INTRODUCTION

THE LOWER MERRIMACK RIVER BASIN INCLUDES PARTS OF 17 MUNICIPALITIES IN ESSEX AND MIDDLESEX COUNTIES.—This atlas provides a description of the quantity, quality, and availability of water in the lower Merrimack River basin. The study area includes that part of the Merrimack River basin within Massachusetts that lies east of the Beaver Brook and Concord River basins but excludes the Shawsheen River basin and includes the Blackwater River basin within Massachusetts. This atlas was prepared by the U.S. Geological Survey in cooperation with the Commonwealth of Massachusetts Water Resources Commission, as part of a Statewide program of river-basin studies. It is based on field investigations from 1972 to 1974.

From its headwaters in south-central New Hampshire, the Merrimack River flows southward into Massachusetts, where it turns northeastward and flows parallel to the State border, emptying into the ocean at Newburyport north of Boston. It drains 5,006 mi² in south-central New Hampshire and northeastern Massachusetts. The drainage area of the Merrimack River basin below its confluence with the Concord River and excluding the Shawsheen River basin is 301 mi². This drainage area includes 125 mi² of the Spicket, Little, and Powwow Rivers drainage into Massachusetts. (See map in "Low-Streamflow" section on sheet 2 for stream locations and drainage divides.) The drainage area of the Blackwater River basin in Massachusetts is 8.2 mi².

The Merrimack River flows in a well-defined channel that ranges in width from 400 to 1,400 feet. One dam, the Essex Company Dam, a few feet upstream of O'Leary Bridge (State Highway 28) at Lawrence, spans the river. It was built to divert water into canal systems on either side of the river. This diverted water is returned to the Merrimack River just below Lawrence. The lower 22 river miles of the river is affected by tidal fluctuations (Cotton, 1975).

Altitudes range from sea level to about 300 feet above at the tops of many small rolling hills. This low relief and associated low stream gradients contribute to maintaining many upland wetlands along tributary streams.

Streamflow in the lower Merrimack is affected by major flood-control, public water-supply, and power-production, or recreation reservoirs in the upper part (table 2). Four of these reservoirs divert water for use outside the basin. The greatest impact on streamflow in the lower Merrimack is from flood-control and water-supply reservoirs. Flood-control reservoirs store water during peak streamflow for subsequent release during lower streamflow, thus reducing flood discharge and stage in the lower Merrimack River. Similarly, water-supply reservoirs generally reduce streamflow, but commonly are required by legislation to release some specified minimum daily amount for conservation and for downstream users. Water diverted by the city of Worcester and the Metropolitan District Commission (MDC) from the Nashua and Concord River basins by way of Pine Hill, Kendall, Sudbury, and Wachusett Reservoirs has for the last 15 years (1960–74) reduced the mean annual streamflow by approximately 177 ft³/s in the Merrimack River below its confluence with the Concord River at Lowell.

Hydroelectric power production at facilities along the Merrimack or its tributaries in the upper Merrimack River basin cause diurnal fluctuations in streamflow at Lowell. The fluctuations are more noticeable from July through September when streamflow contributed from intervening drainage areas is small.

Base from U.S. Geological Survey

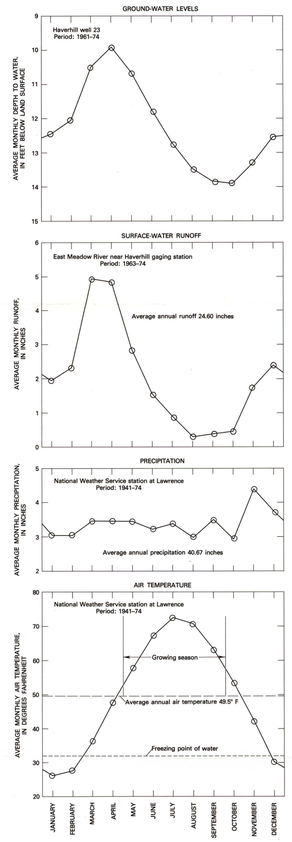
EXPLANATION

- Area discussed in atlas
- Basin boundary
- Dam

TABLE 1.—CONVERSION FACTORS OF ENGLISH UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

