Water Problems in the Springfield-Holyoke Area, Massachusetts

By J. C. KAMMERER and H. L. BALDWIN

A layman's look at water in a metropolitan area

ACKNOWLEDGMENTS

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PICTURE CREDITS

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THE WATER PROBLEMS

Everywhere in the United States we hear scare stories about an apparently diminishing supply of water. We are told that our national use of water is expected to rise to 600 billion gallons a day by 1980. We have heard about restrictions on sprinkling, or rationed bathing and car washing, or fines for leaky taps.

Yet—in central New England, for example—the Connecticut River sends more than 9,000 million gallons of water past Holyoke, Mass., on a single average day.

As the river passes Springfield, the Chicopee and Westfield Rivers add nearly 1,300 million gallons a day more.

An average of only about 400 million gallons a day is withdrawn from the streams and rivers in the Springfield-Holyoke area, and most of that is returned to the streams after use.

Doesn't sound like a water problem, does it?

Well, quantity is not the only water problem. You can have water, water, everywhere, and still not have a drop to drink, if the water isn't fit for drinking. It has to be clean, pure water suitable for a variety of uses—for housework, for industry, for recreation. There has to be enough of it in the hot dry periods of summer when streams become sluggish, water levels fall, and shallow wells run dry. It has to be controlled when there is too much of it, when the snows melt in the spring, or when torrential rains make the rivers roar over the land, bringing death and destruction.

With these thoughts in mind, we look at the water resources of the Springfield-Holyoke area a little differently.

For instance—

• Did you know that in 1955, 40 million gallons of wastes from industry were discharged every day into the Connecticut River at Holyoke?

• Did you know that water pollution has killed off the salmon that used to breed in the river below Holyoke, and that the shad are in danger of being exterminated also?

• Did you know that even though the average daily flow of the Connecticut River at Springfield is more than 10,000 million gallons a day, it has dropped to as little as 680 million gallons a day during the summer?

• Did you know that floods in the Connecticut River basin in 1936, 1938, and 1955 together caused damages of nearly 245 million dollars?

Yes, the area does have a problem—a water management problem. This is not the same thing as a water *supply* problem. You can see what some of the management problems are: pollution control; storage of water for dry or "low-flow" periods; flood control; development of recreational facilities and fisheries. These are water problems that may exist wherever you have water resources. They are not nearly as critical as the water problems in some other areas of the United States, but on the other hand, without proper management, they might become more serious. The problems are complicated by the fact that several States are involved. The Connecticut

River begins to flow in New Hampshire, and journeys southward along the New Hampshire-Vermont boundary into Massachusetts. After it leaves Springfield, it flows on into Connecticut and ends in Long Island Sound. Obviously, the people living upstream and dowstream from Springfield may also have something to say about management of the Connecticut River and its tributaries.

To add to the complications, there are several Federal Government agencies involved. The Corps of Engineers of the U.S. Army builds the larger dams in the Connecticut River basin. The Soil Conservation Service of the Department of Agriculture helps to increase the usefulness of water resources by guiding people in careful land management of some watersheds. The Department of Health, Education, and Welfare is concerned with control of pollution in rivers and streams, through its Public Health Service. The Geological Survey of the Department of the Interior collects basic information on streamflow, floods, quality of water, and ground-water resources, and appraises the availability and use of water. The basic facts obtained by the Survey can be used by all those concerned with water problems. There are State agencies involved also—the Massachusetts Water Resources Commission and the Department of Public Health are just two.

But the problems themselves have to be solved by people. You can understand the problems better if you have a clear picture of the water resources of the Springfield-Holyoke area. Other people outside the area who read this report may gain an understanding of the water resources and problems of their own towns and rivers. Although water resources and therefore water problems vary from place to place, the basic principles of water management remain the same. This pamphlet is written to give you some idea of the complexities involved in managing the water resources of an industrial urban area.

First, let us look at the geography of the area itself, study the map, and see what we find (figure 1).

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FIG. 1 SPRINGFIELD-HOLYOKE AREA

WHERE THE WATER COMES FROM

The Springfield-Holyoke area lies in the valley of the Connecticut River in Hampden County, Mass. It contains 313 square miles and a population of 420,000. It is shaped somewhat like the wooden engine on a toy train, facing west, with a bell on top and a cowcatcher on the front. It is bounded on the south by the Massachusetts-Connecticut State line and, on the north, roughly by the Manhan River and the Holyoke Range. The Connecticut River flows more or less north-to-south through a valley plain which is a center of diversified industry and of tobacco and vegetable growing. Most of the population is located within the valley in and near Springfield, Holyoke, Chicopee, and Westfield.

The valley is bounded by hills on both east and west. On the east are the central uplands of Massachusetts, between 500 and 1,000 feet high, and on the west are the beautiful Berkshire Hills, rising to more than 2,000 feet in Berkshire County. Running up and down through the center of the area, and turning sideways, like the bar on a loosely joined "H", is a narrow ridge called the Holyoke Range, 500 to 1,200 feet high.

Climate is one of the attractions that has made the Springfield-Holyoke area a center of industry, recreation, and education. It is generally moderate with average monthly temperatures ranging from 25° F. in January to 74° in July. Occasionally it gets hotter or colder, but on the whole it is the temperate climate characteristic of the New England States. Monthly rainfall ranges from 2.6 to 4.7 inches. The yearly average at Springfield is a little higher than the national average. Of course, not all of the water falling in the area can be used. Slightly more than half the moisture returns to the atmosphere, either by evaporation from land and water surfaces or by loss through the leaves of plants. The latter kind of evaporation is called transpiration. The remaining water runs off the land into streams or seeps slowly underground. We call the runoff water "surface water." The water which seeps underground is called

IG. 2—FLOW OF PRINCIPAL RIVERS

"ground water." Surface water and ground water are the sources of man's water supply. Of course, somewhat less is available from either source during the summer because more water is lost to the atmosphere by evaporation and transpiration.

The Connecticut River, which divides the Springfield-Holyoke area into an eastern and a western half, is the largest river in New England. With its two local tributaries, the Chicopee and the Westfield Rivers, it supplies tremendous quantities of water to a relatively small area. The 313 square miles of the area can draw upon the runoff of more than 9,000 square miles. The Connecticut River system not only furnishes water for municipal use in the area but also for a great industrial complex, including power plants, paper mills, metal processing plants, and chemical industries.

The Connecticut River itself rises in Third Connecticut Lake in northern New Hampshire near the Canadian border. Here is the drainage pattern of the river and some information about several of the local tributaries (figure 2), where they have been measured by the Geological Survey. The map shows you the approximate drainage area in square miles, the average flow per day, and the minimum daily flow.

As you can tell from the average daily flow of most of the rivers, there is generally an enormous amount of water available in the Connecticut River basin. There are times, however, when there is not so much water flowing through the stream channels. For instance, in the drought year of 1957, river flows were greatly reduced, and smaller ones dried up completely. For man's purpose—planning the use of water—it is important to know what the minimum 7-day flow of a river is likely to be. The U.S. Geological Survey, in cooperation with State agencies, maintains gaging stations on rivers to measure the height ("stage") and flow ("discharge") of the rivers, including the minimum flows. The minimum 7-day flow is usually recorded in late summer or early fall when there has been little rain and much evaporation. The low flow periods unfortunately come at just the time of year when people use the most water for bathing, swimming, watering lawns, and irrigating crops. Besides cutting down the amount of water available for municipal supplies, such low flows can also be harmful to the fish life in the rivers. If wastes are disposed of in the rivers—as in much of the Springfield-Holyoke area—low flows are insufficient to dilute these wastes adequately, and they become offensive and a nuisance.

Man has not only learned to record high and low flows of the river he uses but also how to regulate the flow, at least to some extent. We do this by building a dam and storing water in an artificial lake or reservoir. When the flow of a river begins to lessen, some of this stored water can be released to augment natural low flows.

Dams and reservoirs can serve several purposes at one time. When used solely for conservation storage they help to increase low flows of rivers. However, some reservoirs are also used for municipal supply. Some are used for the manufacture of water power. Some are used for recreational purposes—boating, fishing and swimming. Some are used for flood control. In a flood-control reservoir, little or no water is kept in storage after storm and flood dangers have passed. The space is reserved for the tremendous amounts of extra water resulting from the next heavy rains, or from suddenly melting snows. A reservoir used for two or more purposes must have greater capacity than one used only for flood control, if it is to provide effective flood protection.

We have been discussing reservoirs which can be used for one or more purposes. Many flood-control reservoirs, however, are detention or "dry-bed" reservoirs, which do not contain water at all except during times of flood. During flood periods the detention reservoirs give the water a safe place in which to accumulate, and lessen the flow of rivers so that they do not overflow their banks. There are many such single-purpose flood-control reservoirs in the Connecticut River basin, but there are many other reservoirs that are used for water-supply storage or for power generation. The flow of the Connecticut River is regulated by more than two million acre-feet of storage in 23 nonflood-control reservoirs. This regulation

Table 1. Principal types of rocks, and yields of wells (listed in order from youngest rocks to oldest).

Age	Principal types of rocks	Approximate thickness (feet)	Yields of wells
Pleistocene (glacial epoch, within past 1 million years).	Stratified deposits; mainly layers of clay and sand; also, in some places, gravel and boulders.	0-200+	Highest yielding wells in area, where tapping sand and gravel—large-capacity wells yielding 100 to 1,000 gpm; much smaller yields from fine-grained sands and clayey sands.
	Till—an unsorted mixture of clay, sand, gravel, and boulders.	0-100+	Generally less than 10 gpm; sometimes less than 1 or 2 gpm.
Late Triassic (a period of time ending about 155 million years ago).	Shale, sandstone, shaly sandstone; some conglomerate near eastern and western borders of area.	100-8,000 (or more; thickest near center of valley).	Wide variations in yield, such as between 10 and 500 gpm.
	Diabase—a dark weather-resistant rock of volcanic origin.	100-550 (at or near surface in the Holyoke Range).	Little information; probably less than 2 gpm in most places.
Pre-Triassic (approximately 200 to 500 million years ago).	Crystalline rocks such as schist, gneiss, and granite.	Many thousands (underlying entire area).	Little information; most yields reported to be less than 10 gpm.

helps to increase natural low flow. The greater the demand for water, the more regulation of river flow is necessary if supply is to be reasonably constant.

