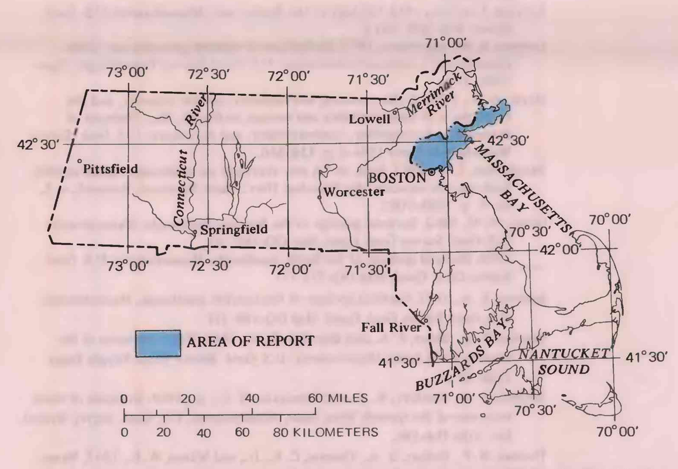
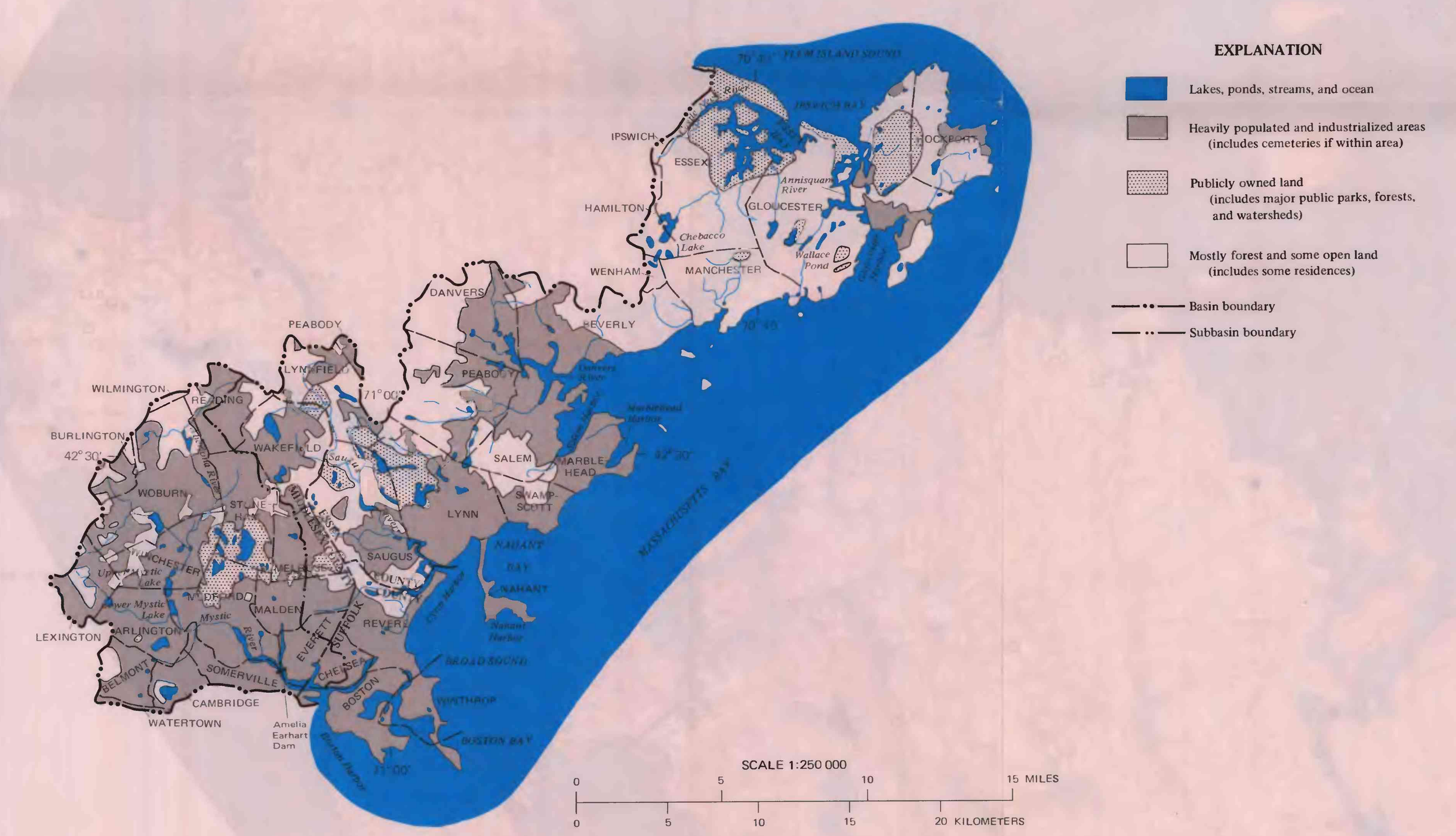
PREPARED IN COOPERATION WITH THE
COMMONWEALTH OF MASSACHUSETTS WATER RESOURCES COMMISSION
BOSTON, MASSACHUSETTS



