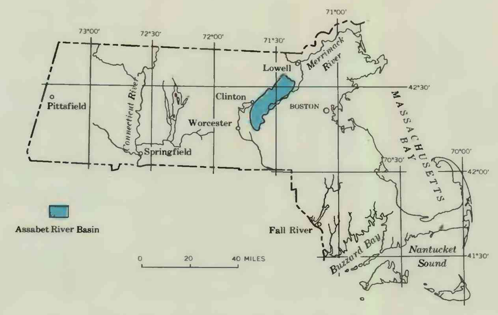
INTRODUCTION

The Assabet River drainage basin has an area of approximately 177 square miles and includes all or parts of the following 20 towns in Worcester and Middlesex Counties in central Massachusetts (see index map): Acton, Berlin, Bolton, Boxborough, Boylston, Carlisle, Clinton, Concord, Grafton, Harvard, Hudson, Littleton, Marlborough, Maynard, Northborough, Shrewsbury, Stow, Sudbury, Westborough, and Westford.



Index map showing location of Assabet River Basin

The growing population's water supply consists of approximately 63 percent surface water and 37 percent ground water (1964) provided mainly through municipal supplies. To aid the towns in increasing the water supplies and in planning water-resources development, the U.S. Geological Survey made a study in 1965 of the Assabet River drainage basin with particular emphasis on ground water.

Much of the most favorable area for ground-water development (see map) is underlain by sand and gravel of relatively high permeability. However, fine-grained materials of low permeability exist both adjacent to and interlayered with the better aquifer materials. The lateral and vertical extent of the coarser water-bearing materials can be delineated only by intensive subsurface exploration.

Further ground-water supplies in the basin may have to be developed from wells yielding 100-150 gpm (gallons per minute) distributed throughout the basin in these most favorable areas. However, localities where higher safe yields can be obtained may exist along perennial streams. The two most favorable of these localities are along the Assabet River in the town of Stow; one near the Assabet Country Club and the other a short distance upstream on "Crows Island". Seismic investigations in these two areas showed saturated thicknesses of 50 to 70 feet and velocities indicative of loosely packed materials.

The chemical quality of most of the ground water in the basin is generally suitable for most uses although iron and manganese may be a problem locally. A lack of water-quality data prohibits a comprehensive discussion of this subject.

Acknowledgment is made to the representatives of the water departments of the towns in the Assabet Basin who furnished data on wells, borings, and pumpage.

GROUND WATER AVAILABILITY

Yields and Recharge

The yields of individual wells in the Assabet River Basin are limited by at least two factors: (1) permeability of the saturated materials adjacent to the well, and (2) extent of these saturated materials both laterally and vertically.

The more permeable materials are sand and gravel deposits found generally in valleys bounded by till and bedrock. These deposits are confined by the relatively impermeable sides and bottoms of the valleys and are discontinuous along the valleys.

Recharge to these deposits may come from four sources: (1) precipitation; (2) adjacent till and bedrock valley sides; (3) hydraulically connected stratified deposits up-gradient; and (4) adjacent stream by induced recharge.

The first two sources of recharge may be considered to be the same for all such deposits. Recharge may be developed from hydraulically continuous deposits upstream if the gradient established by the pumped well extends to the upstream deposit. If the aquifer material and the pumping gradient extend to the stream, water will flow from the stream through the aquifer to the well. In such cases, it may be possible to divert the entire flow of the streams to the well, thereby expanding the yield limit of the well to include the low flow of the stream.

Great thicknesses of permeable materials adjacent to perennial streams offer the greatest potential for recovering the most water per well by virtue of the hydraulic connection to the streams.

