reasons previously stated the period studied is generally less than that of the record of run-off. No period extends beyond 1934 because more recent run-off records had not been published at the time the basic computations were made (1935–36). Where data were taken from other published records the period corresponds to that used in those records. For example, for basins in Pennsylvania, the period studied begins in 1921, as that was the first year for which basin rainfalls were published by the Department of Forests and Waters. Other periods to be studied were determined by the availability of rainfall records.

The remaining columns in table 1 give the mean annual precipitation, mean annual run-off, and mean annual water loss for the periods listed in the second column. The results are usually the arithmetical averages of the individual values for each year, given in table 2, computed to the nearest tenth.
PRESENTATION OF RESULTS

The mean annual water loss is shown graphically in plate 1, where each value is plotted approximately in the center of the basin studied.

**Table 1.** Summary of precipitation, run-off, and water loss

### Merrimack River Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Branch of Nashua River at Clinton, Mass.</td>
<td>1904-33</td>
<td>43.8</td>
<td>21.8</td>
<td>22.0</td>
</tr>
<tr>
<td>Sudbury River at Framingham Center, Mass.</td>
<td>1904-33</td>
<td>43.0</td>
<td>18.5</td>
<td>24.5</td>
</tr>
<tr>
<td>Lake Cochituate outlet at Cochituate, Mass.</td>
<td>1904-33</td>
<td>41.9</td>
<td>18.7</td>
<td>23.2</td>
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### Connecticut River Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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<tbody>
<tr>
<td>West River at Newfane, Vt.</td>
<td>1929-33</td>
<td>46.5</td>
<td>25.0</td>
<td>21.5</td>
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<tr>
<td>Swift River at West Ware, Mass.</td>
<td>1929-34</td>
<td>45.4</td>
<td>22.4</td>
<td>23.1</td>
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<tr>
<td>Middle Branch of Westfield River at Goss Heights, Mass.</td>
<td>1929</td>
<td>45.6</td>
<td>25.9</td>
<td>19.6</td>
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### Delaware River Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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<tbody>
<tr>
<td>Delaware River at Port Jervis, N. Y.</td>
<td>1921-34</td>
<td>41.9</td>
<td>24.6</td>
<td>17.3</td>
</tr>
<tr>
<td>Delaware River at Belvidere, N. J.</td>
<td>1924-34</td>
<td>42.8</td>
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<td>19.3</td>
</tr>
<tr>
<td>Delaware River at Riegelsville, Pa.</td>
<td>1924-34</td>
<td>42.7</td>
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<td>19.5</td>
</tr>
<tr>
<td>Delaware River at Trenton, N. J.</td>
<td>1924-34</td>
<td>43.2</td>
<td>23.1</td>
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<td>Lackawaxen River at West Hawley, Pa.</td>
<td>1929-34</td>
<td>43.6</td>
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<td>Wallenpaupack Creek at Wilsonville, Pa.</td>
<td>1929-32</td>
<td>42.1</td>
<td>21.3</td>
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<tr>
<td>Bushkill Creek at Shoemaker's</td>
<td>1931-34</td>
<td>44.2</td>
<td>26.1</td>
<td>18.0</td>
</tr>
<tr>
<td>McMichaels Creek at Stroudsburg, Pa.</td>
<td>1931-34</td>
<td>45.6</td>
<td>22.7</td>
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<tr>
<td>Lehig River at Tannery, Pa.</td>
<td>1928-34</td>
<td>43.6</td>
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<td>Lehig River at Bethlehem, Pa.</td>
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<tr>
<td>Nesleming Creek at Rushland, Pa.</td>
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<tr>
<td>Schuykill River at Pottstown, Pa.</td>
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<tr>
<td>Little Schuykill River at Tamaqua, Pa.</td>
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<td>28.2</td>
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<tr>
<td>Perkiomen Creek at Graters Ford, Pa.</td>
<td>1927-34</td>
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<tr>
<td>Crum Creek at Woodlyn, Pa.</td>
<td>1932-34</td>
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<td>18.5</td>
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<tr>
<td>Ridley Creek at Moylan, Pa.</td>
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<tr>
<td>Chester Creek near Chester, Pa.</td>
<td>1932-34</td>
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<td>15.5</td>
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<tr>
<td>Brandywine Creek at Chadds Ford, Pa.</td>
<td>1921-34</td>
<td>43.2</td>
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### Susquehanna River Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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<tbody>
<tr>
<td>Susquehanna River at Towanda, Pa.</td>
<td>1921-34</td>
<td>35.9</td>
<td>17.3</td>
<td>18.6</td>
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<tr>
<td>Susquehanna River at Wilkes-Barre, Pa.</td>
<td>1921-34</td>
<td>36.3</td>
<td>17.2</td>
<td>19.1</td>
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<tr>
<td>Susquehanna River at Danville, Pa.</td>
<td>1933-34</td>
<td>37.3</td>
<td>17.6</td>
<td>19.70</td>
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<tr>
<td>Susquehanna River at Harrisburg, Pa.</td>
<td>1921-34</td>
<td>35.3</td>
<td>17.6</td>
<td>20.8</td>
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<tr>
<td>Susquehanna River at Marietta, Pa.</td>
<td>1922-34</td>
<td>38.8</td>
<td>15.7</td>
<td>23.1</td>
</tr>
<tr>
<td>Towanda Creek near Monoecton, Pa.</td>
<td>1921-34</td>
<td>39.4</td>
<td>16.8</td>
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<tr>
<td>Tunkhannock Creek at Dixon, Pa.</td>
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<td>49.5</td>
<td>19.8</td>
<td>22.1</td>
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<tr>
<td>Leckewanna River at Mexico, Pa.</td>
<td>1921-26</td>
<td>40.9</td>
<td>27.5</td>
<td>13.5</td>
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<tr>
<td>Wapwallopen Creek near Wapwallopen, Pa.</td>
<td>1921-34</td>
<td>44.6</td>
<td>17.8</td>
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<tr>
<td>Nesopec Creek near St. Johns, Pa.</td>
<td>1921-26</td>
<td>45.4</td>
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<tr>
<td>Fishing Creek at Bloomsburg, Pa.</td>
<td>1921-26</td>
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<tr>
<td>West Branch of Susquehanna River at Bower, Pa.</td>
<td>1921-34</td>
<td>41.4</td>
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<tr>
<td>West Branch of Susquehanna River at Renovo, Pa.</td>
<td>1921-34</td>
<td>40.2</td>
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<td>19.6</td>
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<tr>
<td>West Branch of Susquehanna River at Williamsport, Pa.</td>
<td>1921-34</td>
<td>38.4</td>
<td>20.1</td>
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<tr>
<td>Clearfield Creek at Dimolding, Pa.</td>
<td>1921-34</td>
<td>42.0</td>
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<tr>
<td>Driftwood Branch of Sinnemahoning Creek at Sterling Run, Pa.</td>
<td>1921-34</td>
<td>42.0</td>
<td>22.1</td>
<td>19.8</td>
</tr>
<tr>
<td>North Bald Eagle Creek at Milesburg, Pa.</td>
<td>1921-28</td>
<td>39.8</td>
<td>20.5</td>
<td>19.0</td>
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<tr>
<td>North Bald Eagle Creek at Beech Creek Station, Pa.</td>
<td>1921-34</td>
<td>37.9</td>
<td>17.8</td>
<td>20.1</td>
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</tbody>
</table>

