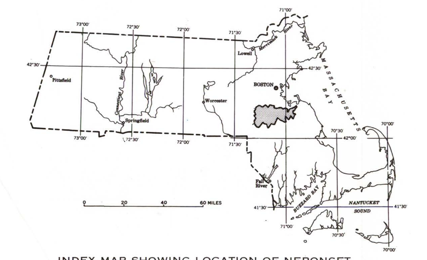
PREPARED IN COOPERATION WITH
THE MASSACHUSETTS WATER RESOURCES COMMISSION
BOSTON, MASSACHUSETTS

INTRODUCTION

Because of rapidly increasing needs for water supplies, the U.S. Geological Survey in cooperation with agencies of the Commonwealth is investigating the water resources of Massachusetts. The goal of the investigation is to provide information for use in water-resources planning and to aid in the selection of sites for potential water-supply development. The investigation is subdivided into a series of river-basin studies. The regions included in this report are those parts of the Neponset, Weymouth Fore, and Weymouth Back River basins that are upstream from the tide-affected or heavily-urbanized areas of their lower basins (see index map). These streams drain the area south of Boston and flow in a northerly direction to Boston Harbor. The study area encompasses 135 square miles of gently rolling terrain having a local relief of generally 50 to 100 feet.



INDEX MAP SHOWING LOCATION OF NEPONSET AND WEYMOUTH RIVER BASINS (SHADED)

SUMMARY

Precipitation in the study area is fairly uniformly distributed. On the average, the eastern watersheds receive about 2 inches per year more than those in the west. Average precipitation is about 45 inches per year. Of this, about 22 inches is lost through evapotranspiration, about 20 inches is discharged from the area as streamflow, about 2 inches is piped out as sewage or for use outside the area, and the remainder leaves as ground-water underflow.

Outflow from many of the subbasins is affected by ground-water pumpage, and most of the major streams are affected additionally by regulation of storage facilities. Low flows in tributary streams vary considerably because of differences in ground-water discharge brought about by ground-water withdrawals and by diversities of the geology (7-day, 10-year recurrence interval low flows range from 0.00 to 0.27 cubic feet per second per square mile). Because of the abundance of storage space available in the reservoirs, ponds, and wetlands and because the flood plains are relatively undeveloped, floods are not a major problem. At times, Mill River and Mine Brook were found dry in the vicinity of well fields, and data indicate there may be reduction of flow in the main stem of the Neponset River near well fields. These losses of streamflow emphasize the interdependence and interaction of surface water and ground water.

Aquifers of glacial stratified drift overlie about half the area. In some parts of the Neponset River valley, these deposits are more than 150 feet thick. Where the transmissivity of the drift is high, the aquifers are favorable for the development of large-capacity wells. The estimated average recharge to the stratified drift is approximately 55 mgd (million gallons per day), and the total recharge is about 80 mgd. Municipal pumpage, which accounts for all but a small percentage of the ground-water withdrawal, averaged about 10 mgd in 1969. Although ground-water development may be expanded, planning of well sites should include factors other than just desired yield and existing ground-water quality. Wells drilled near streams may capture part or all of the water flowing in the streams. This alone might be considered undesirable, but, in addition, such infiltrated water could seriously degrade the quality of the ground water supply if the surface water happened to be polluted or highly mineralized. Locally, the chemical quality of ground water has been deteriorating during recent years.

Surface water and ground water are generally soft to moderately hard and mildy acid. The major quality problems in most streams and in much of the ground water are concentrations of iron and manganese that exceed the limits recommended for public water supplies by the U.S. Public Health Service. Color also exceeds these limits in most streams. Although the chloride concentration in surface water and ground water presently exceeds the limit of 250 milligrams per liter in only rare instances, it has increased significantly in ground water, and presumably in surface water, since about 1960. The chloride increase has been accompanied by an increase of hardness in ground water. These increases of dissolved solids reflect the increased use of highway salting chemicals and increased loads from dumps, septic systems, and other sources.

