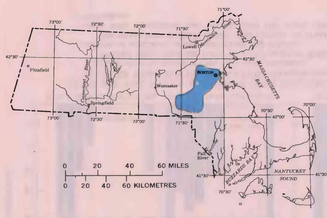
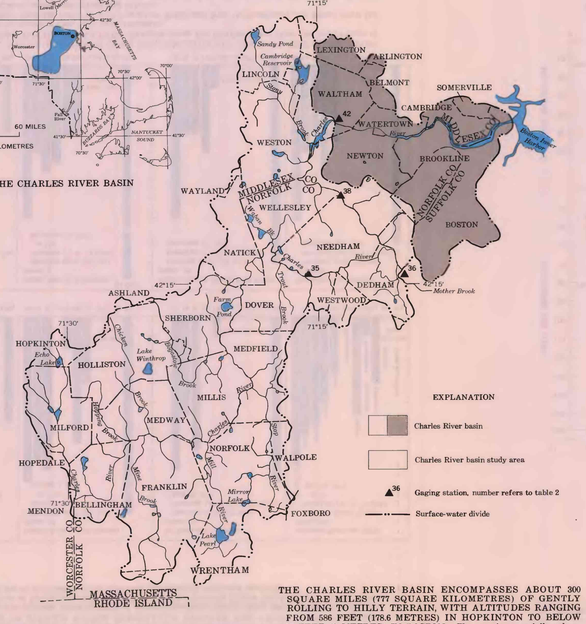
INTRODUCTION



LOCATION OF THE CHARLES RIVER BASIN



EXPLANATION

- Charles River basin
- Charles River basin study area
- ▲36 Gaging station, number refers to table 2
- Surface-water divide

0 5 10 15 MILES
0 5 10 15 KILOMETRES

THE CHARLES RIVER BASIN ENCOMPASSES ABOUT 300 SQUARE MILES (777 SQUARE KILOMETRES) OF GENTLY ROLLING TO HILLY TERRAIN, WITH ALTITUDES RANGING FROM 586 FEET (178.6 METRES) IN HOPKINTON TO BELOW 10 FEET (3 METRES) IN BOSTON.—The area is essentially urban, although the towns in the upper basin still retain some rural character despite rapid growth in recent years. The population of the middle and upper parts increased 80 percent between 1950 and 1970, while the population in the lower part declined 4 percent.

The purpose of this atlas is to summarize the water resources and associated water problems of the area. The investigation upon which the atlas is based was made from 1968 to 1971 and is part of a series covering the major river basins in Massachusetts. The study area includes 251 mi^2 (650 km^2) of drainage area above the gaging station at Waltham. The remaining area is covered by the U.S. Army, Corps of Engineers (1968) interim report.

CONVERSION FACTORS

TABLE 1.—CONVERSION FACTORS OF ENGLISH AND METRIC UNITS, WITH ABBREVIATIONS, FOR EXPRESSING RATES AND VOLUME OF FLOW

TO CONVERT FROM	TO	MULTIPLY BY
Cfs-day (ft^3/s-day)	Cubic feet (ft^3)	86,400
Inches per year (in/yr)	Cubic feet per second per square mile ((ft^3/s)/mi^2)	0.07367
Cubic feet (ft^3)	Gallons (gal)	7.4805
Cubic feet per second (ft^3/s)	Million gallons per day (Mgal/d)	0.6463
Inches (in)	Million gallons per day per square mile [(Mgal/d)/mi^2]	17.359

ENGLISH UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

TO CONVERT FROM	TO	MULTIPLY BY
Inches (in)	Centimetres (cm)	2.54
Feet (ft)	Metres (m)	0.3048
Miles (mi)	Kilometres (km)	1.609
Cubic feet per second (ft^3/s)	Cubic metres per second (m^3/s)	0.02832
Million cubic feet (Mft^3)	Cubic hectometres (hm^3)	0.02832
Square miles (mi^2)	Square kilometres (km^2)	2.59
Gallons (gal)	Cubic metres (m^3)	0.003785
Million gallons (Mgal)	Cubic hectometres (hm^3)	0.003785
Gallons per minute (gal/min)	Cubic metres per second (m^3/s)	0.0000631
Gallons per minute (gal/min)	Litres per second (l/s)	0.06309
Gallons per acre (gal/acre)	Cubic metres per hectare (m^3/ha)	0.009353
Million gallons per day (Mgal/d)	Cubic metres per second (m^3/s)	0.04381
Degree Fahrenheit (°F)	Degree Celsius (°C)	0.555(°F–32)