1. Rainfall and run-off data of the water division of the Metropolitan District Commission.
2. Results adjusted on basis of altitude-rainfall relation. See p. 10.
4. Rainfall and run-off data compiled by Pennsylvania Department of Forests and Waters.
TABLE 1.—Summary of precipitation, run-off, and water loss—Continued

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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<tbody>
<tr>
<td>Pine Creek at Cedar Run, Pa.</td>
<td>1921-34</td>
<td>33.2</td>
<td>16.7</td>
<td>16.5</td>
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<tr>
<td>Lycoming Creek near Trout Run, Pa.</td>
<td>1921-34</td>
<td>37.9</td>
<td>19.0</td>
<td>19.0</td>
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<tr>
<td>Loyalsock Creek at Loyalsock, Pa.</td>
<td>1926-34</td>
<td>39.4</td>
<td>21.4</td>
<td>18.0</td>
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<tr>
<td>Penn Creek at Penns Creek, Pa.</td>
<td>1930-31</td>
<td>41.9</td>
<td>17.2</td>
<td>24.7</td>
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<tr>
<td>Mahantango Creek East near Dalmatia, Pa.</td>
<td>1930-34</td>
<td>40.7</td>
<td>14.9</td>
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<tr>
<td>Frankstown Branch of Juniata River at Williamsburg, Pa.</td>
<td>1921-34</td>
<td>40.2</td>
<td>17.0</td>
<td>23.2</td>
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<tr>
<td>Juniata River at Newport, Pa.</td>
<td>1921-34</td>
<td>38.9</td>
<td>16.2</td>
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</tr>
<tr>
<td>Shaver Creek near Petersburg, Pa.</td>
<td>1931-34</td>
<td>36.9</td>
<td>13.1</td>
<td>23.8</td>
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<tr>
<td>Standing Stone Creek near Huntingdon, Pa.</td>
<td>1931-34</td>
<td>39.2</td>
<td>13.1</td>
<td>26.1</td>
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<tr>
<td>Raystown Branch of Juniata River at Saxton, Pa.</td>
<td>1931-34</td>
<td>38.4</td>
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<tr>
<td>Dunning Creek at Yount, Pa.</td>
<td>1931-34</td>
<td>38.0</td>
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<tr>
<td>Brush Creek at Gapsville, Pa.</td>
<td>1932-34</td>
<td>36.4</td>
<td>15.3</td>
<td>21.0</td>
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<tr>
<td>Great Trough Creek near Marksburg, Pa.</td>
<td>1931-34</td>
<td>38.1</td>
<td>12.7</td>
<td>25.4</td>
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<tr>
<td>Aughwick Creek near Orbisonia, Pa.</td>
<td>1932-34</td>
<td>39.5</td>
<td>15.8</td>
<td>23.7</td>
</tr>
<tr>
<td>Tuscarora Creek near Port Royal, Pa.</td>
<td>1921-34</td>
<td>39.6</td>
<td>16.3</td>
<td>23.3</td>
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<tr>
<td>Cocalamus Creek near Millerstown, Pa.</td>
<td>1931-34</td>
<td>40.9</td>
<td>14.9</td>
<td>26.0</td>
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<tr>
<td>Sherman Creek at Shermandale, Pa.</td>
<td>1930-34</td>
<td>41.7</td>
<td>15.1</td>
<td>26.6</td>
</tr>
<tr>
<td>Conodoguinet Creek near Hogestown, Pa.</td>
<td>1930-34</td>
<td>40.2</td>
<td>12.9</td>
<td>27.3</td>
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<tr>
<td>Swatara Creek at Harper Tavern, Pa.</td>
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<td>42.7</td>
<td>21.2</td>
<td>21.5</td>
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<tr>
<td>Upper Little Swatara Creek at Pine Grove, Pa.</td>
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<td>42.0</td>
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<tr>
<td>West Conewago Creek near Manchester, Pa.</td>
<td>1930-34</td>
<td>39.8</td>
<td>12.6</td>
<td>27.2</td>
</tr>
<tr>
<td>Codorus Creek at Spring Grove, Pa.</td>
<td>1930-34</td>
<td>42.1</td>
<td>14.4</td>
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</tr>
<tr>
<td>South Branch of Codorus Creek near York, Pa.</td>
<td>1928-29</td>
<td>50.0</td>
<td>20.0</td>
<td>30.0</td>
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<tr>
<td>Conestoga Creek at Lancaster, Pa.</td>
<td>1929-31</td>
<td>36.7</td>
<td>12.4</td>
<td>24.3</td>
</tr>
<tr>
<td>Muddy Creek at Castle Fin, Pa.</td>
<td>1930-34</td>
<td>39.7</td>
<td>13.7</td>
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Savannah River Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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<tbody>
<tr>
<td>Broad River near Carlton, Ga.</td>
<td>1903-12</td>
<td>52.5</td>
<td>23.9</td>
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Altamaha River Basin

<table>
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<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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<tbody>
<tr>
<td>Ocmulgee River near Jackson, Ga.</td>
<td>1907-15</td>
<td>48.6</td>
<td>18.3</td>
<td>30.3</td>
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<tr>
<td>Oconee River near Greensboro, Ga.</td>
<td>1904-13</td>
<td>50.7</td>
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Suwannee River Basin

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<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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<tr>
<td>Suwannee River at Fargo, Ga.</td>
<td>1928-31</td>
<td>54.8</td>
<td>23.9</td>
<td>31.9</td>
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Apalachicola River Basin