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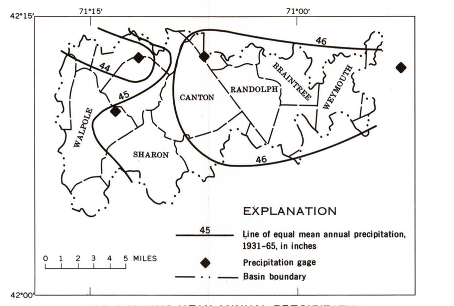
GLOSSARY

Aquifer	An aquifer is a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs[1]
Evapotranspiration	Water withdrawn from a land area by evaporation from water surfaces and moist soil and plant transpiration[2]
Ground water	That part of the subsurface water in the zone of saturation[3]
Infiltration	The flow of a fluid into a substance through pores or small openings. It connotes flow into a substance in contradistinction to the word percolation, which connotes flow through a porous substance[2]
Recharge	The process by which water is absorbed and is added to the zone of saturation[4]
Storage, ground water	The volume of water in the saturated zone
Transmissivity	The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient[1]
Yield, optimum	In this report refers to the rate at which a well will pump water most efficiently. This occurs when drawdown at the well is about equal to two-thirds of the saturated-zone thickness.
Yield, "safe"	The rate at which water can be withdrawn from an aquifer for human use without depleting the supply to such an extent that withdrawal at this rate is no longer economically feasible[4]
Zone, saturated	In the saturated zone all voids, large and small, are ideally filled with water. The water table is the upper limit of this zone, and the water in it is under pressure greater than atmospheric[1]

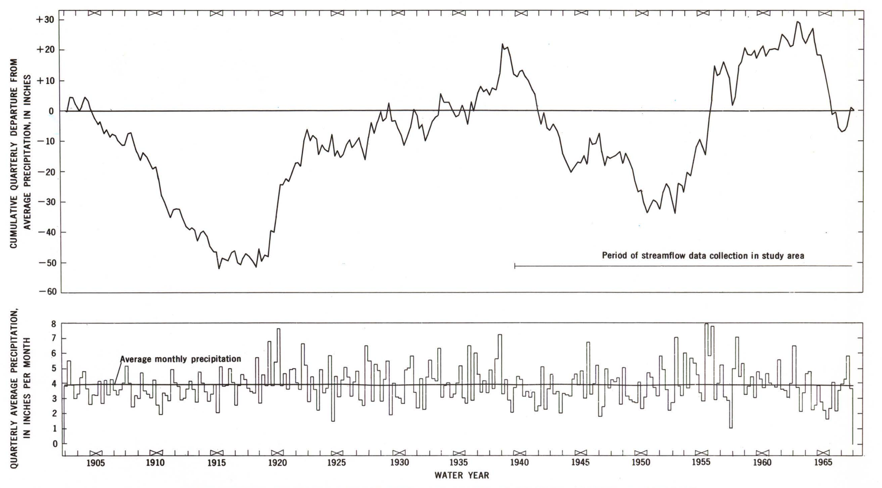
[1] Lohman and others, 1970
[2] Langbein and Iseri, 1960
[3] Meinzer, 1923a
[4] Meinzer, 1923b

PRECIPITATION

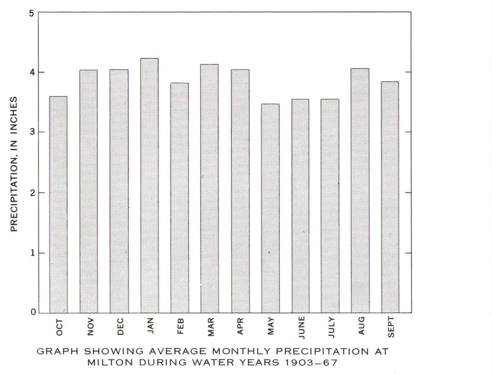


MAP SHOWING MEAN ANNUAL PRECIPITATION

The eastern half of the study area receives about 5 percent more precipitation than the western half. Average precipitation in the study area is about 45 inches.



