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EFFECT OF DROUGHT ON WATER RESOURCES IN THE NORTHEAST

By

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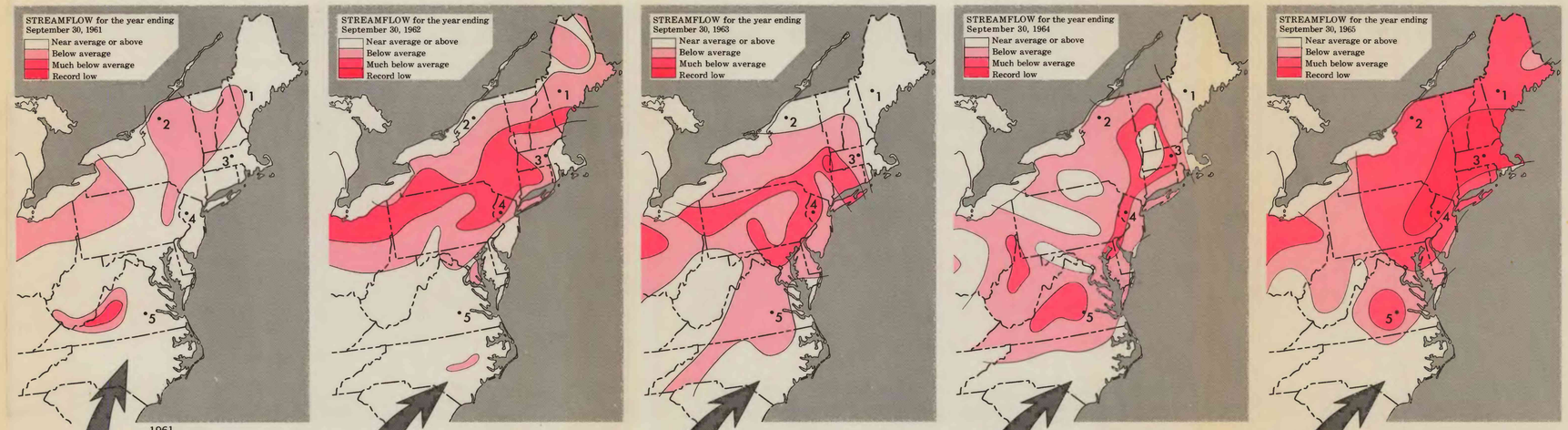


The water in the ground in the spring sustains the streamflow during the succeeding summer and fall growing season

The numbers on the streamflow maps and the letters on the ground water level maps pertain to the graphs below.

PRELIMINARY APPRAISAL OF DROUGHT EFFECTS, MARCH 31, 1966

Purpose

This preliminary appraisal of the effects of the current drought in the Northeast is presented in the hope that it will be of value to public officials and others who must make decisions relating to water resources. For each year it presents maps showing the areas where runoff and ground-water levels were most severely affected, it emphasizes the effects of the drought and outlines the significant shifts in the areas most greatly affected. The possible continuation of water resources problems related to the drought must be considered seriously as the beginning of a new growing season approaches without full replenishment of natural and artificial storage. Accordingly, this summary is presented as an interim report--before the drought has been broken--because only then will it be of the greatest aid in the formulation of prudent public plans and necessary actions for meeting the effects of possible continued drought.

The Maps and Graphs

The maps and graphs hereon are largely self-explanatory. In using the maps it is necessary to recognize the difference in the climatic years used to show streamflow and ground water. The maps are offset on the sheet partly to emphasize the difference in climatic years but mainly to facilitate correlation because ground-water levels tend to influence streamflow in the succeeding months.

Ground-water levels are not amenable to a summation such as is used for streamflow because they represent stages of the ground-water reservoir, not quantities of water. A base period, 1946 to 1960, was chosen for comparison with levels during the drought at each of the 72 wells selected as representative. The data were then plotted on the maps on a percentage basis to eliminate differences in range of fluctuations between wells. The maps resulting from this procedure are believed to be representative of the regional effects of the drought on ground-water levels.

In the box at the bottom of the sheet are graphs showing the accumulated deficiency in runoff (streamflow) at five selected gaging stations in the region during the drought years. A downward slope of the accumulated-deficiency line for any period indicates deficient flow in that period. A second group of graphs shows the fluctuations of ground-water levels in selected wells in different parts of the region. For each well the observed water levels during the drought years are compared with the average low levels in that well for the base period (1946 to 1960). The graphs were selected as representative of the varying conditions in different parts of the region. They are keyed to the maps by numbers and letters.