<table>
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<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
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<tbody>
<tr>
<td>Chattahoochee River near Norcross, Ga.</td>
<td>1905-23</td>
<td>58.2</td>
<td>28.2</td>
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<tr>
<td>Flint River near Woodbury, Ga.</td>
<td>1902-15</td>
<td>48.4</td>
<td>19.0</td>
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<tr>
<td>Flint River between Culloden and Woodbury, Ga.</td>
<td>1914-15</td>
<td>48.8</td>
<td>16.0</td>
<td>32.8</td>
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Choctawhatchee River Basin

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<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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<tbody>
<tr>
<td>Choctawhatchee River near Newton, Ala.</td>
<td>1922-24</td>
<td>57.1</td>
<td>18.2</td>
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Escambia River Basin

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<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
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<tbody>
<tr>
<td>Consecuh River near Andalusia, Ala.</td>
<td>1905-19</td>
<td>53.3</td>
<td>19.4</td>
<td>33.9</td>
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### Mobile River Basin

<table>
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<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
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### Pearl River Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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</thead>
<tbody>
<tr>
<td>Pearl River at Edinburg, Miss. Strong River at Dio, Miss.</td>
<td>1929-33</td>
<td>55.5</td>
<td>16.6</td>
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### Ohio River Basin

#### Allegheny River Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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#### Monongahela River Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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#### Chartiers Creek Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chartiers Creek at Carnegie, Pa.</td>
<td>1921-30</td>
<td>39.5</td>
<td>17.7</td>
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#### Beaver River Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
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<table>
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<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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</table>

#### Raccoon Creek Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raccoon Creek at Adamsville, Ohio</td>
<td>1916-27</td>
<td>41.9</td>
<td>19.9</td>
<td>22.0</td>
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</tbody>
</table>

1 Rainfall and run-off data compiled by Pennsylvania Department of Forestry and Waters. 2 Data compiled in Ohio State University Engineering Experiment Station Bull. 49, 1929.
TABLE 1.—Summary of precipitation, run-off, and water loss—Continued

Ohio River Basin—Continued

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCIOTO RIVER BASIN</strong></td>
<td></td>
<td></td>
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<tr>
<td>Scioto River at Grigg’s Dam and at Dublin, Ohio</td>
<td>{1911-18, 1922-24}</td>
<td>39.6</td>
<td>12.6</td>
<td>26.2</td>
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<tr>
<td>Scioto River at Columbus, Ohio</td>
<td>1899-1908</td>
<td>36.7</td>
<td>11.2</td>
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<td><strong>MIAMI RIVER BASIN</strong></td>
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<tr>
<td>Miami River at Dayton, Ohio</td>
<td>1894-1918</td>
<td>37.7</td>
<td>11.9</td>
<td>25.8</td>
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<td><strong>WABASH RIVER BASIN</strong></td>
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<td>Wabash River at Logansport, Ind.</td>
<td>1924-33</td>
<td>38.3</td>
<td>13.7</td>
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<td>Salamonie River at Dora, Ind.</td>
<td>1931-33</td>
<td>37.0</td>
<td>11.6</td>
<td>25.4</td>
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<td>Mississinewa River at Marion, Ind.</td>
<td>1931-33</td>
<td>39.7</td>
<td>10.7</td>
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<td>Eel River at North Manchester, Ind.</td>
<td>{1916-21}</td>
<td>31.8</td>
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<td>West Fork of White River near Noblesville, Ind.</td>
<td>{1930-33}</td>
<td>37.0</td>
<td>12.6</td>
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<td>Fall Creek at Millersville, Ind.</td>
<td>1928-33</td>
<td>41.7</td>
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<td>Flatrock Creek at St. Paul, Ind.</td>
<td>1931-33</td>
<td>42.0</td>
<td>12.4</td>
<td>29.5</td>
</tr>
</tbody>
</table>

St. Lawrence River Basin

| STREAMS TRIBUTARY TO LAKE MICHIGAN                   |                             |                                   |                            |                               |
|-----------------------------------------------------|-----------------------------|-----------------------------------|----------------------------|                               |
| Thornapple River near Caledonia, Mich.              | 1922-34                     | 32.0                              | 9.3                        | 22.7                          |
| Muskegon River at Newaygo, Mich.                   | 1932-34                     | 30.1                              | 10.2                       | 19.9                          |

**STREAM TRIBUTARY TO LAKE HURON**

| Tittabawassee River at Freeland, Mich.              | {1913-14, 1916-20}          | 29.7                              | 9.3                        | 20.4                          |

**STREAMS TRIBUTARY TO LAKE ERIE**

| River Rouge at Detroit, Mich.                      | 1922-34                     | 28.6                              | 6.0                        | 22.6                          |
| Huron River at Barton, Mich.                       | 1915-20                     | 31.7                              | 9.2                        | 22.5                          |

Hudson Bay Basin

| Red River at Fargo, N. Dak.                        | {1919-23, 1925-33}          | 20.8                              | 0.6                        | 20.3                          |
| Red River at Grand Forks, N. Dak.                 | {1922-24, 1926-33}          | 20.9                              | 1.2                        | 19.7                          |

Upper Mississippi River Basin

**CHIPPEWA RIVER BASIN**

| Jump River at Sheldon, Wis.                        | 1916-34                     | 30.5                              | 12.9                       | 17.6                          |

**TREMPEAULEAU RIVER BASIN**

| Trempealeau River at Dodge, Wis.                   | 1915-19                     | 29.5                              | 8.3                        | 21.2                          |

**BLACK RIVER BASIN**

| Black River at Neillsville, Wis.                   | 1915-34                     | 31.1                              | 9.6                        | 21.5                          |

**LA CROSSE RIVER BASIN**

| La Crosse River near West Salem, Wis.               | 1915-34                     | 30.3                              | 10.0                       | 20.4                          |

**WISCONSIN RIVER BASIN**

| Rib River at Rib Falls, Wis.                       | 1926-34                     | 30.1                              | 12.4                       | 17.7                          |
| Yellow River at Sprague, Wis.                      | 1927-34                     | 28.8                              | 8.3                        | 22.5                          |
| Kickapoo River at Gays Mills, Wis.                 | 1915-33                     | 31.6                              | 9.3                        | 22.3                          |