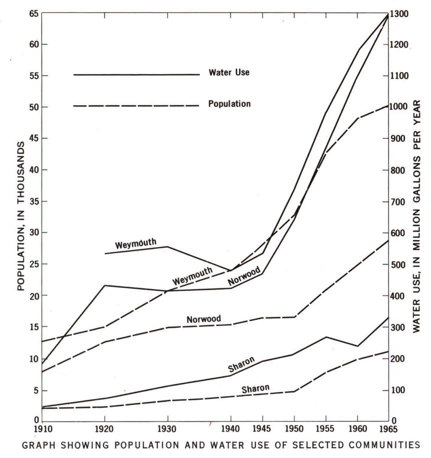
GRAPH SHOWING QUARTERLY AVERAGE PRECIPITATION AND CUMULATIVE QUARTERLY DEPARTURE FROM AVERAGE PRECIPITATION AT MILTON, WATER YEARS 1903–67



GRAPH SHOWING AVERAGE MONTHLY PRECIPITATION AT MILTON DURING WATER YEARS 1903–67

Long-term precipitation trends are reflected by the cumulative sums of the differences (departures) between quarterly precipitation and average quarterly precipitation. For instance, precipitation at Milton was essentially below average during the 11-year period 1905–15 and above average during the 19-year period 1920–38. Droughts are shown as prolonged steeply downward lines, for example, 1949–50 and the mid 1960's. The graph demonstrates that long-term hydrologic data must be available in order to determine parameters that are representative of average or normal conditions. For instance, if only data for a period such as 1951–56 were used in an analysis, over-optimistic figures of long-term water availability would result.

WATER USE



GRAPH SHOWING POPULATION AND WATER USE OF SELECTED COMMUNITIES

Population and industrial expansion, particularly after World War II, have caused an increase in water use. Pumpage for municipal supplies increased from about 3 billion gallons during 1945 to about 6 billion gallons during 1965. At present rates of increase, municipal pumpage would rise to about 13 billion gallons per year in the year 2000.

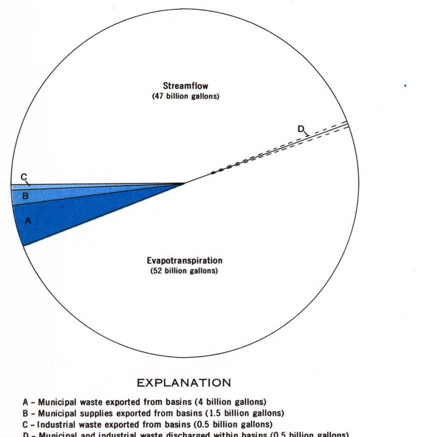


DIAGRAM SHOWING DIVERSIONS FROM STUDY AREA

The amount of water pumped in the study area and ultimately released outside of the area is equal to approximately 6 percent of the precipitation. Water returned to streams or aquifers within the area is about 0.5 percent of the precipitation. Pumpage from surface-water and ground-water sources is about equal. Streamflow and evapotranspiration are estimates of long-term averages. Pumpage and estimates of waste are based on 1965 data.