MAP SHOWING AREAS FAVORABLE FOR DEVELOPMENT OF GROUND-WATER RESOURCES

EXPLANATION

Areas where most wells will yield less than 25 gallons per minute. The aquifer consists of poorly permeable material, chiefly till and bedrock, but also includes some areas of sand and gravel, the saturated thickness of which generally is less than 25 feet

Areas where yields from properly constructed wells may range from 25 to 75 gallons per minute (also includes some areas whose ground-water potential is unknown). In these areas the aquifer consists of sand and gravel, the saturated thickness of which generally is greater than 25 feet

Areas most favorable for the location of wells that may yield more than 75 gallons per minute. This unit generally consists of sand and gravel, the saturated thickness of which is greater than 25 feet. Although yields from wells in these areas may, in places, range as high as 500 gallons per minute, the most common safe yield to be expected from properly constructed wells is probably in the 100 to 150 gallons per minute range

0.258
Location of public-supply wells. Number is average daily pumpage in millions of gallons per day for 1964

0.711
Location of public-supply surface-water reservoirs. Number is average daily pumpage, in million gallons per day for 1964

Stream-gaging station

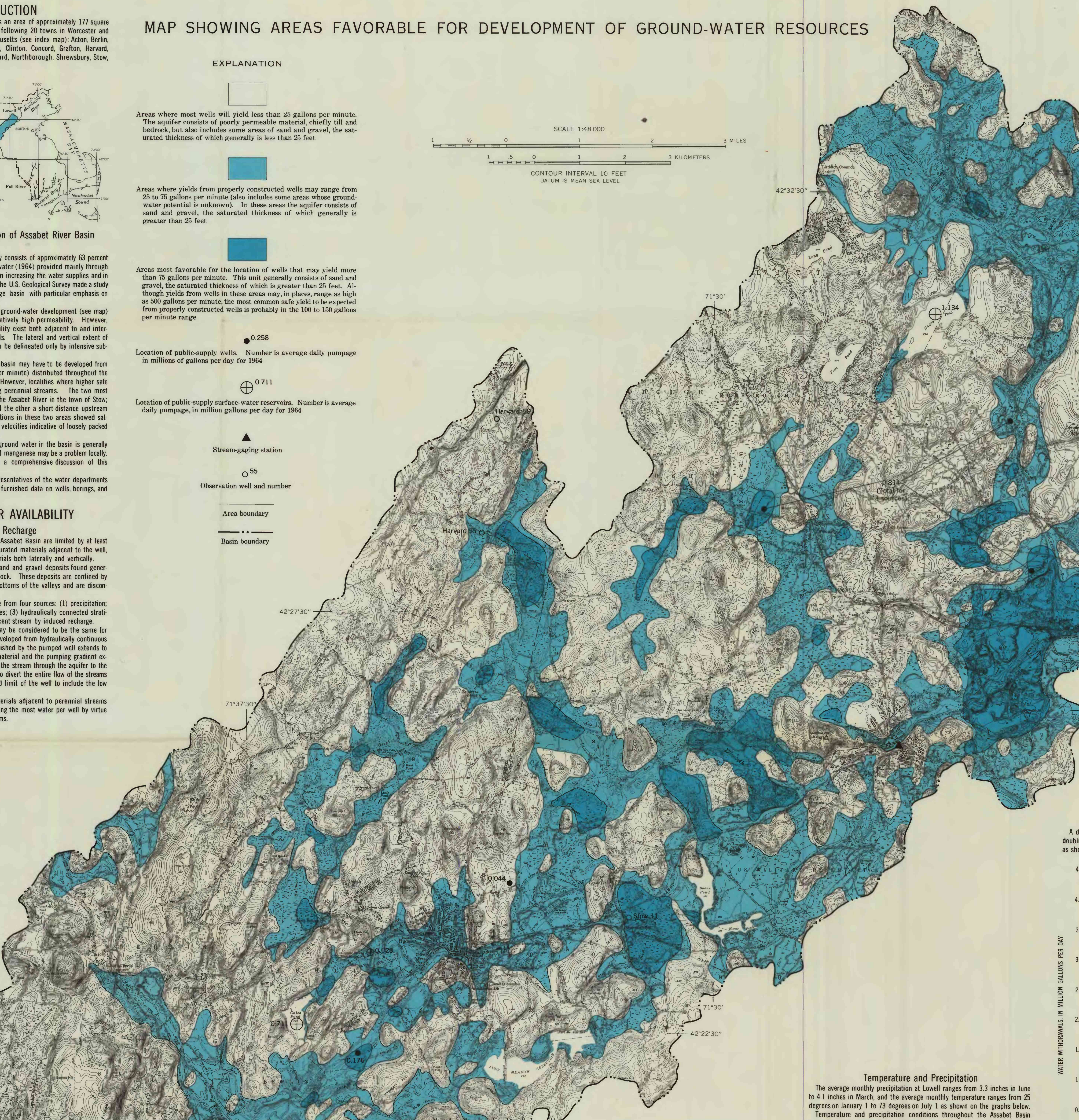
55
Observation well and number

Area boundary

Basin boundary

SCALE 1:48 000

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL



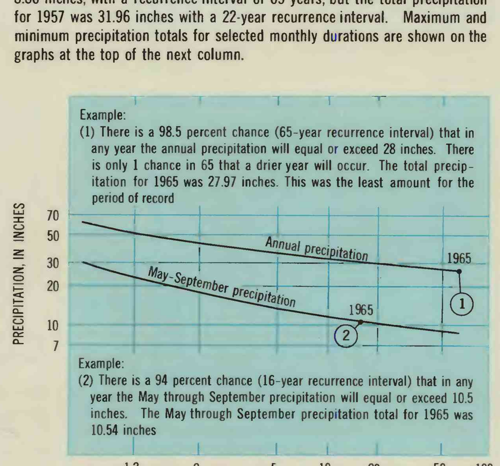
APPROXIMATE MEAN DECLINATION, 1969

Base map from U.S. Geological Survey topographic quadrangles: Ayer, 1935–50; Westford, Mass., 1939–50; Billerica, 1939–50; Clinton, Mass., 1923–50; Hudson, 1923–50; Maynard, 1941–50; Concord, 1942–58; Shrewsbury, 1941–53; Marlboro, 1941–53; Grafton, 1943–53

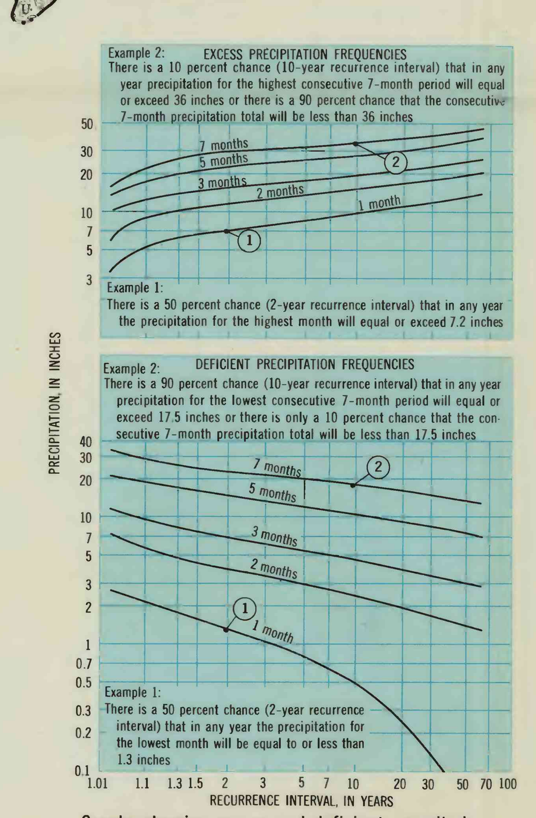
PRECIPITATION —The primary source of water

Magnitude and Frequency of Occurrence

Magnitude and frequency relations of precipitation for selected durations can be used to determine precipitation totals for the durations as shown by the graph below. The least May-September precipitation occured in 1957, 8.86 inches, with a recurrence interval of 65 years, but the total precipitation for 1957 was 31.96 inches with a 22-year recurrence interval. Maximum and minimum precipitation totals for selected monthly durations are shown on the graphs at the top of the next column.