**ROCK RIVER BASIN**

| Sugar River near Brodhead, Wis.                    | 1915-34                     | 32.5                              | 9.2                        | 23.3                          |

\[1\] Data compiled in Ohio State University Engineering Experiment Station Bull. 49, 1929.
\[2\] Data compiled in Geological Survey Water-Supply Paper 772, 1936.
<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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<tbody>
<tr>
<td><strong>Missouri River Basin</strong></td>
<td></td>
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<td><strong>GEAND RIVER BASIN</strong></td>
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<tr>
<td>Grand River near Wakpala, S. Dak</td>
<td>1931-33</td>
<td>14.9</td>
<td>0.3</td>
<td>14.5</td>
</tr>
<tr>
<td>Moreau River at Promise, S. Dak</td>
<td>1931-33</td>
<td>14.6</td>
<td>0.4</td>
<td>14.1</td>
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<tr>
<td>White River near Oscoma, S. Dak</td>
<td>1929-33</td>
<td>17.8</td>
<td>0.6</td>
<td>17.2</td>
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<tr>
<td>Niobrara River near Spencer, Nebr</td>
<td>1928-33</td>
<td>18.6</td>
<td>1.6</td>
<td>17.0</td>
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<td><strong>MOEAU RIVER BASIN</strong></td>
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<tr>
<td>Moreau River at Promise, S. Dak</td>
<td>1931-33</td>
<td>15.1</td>
<td>0.1</td>
<td>15.0</td>
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<tr>
<td>James River at Jamestown, N. Dak</td>
<td>1929-32</td>
<td>15.7</td>
<td>0.1</td>
<td>17.3</td>
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<tr>
<td><strong>WHITE RIVER BASIN</strong></td>
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<tr>
<td>Middle Loup River at St. Paul, Nebr</td>
<td>1929-33</td>
<td>22.4</td>
<td>2.3</td>
<td>20.0</td>
</tr>
<tr>
<td>North Loup River near St. Paul, Nebr</td>
<td>1929-33</td>
<td>22.1</td>
<td>3.3</td>
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<tr>
<td>Elkhorn River at Waterloo, Nebr</td>
<td>1930-33</td>
<td>24.5</td>
<td>1.9</td>
<td>22.6</td>
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<td><strong>PLATTE RIVER BASIN</strong></td>
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<tr>
<td>Republican River between Wakefield and Scandia, Kans.</td>
<td>1920-24</td>
<td>24.8</td>
<td>1.4</td>
<td>23.4</td>
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<tr>
<td>Kansas River at Wamego, Kans., minus Kansas River at Ogden and Big Blue River at Randolph.</td>
<td>1920-25</td>
<td>29.8</td>
<td>3.8</td>
<td>27.2</td>
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<tr>
<td>Kansas River between Topeka and Wamego, Kans.</td>
<td>1930-33</td>
<td>33.4</td>
<td>4.9</td>
<td>28.5</td>
</tr>
<tr>
<td>Smoky Hill River between Lindsborg and Ellsworth, Kans.</td>
<td>1931-33</td>
<td>24.0</td>
<td>0.5</td>
<td>23.5</td>
</tr>
<tr>
<td>South Fork of Solomon River at Alton, Kans.</td>
<td>1920-24</td>
<td>21.9</td>
<td>0.5</td>
<td>21.4</td>
</tr>
<tr>
<td>Solomon River between Niles and Beloit, Kans.</td>
<td>1929-31</td>
<td>23.4</td>
<td>0.9</td>
<td>22.6</td>
</tr>
<tr>
<td>North Fork of Solomon River at Kirwin, Kans.</td>
<td>1920-24</td>
<td>22.2</td>
<td>0.6</td>
<td>21.6</td>
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<tr>
<td>Soldier Creek at Topeka, Kans.</td>
<td>1929-30</td>
<td>34.5</td>
<td>5.5</td>
<td>29.0</td>
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<tr>
<td>Delaware River at Valley Falls, Kans.</td>
<td>1929-30</td>
<td>34.6</td>
<td>4.9</td>
<td>29.7</td>
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<tr>
<td>Wakarusa River near Lawrence, Kans.</td>
<td>1930-33</td>
<td>32.7</td>
<td>2.6</td>
<td>30.2</td>
</tr>
<tr>
<td>Stranger Creek near Tonganaste, Kans.</td>
<td>1930-33</td>
<td>34.9</td>
<td>6.1</td>
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<tr>
<td><strong>KANSAS RIVER BASIN</strong></td>
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<tr>
<td>Grand River near Gallatin, Mo.</td>
<td>1922-33</td>
<td>35.3</td>
<td>7.2</td>
<td>28.0</td>
</tr>
<tr>
<td>Thompson River at Trenton, Mo.</td>
<td>1929-33</td>
<td>32.9</td>
<td>7.9</td>
<td>25.0</td>
</tr>
<tr>
<td>Locust Creek near Milan, Mo.</td>
<td>1922-33</td>
<td>37.3</td>
<td>9.2</td>
<td>28.1</td>
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<td><strong>CHARITON RIVER BASIN</strong></td>
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<td>Chariton River at Elmer, Mo.</td>
<td>1922</td>
<td>36.2</td>
<td>9.5</td>
<td>26.7</td>
</tr>
<tr>
<td>Blackwater River at Blue Lick, Mo.</td>
<td>1924-30</td>
<td>38.6</td>
<td>7.8</td>
<td>30.9</td>
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<tr>
<td><strong>OSSAGE RIVER BASIN</strong></td>
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<tr>
<td>Osage River near Ottawa, Kans.</td>
<td>1920-33</td>
<td>34.4</td>
<td>4.4</td>
<td>30.0</td>
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<tr>
<td>Sac River near Stockton, Mo.</td>
<td>1926-32</td>
<td>43.0</td>
<td>14.8</td>
<td>29.1</td>
</tr>
<tr>
<td>South Grand River near Brownington, Mo.</td>
<td>1922-33</td>
<td>38.0</td>
<td>7.5</td>
<td>30.5</td>
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</table>
### NATURAL WATER LOSS IN DRAINAGE BASINS