SELECTED REFERENCES

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Riggs, H. C., 1968a, Some statistical tools in hydrology: U.S. Geol. Survey Techniques Water-Resources Inv., book 4, ch. A1, 39 p.
———1968b, Frequency curves: U.S. Geol. Survey Techniques Water-Resources Inv., book 4, ch. A2, 15 p.
———1972, Low-flow investigations: U.S. Geol. Survey Techniques Water-Resources Inv., book 4, ch. B1, 18 p.
Swallow, L. A., Peterson, R. G., and Searles, G. H., 1971, Flood of March 1968 on the Charles River, Massachusetts: U.S. Geol. Survey Hydrol. Inv. Atlas HA–419.
U.S. Army, Corps of Engineers, 1967, Flood plain information, Charles River, Town of Medway, Massachusetts: 49 p., 10 pl.
———1968, Interim report on Charles River for flood control and navigation, Lower Charles River, Massachusetts: 90th Cong., 2d sess., House Doc. 370.
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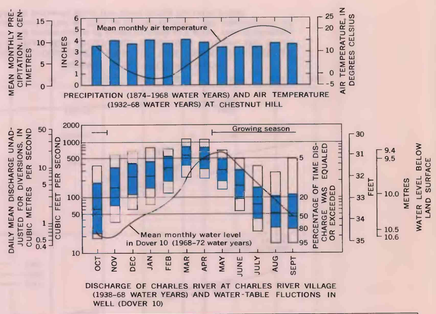
U.S. Geological Survey, 1966–71, Water resources data for Massachusetts, New Hampshire, Rhode Island, and Vermont—pt. 1, surface water records, pt. 2, water quality records: Boston, Mass., Water Resources Division, issued annually.
Wood, G. K., Swallow, L. A., Johnson, C. G., and Searles, G. H., 1970, Flood of March 1968 in eastern Massachusetts and Rhode Island: U.S. Geol. Survey open-file rept., 81 p.

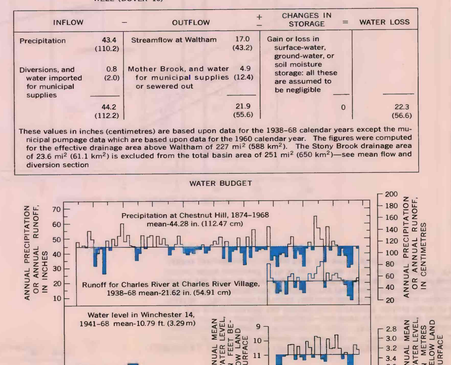
HYDROLOGIC CYCLE



INFLOW		– OUTFLOW		+ CHANGES IN STORAGE	= WATER LOSS
Precipitation	43.4 (110.2)	Streamflow at Waltham	17.0 (43.2)	Gain or loss in surface-water, ground-water, or soil moisture storage: all these are assumed to be negligible	
Diversions, and water imported for municipal supplies	0.8 (2.0)	Mother Brook, and water for municipal supplies or sewered out	4.9 (12.4)		
	44.2 (112.2)		21.9 (55.6)	0	22.3 (56.6)

These values in inches (centimetres) are based upon data for the 1938–68 calendar years except the municipal pumpage data which are based upon data for the 1960 calendar year. The figures were computed for the effective drainage area above Waltham of 227 mi^2 (588 km^2). The Stony Brook drainage area of 23.6 mi^2 (61.1 km^2) is excluded from the total basin area of 251 mi^2 (650 km^2)—see mean flow and diversion section

WATER BUDGET

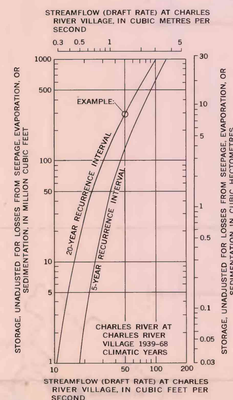


LONG-TERM TRENDS IN STREAMFLOW AND THE WATER TABLE FOLLOW THE PRECIPITATION PATTERN. THE ANNUAL CYCLE IN STREAMFLOW AND THE WATER TABLE IS CAUSED BY EVAPOTRANSPIRATION IN SPRING AND SUMMER (GROWING SEASON) AND SNOWMELT IN LATE WINTER OR EARLY SPRING AND NOT BY THE AVAILABILITY OF PRECIPITATION, WHICH IS FAIRLY UNIFORM THROUGHOUT THE YEAR.