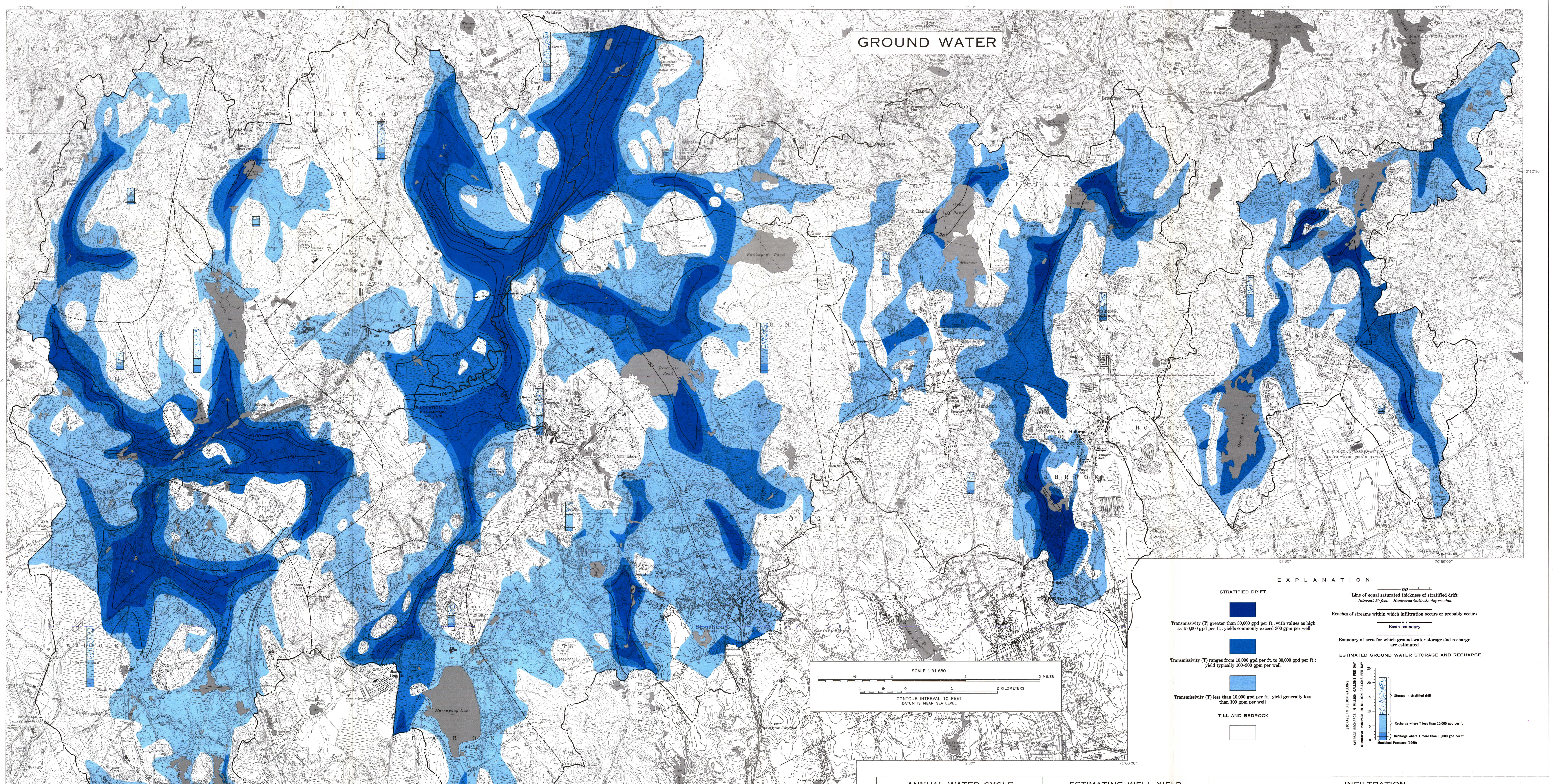
HYDROLOGIC BUDGET

	Neponset River at Norwood (35.2 sq mi) Inches	East Branch Neponset River at Canton (27.2 sq mi) Inches
Precipitation	43.7	45.2
- Streamflow	-19.5	-22.6*
- Ground-water seepage	-.1	-2.3
- Diversions	-2.4	-1.1
= Evapotranspiration	21.7	19.2*

*Streamflow may include some ground water originating in the Taunton River basin. Consequently, calculated evapotranspiration may be somewhat less than actual.

The budgets are computed from data collected during or statistically extended to the period 1940–67. The magnitudes of the budget components probably are representative for the study area as a whole. However, in smaller basins where pumpage or vegetal cover differs from overall conditions, they may not be representative. The base period of the budgets probably represents long-term conditions well because average precipitation during the base period was about equal to that during 1903–67.