#### Table 1.—Summary of precipitation, run-off, and water loss—Continued

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual run-off (inches)</th>
<th>Mean annual water loss (inches)</th>
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<tbody>
<tr>
<td><strong>Lower Mississippi River Basin</strong></td>
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<td></td>
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<tr>
<td><strong>MERAMEC RIVER BASIN</strong></td>
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<tr>
<td>Meramec River near Steeleville, Mo</td>
<td>1924-34</td>
<td>41.0</td>
<td>9.4</td>
<td>31.6</td>
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<tr>
<td>Bourbeuse River at Union, Mo.</td>
<td>1922-34</td>
<td>39.4</td>
<td>11.2</td>
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<td><strong>ST. FRANCIS RIVER BASIN</strong></td>
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<td>St. Francis River near Patterson, Mo</td>
<td>1922-34</td>
<td>42.4</td>
<td>15.6</td>
<td>26.9</td>
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<tr>
<td><strong>WHITE RIVER BASIN</strong></td>
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<tr>
<td>James River at Galena, Mo.</td>
<td>1923-34</td>
<td>42.7</td>
<td>13.6</td>
<td>29.1</td>
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<td><strong>ARkANSAS RIVER BASIN</strong></td>
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<td>Pawnee River near Larned, Kans.</td>
<td>1926-33</td>
<td>20.6</td>
<td>2</td>
<td>20.4</td>
</tr>
<tr>
<td>Little Arkansas River at Valley Center, Kans.</td>
<td>1925-33</td>
<td>25.0</td>
<td>1.6</td>
<td>27.4</td>
</tr>
<tr>
<td>Walnut River at Winfield, Kans.</td>
<td>1923-33</td>
<td>32.4</td>
<td>4.6</td>
<td>27.8</td>
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<tr>
<td>Neosho River near Iola, Kans.5</td>
<td>1926-33</td>
<td>33.3</td>
<td>4.9</td>
<td>28.4</td>
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<tr>
<td><strong>Western Gulf of Mexico basins</strong></td>
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<td><strong>NECHES RIVER BASIN</strong></td>
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<tr>
<td>Neches River near Rockland, Tex.</td>
<td>1924-34</td>
<td>42.8</td>
<td>9.0</td>
<td>33.3</td>
</tr>
<tr>
<td>Angelina River near Lufkin, Tex.</td>
<td>1925-34</td>
<td>43.8</td>
<td>10.6</td>
<td>33.2</td>
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<tr>
<td>Angelina River between Horser and Lufkin, Tex.</td>
<td>1929-34</td>
<td>48.9</td>
<td>11.5</td>
<td>37.4</td>
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<tr>
<td><strong>TRINITY RIVER BASIN</strong></td>
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<tr>
<td>Clear Fork of Trinity River at Fort Worth, Tex.</td>
<td>1929-34</td>
<td>31.1</td>
<td>1.8</td>
<td>29.3</td>
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<tr>
<td>Mountain Creek near Grand Prairie, Tex.</td>
<td>1926-32</td>
<td>35.1</td>
<td>3.9</td>
<td>31.2</td>
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<tr>
<td>Elm Fork of Trinity River near Carrollton, Tex.</td>
<td>1925-34</td>
<td>31.9</td>
<td>3.3</td>
<td>28.6</td>
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<tr>
<td>East Fork of Trinity River near Rockwall, Tex.</td>
<td>1925-34</td>
<td>37.5</td>
<td>6.5</td>
<td>31.0</td>
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<tr>
<td><strong>SAN JACINTO RIVER BASIN</strong></td>
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<tr>
<td>San Jacinto River near Humble, Tex.</td>
<td>1930-34</td>
<td>40.8</td>
<td>6.1</td>
<td>34.8</td>
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<td><strong>BRAZOS RIVER BASIN</strong></td>
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<tr>
<td>San Gabriel River at Circleville, Tex.</td>
<td>1925-34</td>
<td>28.6</td>
<td>3.1</td>
<td>25.5</td>
</tr>
<tr>
<td>Yegua Creek near Somerville, Tex.</td>
<td>1925-34</td>
<td>34.8</td>
<td>4.4</td>
<td>30.4</td>
</tr>
<tr>
<td>Navasota River near Eastery, Tex.</td>
<td>1925-34</td>
<td>36.6</td>
<td>5.7</td>
<td>31.0</td>
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<tr>
<td><strong>COLORADO RIVER BASIN</strong></td>
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<tr>
<td>Pedernales River at Stonewall, Tex.</td>
<td>1925-34</td>
<td>27.0</td>
<td>1.3</td>
<td>25.8</td>
</tr>
<tr>
<td>Pedernales River between Spicewood and Stonewall, Tex.</td>
<td>1925-34</td>
<td>28.4</td>
<td>1.6</td>
<td>26.9</td>
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<tr>
<td><strong>GUADALUPE RIVER BASIN</strong></td>
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<tr>
<td>Guadalupe River near Spring Branch, Tex.</td>
<td>1925-34</td>
<td>30.1</td>
<td>2.1</td>
<td>28.0</td>
</tr>
<tr>
<td>Blanco River at Wimberley, Tex.</td>
<td>1923-34</td>
<td>30.4</td>
<td>3.3</td>
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<tr>
<td>Plum Creek near Lullina, Tex.</td>
<td>1931-34</td>
<td>30.6</td>
<td>3.4</td>
<td>28.1</td>
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<tr>
<td>Sandies Creek near Westoff, Tex.</td>
<td>1931-34</td>
<td>28.7</td>
<td>1.6</td>
<td>27.1</td>
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<tr>
<td>Celote River near Schroeder, Tex.</td>
<td>1931-33</td>
<td>32.9</td>
<td>2.5</td>
<td>30.4</td>
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<tr>
<td>Medina River near Pipe Creek, Tex.</td>
<td>1924-34</td>
<td>30.1</td>
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<td><strong>NUECES RIVER BASIN</strong></td>
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<tr>
<td>Nueces River at Laguna, Tex.</td>
<td>1923-34</td>
<td>24.1</td>
<td>2.1</td>
<td>22.0</td>
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</tbody>
</table>

PRESENTATION OF RESULTS

ANNUAL WATER LOSS

The annual precipitation, annual run-off, and annual water loss for each area for each year in the period studied are given in table 2. The areas listed are those given in table 1 and the explanation of the first two columns of table 1 given under "Mean annual water loss" applies also to the first two columns of table 2. The interpretation of water losses computed for short periods is discussed in the section on "Significance of water loss" (pp. 3-4). The rainfall and water-loss data given for the area on the West River above Newfane, Vt., have not been adjusted on the basis of the altitude-rainfall relation described under "Method of determination" (pp. 8-11).