DEFINITIONS

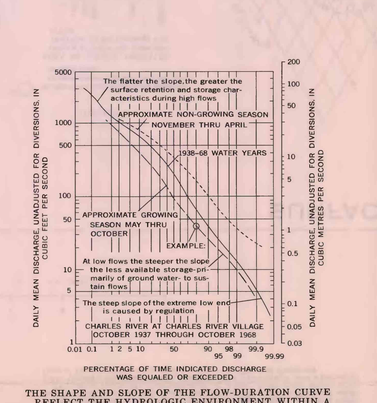
AQUIFER. An aquifer is a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.
CLIMATIC YEAR. A continuous 12-month period during which a complete flow cycle occurs. The climatic year, as used in this report is the 12-month period, April 1 through March 31; it is designated by the calendar year in which it ends.
EVAPOTRANSPIRATION. Water withdrawn from a land area by evaporation from water surfaces and moist soil and plant transpiration.
GROUND WATER. Ground water is that part of the subsurface water in the saturated zone.
MILLIGRAMS PER LITRE. A unit for expressing the concentration of chemical constituents in solution. Milligrams per litre represents the weight of solute per unit volume of water.
PROBABILITY. The percentage chance of occurrence of an event in any 1 year; it is the reciprocal of the recurrence interval for that year.
RECHARGE. The process by which water is absorbed and is added to the saturated zone.
RECURRENCE INTERVAL. The average interval of time between occurrences of a given event, reciprocal of probability.
RUNOFF, IN INCHES. The depth to which the drainage area would be covered if all the runoff (streamflow adjusted for diversions and changes in storage) for a given time period were uniformly distributed on the area.
STORAGE COEFFICIENT. The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.
WATER TABLE. The water table is that surface in an unconfined water body at which the pressure is atmospheric. It is defined by the levels at which water stands in wells that penetrate the water body just far enough to hold standing water. In wells which penetrate to greater depths, the water level will stand above or below the water table if an upward or downward component of ground-water flow exists.
WATER YEAR. The 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Thus, the "1960 water year" began on October 1, 1959, and ended on September 30, 1960.

FLOW AVAILABILITY



DRAFT-STORAGE-FREQUENCY RELATIONS CAN BE USED BY REGIONAL PLANNERS TO COMPUTE STORAGE REQUIREMENTS IF LOW-FLOW AUGMENTATION BECOMES NECESSARY FOR THE CHARLES RIVER.—The within-year storage to sustain selected drafts was computed from the low-flow frequency curves.

EXAMPLE: A storage of 300 M ft^3 (8.5 hm^3) will suffice 19 of 20 years to maintain streamflow at 50 ft^3/s (1.41 m^3/s), or the probability, in any one year, that this amount of storage will suffice is 19 in 20, or 95 percent.



THE SHAPE AND SLOPE OF THE FLOW-DURATION CURVE REFLECT THE HYDROLOGIC ENVIRONMENT WITHIN A DRAINAGE BASIN DURING A SPECIFIED PERIOD OF TIME.—The slope of the flow-duration curve reflects the amount of surface-water and ground-water storage available to equalize the flow. The change in the slope of a curve may be caused by a change in stream regimen, either natural or manmade. The flow-duration curve can be used to estimate future streamflows if the factors influencing runoff, including diversions and regulation, remain essentially the same as in the base period.

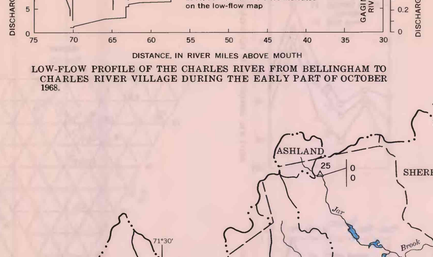
EXAMPLE: During the period May through October, a discharge of 40 ft^3/s (1.13 m^3/s) will be equaled or exceeded 80 percent of the time.