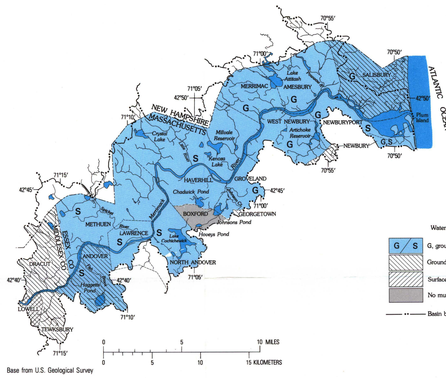
TO CONVERT FROM	TO	MULTIPLY BY
	Length	
Inch (in)	Millimeter (mm)	25.4
Foot (ft)	Meter (m)	0.3048
Mile (mi)	Kilometer (km)	1.609
	Area	
Square mile (mi²)	Square kilometer (km²)	2.590
	Volume	
Million cubic feet (Mft³)	Cubic hectometer (hm³)	0.02832
Million gallons (Mgal)	Cubic hectometer (hm³)	0.003785
Billion gallons	Cubic hectometer (hm³)	3.785
Million gallons per square mile (Mgal/mi²)	Cubic hectometer per square kilometer (hm³/km²)	0.001461
	Flow	
Cubic foot per second (ft³/s)	Cubic meter per second (m³/s)	0.02832
Cubic foot per second per square mile ((ft³/s)/mi²)	Cubic meter per second per square kilometer ((m³/s)/km²)	0.01093
Gallon per minute (gal/min)	Liter per second (L/s)	0.06309
	Cubic meter per second (m³/s)	6.309 X 10⁻⁵
Gallon per day (gal/d)	Liter per day (L/d)	3.785
	Cubic meter per day (m³/d)	3.785 X 10⁻³
Million gallons per day (Mgal/d)	Liter per second (L/s)	43.81
	Cubic meter per second (m³/s)	0.04381
Million gallons per day per square mile ((Mgal/d)/mi²)	Liter per second per square kilometer ((L/s)/km²)	16.91
	Cubic meter per second per square kilometer ((m³/s)/km²)	0.01691
	Hydraulic units	
Square foot per day (ft²/d)	Square meter per day (m²/d)	0.0929
	Mass	
Tons (short)	Megagram (Mg)	0.9072
Tons (short) per day (tons/d)	Megagram per day (Mg/d)	0.9072
Tons (short)per year (tons/yr)	Megagram per year	0.9072
	Temperature	
Degrees Fahrenheit (°F)	Degrees Celsius (°C)	5/9 (°F –32)

GENERALIZED ANNUAL HYDROLOGIC CYCLE



GROUND-WATER LEVELS AND SURFACE-WATER RUNOFF SHOW ANNUAL CYCLICAL PATTERNS, EVEN THOUGH PRECIPITATION IS EVENLY DISTRIBUTED THROUGHOUT THE YEAR.—Decline of ground-water levels and surface-water runoff from a peak in April 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 May 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 October, the rate of evapotranspiration is greatly reduced and slows to near zero from December through February. During October through April, precipitation recharges soil moisture and ground-water bodies, and streamflow increases.

MUNICIPAL WATER USE



Base from U.S. Geological Survey

EXPLANATION

Water-supply sources for municipalities excluding emergency sources

- G, S — G, ground water; S, surface water.—Sources from within the lower Merrimack River basin
- Ground water.—Sources from outside the lower Merrimack River basin
- Surface water.—Sources from outside the lower Merrimack River basin
- No municipal water-supply system
- Basin boundary

EVEN THOUGH THE MERRIMACK RIVER FLOWS THROUGH OR ADJOINS 15 MUNICIPALITIES, ONLY 3 USE IT AS A MUNICIPAL WATER-SUPPLY SOURCE.—Ground water is the sole source of supply for all municipalities having less than 6,000 people, except Newbury, and is the sole source for about half the municipalities of 10,000 to 30,000 people. Municipalities of more than 30,000 people, such as Haverhill, Lawrence, Lowell, and Methuen, rely almost exclusively on surface water and, of these, only Haverhill does not divert water from the Merrimack River.

The populations served by municipal water systems remain fairly constant throughout the year except for Salisbury which increases from about 4,800 to 18,000 during the summer.