Table 2.—Precipitation, run-off, and water loss, by water years

Merrimack River Basin

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Water year</th>
<th>Precipitation (inches)</th>
<th>Run-off (inches)</th>
<th>Water loss (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Branch of Nashua River at Clinton, Mass.1</td>
<td>1904</td>
<td>47.6</td>
<td>23.6</td>
<td>24.0</td>
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<td></td>
<td>1905</td>
<td>41.7</td>
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<td>1906</td>
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<td>1908</td>
<td>47.4</td>
<td>23.0</td>
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<td></td>
<td>1909</td>
<td>43.3</td>
<td>18.7</td>
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<td>1910</td>
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<td>1913</td>
<td>41.4</td>
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<td>1914</td>
<td>41.1</td>
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<td>1915</td>
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1 Rainfall and run-off data of the water division of the Metropolitan District Commission.
### Table 2.—Precipitation, run-off, and water loss, by water years—Continued

#### Merrimack River Basin—Continued

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#### Connecticut River Basin

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¹ Rainfall and run-off data of the water division of the Metropolitan District Commission.
² No altitude-rainfall adjustment applied to data for individual years. See p. 10 and table 1 for results of adjustment to mean rainfall and mean water loss.
³ Data compiled by H. B. Kinnison, district engineer, Geological Survey, Boston, Mass.
## TABLE 2.—Precipitation, run-off, and water loss, by water years—Continued

### Connecticut River Basin—Continued

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### Delaware River Basin 4

| Delaware River at Port Jervis, N. Y.                         | 1927       | 40.0                          | 26.8                    | 13.2                      |
| Delaware River at Belvidere, N. J.                          | 1924       | 44.9                          | 23.6                    | 20.4                      |
| Delaware River at Riegelsville, Pa.                         | 1921       | 42.1                          | 25.0                    | 17.1                      |
|                                                               | 1922       | 44.1                          | 23.0                    | 19.1                      |
|                                                               | 1923       | 36.7                          | 16.8                    | 19.9                      |
|                                                               | 1924       | 45.4                          | 24.2                    | 21.2                      |
|                                                               | 1925       | 38.4                          | 20.4                    | 18.0                      |
|                                                               | 1926       | 41.1                          | 21.3                    | 19.8                      |
|                                                               | 1927       | 45.5                          | 27.6                    | 17.7                      |
|                                                               | 1928       | 60.1                          | 41.5                    | 18.5                      |
|                                                               | 1929       | 38.5                          | 20.6                    | 17.9                      |
|                                                               | 1930       | 37.9                          | 19.5                    | 18.4                      |
|                                                               | 1931       | 38.6                          | 17.2                    | 21.4                      |
|                                                               | 1932       | 34.7                          | 17.4                    | 17.3                      |
|                                                               | 1933       | 53.4                          | 25.5                    | 24.9                      |
|                                                               | 1934       | 40.3                          | 19.4                    | 20.9                      |
| Delaware River at Trenton, N. J.                            | 1924       | 46.1                          | 22.8                    | 23.3                      |
|                                                               | 1925       | 38.9                          | 20.1                    | 17.9                      |
|                                                               | 1926       | 41.2                          | 20.9                    | 20.3                      |
|                                                               | 1927       | 45.0                          | 27.0                    | 18.0                      |
|                                                               | 1928       | 60.0                          | 39.8                    | 20.2                      |
|                                                               | 1929       | 38.2                          | 20.8                    | 17.4                      |
|                                                               | 1930       | 37.6                          | 19.6                    | 18.0                      |
|                                                               | 1931       | 37.9                          | 18.2                    | 21.7                      |
|                                                               | 1932       | 33.8                          | 16.2                    | 17.6                      |
|                                                               | 1933       | 56.4                          | 30.1                    | 27.3                      |
|                                                               | 1934       | 41.2                          | 20.4                    | 20.8                      |
| Lackawaxen River at West Hawley, Pa.                        | 1925       | 37.7                          | 18.1                    | 19.6                      |
|                                                               | 1926       | 41.3                          | 24.2                    | 17.1                      |
|                                                               | 1927       | 44.9                          | 28.4                    | 16.5                      |
|                                                               | 1928       | 62.0                          | 40.1                    | 21.9                      |
|                                                               | 1929       | 35.2                          | 19.0                    | 15.2                      |
|                                                               | 1930       | 39.5                          | 15.5                    | 24.0                      |
|                                                               | 1931       | 39.5                          | 16.0                    | 23.5                      |
|                                                               | 1932       | 38.9                          | 17.1                    | 20.9                      |
|                                                               | 1933       | 54.5                          | 25.6                    | 28.7                      |
|                                                               | 1934       | 43.5                          | 20.2                    | 23.3                      |
| Wallenpaupack Creek at Wilsonville, Pa.                     | 1921       | 38.9                          | 26.2                    | 12.7                      |
|                                                               | 1922       | 42.7                          | 25.7                    | 19.0                      |
|                                                               | 1923       | 40.5                          | 19.2                    | 21.6                      |
|                                                               | 1924       | 46.5                          | 27.0                    | 19.5                      |

Rainfall and run-off data compiled by Pennsylvania Department of Forests and Waters.
## TABLE 2.—Precipitation, run-off, and water loss, by water years—Continued

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* Rainfall and run-off data compiled by Pennsylvania Department of Forests and Waters.
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Savannah River Basin

| Broad River near Carlton, Ga            | 1903       | 60.2                          | 32.3                    | 27.9                       |
|                                         | 1904       | 34.7                          | 14.0                    | 20.7                       |
|                                         | 1905       | 43.2                          | 14.5                    | 28.7                       |
|                                         | 1906       | 69.2                          | 30.2                    | 39.0                       |
|                                         | 1907       | 44.0                          | 18.1                    | 25.9                       |
|                                         | 1908       | 50.1                          | 30.8                    | 20.0                       |
|                                         | 1909       | 58.7                          | 32.6                    | 26.1                       |
|                                         | 1910       | 47.5                          | 20.8                    | 27.0                       |
|                                         | 1911       | 37.6                          | 14.8                    | 22.8                       |
|                                         | 1912       | 59.7                          | 30.3                    | 29.3                       |