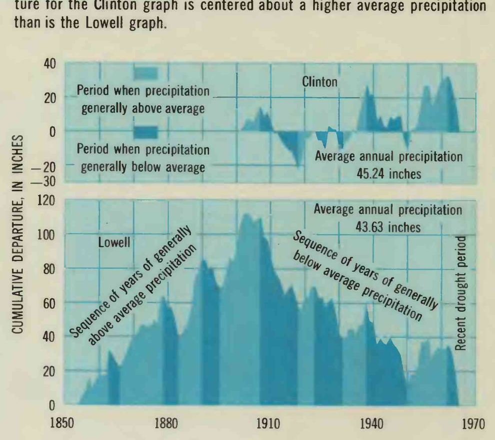
Graph showing magnitude and frequency of precipitation at Clinton (1902-65)



Graphs showing excess and deficient magnitude and frequency relations of selected consecutive monthly durations for precipitation at Clinton (1902-65)

Cumulative Departures from Average

Precipitation from 1901 to 1965 at Clinton followed the same general year-to-year trend as at Lowell. The shorter Clinton record does not include the greater than average precipitation that occurred between 1854 and 1902, as shown in the Lowell graph below. Therefore, the graph of cumulative departure for the Clinton graph is centered about a higher average precipitation than is the Lowell graph.

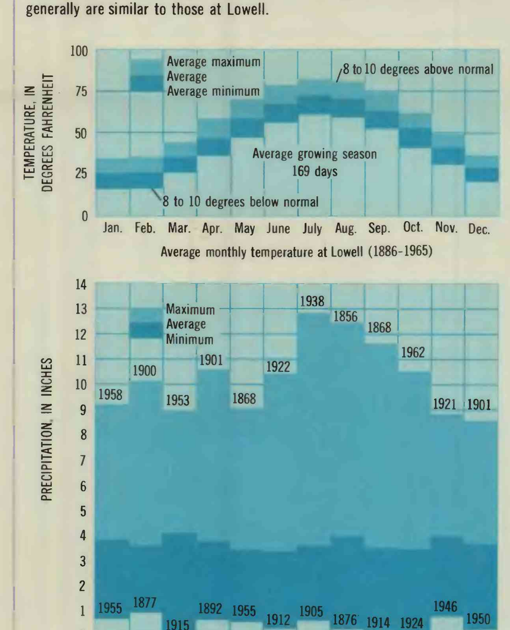


Graphs showing cumulative departure from average annual precipitation at Clinton (1901-65) and at Lowell (1854-1965)

Temperature and Precipitation

The average monthly precipitation at Lowell ranges from 3.3 inches in June to 4.1 inches in March, and the average monthly temperature ranges from 25 degrees on January 1 to 73 degrees on July 1 as shown on the graphs below.

Temperature and precipitation conditions throughout the Assabet Basin generally are similar to those at Lowell.



Graphs showing average monthly temperature and precipitation at Lowell

WATER AVAILABILITY AND USE

Water Budget for 1965

Average runoff in the Assabet River drainage basin is about half of the water that enters the basin as precipitation (see diagram below), of which only a small percentage is used by man.

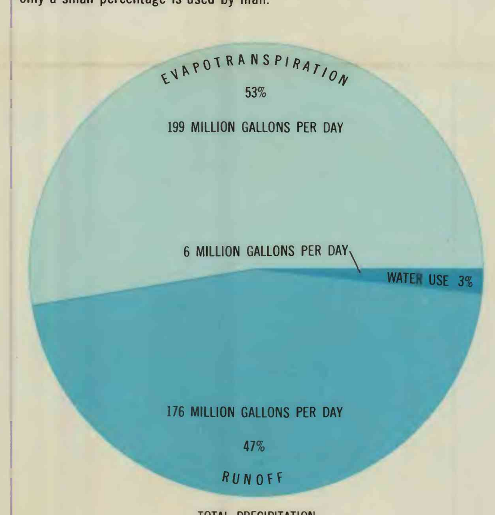
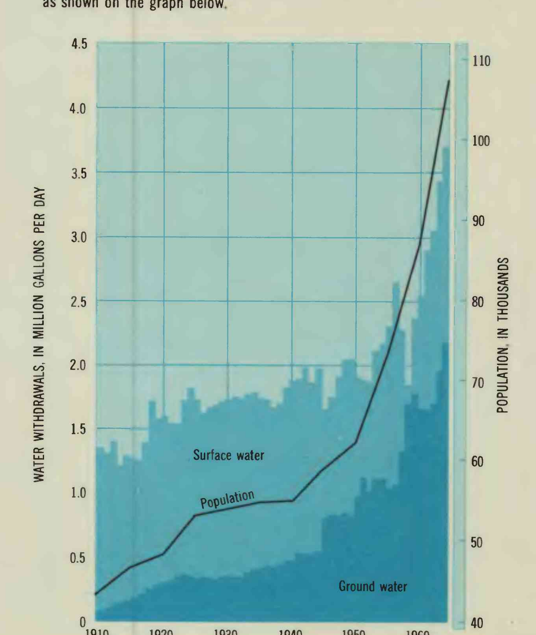