There is another source of water in the area as well as the Connecticut River and its tributaries. It is the water lying beneath the surface of the land, "ground water," as it is called by geologists and hydrologists. It moves slowly through the rocks, emerging sometimes as a spring, or flowing into a river or lake. Rock formations which are capable of yielding water to wells are known as aquifers. Geologists use the word "rock" to mean both consolidated formations such as sandstone or granite, and unconsolidated sediments like gravel, sand, and clay. Sand and gravel aquifers contain and yield great quantities of water because they are permeable and porous. Tighter rocks such as clay, shale, granite, or other hard rocks yield less water.

Underneath the aquifers everywhere at some depth is rock that is water-tight, because the great pressure at depths has closed up the pores and spaces. Water seeping down from the earth's surface collects above the impervious layer. The top of this zone of free water or saturation is called the water table. The level of the water table fluctuates according to the amount of precipitation.

There are three major groups of rocks in the Springfield-Holyoke area, and some ground water is obtainable from parts of each of the three groups, as shown in table 1. The youngest group consists of clay, sand, and gravel—all unconsolidated rocks—of Pleistocene (glacial) age. These rocks cover the surface of most of the area described in this report and are generally between 30 and 200 feet in thickness. The second and next older group are of Triassic age and consist mainly of red or gray shale and sandstone. Diabase, a dark gray and very hard volcanic rock, also part of the Triassic age group of rocks, underlies the Holyoke Range. The Triassic rocks fill a roughly wedge-shaped trough to a depth of some thousands of feet beneath the Connecticut Valley in south-central Massachusetts, as shown in cross section in figure 3.

Finally, the third and oldest, deepest, and thickest group of rocks in the area are crystalline rock-types such as schist, gneiss, and granite. Some of these rocks occur at or near the land surface in the uplands east and west of the Connecticut Valley (figure 3). The word "bedrock" applies to all the consolidated rocks in the area, and therefore includes both the second and third groups described in this paragraph.

The largest supplies of ground water for public and industrial uses are obtained from wells tapping Pleistocene deposits of sand and gravel at depths less than 200 feet below the land surface, and from wells tapping Triassic sandstone or shaly sandstone at depths no greater than 1,000 feet, and usually less than 600 feet. Most of the Springfield-Holyoke area is covered by one or more layers of Pleistocene deposits, but there is wide variation in thickness, structure, and composition of these deposits and therefore also in the availability of water contained in these rocks. Many are principally clay and fine-grained sand, or an unsorted mixture (till), yielding only a few gallons per minute to wells. The larger yields occur where there is sand or sand and gravel brought down by water from melting of glaciers during the glacial epoch 10,000 to 20,000 years ago.

The five wells reported to have the largest yields in the area, each more than 800 gallons per minute, withdraw water from sand and gravel in Westfield and Southwick. These wells penetrate between 50 and 110 feet of waterbearing sand and gravel, a saturated thickness greater than that usually encountered in other places in the area. Most of the glacial deposits likely to yield large amounts of water occur in the eastern and western parts of the valley. Most of the larger industrial ground-water developments to date are located in the central part of the valley, simply because most of the people and industries are located there. These industrial wells generally draw water from rocks of Triassic age.

During dry periods the yield of shallow wells is generally less than in the winter or spring. In such dry periods the water table is lowered below the bot-

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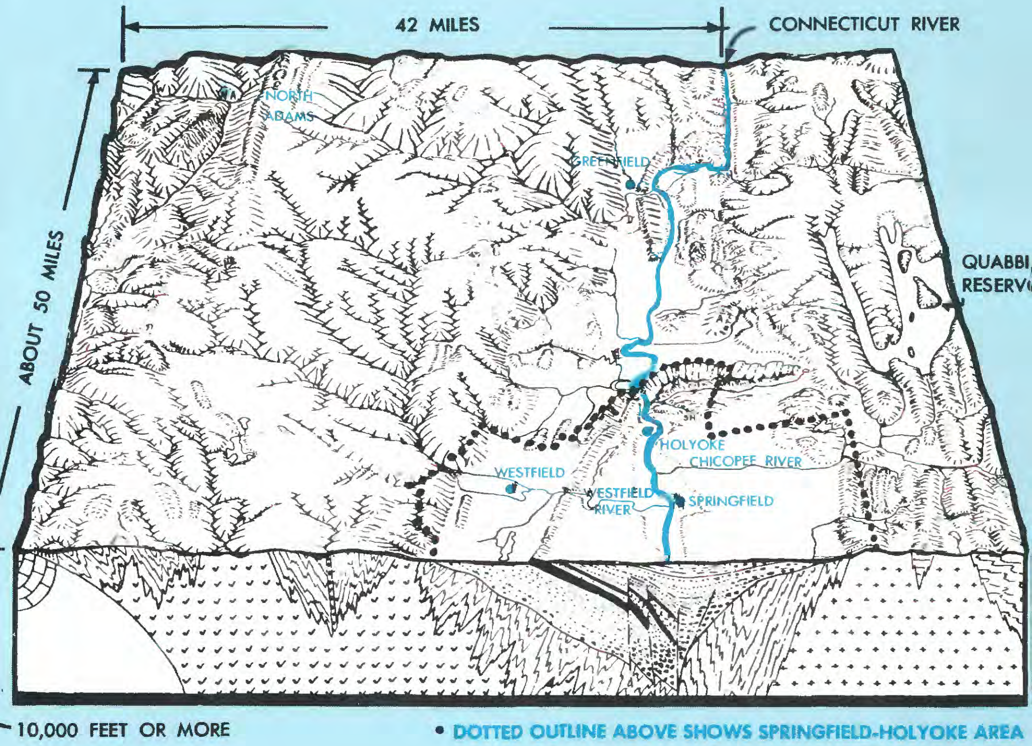


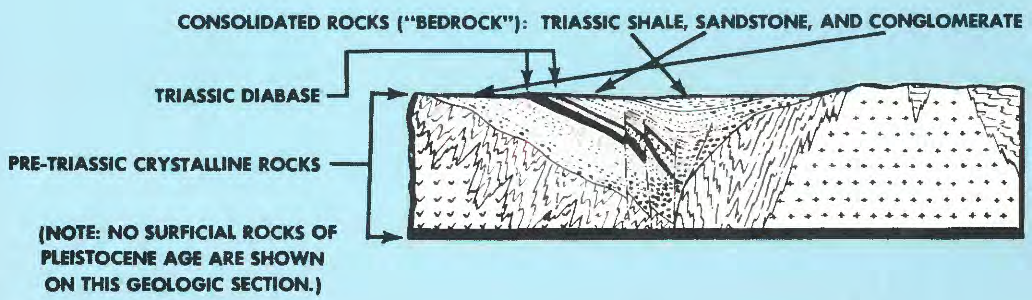
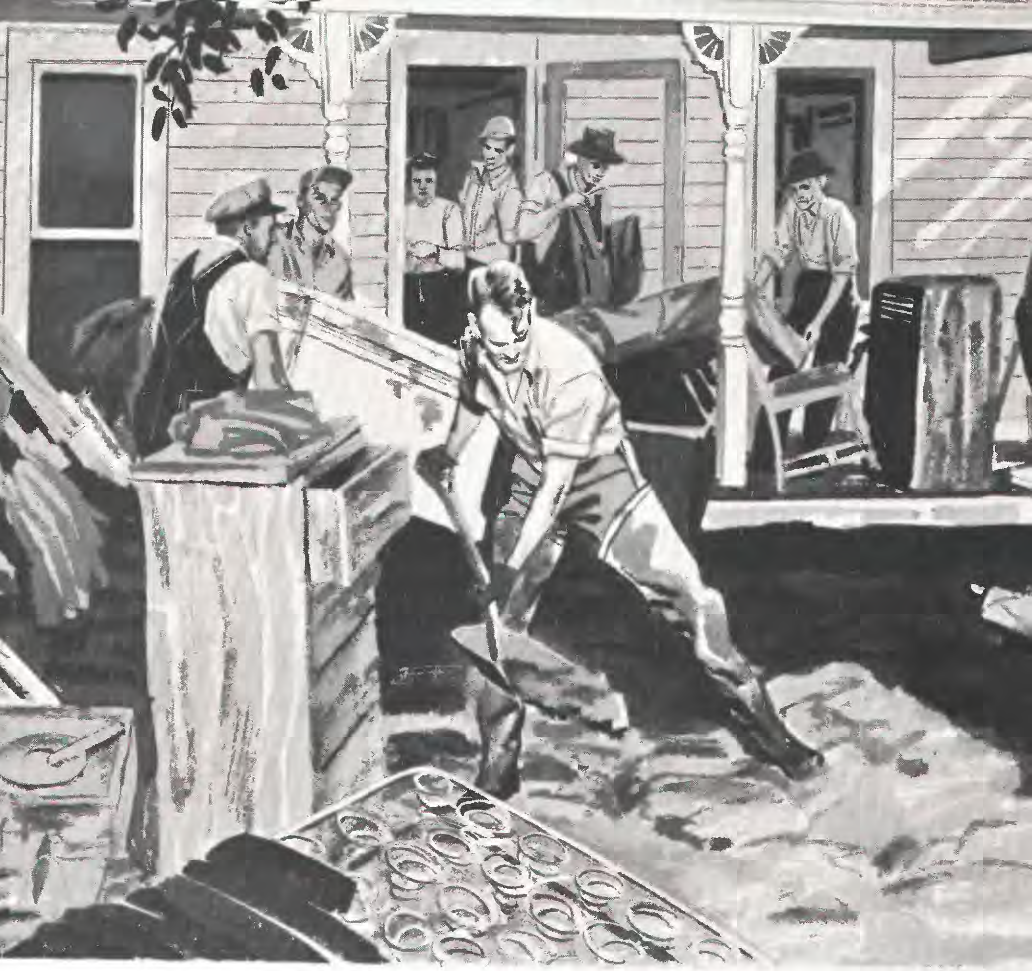


Figure 3.—Landforms of western Massachusetts and subsurface geology along southern border section from diagram (adapted from Bain and Meyerhoff, 1942.)

tom of the shallow wells. However, drought will seldom cause failure of wells which are drilled to a considerable depth. A declining level may also occur because the underground reservoir (aquifer) is emptied by pumping faster than it is replenished by precipitation. Such a condition is not likely to be a serious problem at present in the Springfield-Holyoke area because of the relatively limited development of ground water in the region.