# INTRODUCTION




LOCATION OF THE COASTAL DRAINAGE BASINS OF NORTHEASTERN MASSACHUSETTS, FROM CASTLE NECK RIVER, IPSWICH, TO MYSTIC RIVER, BOSTON.




**THE STUDY AREA INCLUDES ALL OR PARTS OF 38 MUNICIPALITIES IN ESSEX, MIDDLESEX, AND SUFFOLK COUNTIES.** – *The coastal drainage basins study area lies northeast of the Boston metropolitan area in eastern Massachusetts and is bordered on the northwest by the Ipswich River basin, on the west by the Shawsheen River basin, on the south by the Charles River basin, and on the east and north by the Atlantic Ocean. From north to south, the basin is comprised of four drainage systems: the Annisquam, Danvers, Saugus, and Mystic Rivers, and several smaller drainage systems, all of which drain to the ocean. The area includes approximately 230 mi². Topographic relief is low; altitudes range from sea level to about 350 feet above at the tops of many small rolling hills.*

*The streams have low gradients; for example, the combined Aberjona and Mystic River system loses about 80 feet of altitude in 16 miles from its headwaters in Reading to the Amelia Earhart Dam near its mouth at Boston Harbor. Low relief and poor drainage result in numerous wetlands.*

*Population in the study area was estimated to be 975,000 in 1974. Urbanization has spread inland from the coastal areas and northward from Boston and has been particularly intense in the Mystic River basin. The northern part of the area is forested; however, there is some undeveloped open land, particularly in the towns of Essex, Gloucester, Manchester, and Rockport. Some north-coastal municipalities, particularly Essex, Gloucester, Manchester, and Rockport experience seasonal fluctuations in population because of a large number of summer residences and a flux of tourists.*

*Amount and availability of ground water are determined largely by variations in the type and thickness of unconsolidated deposits overlying bedrock. In most of the study area, bedrock is at or near land surface; in some places it is overlain by a mantle of till. The bedrock aquifer is capable of supplying only a few gallons per minute to wells, the amount needed for domestic supplies. The most productive aquifers, capable of sustaining well yields of several hundred gallons per minute, are composed of sand and gravel deposited during Pleistocene glaciation in the Aberjona, Malden, and Mystic River valleys.*

*This atlas provides information on the quantity, quality, and availability of water in the coastal drainage basins of northeastern Massachusetts. The atlas was prepared by the U.S. Geological Survey in cooperation with the Commonwealth of Massachusetts, Department of Natural Resources, as part of a Statewide program of river-basin studies. It is based on field investigations conducted from 1972 to 1974.*

*Well logs, chemical data, and water-use data supplied by the Massachusetts Department of Public Works, Massachusetts Department of Public Health, town officials, local well drillers, and individuals are gratefully acknowledged. The authors appreciate the contributions of the Massachusetts Division of Water Pollution Control during the time-of-travel studies on the Aberjona River.*