Diagram showing water budget for 1965

Annual Water Withdrawals and Population

A doubling of the population from 1920 to 1964 was accompanied by a doubling of surface-water use and a seven-fold increase in ground-water use as shown on the graph below.



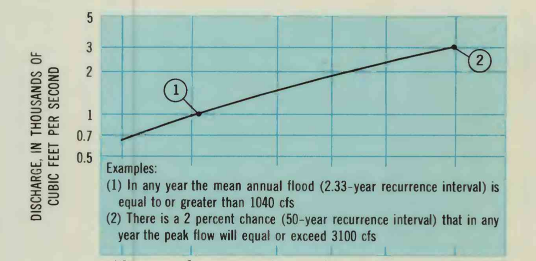
Graph showing annual water withdrawals and population

STREAMFLOW

Frequency of Floods

A knowledge of the magnitude and frequency of floods that may be expected is essential in proper design of flood-control structures, bridges, culverts, or other structures affected by floods and in studies of flood damage.

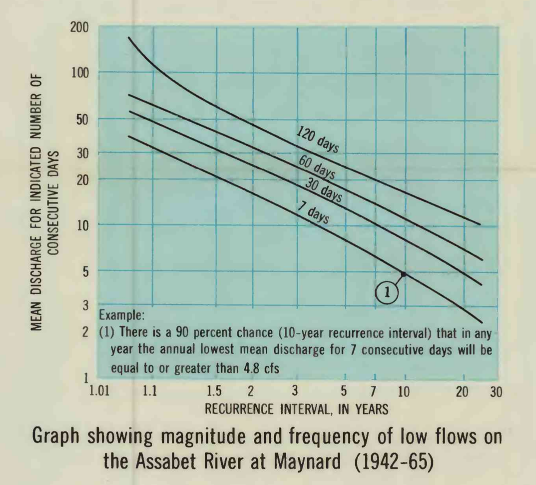
Data on the magnitude and frequency of floods (see graph below) may be used to estimate the percent chance of occurrence in any year if there are no significant hydrologic changes. A recurrence interval is the average interval of time within which the given flood will be equaled or exceeded once.



Graph showing magnitude and frequency of floods on the Assabet River at Maynard (1942-65)

Frequency of Low Flows

Low-flow frequency curves (see graph below) show the average interval at which a specific discharge may be expected to recur as the lowest discharge in the climatic year (April 1 to March 31) and the maximum number of days during which the flow would be equal to or less than a specified discharge.

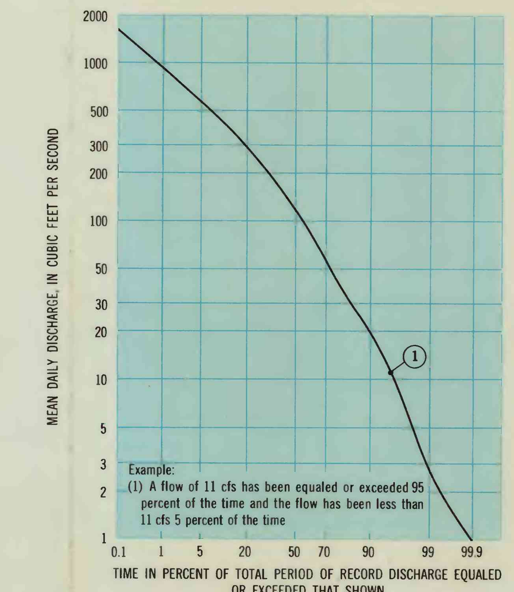


Graph showing magnitude and frequency of low flows on the Assabet River at Maynard (1942-65)

Flow Duration

The flow-duration curve (see graph at the top of the next column) is a cumulative frequency curve that shows the percent of time specified discharges were equaled or exceeded for the period of record.