SURFACE WATER

DATA NETWORK

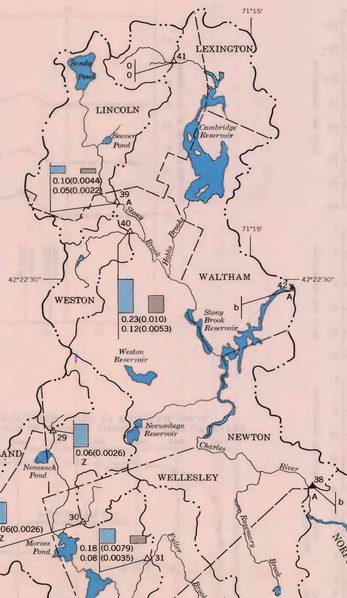
TABLE 2.—HYDROLOGIC DATA NETWORK

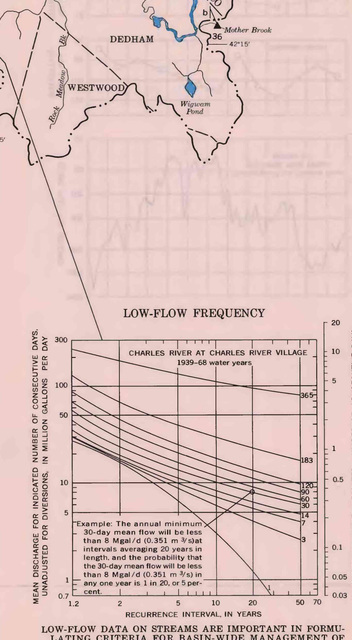
NO.	STREAM	DRAINAGE AREA –(MI^2)	LOCATION
1	Charles River	1.58	Cedar St.
2	Charles River tributary	.63	State Highway 140
3	Charles River	14.5	Depot St.
4	Stall Brook	3.79	State Highway 126
5	Beaver Brook	1.98	Marshall St.
6	Hopping Brook	10.0	West St.
7	Miscoe Brook	1.15	South St.
8	Miscoe Brook	2.14	Washington St.
9	Dix Brook	.24	Vine St.
10	Mine Brook	14.1	Pond St.
11	Chicken Brook	2.12	0.1 mile below State Highway 16
12	Chicken Brook	7.19	Cottage St.
13	Charles River	60.1	Shaw St.
14	Shepards Brook tributary	1.05	Lincoln St.
15	Shepards Brook	2.11	Lincoln St.
16	Safe Meadow Brook	.74	Whiting St.
17	Mill River	13.8	Miller St.
18	Cress Brook	1.55	Myrtle St.
19	Stony Brook	1.45	Diamond St.
20	Stop River tributary	.78	Boardman St.
21	Stop River	12.8	South St.
22	Stop River tributary No. 2	0.71	Indian Hill Rd.
23	Vine Brook	.94	State Highway 27
24	Mill Brook	2.14	Farm St.
25	Jar Brook	.66	Winter St.
26	Bogastow Brook	13.1	Orchard St.
27	Charles River	141	State Highway 27
28	Sewall Brook	2.68	Forest St.
29	Bogle Brook tributary	.82	State Highway 30
30	Boulder Brook	.87	Weston Rd.
31	Fuller Brook	3.94	Brook St.
32	Trout Brook tributary	.63	Springdale Ave.
33	Trout Brook	3.74	Haven St.
34	Noanet Brook	1.92	Dedham St.
35	Charles River	184	0.3 mile below Willow St.
36	Mother Brook	b	Washington St.
37	Sawmill Brook	1.94	Baker St.
38	Charles River	211	State Highway 9
39	Stony Brook	5.84	Merriam St.
40	Cherry Brook	2.15	Conant Rd.
41	Hobbs Brook	1.31	0.6 mile above Cambridge Reservoir
42	Charles River	227	0.2 mile below Moody St.



LOW-FLOW PROFILE OF THE CHARLES RIVER FROM BELLINGHAM TO CHARLES RIVER VILLAGE DURING THE EARLY PART OF OCTOBER 1968.