History and Impact of the Drought

Although climate is the underlying natural physical factor in determining the severity of a drought, other factors such as the concentration of human beings and the normal pattern and intensity of human activity in the affected area are equally important. For example, if the area of subnormal precipitation should drift out to sea, as it once seemed inclined to do, it could hardly be said to create a drought there. In the Northeast the drought of the 1960's has affected human activities mainly by its impact upon water resources as reflected in its effects upon agriculture and upon water supply. The water resources available to soften these impacts are the subject of this presentation.

The drought in the Northeast is now well into its fifth year. Already it is the longest and most severe in the history of the region. Its future cannot be foretold, depending as it does upon future precipitation which cannot be predicted very far in advance. There are, however, hydrologic factors that indicate the probable severity of the effects of drought during the coming growing season, in the absence of ample precipitation. Perhaps the most important of these is the volume of water in natural and artificial storage as the growing season begins.

The relation of the growing season to the impact of the drought becomes apparent when it is considered that during that season both agriculture and water supply must be satisfied by the input from precipitation plus the water in storage. Between rains plants draw on water stored in the soil. Thus a soil-moisture deficiency is built up. Water from the next rain cannot pass through the soil to recharge the ground-water reservoir until sufficient moisture has been added to the soil to eliminate the deficiency. In the Northeast, evaporation and the demands of vegetation normally account for virtually all of the precipitation that penetrates the soil during the growing season. Indeed, normal precipitation seldom fully satisfies the requirements of vegetation--hence the need for supplemental irrigation of crops and the fact that at the end of each growing season there is usually an accumulated deficiency in soil moisture. The demands for water supply during a normal growing season in the Northeast must be satisfied by water in storage and by the small portion of the precipitation that runs off immediately in severe storms. Most of the moisture from precipitation is preempted by evapotranspiration.

The largest single source of stored water is the vast quantity of water stored beneath the water table. Other sources include soil moisture, artificial surface reservoirs, and the water stored at the higher stages of lakes, swamps, ponds, and stream channels. The ground-water reservoir is far larger than all the other bodies of stored water combined. It is the primary source of streamflow between periods of rainfall. Even in excessively wet years ground-water discharge, termed "base flow," is a substantial part of the total water discharged through streams. In dry years it is more than 50 percent of the total flow of major streams such as the Delaware, Susquehanna, and Potomac Rivers. More significantly, during the growing season in a dry year ground-water discharge may account for as much as three-fourths of the total discharge of such major streams. Ordinarily in the Northeast, soil moisture and ground-water storage are replenished during each nongrowing season and the system enters each new growing season with the ground-water reservoir full or nearly full and ready to contribute substantially to the streamflow in the coming months. Rarely, and only in times of severe drought, is a deficiency of ground-water storage carried over from one growing season to the next. Such a carryover was observed in the 1964-65 winter and resulted in the record low streamflows in the 1965 growing season. As the 1966 growing season approaches a similar and in some places an even greater carryover of ground-water deficiency is threatened.

Agricultural drought occurs when the soil moisture is so depleted that the yield of crops, pastures, and forests is reduced and as a consequence agricultural operations result in economic loss. A continued decrease in the moisture content of the soil and of the environment may result in total loss of crops and even in the death of forest trees. When such a situation occurs or seems imminent, agricultural drought is said to have reached disaster proportions and State or Federal aid is sometimes invoked. A factor of severe agricultural drought is the development of conditions favoring forest fires, such as occurred in New Jersey in 1963 and in Maine in 1965. In general an agricultural drought is terminated either by rainfall or by the end of the growing season.

Unlike agricultural drought, the manifestations of water-supply drought tend to persist and intensify from one growing season to the next. Water-supply shortages in the Northeast are more closely related to the nature and capacity of the facilities provided for collecting, treating, storing, and delivering water than to the natural availability of water in the region. Such facilities ordinarily require at least a few years for their planning, financing, and construction. In the Northeast during the 1960's a considerable number of water-supply facilities failed. Designed at best to meet a repetition of the less severe 1930 drought and overtaxed by unanticipated increases in population and industry, their capacity to meet the demands placed upon them gradually and progressively declined until the imposition of stringent restrictions on water use became necessary.

An overwhelming majority of the public water-supply facilities in the region continued to meet the demands placed upon them. Many communities moved to utilize planned emergency supplies and accelerated the construction of supplementary facilities.

Nevertheless, in 1965 more than 100 public water supplies in the Northeast found themselves critically short of water or seriously threatened with critical water-supply problems. The President declared a limited national emergency in parts of Delaware, New Jersey, New York, and Pennsylvania, primarily in the so-called Delaware River Basin service area. He also ordered all Federal agencies to assist communities having water-supply problems throughout the drought area by every means at their disposal. The Geological Survey as its share of this activity was directed to locate, identify, and estimate the capacity of sources of emergency supply for communities that had been identified as having critical water-supply problems. Although the accessibility and desirability of emergency supplies varied widely it is believed to be significant that in no case was it found impossible to locate suitable emergency supplies.