In a strict sense, a duration curve applies only to the period for which data were used to develop the curve. However, if the period is long enough to give a reasonable representation of the flow pattern and if no appreciable change is made in the drainage basin, a duration curve may be used to estimate the percent of time a specified discharge will be equaled or exceeded in the future. By simple subtraction the percent of time that flow may be equal to or less than a specified amount may also be estimated. However, the curve does not show either how frequently or the number of consecutive days during that period of time discharges of a lesser magnitude will occur.



Flow duration curve of the Assabet River at Maynard (1942-65)

AQUIFERS AND WELLS

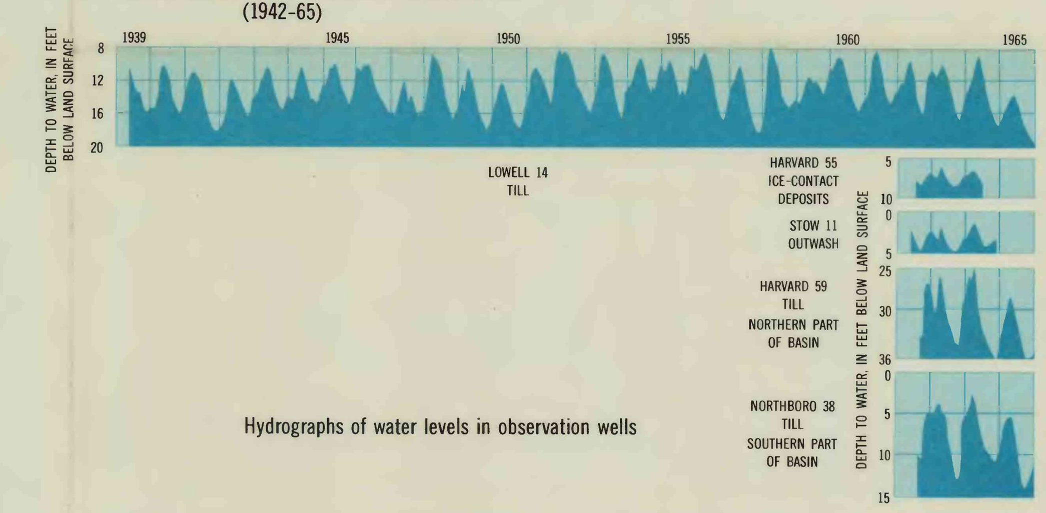
Fluctuation of Ground-Water Levels

Ground-water levels in the basin fluctuate in an annual cycle (see well hydrographs). The water levels are at their lowest in the fall at the end of the growing season. During the winter and spring the water levels rise, generally reaching their highest point just before the start of the growing season in the spring. During the growing season water levels generally decline.