All cities and towns use water from sources within their boundaries or from contiguous municipalities. Many supply wells are partly sustained by infiltration from streams or lakes. Amesbury has wells near the Powwow River; Groveland has wells near Johnson Creek and one of its tributaries; Merrimac has a well field near Lake Attitash; and Salisbury has wells near a tributary to Cains Brook.

Several ponds are sources of municipal water supply. All are used as storage reservoirs for water from their own catchment area. Only one, Haggetts Pond, stores additional water pumped to it from the mouth of Fish Brook.

Per capita usage ranges from 63 to 127 gal/d and depends, in part, on the amount of industrial use and leakage from water mains.

TABLE 2.—MAJOR RESERVOIRS IN THE MERRIMACK RIVER BASIN THAT AFFECT STREAMFLOW IN THE MERRIMACK RIVER BELOW THE CONFLUENCE WITH THE CONCORD RIVER AT LOWELL, MASS.

Reservoir in downstream order	Stream reservoir flows into	Location of reservoir's outlet	Drainage area above dam, in square miles	Usable capacity[1], in million cubic feet	Use of reservoir	Date dam completed	Agency controlling reservoir	General remarks
Reservoirs not diverting water outside the Merrimack River basin								
Squam Lake and Little Squam Lake	Squam River	0.9 mile north of Ashland, N. H.	57.6	1,650	Recreation, industrial use, and storage of water for power production.	....	New Hampshire Water Resources Board	.....
Newfound Lake	Newfound River	1.7 miles north of Bristol, N. H.	98.0	1,690	Recreation and storage of water for power production.	....	Public Service Co. of New Hampshire	.....
Franklin Falls Reservoir	Pemigewasset River	2 miles north of Franklin, N. H.	1,000	6,700	Flood control	1942	U.S. Army, New England Division, Corps of Engineers	.....
Merrymeeting Lake	Merrymeeting River	2.5 miles northeast of Alton, N. H.	About 12	368	Recreation and storage of water for power production.	....	New Hampshire Fish and Game Department	.....
Lake Wentworth	Lake Winnipesaukee tributary	Above Lake Winnipesaukee at Wolfeboro Falls, N. H.	About 23	854	Recreation and storage of water for power production.	....	Town of Wolfeboro, N. H.	.....
Lake Winnipesaukee	Winnipesaukee River	At Lakeport, N. H.	363	7,220	Recreation and conservation for development of water power.	1845	New Hampshire Water Resources Board	.....
Edward MacDowell Reservoir	Nubanusit Brook	At West Peterborough, N. H., and 2 miles northwest of Peterborough, N. H.	44.0	558	Flood control	1950	U.S. Army, New England Division, Corps of Engineers	.....
Jackman Reservoir	North Branch Contoocook River	At Hillsboro Lower Village, N. H., and 2.7 miles west of Hillsboro, N. H.	69	365	Recreation and storage of water for power production.	1926	Public Service Co. of New Hampshire	.....
Hopkinton Lake	Contoocook River	At West Hopkinton, N. H.	427	[2]3,084	Flood control and recreation	1962	U.S. Army, New England Division, Corps of Engineers	.....
Blackwater Reservoir	Blackwater River	At Swetts Mills, N. H., and 1 mile south of Webster, N. H.	128	2,004	Flood control	1941	U.S. Army, New England Division, Corps of Engineers	.....
Everett Lake	Piscataquog River	1.3 miles southeast of East Weare, N. H.	63.0	[2]3,768	Flood control and recreation	1962	U.S. Army, New England Division, Corps of Engineers	.....
Tower Hill Pond	Maple Falls Brook	2.3 miles north of Auburn, N. H.	12.5	182	Storage of water for municipal supply	1939	Manchester Water Works	.....
Massabesic Lake	Cohas Brook	2.5 miles southeast of Manchester, N. H.	About 43	724	Storage of water for municipal supply and recreation.	About 1738	Manchester Water Works	.....
Reservoirs diverting water for use outside the Merrimack River basin								
Pine Hill Reservoir and Kendall Reservoir	Asnebumskit Brook	Pine Hill Reservoir on Asnebumskit Brook 2.2 miles west of Holden, Mass.; Kendall Reservoir on tributary to Asnebumskit Brook 1.4 miles west of Holden, Mass.	9	.....	A water-supply source for city of Worcester, Mass.	1929 (Pine Hill) —(Kendall)	City of Worcester, Mass.	.....
Wachusett Reservoir	Nashua River	On Nashua River 1.0 mile south of Clinton, Mass.	108	.....	A water-supply source for the Metropolitan District Commission (MDC) and the city of Worcester, Mass.	1896	Metropolitan District Commission	Legislation requires 12 Mgal per week must be released to the Nashua River.
Sudbury Reservoir	Stony Brook (also called North Branch Sudbury River)	On Stony Brook, 1.5 miles east of Southborough, Mass.	[3]22.3	.....	A water-supply source for the MDC and the towns of Southborough and Framingham, Mass.	Between 1875 and 1898	Metropolitan District Commission	Sudbury Reservoir and Framingham Reservoir No. 3, located immediately downstream from Sudbury Reservoir, are used to supplement water supply during summertime high-demand periods and are available as an emergency source of supply.