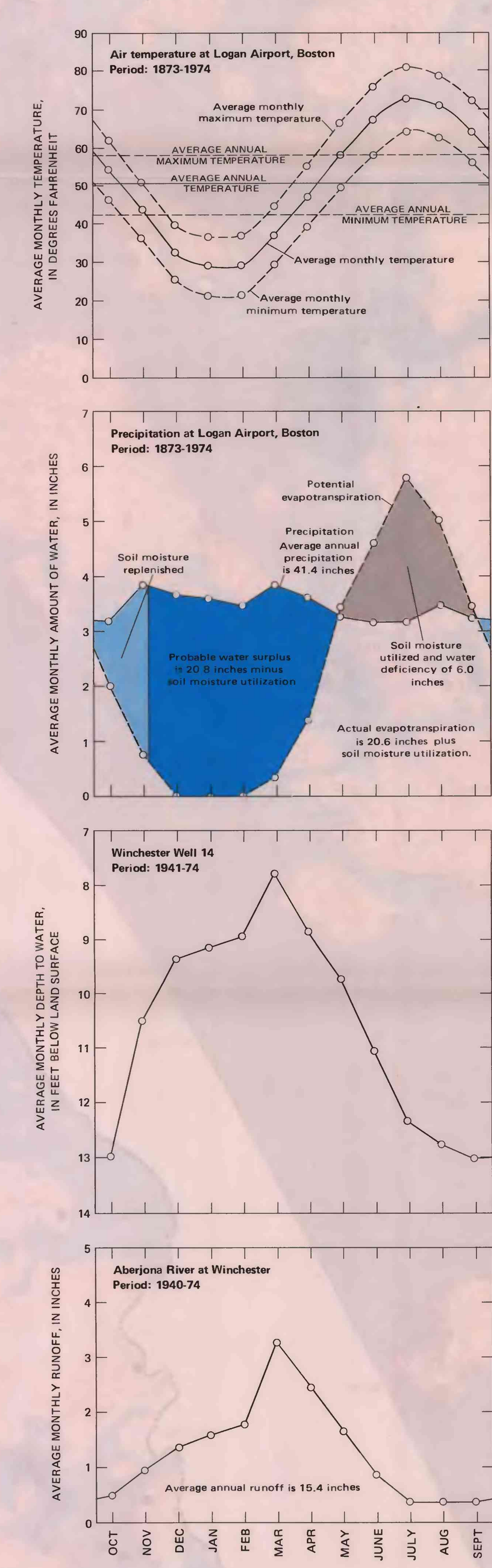
## METRIC CONVERSION FACTORS

**Table 1.– FACTORS WHICH CAN BE USED TO CONVERT U.S. CUSTOMARY UNITS TO INTERNATIONAL SYSTEM OF UNITS (SI), WITH ABBREVIATIONS**

Metric Conversion Factors

| Multiply U.S. Customary units | By | To obtain SI units |
|---|---|---|
| | Length | |
| inches (in) | 25.4 | millimeters (mm) |
| feet (ft) | .3048 | meters (m) |
| miles (mi) | 1.609 | kilometers (km) |
| | Area | |
| square miles ($mi^2$) | 2.590 | square kilometers ($km^2$) |
| | Volume | |
| million gallons (Mgal) | .003785 | cubic hectometers ($hm^3$) |
| million gallons per square mile ($Mgal/mi^2$) | .001461 | cubic hectometers per square kilometer ($hm^3/km^2$) |
| | Flow | |
| cubic feet per second ($ft^3/s$) | .02832 | cubic meters per second ($m^3/s$) |
| cubic feet per second per square mile [$(ft^3/s)/mi^2$] | .01093 | cubic meters per second per square kilometer [$(m^3/s)/km^2$] |
| gallons per minute (gal/min) | .06309 | Liters per second (L/s) |
| | $6.309 \times 10^{-5}$ | cubic meters per second ($m^3/s$) |
| gallons per day (gal/d) | 3.785 | Liters per day (L/d) |
| | $3.785 \times 10^{-3}$ | cubic meters per day ($m^3/d$) |
| million gallons per day per square mile [$(Mgal/d)/mi^2$] | .01691 | cubic meters per second per square kilometer [$(m^3/s)/km^2$] |
| | Temperature | |
| degrees Fahrenheit (°F) | 5/9 (°F −32) | degrees Celsius (°C) |
| | Hydraulic units | |
| square feet per day ($ft^2/d$) | .0929 | square meters per day ($m^2/d$) |