The Geological Survey works with State authorities to locate and map ground-water sources in the Commonwealth of Massachusetts, as in other States. However, in this area there is still a serious lack of information about the locations of favorable sites for ground-water development.

Other wells could probably be developed in the eastern and western parts of the valley. It might be useful to find out more about ground water in the area, partly because the population may continue to increase, partly because new industries using large amounts of water may move into the area, and also because extra sources of water might be needed in case of a national or regional emergency.



FLOODS

There can be too much water, as the people of Springfield and Holyoke know to their cost. Though the Connecticut River is extremely valuable to them and to their businesses and industries, it sometimes goes on a rampage, wrecking homes and factories, killing some and making others homeless and jobless. Many serious floods have occurred in the recorded history of the Connecticut Valley. The average annual loss due to floods in the Connecticut River basin is estimated at $19,635,000. In 1927, although the major flood damage was done in Vermont, 10,000 persons were left homeless in the suburbs of Springfield. In 1936, just as the valley was struggling out of the great depression, it was hit by flood damages of 66½ million dollars. Twenty-four lives were lost; 77,000 were homeless. Extensive damage was done in the industrial areas of Springfield, West Springfield, Chicopee and Holyoke. The water rose above the second floor in many buildings. In 1938, damage from floods in the Connecticut River basin amounted to $48,500,000. The flows of streams in the 1938 flood exceeded those of 1936 on many tributaries of the Connecticut River. In comparison, the floods of 1948 were relatively minor, and resulted in less injury and loss of property—four dead, a thousand homeless, and over a million dollars worth of damage. Floods in 1955 made up for the less damaging year of 1948, however, with 34 deaths and property damage of $130 million in the Connecticut River basin.

There is a point to all these figures. It is to show that although floods may occur at infrequent intervals, the damage they cause is extremely expensive. The sheer human suffering—the loss of loved ones or of homes and memoried treasures—cannot be measured. In addition, floods can dislocate the economy of a region for several years. Flood waters can wash away bridges and roads, factories and properties. A community may take several years to recover from debt incurred in trying to repair flood damages.

Of course, there wouldn't be nearly as much damage if everyone built homes and factories on high ground away from the banks of the river. But the flat, level flood plains are inviting, and usually are built up first. On the whole, the general public seems rather unaware of the problem presented by flood plains. Many individuals or companies buy or build on lands subject to flood, seemingly unaware of the possible consequences.

Some communities today adopt flood plain zoning as a way of protecting themselves against flood damages. By flood plain zoning, we mean restrictions on the kinds of dwellings or businesses which may be developed on the level banks of a river. Zoning might mean restriction of use of flood lands to agriculture or municipal parks. Commercial enterprises might be permitted on flood plains if only the floors above flood levels are used for offices, permanent records, and valuable equipment.

A State law permitting flood plain zoning was passed by the Commonwealth of Massachusetts in 1954. Only five municipalities have adopted it, none of them in the Springfield-Holyoke area. Flood zoning is being considered for Agawam, however. It is, of course, easier to regulate flood plain zoning in new subdivisions and communities. In older communities, zoning patterns are already set, and considerable amounts of money may already be invested in the homes or businesses located on the flood plain. It is easier to leave them there instead of relocating, and to use Federal and State funds for flood protection works.

There are several ways in which the existing use of the flood plain might be changed. Zoning is one way. Another way is for public organizations to buy up land along river banks whenever it is vacant or for sale. Such land could be used for parks or recreation areas. A third way would be for the Federal Government to make zoning a condition of funds for rehabilitation and flood protection. However, the possibility of such legislation seems remote at present.

The U.S. Government has measured flood stage on the Connecticut River and its tributaries for about 100 years. The expression "flood stage" simply means the height of the river water at which floods occur. The highest flood stages since the Government started keeping records have been those of 1936, 1938, and 1955. Most of the floods occur in the spring when heavy rain and melting snow increase the runoff into rivers. However, a number of floods have occurred at other times of the year, when hurricanes bringing heavy rains have followed one another. For instance, the flood of March 1936 was caused by heavy rains and melting snow. That of September 1938 was caused by heavy rains followed by the rains of a tropical hurricane. In August 1955 the flood was caused

by hurricane Diane following within several days of hurricane Connie.

When there are floods on the Connecticut River, there undoubtedly are floods on some of its tributaries as well. High flows on the Chicopee were recorded in the same three outstanding flood years—1936, 1938, and 1955. Historical records show that the 1938 flood was the highest since 1847. We know the years when floods have occurred on the Westfield River since 1692, although we don't know how severe the early ones were. Flood records have been kept at the gaging station near Westfield since 1914, and these measurements along with historical records show that the flood of 1955 was the greatest in the past 160 years. This flood, which isolated the city of Westfield, reached a stage of 34.2 feet. Almost 20 inches of rainfall was measured, of which 18 inches fell in a single 24 hour period. Most of the damage done in the Springfield-Holyoke area by the '55 flood occurred in the Westfield River basin.

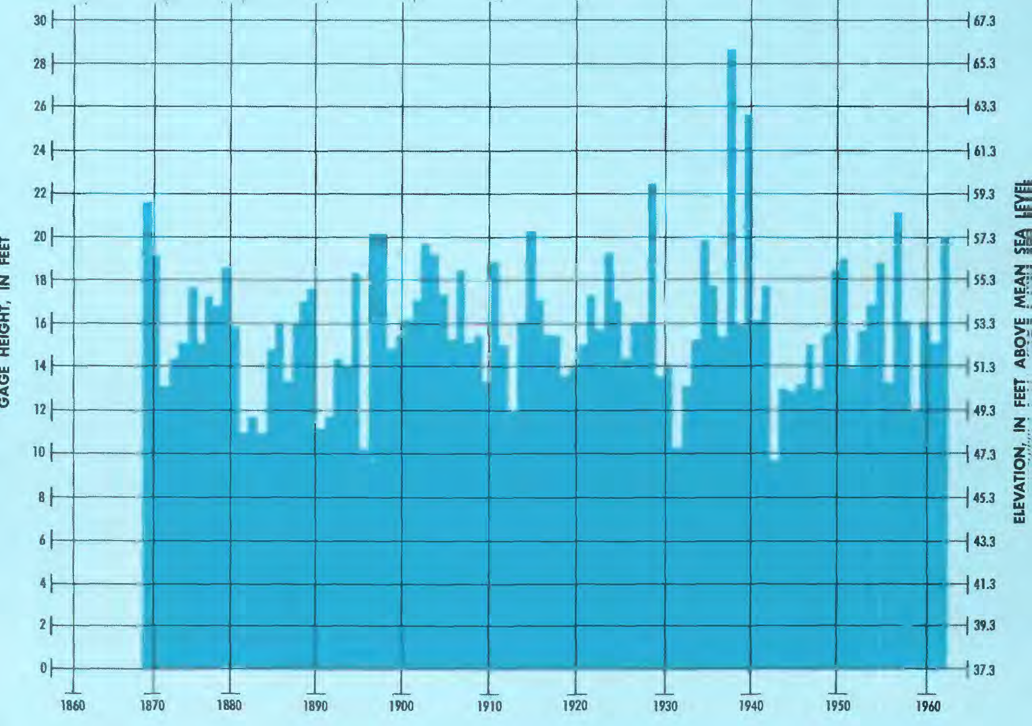


Figure 4.—Maximum annual stage of Connecticut River at Springfield, 1869-1960

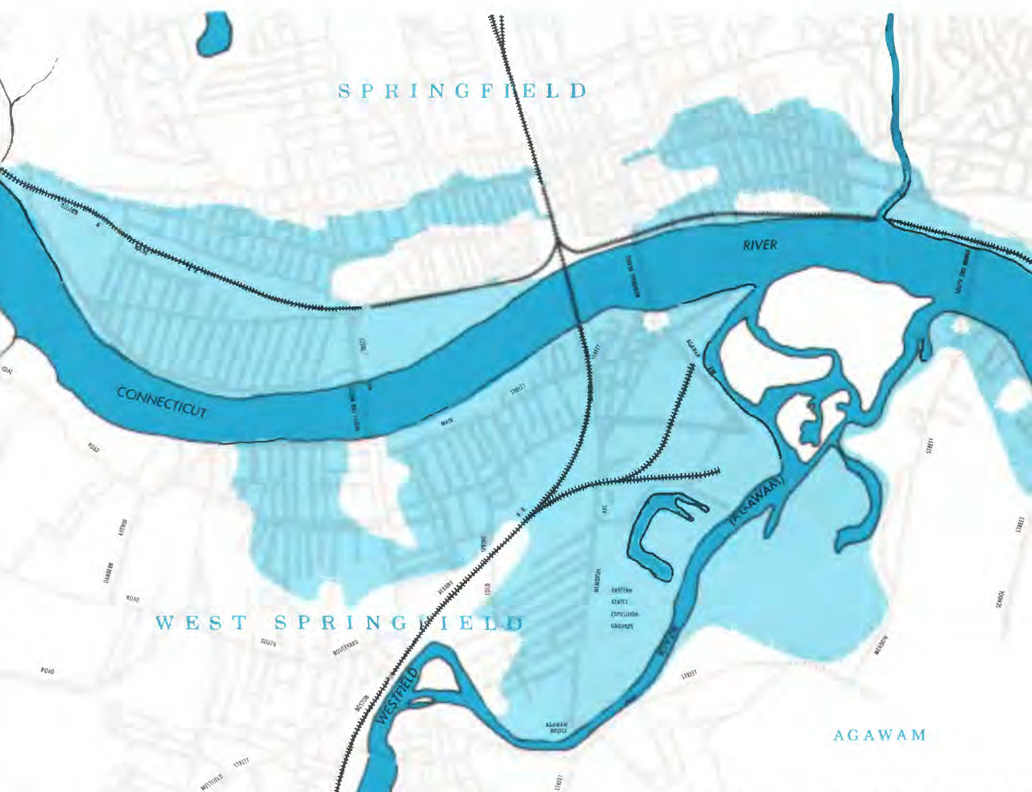


Figure 5. Flooded area of Springfield and West Springfiel
March 1936

Records for the Connecticut River at Springfield show that floods of 20 or more feet during a single year have occurred at average intervals of 11 years. In figure 4 you can see the maximum annual stage of the Connecticut River from 1869 to 1960. Even though the actual interval between floods was shorter or longer than the average, high stages have occurred too frequently for comfort. You can get some idea of the damage done in Springfield itself by the flood of 1936 from figure 5, which shows the overflow limits of the river. This flood was so disastrous that it stimulated public interest in flood control. People everywhere in the valley backed their senators and representatives in seeking Federal flood-control legislation and funds.