[1]To convert usable capacity of million cubic feet to million gallons, multiply by 7.48.
[2]Hopkinton and Everett Lakes are connected by a canal and are operated as a unit above altitude 400.00 feet.
[3]Drainage area from Metropolitan District Commission.

TABLE 3.—MUNICIPAL WATER USE IN 1974

Municipality[1]	Total water use,[2] in million gallons	Estimated year-round population[3]	Estimated year-round population served,[4] in percentage	Estimated water use by year-round population served, in gallons per day per capita	Water-supply sources[5]
Amesbury	482.2	13,280	97	102	A well field of 2½-inch diameter wells and a 12-inch diameter well.
Andover[6]	1,210.3	25,580	98	133	Haggetts Pond, diversions from Fish Brook, and a gravel-packed well.
Boxford[6]	0	4,460	0	0	The town has no municipal water-supply system.
Dracut[6]	384.2	19,870	84	63	Gravel-packed wells.
Georgetown[6]	154.0	5,790	96	76	Gravel-packed wells and a well field of 2½-inch diameter wells.
Groveland[6]	222.7	5,280	97	120	Gravel-packed wells.
Haverhill	Estimated 2,100	44,740	98	131	Millvale Reservoir, Kenoza and Crystal Lakes, Hoveys, Chadwick, and Johnsons Ponds.
Lawrence[6]	2,637.5	67,400	100	107	Diversions from Merrimack River.
Lowell[6]	3,940.5	91,790	99	118	Diversions from Merrimack River and gravel-packed wells.
Merrimac	181.4	4,210	91	130	A well field of 2½-inch diameter wells and a well field of 8-inch diameter wells.
Methuen	1,151.2	35,500	98	91	Purchases water from City of Lawrence.
Newbury[6] Byfield section Old Town section	.... 48.4 (7)	4,150	64	....	Byfield section—a gravel-packed well; Old Town section—served by City of Newburyport.
Newburyport[6]	[8]765.0	16,230	97	....	Artichoke Reservoir, Bartlett Springs, and gravel-packed wells.
North Andover[6]	774.5	15,950	97	137	Lake Cochichewick.
Salisbury	279.4	4,810	94	[9]113	Gravel-packed wells.
Tewksbury[6]	709.6	23,790	94	87	Gravel-packed wells.
West Newbury[6]	52.6	2,550	90	63	Purchases water from Town of Groveland.

[1]Data apply to entire municipality.
[2]Data are from Massachusetts Department of Public Health, city and town officials, and Water District officials, and includes only water used from a municipal system.
[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]Does not include emergency water-supply sources.
[6]Municipality is partly within study area.
[7]Included in water use for Newburyport.
[8]Includes water use for the Old Town section of Newbury.
[9]Estimated water use by year-round population served has been adjusted to reflect the influx of summer residents.

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HYDROLOGY AND WATER RESOURCES OF THE LOWER MERRIMACK RIVER BASIN, MASSACHUSETTS, FROM CONCORD RIVER, LOWELL, TO PLUM ISLAND, NEWBURYPORT

By
Frederick B. Gay and David F. Delaney

1980

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