Altamaha River Basin

<p>| Ocmulgee River near Jackson, Ga         | 1907       | 45.3                          | 16.7                    | 28.6                       |
|                                         | 1908       | 49.8                          | 23.8                    | 26.0                       |
|                                         | 1909       | 56.3                          | 22.9                    | 33.4                       |
|                                         | 1910       | 43.5                          | 16.5                    | 27.0                       |
|                                         | 1911       | 34.7                          | 8.6                     | 26.1                       |
|                                         | 1912       | 71.1                          | 29.1                    | 42.0                       |
|                                         | 1913       | 48.1                          | 18.5                    | 29.6                       |
|                                         | 1914       | 33.8                          | 8.9                     | 24.9                       |
|                                         | 1915       | 54.5                          | 19.4                    | 35.1                       |</p>
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TABLE 2.—Precipitation, run-off, and water loss, by water years—Continued

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### TABLE 2. Precipitation, Run-off, and Water Loss, by Water Years—Continued

**Allegheny River Basin**

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## Table 2.—Precipitation, run-off, and water loss, by water years—Continued

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*Rainfall and run-off data compiled by Pennsylvania Department of Forests and Waters.*
## TABLE 2.—Precipitation, run-off, and water loss, by water years—Continued

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### Table 2.—Precipitation, run-off, and water loss, by water years—Continued

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Data compiled in Ohio University Engineering Experiment Station Bull. 49, 1929.
# Table 2.—Precipitation, run-off, and water loss, by water years—Continued

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### Table 2. Precipitation, run-off, and water loss, by water years—Continued

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### TABLE 2.—Precipitation, run-off, and water loss, by water years—Continued

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### Table 2.—Precipitation, run-off, and water loss, by water years—Continued

**Missouri River Basin—Continued**

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## Table 2.—Precipitation, run-off, and water loss, by water years—Continued

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### Western Gulf of Mexico basins

#### Neches River Basin

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#### Angelina River near Lufkin, Tex.

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#### Angelina River between Horger and Lufkin, Tex.

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### Table 2.—Precipitation, run-off, and water loss, by water years—Continued

#### Western Gulf of Mexico basins—Continued

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DISCUSSION OF RESULTS

There are many factors that cause variations in the annual water loss from a given basin from year to year and still other factors that cause variations in the annual water loss between basins in the same...
or similar regions. The following are some of the factors that cause variations in annual water loss from year to year in the same basin:

(a) Annual rainfall, its distribution among seasons, and the volumes and intensities associated with individual storms. This factor is of major importance in arid and semiarid regions.

(b) Sequence of wet and dry years and associated hydrologic and ecologic conditions.

(c) Temperature, wind, sunshine, humidity, and other factors that influence evaporation and transpiration.

Variations in annual water loss between basins in the same or similar regions may be caused by differences in the following factors:

(a) Topography.

(b) Soil.

(c) Vegetal cover.

(d) Rainfall.

(e) Temperature and other climatic factors.

The lack of comparability of the results in this report is due not only to the natural conditions listed above but to inadequacies in the basic information and to the possibility that the records are perhaps too short to assure satisfactory elimination of errors resulting from differences in the volume of water held in the basins at the beginning and end of the periods studied. Furthermore each value was independently determined from periods of record many of which differed from those used for nearby basins, and hence offered opportunity for the magnification of variations due to the vagaries of weather. Considering all the possible causes of differences in natural water loss, the consistency shown in the values for the mean annual water loss, as listed in table 1 and plotted in plate 1, is perhaps surprising.

RELATION BETWEEN WATER LOSS AND TEMPERATURE

Of all the factors affecting the mean annual water loss from a river basin in a humid region, the temperature is perhaps the most significant. Accordingly, it was thought desirable to expand this study to explore the relation between water loss and temperature.

In attempting to examine such a relation the first problem is to determine the manner in which the temperature data should be expressed in order to disclose effectively the correlation between temperature and water loss. At least two methods of expressing mean temperature are available, (1) as mean temperature in degrees and (2) as total degree-days of the mean daily temperature above some base temperature selected in relation to the effectiveness in producing evaporation. Inasmuch as little or no water loss, which
is made up of evaporation and transpiration, takes place below 32°F., the base temperature in the second method might at first thought be taken as 32°. However, in dealing with mean temperatures for periods of a day or more having minimum temperatures below 32°, a base temperature of less than 32° probably should be used, because with a mean temperature of 32° there will necessarily be significant periods in which the temperature is above 32°. Thornthwaite indicates that a month in which the mean temperature is 28.4° has negligible periods above 32°.6 Because this study is confined to annual water loss and annual temperature, it is not considered necessary to attempt such refinement in the selection of a suitable base temperature.

To give some indication of the characteristics of the two methods of expressing temperature, both annual mean temperatures and total degree-days above 32° were compiled for several temperature stations and years of record selected at random. The results of the compilation are shown in table 3 and are illustrated graphically in figure 4. If degree-days above 32° could be computed precisely for days in which the minimum temperature was less than 32°, the total degree-days above 32° would be increased by relatively small amounts. No attempt was made to apply this refinement. Assuming that the number of degree-days above 32° as computed is a fair index of evaporation, figure 4 seems to indicate that the annual mean temperature is also a fair index of the influence of temperature on evaporation. Since the annual mean temperature was much more readily obtained, it was used to show the relation between temperature and water loss.

As facilities were not available for compiling temperatures for all the areas listed in the preceding sections of this report, representative areas in different parts of the country were selected for study. In making the selection the points considered were length of record of water loss and number of available temperature stations and length of record at each.

The areal temperatures for the areas were obtained by taking the arithmetic mean of the records at the temperature stations in and adjacent to the area. After preliminary examination it was not considered as warranted or feasible to determine weighted mean temperatures or to attempt to adjust the mean temperatures by the application of altitude-temperature relations. The annual mean temperatures for water-years at the temperature stations were obtained by taking the mean of the monthly temperatures as given in the publications of the Weather Bureau.

Figure 4.—Graph showing comparison of annual mean temperature and annual total degree-days above 32° F. for selected temperature stations.
Table 3.—Annual mean temperature and total degree-days above 82° F. for selected stations

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<th>Mean temperature (°F.)</th>
<th>Total degree-days above 82° F.</th>
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</table>

Table 4 gives the mean annual precipitation, mean annual water loss, and mean annual temperature for all the areas for which temperatures were computed. It should be noted that for seven of the stations listed the periods studied differ slightly from those given in table 1, and for that reason the mean annual precipitation and mean
annual water loss differ from the corresponding values in table 1. The changes in the period studied were necessary because adequate temperature records were not available for the entire period for which the water loss was initially determined.

The yearly values used in computing the averages given in table 4 are listed in table 5.