The Flood Control Act of 1936 authorized construction of reservoirs on tributaries of the Connecticut River. Because of the concentration of population and the extensive development of the area, the plan recommended by the Corps of Engineers was based on the construction of moderate-size dams on tributary streams, combined with local flood-protection works such as levees and flood walls. Levees are earth embankments to prevent flooding. Flood walls are made of reinforced concrete, and are more often used in cities where space is at a premium.

The Act also granted permission to two or more States to enter into flood-control compacts, to share costs of acquiring lands and rights of way necessary for building the dams. For this purpose the Connecticut River Valley Flood Control Commission was established, consisting of 12 commissioners, 3 from each of the 4 States concerned—Massachusetts, Connecticut, Vermont and New Hampshire. Later legislation has authorized a total of 27 reservoirs. Of these, 11 have been built. In downstream order they are: Union Village, North Hartland, North Springfield, Ball Mountain and Townshend, all in Vermont; Surry Mountain and Otter Brook in New Hampshire; Birch Hill, Tully, Barre Falls and Knightville, in Massachusetts. It must be understood that these reservoirs are part of the comprehensive plan for the *whole* Connecticut River basin.

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KEY

STATUS OF FLOOD-CONTROL RESERVOIRS

● COMPLETED OR UNDER CONSTRUCTION

* UNDER DESIGN OR ACTIVE PLANNING

✱ OTHER RESERVOIR SITES PROPOSED AS PART OF COMPREHENSIVE SYSTEM (SUGAR HILL, N.H. SITE OMITTED)

FIG. 6

FIGURE 6.—Present and Proposed Flood-Control Reservoirs (Adapted From Reports of The U. S. Army Corps of Engineers and the New England-New York Interagency Committee)

Not all of them directly affect river stages in the Springfield-Holyoke area. In fact, 4 of the proposed 27 reservoirs are on tributaries below Springfield.

The reservoirs which have the most direct effect on the Springfield-Holyoke area are: Barre Falls, which reduces flood stages at North Wilbraham, Ludlow, Indian Orchard, Chicopee Falls and Chicopee, and other centers below the meeting of the Chicopee and Connecticut Rivers; and Knightville, which protects Westfield. Nevertheless, reservoirs on any tributaries of the Connecticut River north of Springfield and Holyoke have some effect in lowering stages downstream.

Other flood-protection works, such as dikes and flood walls, were also authorized and have been built at Holyoke, Chicopee, West Springfield, and Springfield. These works protect highly developed industrial, commercial and residential areas. The dikes and flood walls have a top elevation from 1.8 to 4.8 feet higher than the stage which would have been reached in the flood of 1936, had the five upstream reservoirs completed in 1956 been in operation. A new project, authorized in 1960, will be located along the east bank of the Chicopee River in the city of Chicopee. Together with the existing Barre Falls Reservoir, these works will provide flood protection for Chicopee Falls. Also authorized in 1960 was the Westfield local protection project. These works will be located at the junction of the Westfield and Westfield Little Rivers. Together with Knightville Reservoir and the authorized Littleville Reservoir, the project will provide major protection for the city of Westfield.

An additional 2 of the 27 reservoirs are presently under construction or design. Only one of these two—at Littleville in Massachusetts—would affect the Springfield-Holyoke area directly. Figure 6 shows the location of the flood-control reservoirs which have been authorized and those which are already constructed.

A number of industrial plants have privately financed construction of flood-control works for their own protection. Districts which have no flood-protection works now at least have the advantage of a warning system so that people and valuables can be evacuated before the waters rise too high. The Flood Warning Center is at Bradley Field, Windsor Locks, Conn., and is operated by the Weather Bureau for the benefit of New York and New England.

Building reservoirs is a slow and costly business. Land for the reservoirs has to be bought or leased, usually from farmers living along or near an upstream tributary. Families—sometimes whole communities—have to find homes and ways of earning a living elsewhere. It is hard to fix a price for the acquisition of land that is fair to both landowner and government. Finally, a great deal of time may elapse between authorization to build a dam, and the actual beginning of construction. The delay is necessary for surveying, planning, and negotiation, but the resulting uncertainty is a hardship for the landowners in the area.

Even if the people upstate did not object to selling or leasing their land for reservoirs, there is still the loss to the economy to consider in choosing reservoir sites. Productive farm land is needed in New England, which contains about six percent of the nation's population but produces only two percent of its farm products.

While each of the reservoirs has beneficial effects in lowering flood stages on the respective tributaries, the prime purpose of the whole system is to lower stages of the Connecticut River at damage points in Massachusetts and Connecticut. At different times in the past, citizens in New Hampshire and Vermont have banded together to try to prevent inundation of their pasture, farmlands, homesteads and graveyards. The people living upstream not unnaturally tend to believe in small projects on tributary rivers, flood-plain zoning, and reforestation as alternatives to large dams and reservoirs. Their spokesmen have recommended that industries and other developments along the Connecticut River should move to higher ground. The people downstream who are subject to floods seem to care less about the flooding of quaint old villages and farms. People in the downstream communities argue that the cost of moving entire industrial and commercial centers away from the flood plains would be enormously expensive, far more than the cost involved in developing and improving new farming areas.

The Interstate Flood Control Compact is a way of trying to settle these differences. Each State now has the right to approve or disapprove sites proposed for reservoirs within its own State. Furthermore, the compact provides for payments by downriver States of the greater share of the costs to the upriver States of the damages and tax losses which result from flooding of farmland. Even with such compensation, however, locating suitable reservoir sites remains a real problem.

No amount of construction can prevent floods; it can only lessen their effects. The flood plain belongs to the river; it is difficult and expensive to keep the river from occupying the flood plain. Warnings to those who live or work on the flood plain should be clear and unmistakable. Where possible, State and local governments might well give serious consideration to the adopting of flood zoning regulations. In the final analysis, we must adapt our use to the river, as well as adapt the river to our use.

QUALITY OF WATER

When we turn on the tap, we seldom give any thought to the quality of the water. We may notice slight differences in taste from one area to another, but that is all. We take the purity of water for granted. But in one sense, there is no such thing as "pure" water. All water contains dissolved matter of one kind or another. Rainfall is as nearly pure as water can be in the hydrologic cycle, yet it contains dust, minerals, carbon dioxide and other substances. As water flows over the earth or under the earth it gradually dissolves minerals. In many waters these "natural" substances occur in such small quantities that the water in its natural state—before contamination by man's activities—is usable for many purposes, including public water supplies.

We express the amount of dissolved matter in parts per million. That is, a million pounds of water which contains ten pounds of dissolved material is said to have a concentration of 10 parts per million. More than 500 parts per million of dissolved matter is considered undesirable for a public water supply.

In its natural state, the chemical quality of the water in the Springfield-Holyoke area is excellent to very good in most places. It can be used with a minimum of treatment. Most of the river waters contain less than 100 parts per million of dissolved mineral matter (figure 7), and are classed as "soft" waters. Iron is the only chemical which generally occurs in undesirable concentrations and such water may require treatment. If not treated, water with iron in it may stain textiles and porcelain fixtures. The excellent quality and abundance of the local water is one reason why many industries have located in and near Springfield and Holyoke. Some of the ground water in the area contains several hundred parts per million of dissolved solids and is hard, so that treatment would be desirable prior to some types of water use.

When we speak of pollution, however, we do not usually mean the minerals or chemicals which are naturally in water. We mean the wastes which are a result of our urban and industrial way of life.

Figure 7.—Chemical quality of water from streams and wells

These may be of two kinds—sanitary sewage or industrial wastes. The larger streams in the Springfield-Holyoke area are polluted much of the time, because they serve for disposal of both kinds of wastes. Water suitable for drinking and for recreational purposes can be found upstream on the tributaries, some distance east and west of the urban and industrial centers. At these sources the condition of the water is good to excellent. Yet there may be some variation in the sanitary quality of even these waters, as certain small communities upstream add untreated domestic sewage to the water.

In 1947, the New England Interstate Water Pollution Control Commission was established to coordinate antipollution surveys and programs in the New England States and New York. This agency has established a code for classification of waters according to their sanitary condition. You will find this code in table 2, which shows the standards laid down for each use classification. Water classified "A" is excellent; water classified "E" is of unsatisfactory sanitary quality. Federal Public Law 660 provides financial aid to States for water pollution control. Much basic research is needed, for there is as yet no inexpensive or economically feasible way of removing dissolved materials such as detergents in water. Particularly difficult is the removal of dissolved chemicals from chemical and plastic industries. Many of these wastes are complex compounds, the exact chemical nature of which has not even been identified.