This experience, coupled with an analysis of the use of water in the region as compared to the available supply, leads inescapably to the conclusion that there is not and has never been an overall shortage of water for public supply in the region. Where water shortages have occurred the cause has been a shortage of adequate facilities for the collection, storage, treatment, and delivery of water. It would appear that the timely execution of carefully laid long-range plans, together with pollution abatement and reasonable measures of water conservation would make the water supplies of the Northeast region practically droughtproof for many years to come.

1961

Runoff during the year ended September 30, 1961, was near normal for the northeastern part of the United States. Storage in major reservoirs in the Northeast generally was near or above normal as of September 30. During September, streamflow receded throughout much of the area.

Ground-water levels during the year ended March 31, 1962, reached new record lows in six observation wells scattered from southern Maine to western Maryland. (See introductory text for explanation of the different years used.) A total of 72 long-record wells were considered. Only 18 wells reached lows more than 25 percent below the average of the lows recorded in the 1946-60 base period. Annual lows in the majority of the remaining 54 wells were above the average low-water level for the base period.

1962

Runoff during the year ended September 30, 1962, was below normal in a wide band extending from southern Maine and western Connecticut and Massachusetts into northeastern Ohio. Streamflow in much of the Northeast was especially low from May to August. However, rainfall in September alleviated somewhat the serious drought conditions that had been developing.

Ground-water levels during the year ended March 31, 1963, reached new record lows in five observation wells scattered along the Pennsylvania-New York boundary and southward through central Pennsylvania to western Maryland. Two additional wells near the head of Chesapeake Bay also registered record lows. Of 72 observation wells, 32 recorded lows more than 25 percent below the average of the lows recorded in the base period. In only 13 wells were the annual lows near normal or above.

Water-supply conditions in the Delaware River Basin became serious, and the Delaware River Master ordered large releases of water from the New York reservoirs to maintain the required flow in the river.

Shortage of water for crops and lawns was prevalent throughout New England and New York. Serious agricultural drought in some counties in New York resulted in the declaration of an emergency to make special assistance available to farmers there.

1963

During the year ended September 30, 1963, streamflow receded sharply, beginning in January, after maintaining near normal levels from October through December 1963. Low streamflow persisted throughout the Northeast through September.

Ground-water levels for the year ended March 31, 1964, reached new record lows in 10 observation wells located along the Pennsylvania-New York boundary and extending southwestward into Ohio, and in six additional wells extending from central Pennsylvania southward into Virginia and eastward toward the head of Chesapeake Bay. Of the 72 observation wells, 51 recorded lows more than 25 percent below the average of the lows recorded in the base period. In only five wells were the annual lows near normal or above.

By May, storage in the New York City reservoir system dropped to 42 percent of capacity, the lowest of record for that time of year. Only conservation releases were made from the city's Delaware River Basin reservoirs; the effect was reduction of the already low flows into the head of the estuary. Salinity in the lower Delaware estuary rose sharply as a result.

Many shallow wells went dry, especially in Vermont, Connecticut, and Ohio.

1964

Runoff for the year ended September 30, 1964, was below average in a large part of the Northeast, from southern Vermont and New Hampshire southward through western New Jersey and eastern Pennsylvania. Drought conditions intensified in the Delaware River Basin, and the river's flow in September was the lowest of record at Montague. Flow at Montague had been below normal in 32 of the 37 months since August 1961. After moderate winter runoff, streamflow declined to record lows during the summer.

Ground-water levels for the year ended March 31, 1965, fell to new record lows in 18 observation wells, extending the drought area from the nucleus of the previous year in every direction except westward. Of the 72 observation wells, 52 recorded lows more than 25 percent below the average of the lows recorded in the base period. In only nine wells were the annual lows near normal or above. At the end of March 1965, ground-water levels were exceptionally low for that time of year.

By August, many small communities were experiencing water shortages. Water-use restrictions were imposed on several communities in New York, Massachusetts, and Rhode Island.

New York reported a drought-caused reduction in agricultural production, and closed forests because of fire hazard resulting from extreme dryness.