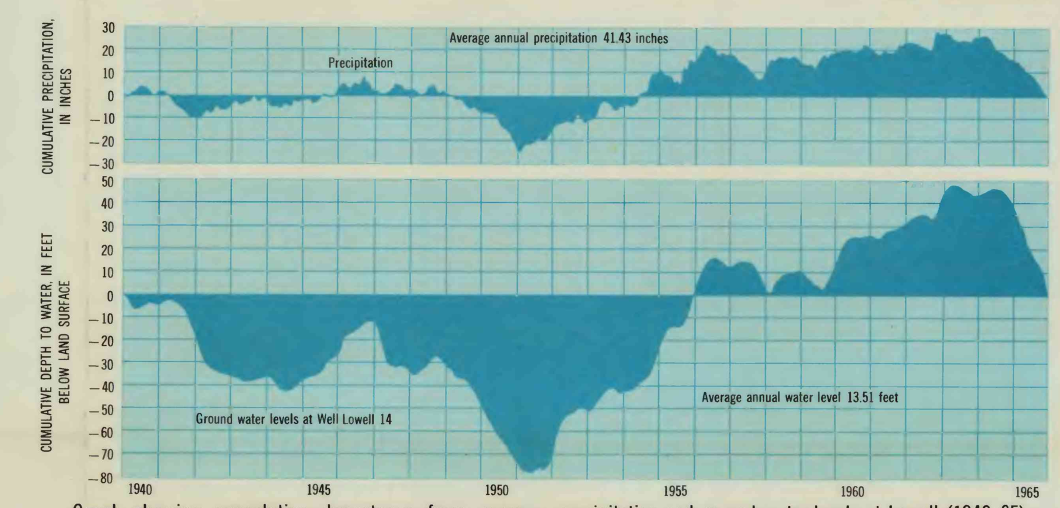
The magnitude of annual ground-water fluctuations in any given well depends upon the nature of the aquifer and the topographic position of the well. Water levels in till and bedrock generally fluctuate more than water levels in unconsolidated ice-contact and outwash deposits (see well hydrographs). Because of topography and ground-water gradients, water levels beneath hills and slopes generally fluctuate more than water levels in valleys. Fluctuations of ground-water levels provide an index to storage and, thus, safe yield of an aquifer.

The ground-water levels in well Lowell 14, approximately 7 miles north of the Assabet Basin (see graph below) show some long-term departures from average in the period of record.

The drought period, as shown by the cumulative departure from the precipitation average, actually began in the fall of 1962. The effect of below normal precipitation, however, was not shown by the cumulative departure from the average ground-water level until about six months later.



Hydrographs of water levels in observation wells



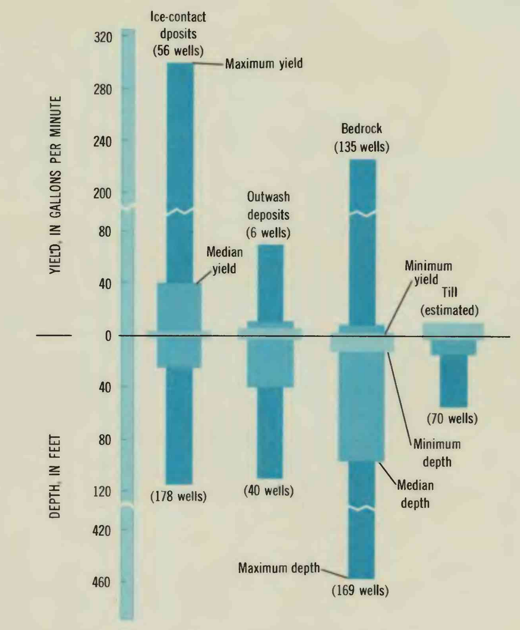
Graph showing cumulative departures from average precipitation and ground-water levels at Lowell (1940-65)

Relationship of Well Depth to Yield of Aquifer

The depth and yield of wells depends mainly upon the materials encountered in constructing the well.

Wells completed in ice-contact deposits generally have the highest yields, wells in outwash have somewhat lower yields, wells in bedrock yield even less, and wells in till yield very small amounts of water, generally less than 10 gpm (see graph at right).

Most wells are deepened below the level at which water is first found in order to provide storage. This is particularly true of bedrock wells. In bedrock, the water is found in cracks in the rock that are randomly distributed and generally decrease in abundance with depth.



Graph showing relationship of well depth to yield of aquifer

COMPARISON OF AIR TEMPERATURE, GROUND-WATER LEVELS, STREAM DISCHARGE, AND PRECIPITATION, 1962

The graphs below show the fluctuations of four selected hydrologic parameters during 1962. In the spring, the river discharge increased and the ground-water levels rose. These increases probably resulted from a combination of snowmelt and rainfall. During the growing season, approximately May-September, when evapotranspiration is greatest and recharge is least, the ground-water levels and river discharge both declined. Very large rainstorms in the fall contributed to an abrupt rise in the ground-water level and the river discharge.