GROUND WATER



Base from U.S. Geological Survey 1:24,000
Norwood, Blue Hills, Weymouth, Medfield, 1951;
Brockton, 1946; Mansfield, 1946; Wrentham, 1945

GROUND-WATER FAVORABILITY MAP

Large parts of the Neponset River basin could provide good to excellent sources of ground water for the development of industrial or municipal supplies. Recharge to the ground-water reservoirs indicates water potentially available for development. Induced infiltration of surface water and salvage of evapotranspiration may increase available supply substantially.

Three aquifers capable of yielding water to wells are bedrock, glacial till, and stratified drift. These three rock units form the ground-water reservoir. Wells in bedrock and till capable of yielding a few gallons per minute are common. Because wells in bedrock and till have low yields, they are subject to wide seasonal fluctuations of water level and may go dry occasionally. Hence, they are less reliable than wells in stratified drift.

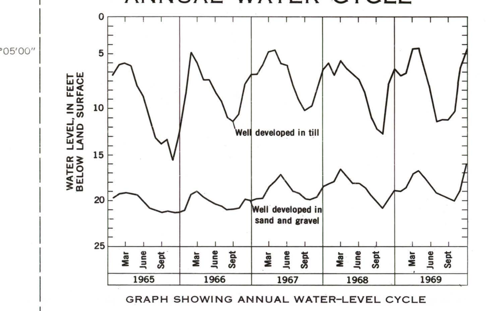
The principal source of ground water is the stratified drift that occupies about 52 percent of the study area and is composed of gravel, sand, silt, and clay in discontinuous layers. Accumulations of stratified drift of 100 feet or more form ground-water reservoirs of significant economic value. Where saturated sand and gravel beds are sufficiently thick, high-capacity wells yielding 300 gpm (gallons per minute) or more can be developed. Favorable areas for gound water shown on the map are interpreted from sparse data and are intended to show only the areal extent and general distribution of the best aquifers. Development of a successful well at a particular site may require test drilling to determine the location of the most productive sand and gravel deposits.

Recharge to the ground-water reservoir is estimated to average 80 mgd (million gallons per day). Of this amount, recharge in the more favorable stratified drift deposits, where large-capacity wells could be developed (transmissivity over 10,000 gpd per ft), averages about 25 mgd. An additional 30 mgd occurs in deposits of stratified drift where the thickness is inadequate for the development of large-capacity wells. However, much of this recharge seeps to the thicker drift deposits. The estimated recharge in till is 25 mgd. Only a small part of this recharge is available for development because of the low water-yielding characteristic of till.

Ground-water storage in the stratified drift is about 95 billion gallons, and that in till is approximately 15 billion gallons. Municipal pumpage during 1969 was about 10 mgd or 12 percent of the estimated total recharge.

Recharge, storage, and pumpage information are shown in more detail by subdividing the study area into 16 smaller areas. In each of these areas, the annual municipal pumpage was less than the average yearly recharge. In any of the areas pumping may be maintained at a higher rate than the recharge by lowering the water table and consequently reducing evapotranspiration from the ground-water body, by inducing recharge from surface-water bodies, and by recycling waste water returned to the aquifers. Salvage of evapotranspiration may cause changes in plant ecology. Diversion of ground water from ground-water runoff or diversion of surface water to wells will reduce streamflow and may on occasion dry up streams. Infiltration of surface water or re-use of waste water will probably degrade water quality. Therefore, the "safe" yield of the ground-water reservoir will depend in part on the hydrologic, ecologic, and quality changes that are acceptable in order to obtain water.