Presently, the sanitary quality of the Connecticut, Chicopee and Westfield Rivers in the immediate metropolitan area is of condition "D." This condition results partly from disposal of industrial wastes and partly from disposal of untreated sanitary sewage. If raw sewage is dumped into a river, the oxygen in the water will gradually decompose it. The oxygen in the river water is absorbed from the air and from plants growing in and near the water. However, a river may become so overloaded with wastes that the natural oxygen in the water cannot cope with the load. This is the situation on parts of the Connecticut River and its local tributaries.

Table 2. Classification of sanitary condition of waters (by New England Interstate Water Pollution Control Commission)

SUITABILITY FOR USE

	Class A	Class B	Class C	Class D
	Suitable for any water use. Character uniformly excellent.	Suitable for bathing and recreation, irrigation, and agricultural uses; good fish habitat; good aesthetic value. Acceptable for public water supply with filtration and disinfection.	Suitable for recreational boating, irrigation of crops not used for consumption without cooking; habitat for wildlife and common food and game fishes indigenous to the region.	Suitable for transportation of sewage and industrial wastes without nuisance, and for power, navigation, and other industrial uses.

STANDARDS OF QUALITY

Dissolved oxygen . .	Not less than 75 percent saturation.	Not less than 75 percent saturation.	Not less than 5 parts per million.	Present at all times.
Oil and grease	None	No appreciable amount.	Not objectionable . .	Not objectionable.
Odor, scum, floating solids, or debris.	. . . . do	None	None	Do.
Sludge deposits . . .	. . . . do	. . . . do	. . . . do	Do.
Color and turbidity .	. . . . do	Not objectionable . .	Not objectionable . .	Do.
Phenols or other taste-producing substances.	. . . . do	None	None	
Substances potentially toxic.	. . . . do	. . . . do	Not in toxic concentrations or combinations.	Not in toxic concentrations or combinations.
Free acids or alkalies.	. . . . do	. . . . do	None	Not in objectionable amounts.
Coliform bacteria . .	Within limits approved by State department of health for uses involved.[1]	Bacterial content of bathing waters shall meet limits approved by State department of health and acceptability will depend on sanitary survey.		

[1] Sea waters used for the taking of market shellfish shall not have a median coliform content in excess of 70 per 100 million.

NOTE.—Waters falling below these descriptions are considered as unsatisfactory and as class E. These standards do not apply to conditions brought about by natural causes. For purpose of distinction as to use, waters used or proposed for public water supply shall be so designated.

The principal sources of industrial wastes at present are paper mills, textile mills, metal industries, chemical plants, breweries, meat and other food processing plants. Usually, pollution by such industrial wastes makes the water unfit for domestic use, but it can still be used for other purposes, such as navigation or power development, or cooling for industries. Or the polluted water can be used by industries which do not need first quality for processing. However, at some times and places, the pollution is severe enough to create a nuisance condition. During periods of low flow and high temperature in the summer, certain stretches of water on the Chicopee and Westfield Rivers are completely unacceptable for any ordinary use. The water into which the wastes are discharged is colored gray or black by decomposing organic matter, and the odor is offensive.

In addition, there are some cities and towns in the area that do little toward treatment of municipal sewage, before it is discharged into these rivers. Because of the expense of building treatment plants, it is usually the smaller towns that discharge untreated sewage into the rivers. Springfield, Ludlow, and Longmeadow have adequate disposal facilities, and Chicopee, Holyoke, Westfield, and Wilbraham plan construction of treatment plants. A sewage treatment plant for South Hadley was completed in 1960. In the city of Springfield proper there has been a serious lack of sewers in the newer areas, such as Sixteen Acres, Boston Road, and Indian Orchard. However, the septic tanks are now being replaced by trunk sewers and lateral lines as quickly as possible. Septic tanks are still used in Southwick. Work is continuing on two interceptors for carrying sewage from Agawam to the Springfield municipal sewage treatment plant.

The quality of the ground water in the area varies. Basically, it is satisfactory for many purposes and usually can be used with a minimum of treatment, even for drinking and bathing. Although it is harder than the water from streams, it is more constant in composition and temperature, and is therefore useful


for certain industries. However, in industrial areas near the Connecticut River, the sanitary quality of the ground water in some wells is reported to be unsatisfactory for drinking purposes. One of the aquifers may have been contaminated locally, by disposal or seepage of waste materials into the ground. Once the water in an aquifer is polluted, it may take years before it is slowly purified by nature. Wells containing polluted waters would not continue in use, if the use depended in any way upon their sanitary quality.

In a third of the wells sampled by the Geological Survey, the water was found to contain a high concentration of iron. This water would have to be treated to prevent staining of porcelain and textiles. In 15 out of the 23 wells, the hardness was over 60 parts per million. Treatment to reduce hardness would also be desirable for some purposes. In general, water from wells drilled in the sand and gravel deposits contains less dissolved solids than that from the older and harder rocks. Where iron is not a problem, water from the younger rocks is satisfactory for many purposes.

Because water for public water supplies is obtained from upstream and relatively unpolluted sources, you may wonder why there should be concern about the quality of the waters in the immediate metropolitan area. What difference does it make, as long as people are not drinking the water and washing in it? Well, they might want to go swimming, boating, or sailing. Such activities would not be very pleasant in waters of condition "D." Fish life can be affected or even wiped out by polluted water. Then, too, many industries need relatively pure, clean water. Plants which make synthetic fabrics, for instance, cannot use polluted or brackish water. New industries coming into an area may be seriously hampered because a possible source of water supply is polluted. (Indeed, their choice of area may be strongly influenced by the availability of a high-quality water supply.) Perhaps the most important reason for concern is that water, unlike the other resources of the earth, is not fixed. It is constantly on the move, on the surface or underground. The water polluted in Holyoke and Springfield flows down the river to Hartford and other towns in Connecticut. One man's pollution is another man's poison, you might say.

Some local municipalities and industries are building treatment plants. The management of some industries may wish to co-operate with the pollution-control program, but may feel they cannot afford the expense of building treatment plants. However, the pollution-control program of the Commonwealth of Massachusetts aims at least at primary treatment of all wastes and sewage. Primary treatment consists of settling the water and applying chlorine to kill the bacteria. Such treatment reduces the pollution load by about 35 percent. By this means, the State hopes to improve the waters at least to condition "C" as soon as possible.

TODAY'S USES

Now that we have a general idea of the quantity and quality of water in the Springfield-Holyoke area, let us take a look at the people who live here, see what kinds of work they do, how they are supplied with water, how much or how little they use the millions of gallons a day poured out by the Connecticut River and its tributaries.

According to the 1960 census, there are 420,000 people living in Springfield and the dozen neighboring cities and towns. Most of these people make their living working in factories. One third of personal income in New England generally comes from factory payrolls. This is the highest percentage in the country, and in the Connecticut River basin this percentage has been increasing. Population in this densely settled area has been increasing also. Although generally speaking, economic growth in New England has not quite kept pace with growth in other areas of the country, certain industrial areas in New England are prospering. Springfield-Holyoke is one such area.

From the earliest times Springfield has been an industrial community with highly skilled workmen. Upon this stable base has grown a well diversified economy, with two great advantages—a moderate climate and ample supplies of soft water. Holyoke was deliberately laid out as a mill town by Boston industrialists to take advantage of the water resources for product processing. Three levels of canals bring water from the Connecticut River through the industrial area to provide power and water for processing. There are about 900 manufacturing industries in the Springfield-Holyoke area. The chief industries are paper mills, metal processing and fabricating plants, textile mills, chemicals, and machinery-making plants. Of these industries, two groups are big water-users—paper mills and chemicals. Names of some of the major companies are shown on figure 8, and at the end of the book you will find a list of most of the large manufacturing industries.

There is also some agricultural activity in the area, chiefly vegetable farming and tobacco. There is some supplemental irrigation during prolonged dry spells, but this usage is too small at present in the Springfield area to constitute a problem of water-use in competition with cities and industries.

There are seven public water systems serving the people of the Springfield-Holyoke area with an average of about 60 million gallons a day for domestic and other uses. These seven systems are: Springfield, Holyoke, Chicopee, West Springfield, Westfield, Wilbraham and South Hadley Fire Districts 1 and 2.

FIG. 8
SOME MAJOR MANUFACTURING INDUSTRIES

Table 3 describes the source of water for each of these systems, and the area and population served. It also shows how the water is treated to make it suitable for domestic use. Figure 9 shows on a map the general area served by each system and the precise location of the source of water for each one. As you can see, most of the water for these public systems comes from tributaries and small rivers upstream or from wells. These waters are not polluted by industrial

Table 3. Public water supplies, 1960

(Sources of data: Records of Massachusetts Department of Public Health, municipal water departments, U.S. Geological Survey, and U.S. Public Health Service)

NOTE: Treatment methods identified as follows: A—aeration; C—coagulation; D—chlorination; F—filtration; N—ammoniation; S—sedimentation; T—activated carbon; X—no treatment.

Name of water system	Other towns and places served	Population served (persons)	Source of water	Water treatment (see above)	Average water use (mgd)
Chicopee	Willimansett	61,500	Quabbin Reservoir (Swift and Ware Rivers).	D	7.5
Holyoke	Southampton	54,000	Reservoirs and ponds on Manhan River and Paucatuck Brook.	D	8.4
South Hadley Fire District 1		9,800	Quabbin Reservoir Leaping Well Brook (auxiliary-supply reservoir).	D D	.84
Fire District 2		4,000 (including college students)	Lithia Springs Reservoir (Elmer Brook). 2 wells near Elmer Brook.	F X	.38
Springfield	Agawam, East Longmeadow, Longmeadow, Ludlow, Southwick, West Wilbraham and Westover Air Force Base.	230,000	Cobble Mountain-Borden Brook Reservoirs (Westfield Little River). Ludlow Reservoir (Higher, Broad, and Jabish Brooks).	ASF FD	37.6
Westfield		22,000	Granville and Montgomery Reservoirs (Moose Meadow and Munn Brooks).	ND	2.9
West Springfield		25,000	Bearhole Brook Reservoir (Paucatuck Brook). 3 wells near Great Brook, Southwick.	AFD D	2.8
Wilbraham		5,000	Quabbin Reservoir.	D	.34

Figure 9—Public water supplies—sources and areas served

and municipal wastes and are of good or excellent quality.