## GENERALIZED HYDROLOGIC CYCLE

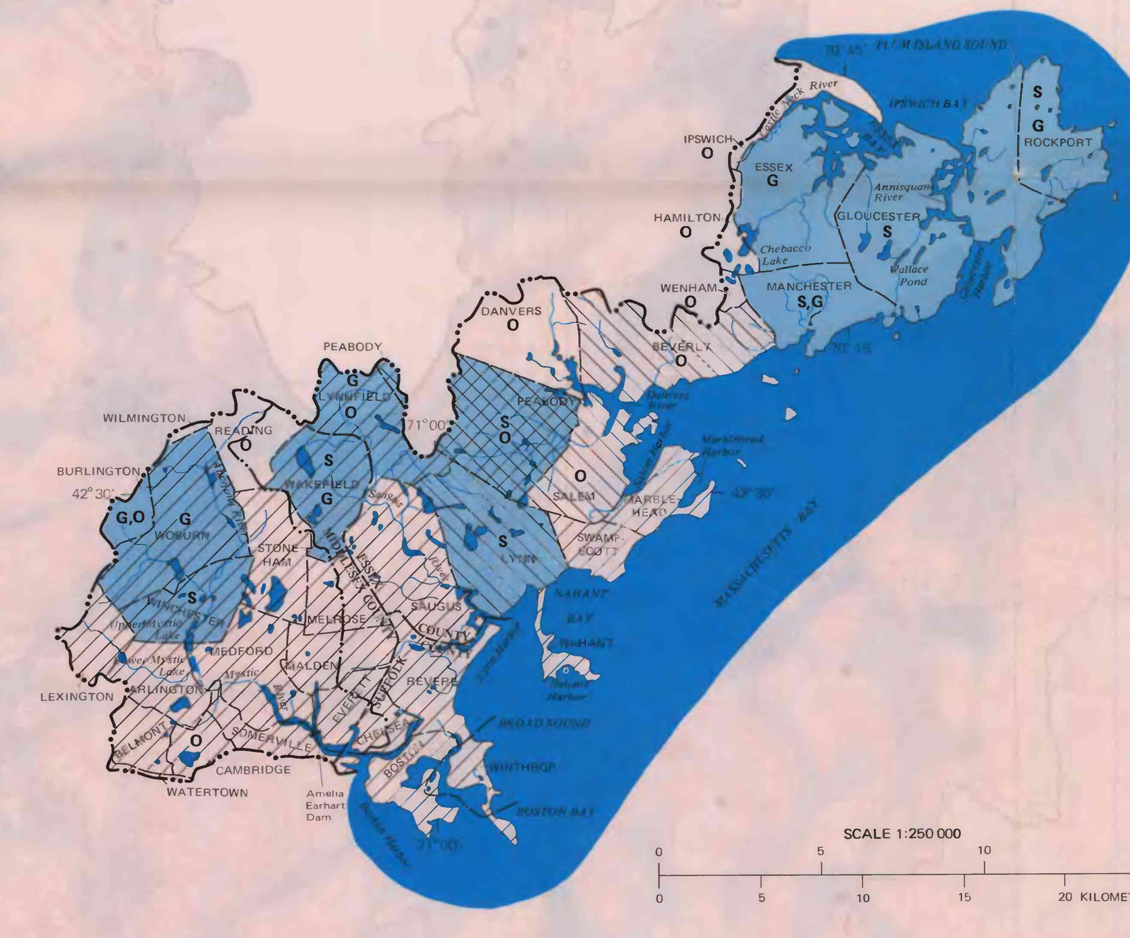



**EVAPOTRANSPIRATION IN SPRING, SUMMER, AND FALL CAUSES ANNUAL CYCLICAL TRENDS IN RUNOFF AND GROUND-WATER LEVELS, EVEN THOUGH PRECIPITATION IS EVENLY DISTRIBUTED THROUGHOUT THE YEAR.** – *Five elements of the hydrologic cycle are portrayed in a column to compare their cyclical patterns.*

*Declines in ground-water levels and surface-water runoff from a peak in March to a low in September are in direct response to increased evapotranspiration. The rates of evaporation and transpiration vary directly with temperature, wind velocity, and hours of sunlight. During the April through September growing period, most precipitation is evaporated or replaces soil moisture removed by transpiring vegetation. Recharge to ground-water bodies becomes negligible, ground water in storage decreases, and base flow in streams, which is sustained by ground-water discharge, gradually declines until October, when the growing season ends. After September, the rate of evapotranspiration slows to near zero from December through February. During the October to April period, precipitation recharges soil moisture and ground-water bodies, and streamflow increases.*