It becomes evident from a casual examination of table 4 that the annual water loss from a drainage area is related to the annual temperature. To illustrate this graphically, the mean water loss and mean temperature for each of the areas listed in table 4 were plotted against each other as shown in figure 5. There is a wide scattering of the points, but there is nevertheless a well-defined trend in their general relation. Short records and inadequate data may contribute somewhat to the scattering. If the water-loss data had been plotted against total degree-days above 32° F., there would probably have been a closer correlation, especially for those points for lower prevailing temperature near the left side of the graph.

Table 4.—Summary of precipitation, water loss, and temperature for selected areas.

<table>
<thead>
<tr>
<th>Gaging station</th>
<th>Period studied (water years)</th>
<th>Mean annual precipitation (inches)</th>
<th>Mean annual water loss (inches)</th>
<th>Mean annual temperature (°F.)</th>
</tr>
</thead>
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<tr>
<td>South Branch of Nashua River at Clinton, Mass.</td>
<td>1904-33</td>
<td>43.8</td>
<td>22.0</td>
<td>47.8</td>
</tr>
<tr>
<td>Sudbury River at Framingham Center, Mass.</td>
<td>1903-33</td>
<td>42.8</td>
<td>24.5</td>
<td>47.9</td>
</tr>
<tr>
<td>Lake Cochituate outlet at Cochituate, Mass.</td>
<td>1904-33</td>
<td>41.9</td>
<td>22.2</td>
<td>47.9</td>
</tr>
<tr>
<td>West River at Newfane, Vt.</td>
<td>1920-23</td>
<td>46.5</td>
<td>21.5</td>
<td>42.3</td>
</tr>
<tr>
<td>Swift River at West Ware, Mass.</td>
<td>1920-34</td>
<td>45.4</td>
<td>23.1</td>
<td>47.9</td>
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<tr>
<td>Middle Branch of Westfield River at Goss Heights,</td>
<td>1920-23</td>
<td>45.4</td>
<td>21.6</td>
<td>46.8</td>
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<tr>
<td>Clearfield Creek at Dimeling, Pa.</td>
<td>1921-34</td>
<td>42.0</td>
<td>21.8</td>
<td>50.1</td>
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<td>Swatara Creek at Harper Tavern, Pa.</td>
<td>1921-34</td>
<td>42.7</td>
<td>21.5</td>
<td>50.7</td>
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<tr>
<td>Upper Little Swatara Creek at Pine Grove, Pa.</td>
<td>1921-32</td>
<td>42.0</td>
<td>20.7</td>
<td>50.8</td>
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<tr>
<td>Oonee River near Greensboro, Ga.</td>
<td>1920-19</td>
<td>50.7</td>
<td>30.2</td>
<td>61.1</td>
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<tr>
<td>Chattahoochee River near Norcross, Ga.</td>
<td>1905-23</td>
<td>58.2</td>
<td>30.0</td>
<td>58.9</td>
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<td>Conocoeh River near Andalusia, Ala.</td>
<td>1910-19</td>
<td>53.0</td>
<td>34.1</td>
<td>55.7</td>
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<tr>
<td>East Fork of Tombigbee River near Fulton, Miss.</td>
<td>1929-33</td>
<td>58.6</td>
<td>39.6</td>
<td>33.0</td>
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<tr>
<td>Pearl River at Edinburg, Miss.</td>
<td>1929-33</td>
<td>55.5</td>
<td>38.8</td>
<td>54.8</td>
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<tr>
<td>Red Bank Creek at St. Charles, Pa.</td>
<td>1921-34</td>
<td>30.5</td>
<td>19.4</td>
<td>46.4</td>
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<tr>
<td>Miami River at Dayton, Ohio.</td>
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<td>West Fork of White River near Noblesville, Ind.</td>
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<td>Tittabawassee River at Freeland, Mich.</td>
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<td>Red River at Fargo, N. Dak.</td>
<td>1919-23</td>
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<td>Red River at Grand Forks, N. Dak.</td>
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<td>20.3</td>
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<td>La Crosse River near West Salem, Wis.</td>
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<td>43.8</td>
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<td>Blackwater River at Blue Lick, Mo.</td>
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<td>55.3</td>
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<td>South Grand River near Brownington, Mo.</td>
<td>1922-33</td>
<td>38.9</td>
<td>30.5</td>
<td>56.1</td>
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<td>Little Arkansas River at Valley Center, Kans.</td>
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<td>Walnut River at Winfield, Kans.</td>
<td>1923-33</td>
<td>32.4</td>
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<td>Neches River near Rockland, Tex.</td>
<td>1920-34</td>
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<td>Angelina River near Lufkin, Tex.</td>
<td>1926-34</td>
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<td>35.0</td>
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1 Period studied differs from that in tables 1 and 2.
MAP OF THE UNITED STATES SHOWING DETERMINATIONS OF MEAN ANNUAL WATER LOSS, IN INCHES, FOR SELECTED RIVER BASINS.
MAP OF THE UNITED STATES SHOWING GENERALIZED LINES OF MEAN ANNUAL WATER LOSS AND LINES OF MEAN ANNUAL TEMPERATURE.
Figure 5.—Comparison of mean annual water loss and mean annual temperature for selected basins with mean annual precipitation in excess of 20 inches.
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<th>Annual precipitation</th>
<th>Annual water loss</th>
<th>Annual temperature</th>
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1 Period studied differs from that in tables 1 and 2.
Table 5.—Precipitation, water loss, and temperature, by water years—Continued

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1 Period studied differs from that in tables 1 and 2.

To illustrate further the relation between water loss and temperature, generalized lines of mean annual water loss were drawn through the water-loss data plotted in plate 1. These lines are shown in plate 2. The solid lines are defined by data given in this report, and the dashed lines are based on interpolations or on mean water loss as determined from published maps showing mean annual precipitation and mean annual run-off.¹⁰

Superimposed on plate 2 are heavier lines showing mean annual temperature as compiled by the Weather Bureau. The increase in annual water loss with an increase in average temperature is clearly indicated from this comparison.

It is interesting to note that the water-loss lines shown in plate 2 turn at about 95° west longitude and cut the temperature lines practically at right angles. This is due to the fact that the rainfall decreases westward and hence fails by notably increasing margins to satisfy the evaporation losses that otherwise would take place at the prevailing temperatures.

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The use of the subjoined mailing label to return this report will be official business, and no postage stamps will be required.