The Cobble Mountain-Borden Brook Reservoirs to the west of Springfield are the largest source of water developed entirely for the Springfield-Holyoke area. Together they have a combined storage capacity of 25,400 million gallons. Supplied at the rate of 60 million gallons a day—which is the average rate of use of public supplies in the area at present—this amount would last about 14 months. The Cobble Mountain-Borden Brook Reservoirs supply Springfield, Longmeadow, Agawam, East Longmeadow, Southwick, Westover Air Force base, and parts of Westfield.

Ludlow Reservoir, six miles northeast of Springfield, provides water for Ludlow and for the Monsanto Chemical Company in Springfield. Holyoke is supplied chiefly by the Tighe-Carmody and White Reservoirs on the Manhan River. West Springfield is supplied by local water sources; about one half the supply being from wells in the northeastern part of Southwick. Quabbin Reservoir, located on the Swift River 15 miles northeast of Springfield, is the source of water for Chicopee, Wilbraham, and South Hadley Fire District 1. (The Quabbin site was developed for the primary purpose of supplying water to Boston and vicinity. About 136 millon gallons a day are diverted from the Swift and Ware Rivers for the Boston metropolitan area.)

The wells which provide part of the public water supply to South Hadley, Westfield, and West Springfield, are listed in table 4. Some of them have been developed fairly recently as a supplemental supply. All the wells draw water from deposits of sand and gravel lying close to the surface. If population and industry increase, more wells may be needed. Ground water sources in the area are largely unmapped as yet, and detailed geologic studies and exploratory drilling will be required to discover the potential ground water resources.

When a plant is to be built, the industry can choose between using public water supplies or developing its own water system from the nearest stream or well. Public water supplies are often the most convenient, because they already have pumping plants and treatment works. But it may be more economical for an industry to develop its own water supply. However, the mere cost of obtaining the water in the first place does not represent the total expense of water to industry. Industries must also consider the expense of treating the water to make it suitable for use (if such treatment is necessary), and the expense of treating it after use, to make it suitable for others to use.

According to the report of the Senate Select Committee on National Water Resources, major water-using industries try to hold the cost of water within a range of 5–10 cents per 1,000 gallons. Smaller volume users will usually buy from public utilities at a cost of 12–20 cents per 1,000 gallons. Costs in Springfield are about average. Home owners and small commercial users pay from 21 to 32 cents per 1,000 gallons. Industries using over 5,000 gallons a day pay 12 cents per 1,000 gallons. Suburban towns using water from the Springfield system are supplied at a rate of 12½ cents per 1,000 gallons. Costs of water in Holyoke are about the same.

Table 4. Public-supply wells—depths and yields.

Town well number	Year constructed	Diameter	Depth of well (feet)	Yield (gpm)
SOUTH HADLEY WELL SUPPLY (Fire District 2)				
1	1911	25 feet	12	about 100 (combined)
2	1919	30 feet	15	
WESTFIELD WELL SUPPLY				
1	1957	24 inches	118	1,400
2	1958	24 inches	118	1,400
WEST SPRINGFIELD WELL SUPPLY				
1	1954	18 inches	130	1,500
2	1954	18 inches	127	850
3	1954	24 to 18 inches	112	850

Look at figure 10 which shows how the annual quantity of water supplied by each of the public systems has increased from 1941 to 1960. The increase during the 20-year period amounted to 76 percent—a rather steep rise which should give us pause for thought. More than half of this water is supplied to commerce and industry. Some small companies use water from public supplies for processing. Many industries use water from public supplies for drinking purposes and their own water supply for processing. In addition, steam-electric power plants on the Connecticut River use, from privately developed systems, nearly 150 million gallons

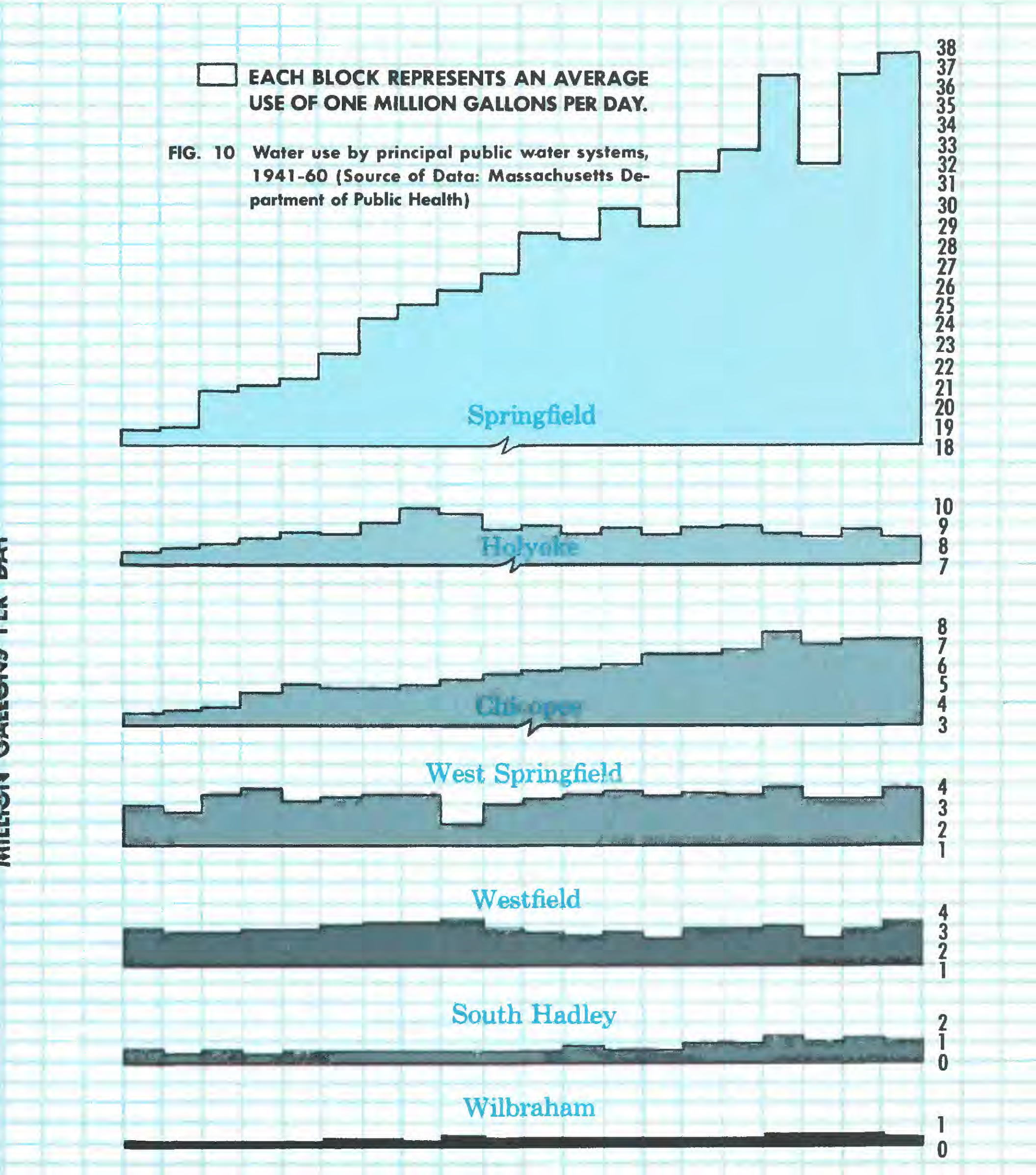


FIG. 10 Water use by principal public water systems, 1941-60 (Source of Data: Massachusetts Department of Public Health)

a day to cool condensers. Other self-supplied industries (including paper mills, metal processing and fabricating plants, textile mills, and chemicals) use 100 to 200 million gallons a day. Some industries use nearby wells, either for auxiliary supplies, or because they need water of constant chemical quality and temperature. The industrial use of water from wells is about 7 million gallons a day. Average use of water for irrigation and other rural supplies probably is about 1 or 2 million gallons a day.

The flow of the Connecticut River is highly regulated by reservoirs and hydroelectric power plants. Altogether, in 1956, there were approximately 95 billion cubic feet of reservoir storage in the Connecticut River and its tributaries, above Thompsonville, Conn. Of this amount, about 30.3 billion cubic feet (32 percent) was storage for hydroelectric power; 8.3 billion cubic feet (9 percent), storage for flood control, and 55.9 billion cubic feet (59 percent), storage for water supply. Although water-supply storage is much greater than power storage, most of it is in Quabbin Reservoir and is held from one year to the next. Water in the power reservoirs, on the other hand, can be released to increase the flow of the river during low-flow periods. The flood-control reservoirs are empty most of the time.

There is less development of electricity from waterpower in the Connecticut River basin than you might expect, considering the amount of water available. Steam-electric power meets nearly all of the base load. For technical reasons there are not many sites remaining suitable for hydropower development in the Connecticut River basin. The New York-New England Interagency Committee, appointed by President Truman to study the water resources of New York and New England, found only 8 feasible sites for water power out of 350 considered. Few flood-control reservoir sites have sufficient storage capacity to provide hydropower development as well as flood control. Of the 11 dams built to date for flood control, only one of them (Tully) is suitable for future hydropower development.

It is difficult to show on a table or figure how much the water resources in the area are used for recreation. We do know that the use is increasing, and will continue to increase if standards of living continue to rise and leisure-time activity grows, as we expect. People everywhere in the United States are becoming more and more interested in boating, water-skiing and skin-diving. At the recent National Watershed Congress, water sports were said to be growing faster than any other kind of recreation in the United States .