LOW FLOW



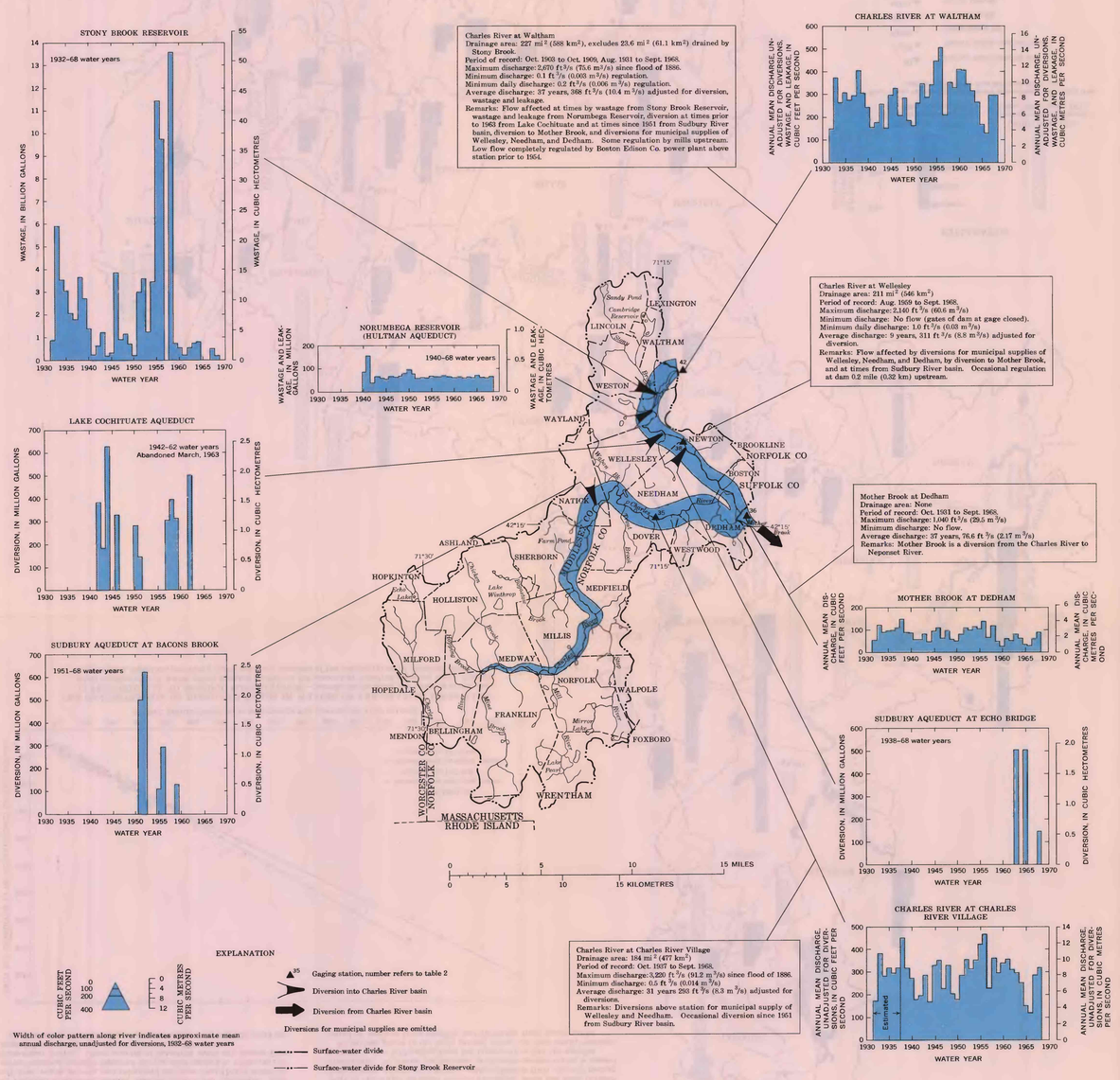


LOW-FLOW DATA ON STREAMS ARE IMPORTANT IN FORMULATING CRITERIA FOR BASIN-WIDE MANAGEMENT OF THE WATER RESOURCES.—The annual minimum 7-day mean flow at the 10-year recurrence interval is used in the design of waste-treatment plants to determine the quantity and quality of effluent the stream may legally accept. Proper dilution of the treated waste is necessary to satisfy the water-quality standards of the Commonwealth.

Low-flow characteristics are useful in planning programs for low-flow augmentation. Possible methods of increasing the low flow include release of water from detention reservoirs, importation of water through the MDC aqueduct system, management of the Mother Brook diversion, or within-basin use of water previously exported from the basin.