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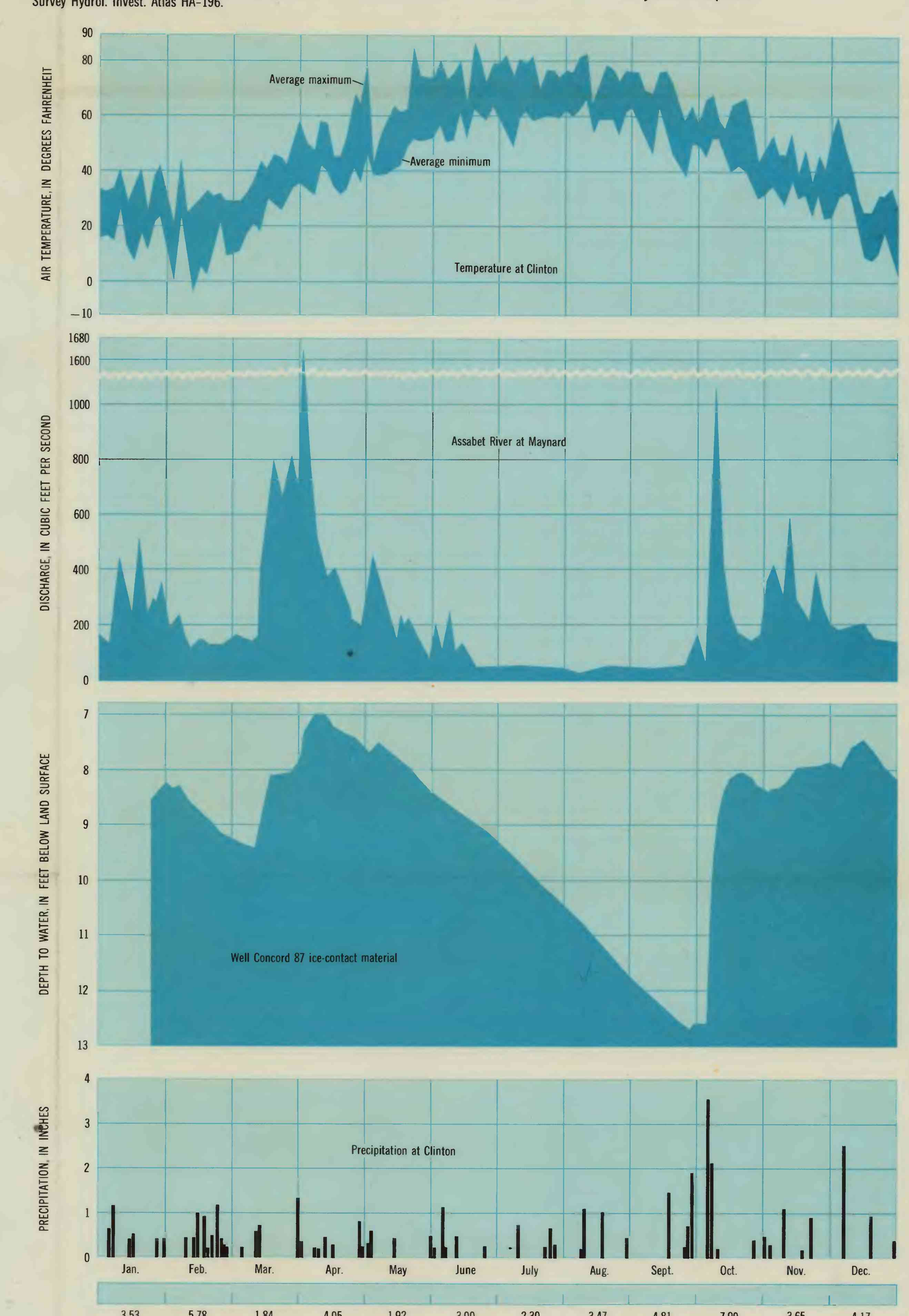

Graphs showing comparison of air temperature, ground-water levels, stream discharge, and precipitation, 1962

WATER RESOURCES OF THE ASSABET RIVER BASIN, CENTRAL MASSACHUSETTS

By
S. J. Pollock, D. F. Farrell, and W. W. Caswell
1969