*For the Aberjona River basin, the difference between a probable water surplus of 20.8 inches from the evapotranspiration diagram and an average annual runoff of 15.4 inches from the surface-water runoff diagram can be attributed to soil-moisture utilization and ground-water diversions from the basin. Soil-moisture utilization throughout the basin probably averages no more than 2 to 4 inches because of the reduced vegetated area and the shallow rooted vegetation typical of a highly urbanized area. This utilization reduces the probable water surplus to the range of 18.9 to 17.7 inches, which compares favorably with 18.2 inches obtained from an equation developed by C. G. Johnson (1970) for estimating average annual runoff in central New England. The remaining deficit of 2.8 inches, or about 20 percent, can be attributed to the reduced ground-water discharge to streams caused by the withdrawal of about 13.6 Mgal/d from ground-water sources and the subsequent diversion from the basin by way of the Metropolitan District Commission (MDC) sewerage system.*

# MUNICIPAL WATER USE




**EXPLANATION**

Water-supply sources for municipalities or parts thereof, excluding emergency sources

- S,G — S = Surface water; G = Ground water — From within study area
- Metropolitan District Commission — From outside study area
- Ipswich River diversions — From outside study area
- O — Not specified
- Basin boundary
- Subbasin boundary

**Table 2.– MUNICIPAL WATER USE IN 1974**

| Municipality[1] | Total water use[2] (million gallons) | Estimated year-round population[3] | Estimated year-round population served[4] (percent) | Estimated water use by year-round population served [(gallons/day)/capita] | Water-supply sources |
|---|---|---|---|---|---|
| Arlington[5] | 1,907.2 | 50,880 | 100 | 103 | MDC. |
| Belmont[5] | 947.5 | 27,790 | 100 | 94 | MDC. |
| Beverly[5] | 1,550.2 | 37,580 | 100 | 113 | Diversions from Ipswich River and surface-water reservoirs. |
| Boston[5] | 52,918.2 | 638,600 | 100 | 227 | MDC. |
| Burlington[5] | 1,014 | 23,840 | 99 | 118 | Diversions from Shawsheen River, gravel-packed wells, and tubular well field. |
| Cambridge[5] | 7,701.9 | 101,750 | 100 | 207 | Surface-water reservoirs and MDC. |
| Chelsea | 1,478.4 | 26,180 | 100 | 155 | MDC. |
| Danvers[5] | 1,164.4 | 25,240 | 99 | 128 | Surface-water reservoirs, gravel-packed well, and tubular well field. |
| Essex | 91.2 | 2,830 | 84 | [6] 105 | Gravel-packed wells. Emergency: Gravel-packed well. |
| Everett | 2,794.4 | 40,270 | 100 | 190 | MDC. |
| Gloucester | 1,118.4 | 27,360 | 98 | [6] 115 | Surface-water reservoirs Emergency: Gravel-packed wells and surface-water reservoirs. |
| Hamilton[5] | 246.7 | 6,620 | 91 | 112 | Gravel-packed wells and tubular well field. |
| Ipswich[5] | 388.4 | 11,390 | 96 | 97 | Gravel-packed wells, tubular well field, and surface-water reservoir. Emergency: Surface-water reservoir. |
| Lexington[5] | 1,465.5 | 32,360 | 100 | 125 | MDC. |
| Lynn | 5,609.7 | 82,250 | 100 | 187 | Surface-water reservoirs and diversions from Saugus and Ipswich Rivers. Emergency: MDC. |
| Lynnfield[5] | 335.4 | 11,770 | 95 | 82 | MDC, gravel-packed well and tubular well field. |
| Malden | 2,760.5 | 55,880 | 100 | 135 | MDC. |
| Manchester | 245.5 | 5,460 | 99 | [6] 124 | Surface-water reservoir and gravel-packed well. Emergency: Gravel-packed well. |
| Marblehead | 836.5 | 21,520 | 100 | 107 | MDC. |
| Medford | 2,883.3 | 61.440 | 100 | 129 | MDC. |
| Melrose | 1,029.7 | 32,410 | 100 | 87 | MDC. |
| Nahant | 149.1 | 4,210 | 100 | 97 | MDC. |
| Peabody[5] | 2,107.3 | 46,020 | 99 | 127 | Diversions from Ipswich River, MDC, surface-water reservoirs, and gravel-packed wells. |
| Reading[5] | 980.4 | 23,470 | 99 | 115 | Gravel-packed wells and tubular well field. |
| Revere | 1,580.2 | 41,670 | 100 | 104 | MDC. |
| Rockport | 270.8 | 6,150 | 98 | [6] 123 | Surface-water reservoirs and tubular well field. |
| Salem | 2,406.1 | 38,950 | 100 | 169 | Diversions from Ipswich River and surface-water reservoirs. |
| Saugus | 850.7 | 24,800 | 99 | 95 | MDC. |
| Somerville | 3,881.2 | 82,230 | 100 | 129 | MDC. |
| Stoneham | 1,280.5 | 21,400 | 100 | 165 | MDC. |
| Swampscott | 574.2 | 14.180 | 100 | 111 | MDC. |
| Wakefield | 1,269.2 | 25,910 | 99 | 135 | MDC, surface-water reservoir, and dug well. |
| Watertown[5] | 1,646.8 | 36,720 | 100 | 123 | MDC. |
| Wenham[5] | 112.4 | 3,460 | 96 | 93 | Gravel-packed wells. |
| Wilmington[5] | 933.3 | 17,550 | 95 | 153 | Gravel-packed wells and tubular well fields. |
| Winchester | 873.3 | 22,590 | 100 | 106 | Surface-water reservoirs and MDC. |
| Winthrop | 669.4 | 20,350 | 100 | 90 | MDC. |
| Woburn[5] | 1,871.0 | 35,740 | 100 | 144 | Gravel-packed wells and MDC. Emergency: Surface-water reservoir. |