Fortunately, the people of the Springfield-Holyoke area are well supplied with park and water resources for recreation. The main recreational facilities convenient to the Springfield-Holyoke area itself are Forest Park in the city of Springfield, Skinner State Park at South Hadley, J. C. Robinson State Park at Westfield, Mount Tom Reservation at Holyoke, and Quabbin Reservoir. J. C. Robinson State Park and Mount Tom Reservation have swimming and fishing facilities. Skinner State Park and Forest Park do not. There are three public outdoor swimming pools in Springfield, but the city's master plan recommends at least five more. There are no extensive municipal facilities for swimming or outdoor recreation in the city of Holyoke, but the Holyoke Master Plan recommends conversion of the Whiting Street Reservoir to a recreation facility, to include swimming. A potential recreation area in Springfield which has been overlooked to date is Watershops Pond (otherwise known as Massisoit Lake).

Public swimming on the Connecticut and Westfield Rivers is not encouraged, and there are no public beaches. Swimming in these rivers (though possibly done unofficially) is dangerous because of the unsanitary condition of the water.

For the last few years, boating has greatly increased in Longmeadow, Ludlow, Southwick and other communities. There is a good deal of whitewater canoeing on the Westfield River above Westfield. New marinas are being opened to accommodate boating enthusiasts. However, the use of larger boats brings up another pollution problem—the disposal of wastes from galleys and toilets.

Fishing is one of the major sports, and any future plans for water resources must take this into consideration. There is plenty of public fishing acreage around Springfield-Holyoke. The Commonwealth of Massachusetts has leased a considerable amount of land as public fishing grounds, and the opening of Quabbin Reservoir for fishing was an important addition to the recreational resources of the area.

In the past, water projects just grew up in answer to immediate needs, without any particular overall plan. In the process, other resources have been lost. For instance, the installation of dams for water power at Holyoke and Turners Falls made it impossible for the salmon to get up the river to their spawning grounds. This situation, combined with an ever increasing pollution of the waters, exterminated the salmon in the area. Experimental fishways tried out at Holyoke in 1873 and 1940 were failures. Another fish-passage device is now being successfully used at Holyoke. This does not mean, however, that the salmon can be restored to the Connecticut River. Pollution of the water will still present a very serious obstacle. Another problem is the water which is returned to the river after being used for cooling. Warmer water temperatures upset the natural cycle of fish life.

The shad were also held below Holyoke by the dam, but they seem to have survived the pollution of the river better than the salmon, at least to date. If pollution and warm water temperatures should go unchecked, or should increase, the shad too may disappear before plans can be made to save them.

Opening the main stem of the Connecticut River to the fish and abating pollution are only two of the problems connected with fisheries. There are dams on all the tributaries and these would have to be made passable for the salmon also. The shad are less dependent on upstream spawning grounds. The effect of water pollution on the fish which actually live on the tributaries, such as trout, is also detrimental. On the other hand, regulation of the flow of rivers during the low-flow periods of summer could be a help to trout and other resident fish. However, at times, the flow

isn't increased early enough in the season to keep the fish alive. This delay is the result of other recreational demands—boating, swimming and so forth—requiring high reservoir and lake levels.

Another problem arises with storage of water for power. In power-storage reservoirs, the water is released according to daily power requirements. On weekends and at nights the flows may be reduced to a point so low that many of the fish die.

Recreational use of water is nonconsumptive; that is, it does not actually reduce the amount of water available. However, it may be contaminating. This is why some people are opposed to use of water-supply reservoirs for recreation, even if the water is treated before it enters the municipal supply system. They feel that where there is plenty of water naturally available, as in the Springfield-Holyoke area, water-supply reservoirs should not be used for boating, fishing and swimming. If it is argued that the river water is too polluted for safe swimming and for certain kinds of fish, they answer that the river should be cleaned up. There is no doubt that control of water pollution in the Connecticut River and its tributaries would increase recreational opportunities in the Springfield-Holyoke area.

The recreational benefit of water resources can hardly be assessed economically. Some people try to do so by computing the value of all the park passes and permits issued, and of the fishing licenses and operating equipment. This kind of economic assessment is useful in planning, but the real benefits of recreation by a lake or stream involve things impossible to measure—health and skill and appreciation of natural beauty. We cannot measure or decide precisely how much these things are worth to us but we must have them in our lives.

Total water use in the Springfield-Holyoke area amounts to between 300 and 400 million gallons a day. Table 5 shows how this use is broken down. The amount used by an individual person in his home for drinking, washing, and other household purposes averages about 50 or 60 gallons a day. Yet the public water systems of Springfield-Holyoke use about 150 gallons per person per day. The difference is accounted for by industrial use of the public water systems, or by municipal uses such as fire-fighting, swimming pools, etc. The national average per person per day for public water supplies is also about 150 gallons. However, the amount used per person per day in the Springfield-Holyoke area for *all* purposes from *all* types of systems is less than 1,000 gallons. The national average is 1,500 gallons per person per day, but this includes use for irrigation. We should bear in mind, moreover, that industrial use is fairly uniform all year (except for air conditioning and power), whereas municipal use is not. During the hot dry months of summer, the rate of use of public water supplies is sometimes more than twice the average rate.

We have said that the present supply of water far exceeds the demand, and this is certainly true in an absolute sense. Yet in the drought year of 1957, 63 municipalities in Massachusetts had to curtail water use, some only because of distribution problems, some because of actual water shortage. Springfield and Agawam both experienced curtailment of water use, due to low pressure. Since water supply is a changeable asset, its use and distribution have to be planned ahead. It might be well to take a look forward to 2,000 A.D., and see whether any major changes may be forthcoming that would affect water supply and use in the Springfield-Holyoke area.

Table 5. Water use in 1957—sources and types of use.

Type of supply and name of system	Ground water (mgd)	Surface water (mgd)	Total (mgd)	Maximum day (mgd)
Public systems:				
Chicopee	0	7.5	7.5	11
Holyoke	0	8.6	8.6	12
South Hadley (2 systems combined).	.1	1.1	1.2	2.4
Springfield { Little River only	0	36	36	62
Springfield { Ludlow supply	0	39	39	66
Westfield	0	2.5	2.5	3.7
West Springfield	1.3	1.5	2.8	5.1
Wilbraham	0	.3	.3	.5
Self-supplied industrial supplies (entire area).	7	320	327	
Irrigation and other rural supplies (entire area).	1	1	2	

TOMORROW'S NEEDS

We know that the important water-management problems of the area are: control of water pollution; flood control; water-supply storage and distribution; and development of recreational facilities and fisheries. It is difficult to say much more about development of recreational facilities than we already have. This use of water is beneficial, but it does not represent the same urgent consideration as water pollution, flood control and water supply. How will these problems be affected by the future? Nobody, of course, knows what the future will bring to Springfield and the surrounding area, but we can make some guesses, based on facts supplied by the Census Bureau, and by publications of the city itself.

The population of the United States increased 98 percent from 1900 to 1950. During the same period, the population of New England increased 66 percent, mostly in the southern half of the Connecticut River basin. It is reasonable to assume that population in the area will continue to increase slowly.

The population of the Springfield-Holyoke Metropolitan area (as defined by the Bureau of the Census) has grown from 318,119 in 1940 to 407,255 in 1950, to 479,000 in 1960. This is a slow, steady increase, estimated at about one percent annually. If it continues at the same rate, the population in 2000 may be on the order of 915,000. Like most other major cities, however, Springfield has experienced a flight to the suburbs. The rate of increase in Springfield itself and Chicopee has slowed down while the rate of population increase in the suburbs of Agawam, East Longmeadow, Wilbraham and Southwick has risen. From the point of view of flood control it is important to notice that the movement to the suburbs has also been a movement away from the Connecticut River, except for Agawam, which has had the least population expansion of the four suburbs. We can say that as far as residential housing is concerned, there has been a kind of spontaneous flood zoning, at least as far as the Connecticut River is concerned. The newer developments—Southwick, Sixteen Acres and Indian Orchard—are inland from the Connecticut. Wards One and Three of Springfield itself, along the river, have leveled off and are losing population. This doesn't imply that there is no one left living or working on the flood plain, however. There is residential housing and business development along the Connecticut in Springfield, Longmeadow, Agawam, Holyoke, South Hadley

and the other towns in the metropolitan area. You can check the location of these municipalities by referring back to figure 1.

There are several factors favoring growth in the Springfield-Holyoke area. A local organization, Future Springfield, Inc., in its "Resources Inventory," says frankly that until recently the city's organization was old-fashioned. All kinds of problems developed in the growing suburbs, while the main city was in need of face-lifting. Now, however, the city has turned over a new leaf, and as a result of its efforts to modernize and streamline its facilities, it is attracting new industries. The Wall Street Journal has built a new headquarters plant north of Springfield. New plants for a motorcycle company and an electronics company are planned. Expansion is on the books for a paper company and a machinery-making company. A 350-acre industrial park in the center of Springfield has attracted new business. Several corporations are investing in plants at the Springfield interchange in Chicopee. Ludlow and Chicopee have also completed industrial parks. A survey made in 1956 showed that there was still plenty of industrial acreage available,

not subject to floods, near transportation, sanitary sewerage, and water supply. Two new highways are to be built. One, U.S. 91, will run north-south from New York to Montreal and will pass through Springfield. The other, U.S. 291, is an expressway to link the Massachusetts Turnpike with Springfield's central business district. These highways will mean improved truck freight service, and will stimulate business and tourist traffic generally.

All these factors indicate growth and should in their turn produce future growth. A study of the city's master plan (1957 edition) shows that most of these industrial parks will be inland from the Connecticut River. However, the plan assumes that there will be further industrial or business development in the North End along the river between Plainfield Street and Riverside Road. The "Resources Inventory" suggests that West Springfield can expect rapid development after U.S. 91 is built, and prophesies that its potential for commercial and industrial development is bright. However, its location between the angle of the Westfield and the Connecticut Rivers ought to arouse some concern about flood zoning of new developments in low-lying sections along and between the rivers. It is interesting that although zoning is discussed in the master plan, nowhere is there any mention of flood zoning. One of the publications of the Chamber of Commerce specifically states that flood damage is "minimal." This may turn out to be too optimistic an outlook, as other communities have found out in time.