Low-flow parameters at these sites were obtained from correlations with data from the Charles River Village gaging station. Variations in low-flow runoffs are caused by differences in geology and soil type, import or export of water, extent of urbanization, precipitation, and other factors.

MEAN FLOW AND DIVERSIONS



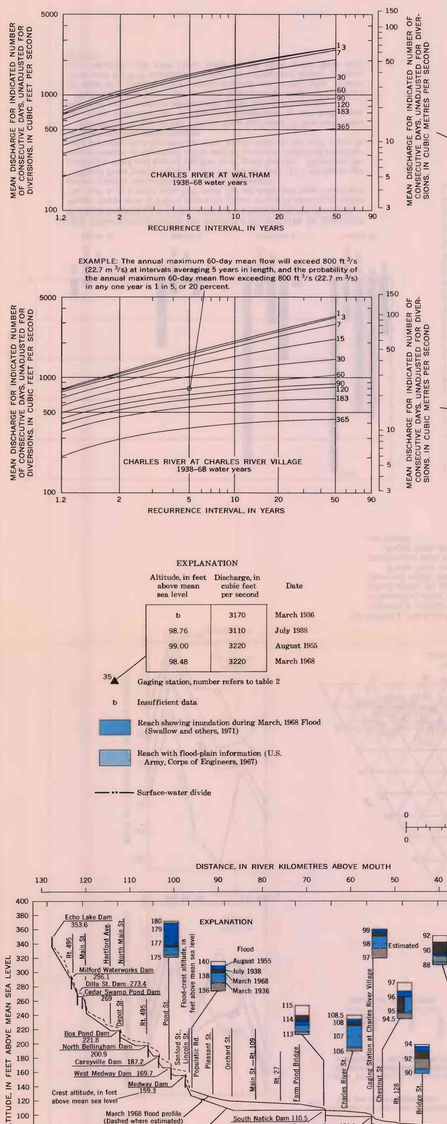
DIVERSIONS ARE AN IMPORTANT CONSIDERATION IN DEVELOPING A COMPREHENSIVE PLAN FOR MANAGING THE WATER RESOURCES IN THE LOWER CHARLES RIVER BASIN.

The largest diversions from the basin are Mother Brook at Dedham and the Stony Brook Reservoir System at the Waltham-Weston town line. The flow in Mother Brook is controlled by the MDC (Metropolitan District Commission). The city of Cambridge diverts streamflow from the Stony Brook basin for water supply by managing Stony Brook Reservoir.

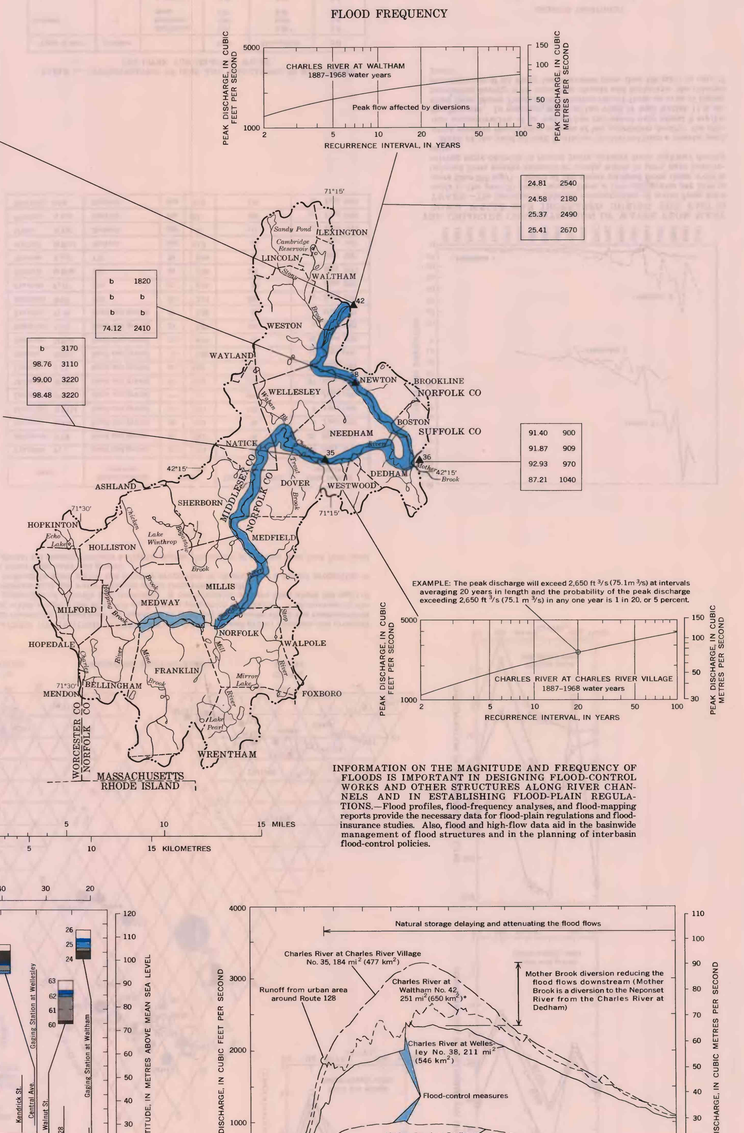
Water imported to the basin through the MDC's water-supply system consists of wastage or leakage from Norumbega Reservoir, which is supplied by the Hultman Aqueduct, and diversions at times from the Sudbury River basin.