[1] Data apply to entire municipality.

[2] Data are from Massachusetts Department of Public Health, Metropolitan District Commission, city and town officials, and Water District officials.

[3] Data are based on a straight-line interpolation of population figures from the Federal census of 1970 (U.S. Department of Commerce, Bureau of the Census, 1972) and the Commonwealth of Massachusetts census of 1975.

[4] Data are based on the Federal census of 1970 (U.S. Department of Commerce, Bureau of the Census, 1972) and are assumed not to have changed significantly between 1970 and 1974.

[5] Municipality is partly within the study area.

[6] Per capita consumption is lower than shown because the estimated year-round population has not been adjusted to reflect the influx of summer residents.

**NINETY PERCENT OF THE MUNICIPALITIES MUST IMPORT WATER.** – *A high degree of urbanization (see introduction) has created a water demand that exceeds the capacity of the few small aquifers and streams in the coastal drainage basins. This effect is greatest in the southern three-quarters of the study area.*

*The mismatch between demand and local water resources in this area and in other metropolitan Boston municipalities led to the formation of the Metropolitan Water Board in 1895, which later became the Metropolitan District Commission (MDC). In 1974, the MDC supplied approximately 60 percent of the water used from sources in central and western Massachusetts. Of the 38 municipalities, the MDC is the sole supplier to 19 municipalities and partial supplier to 5.*

*Two other major sources of imported water are the Ipswich River and the Stony Brook and Hobbs Brook reservoir system in the Charles River basin. Diversions from the Ipswich River supply the cities of Beverly, Lynn, Peabody, and Salem. Diversions are limited by legislation to December through May, inclusive, to specified minimum streamflows, and to total volumes of water. The Stony Brook and Hobbs Brook reservoir system supplies most of the needs of the city of Cambridge (about 98 percent in 1974).*

*Several ponds are used as sources of water supply. They are used mainly as temporary storage reservoirs for diversions as well as for water from their own small catchment areas. Some of these ponds, the municipalities supplied, and the sources of diversion are: Fresh Pond for Cambridge from Stony Brook and Hobbs Brook reservoir system; Spot Pond for MDC from MDC sources; Middle and South Reservoirs for Winchester from Spot Pond; Hawkes, Walden, Birch, and Breeds Ponds for Lynn from the Ipswich and Saugus Rivers; and Suntaug Lake and Spring Pond for Peabody from the Ipswich River. (See transmissivity map on sheet 2 for storage reservoir locations.)*

*Per capita usage ranges from 82 to 227 gal/d in the basin and depends, in part, on the amount of industrial use and on the amount of leakage from water mains.*

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# HYDROLOGY AND WATER RESOURCES OF THE COASTAL DRAINAGE BASINS OF NORTHEASTERN MASSACHUSETTS, FROM CASTLE NECK RIVER, IPSWICH, TO MYSTIC RIVER, BOSTON

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1980

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