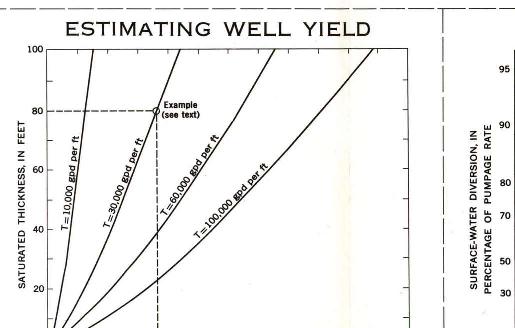
ANNUAL WATER CYCLE



GRAPH SHOWING ANNUAL WATER-LEVEL CYCLE

Typical fluctuations of water table are characterized by high water-levels during the spring, continuous lowering of the table during the summer and early fall, and a continuous rise from fall to spring. Water table changes are usually larger in till than in stratified drift. However, because of the greater porosity of stratified drift the volume of water taken into or released from storage during these fluctuations is usually larger in the stratified drift.

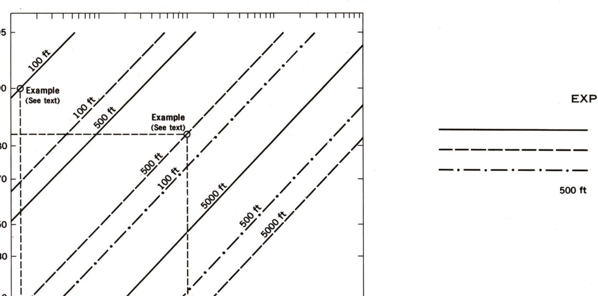
ESTIMATING WELL YIELD



GRAPH SHOWING OPTIMUN YIELD OF 12-INCH DIAMETER WELL DRILLED TO BEDROCK RELATED TO SATURATED THICKNESS AND TRANSMISSIVITY

The optimum yield of a 12-inch well screened in the lower third of the saturated materials and pumped for 200 days of no recharge without lowering the water in the well below the top of the screen can be estimated for a given saturated thickness and transmissivity. For example, if corrections for interference from nearby wells or aquifer boundaries are ignored, a 12-inch-diameter well at site A about 1½ miles west of Canton, shown on the ground-water favorability map, would be expected to yield 360 gpm (gallons per minute), or about 0.5 mgd if the transmissivity is about 30,000 gpd (gallons per day) per foot and the saturated thickness is 80 feet. Doubling the well diameter to 24 inches will increase the yield about 12 percent to 400 gpm, and quadrupling the diameter to 48 inches will increase the yield 26 percent to about 450 gpm.

INFILTRATION



GRAPH SHOWING MAXIMUM PART OF PUMPAGE OBTAINABLE FROM INDUCED INFILTRATION OF WATER FROM NEARBY SURFACE WATER BODY

Streamflow recharges the ground-water reservoir along parts of Bubbling Brook-Bubbling Brook tributary, Mill River, and Mine Brook. Data indicate probable flow loss within the lower reach of the Neponset River also. The infiltration is indicated by streamflow data, and the reaches between the data-collection sites are shown on the ground-water favorability map. Other instances of infiltration may exist in the study area. The flow loss in the Bubbling Brook-Bubbling Brook tributary complex occurs near the inlet to Pettee Pond. Water level in the pond is occasionally lower than streambed elevation, thereby inducing streamflow infiltration. Pumping in municipal wells near the other three channels has lowered ground-water levels and, thereby, presumably causes infiltration. At times, during periods of low flow, sections of Mill River and Mine Brook dry up because of streamflow losses.

Infiltration from a surface-water body to a well at a given distance and in material of a given transmissivity can be estimated from the graph above for conditions of 100 percent hydraulic connection. For example, a well in homogeneous material with a transmissivity of 10,000 gpd per ft, and located 500 feet from a stream may derive about 82 percent of the pumpage from the stream after a year of pumping. A well drilled 100 feet from a surface-water body in material with a transmissivity of 100,000 gpd per ft may obtain 90 percent of its pumpage from surface water within 5 days after pumping begins. The curves are based on the assumption that the supply of water in the surface-water body is always sufficient to meet the potential infiltration rate.

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HYDROLOGY AND WATER RESOURCES OF THE NEPONSET AND WEYMOUTH RIVER BASINS, MASSACHUSETTS

By
R. A. Brackley, W. B. Fleck, and W. R. Meyer
1973

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