By law, water from the Sudbury Aqueduct can be used to augment the low flow of the Charles River. If the MDC has an adequate supply, a maximum of 15 Mgal (56,775 m^3) a day, not to exceed 500 Mgal (1,892,500 m^3) in a year, can be diverted when requested by the Massachusetts Department of Public Health.

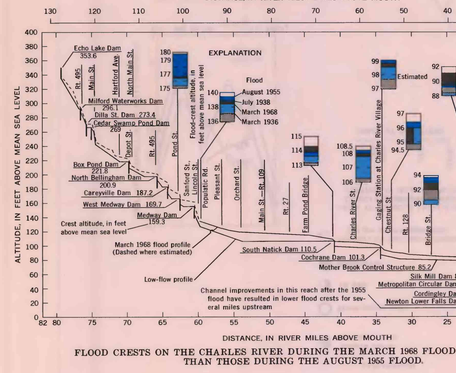
HIGH FLOW



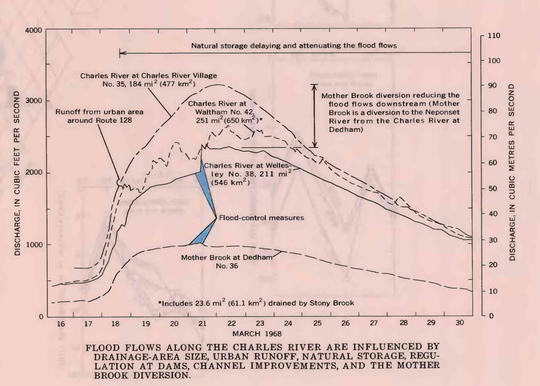
FLOOD FLOW



INFORMATION ON THE MAGNITUDE AND FREQUENCY OF FLOODS IS IMPORTANT IN DESIGNING FLOOD-CONTROL WORKS AND OTHER STRUCTURES ALONG RIVER CHANNELS AND IN ESTABLISHING FLOOD-PLAIN REGULATIONS.—Flood profiles, flood-frequency analyses, and flood-mapping reports provide the necessary data for flood-plain regulations and flood-insurance studies. Also, flood and high-flow data aid in the basinwide management of flood structures and in the planning of interbasin flood-control policies.



FLOOD CRESTS ON THE CHARLES RIVER DURING THE MARCH 1968 FLOOD WERE LOWER THAN THOSE DURING THE AUGUST 1955 FLOOD.



FLOOD FLOWS ALONG THE CHARLES RIVER ARE INFLUENCED BY DRAINAGE-AREA SIZE, URBAN RUNOFF, NATURAL STORAGE, REGULATION AT DAMS, CHANNEL IMPROVEMENTS, AND THE MOTHER BROOK DIVERSION.

Interior—Geological Survey, Reston, Va.—1976—W76108

HYDROLOGY AND WATER RESOURCES OF THE CHARLES RIVER BASIN, MASSACHUSETTS

By
E. H. Walker, S. W. Wandle, Jr., and W. W. Caswell

1976

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