1965

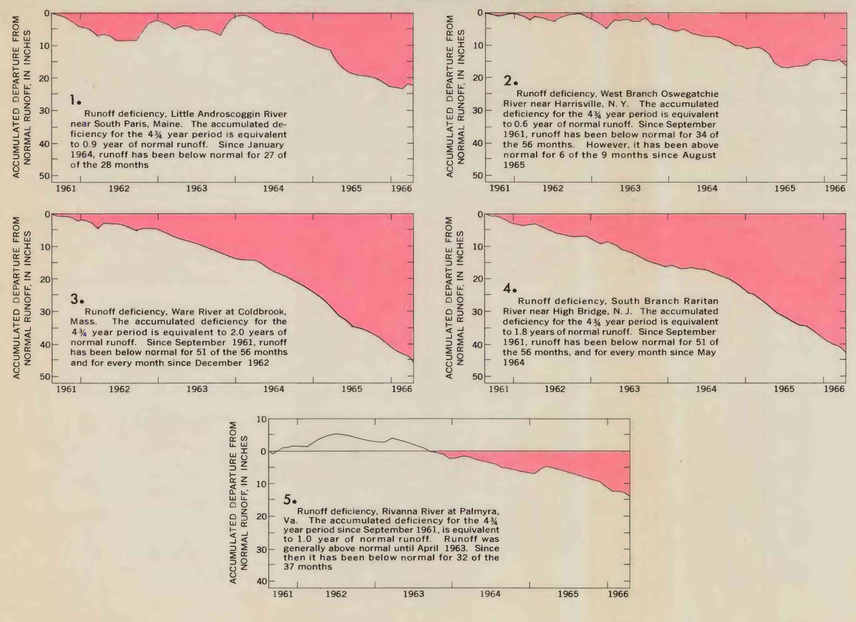
Drought conditions persisted and intensified throughout much of the Northeast during the year ended September 30, 1965. Streamflow was much below normal, and during the year many streams reached record lows, partly as a result of stage-forecaster of ground-water deficiency from the previous growing season. At the year's end, the salt front of 250 ppm (250 parts per million of chloride) was advancing upon the Philadelphia water intake as a result of the exceptionally low flows in the Delaware River.

Ground-water levels for the year ended March 31, 1966, registered new record lows in 14 observation wells. Of the 72 observation wells, 45 recorded lows more than 25 percent below the average of the lows recorded in the base period. In only 11 wells were the annual lows near normal or above.

On August 18, President Johnson declared that those parts of the States of Delaware, New Jersey, New York, and Pennsylvania included within the Delaware River Basin and its service area were affected by the drought to the extent that Federal assistance was warranted to accomplish certain specific emergency actions. Critical water shortages were identified in almost a score of public water supplies outside the Delaware Basin ranging from New Hampshire to Pennsylvania. Federal assistance was provided to them. Several hundred communities in the region experienced water shortages sufficient to require restrictions on water use during the year; many of these were in Massachusetts.

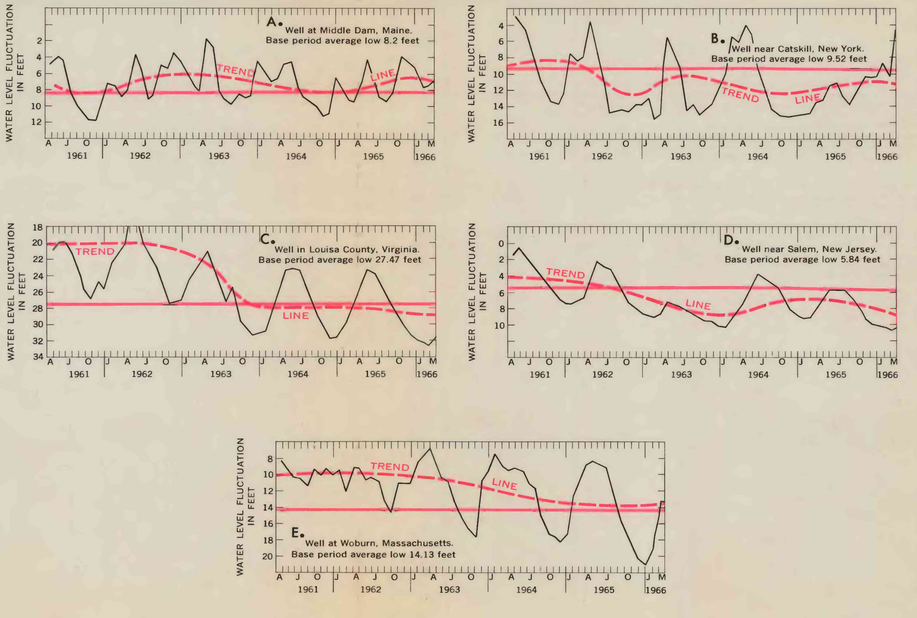
TREND IN STREAM FLOW AT SELECTED SITES DURING THE DROUGHT

For location of sites, see appropriate numbers (1 to 5) in maps above



TRENDS IN WATER LEVELS IN SELECTED OBSERVATION WELLS DURING THE DROUGHT

For location of sites, see appropriate letters (A to E) in maps above



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