We will assume, then, that by year 2000, industry will have expanded, some of it on the flood plains, and the population will have greatly increased. Water use will increase proportionately (figure 11). Domestic use of water will increase, not only because of a greater population but because of more use of automatic appliances, such as disposalls and dishwashers. Perhaps a greater amount of water will be required for lawn watering and home swimming pools. But industry will still be the big water user. Two of the major types of industries in the area are among the six types which use the most water nationally. These are chemicals and paper. The coming of new industries to the area may increase demands on water resources.

Growth of the Boston metropolitan area could increase the demand on the Swift and Ware Rivers through the Quabbin Reservoir. The Report of the Senate Select Committee on National Water Resources (popularly known as the Kerr Report), estimates an increase of nearly 1½ million people in the Boston area by the year 2000. Similarly, water use (from public supplies) in the Boston area may rise from the present 268 million gallons a day to 534 million gallons a day. However, some thought has already been given to increased demand in the Boston area. The suggestion has been made that water be diverted from the Millers River (a tributary of the Connecticut), for the use of Boston. This would require approval of the United States Supreme Court.

In one sense, all these figures sound more frightening than they really are. The Connecticut River basin is not likely to run out of water as far as sheer quantity is concerned, at least not in the foreseeable future. Cobble Mountain, Borden Brook, Ludlow, Tighe-Carmody, and Quabbin Reservoirs afford quite a margin for public water supplies. When we suggest that additional sources of water may need to be de-

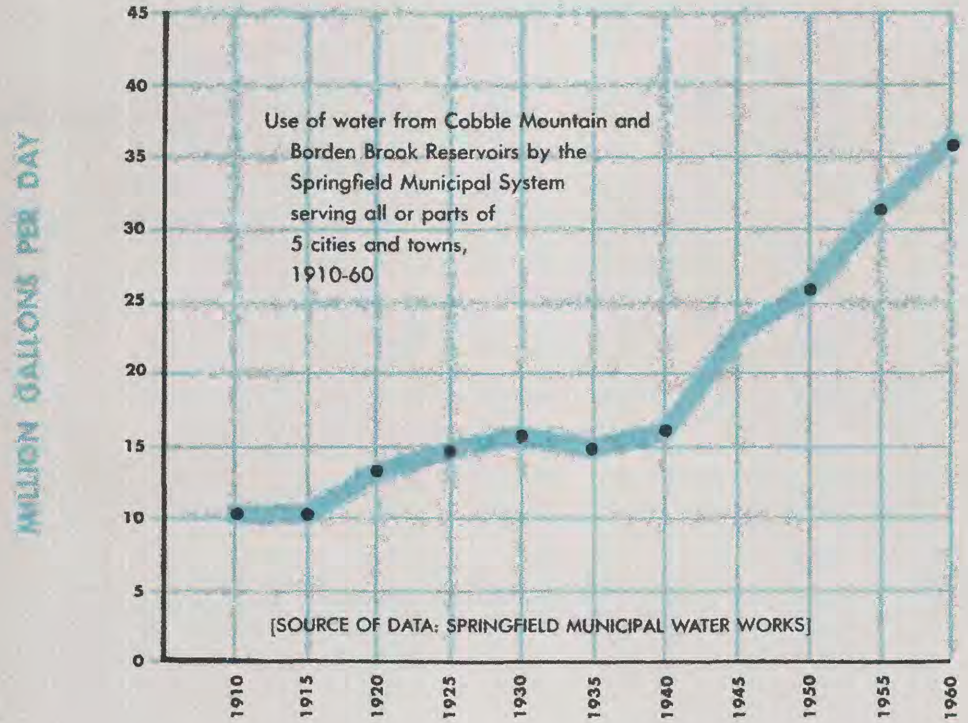
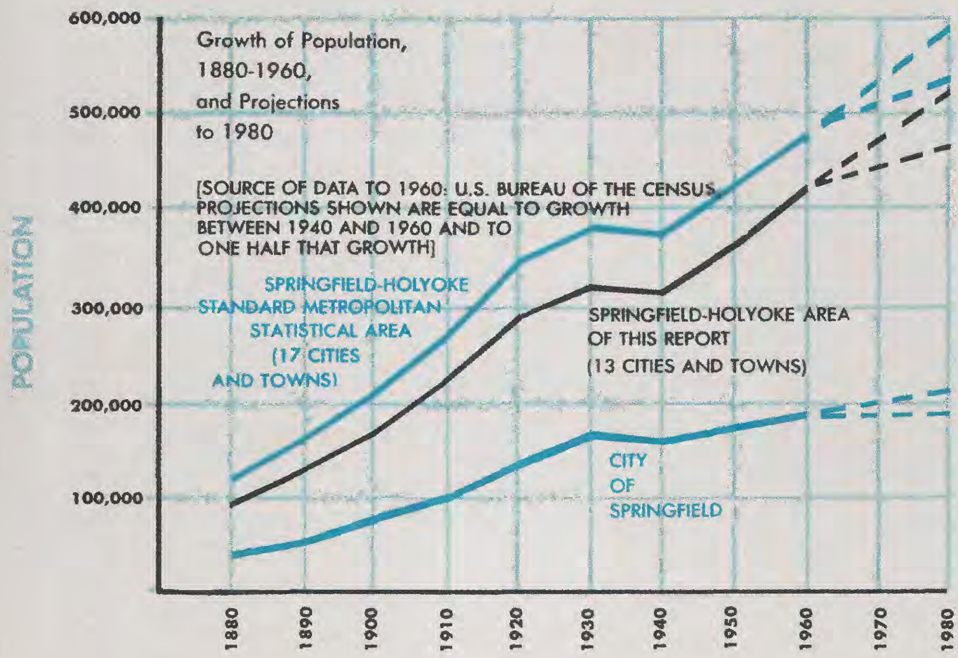


Figure 11.—Trends in Growth of Population and Water Use



veloped, it is because future demands and competitive use may cause shortages at certain places at certain seasons. When the same water is used for municipal systems, industry, and recreation all at the same time, it will inevitably be in short supply occasionally, particularly if it is returned for re-use in a polluted condition.

The problem of pollution abatement can only get worse if population and industry increase in the area as expected. Pollution control is expensive, especially for

industry. It is sometimes difficult to persuade industries to set up treatment plants, but informed public opinion backed up by Federal and State pollution control laws could accomplish a great deal. Here are some of the benefits which would result from pollution abatement: less danger to health from water polluted by sewage; improvement of industrial or residential real estate values; improvement of water for fishing and other recreational uses. The point to keep in mind is that it may be more economical to provide new water by controlling pollution than by any other means. Why build expensive pipelines to carry water from far-away sources, when water is at hand?

There are ways in which industry can conserve water. One way is to use it over and over. If the water is used only for cooling, air cooling systems may sometimes be substituted. Another means of saving water in industry in some areas is to use a greater proportion of polluted water, unfit for domestic supplies. About 67 percent of major water-using industries in the

United States practiced re-use in 1954. This practice reduced total requirements by 44 percent. Generally, only big companies can afford either of these methods of conservation, because of the high cost of installing equipment. In fact, the cost of obtaining and treating water and treating wastes before disposal may cause more and more small industries to connect with public supplies and with public sewage disposal systems. This will increase the load on the municipal systems.

Where is the extra water for the future to come from, if it should be needed? Lakes and ponds in the area, generally untapped as yet, will be one source. Some of them are probably polluted, but can be made potable if people are willing to bear the expense. New sources of ground water can probably be developed as a result of ground-water studies. New reservoirs could provide extra storage for dry seasons. For instance, the Littleville flood-control dam approved by Congress for the Middle Branch of the Westfield River at Chester would provide 17.5 million gallons a day, increasing the Springfield water system's capacity by about one third. By law, Springfield's neighbor communities of Westfield, Chester, Huntington, and Russell must be permitted to meet their own additional water needs from the Littleville system. Nevertheless, the chief engineer of the Springfield Water Department has said that Springfield city alone will need the additional 17.5 million gallons from Littleville by 1980. New sources of water may yet have to be developed by year 2000.

However, a good deal can be accomplished with the water already available. As we've said, one way of saving water is by re-circulating it. Another way is by further controlling pollution. Yet another way is by building reservoirs which serve more than one purpose, where it is feasible and economical of money and water. Reservoirs can be planned so that they are useful for power and water-supply storage, or such storage and flood control, or storage and recreation. The Littleville project itself was originally planned as a dry-bed reservoir, but in 1958, Congress authorized multipurpose projects in the U.S. Corps of Engineers flood-control program. The Littleville Reservoir will be the first Federal flood-control dam project in New England with municipal water supply as its secondary purpose.

Water resources planning for Springfield-Holyoke could stress completion of the authorized flood-control plan. Greater floods than that of 1936 might occur. Flood potentialities in the area are still dangerous enough to warrant further protection measures. If local protection works *are* overtopped, an even greater amount of damage than in 1936 might result, since there has been continuous development on the flood plain behind the levees and flood walls. The inhabitants or owners of businesses in these areas have a sense of security that just might prove illusory. In addition, there are areas in which it was not thought economically justifiable to build local protection works. In Agawam, for instance, there are two areas subject to flooding. One is south of the Westfield River, the other on the west bank of the Connecticut River. Both are presently unprotected. In the event of a flood, the system of upstream reservoirs, if fully developed, would help to reduce the amount of damage to Agawam.

The authorized program is now about 40 percent completed. The Corps of Engineers estimates that with the plan only partly finished, the annual savings are about five million dollars. Knightville Reservoir and the West Springfield levee system have both been in operation twenty years. The Corps estimates that these two projects have saved $2.50 and $11.90 respectively for each dollar of cost.

If the authorized plan is completed, 23 of the existing and proposed reservoirs will be most important to the people in the Springfield-Holyoke area. These measures would produce a 36 percent reduction in flood stage and a satisfying 92 percent reduction in damage. Without the reservoirs of the authorized project, all of the completed dikes and walls would be overtopped in the event of what the hydrologists call a "Standard Project Flood." This is an imaginary but wholly possible flood greater than that of 1936. The design of the levees and flood walls was based on the assumption that they would be backed up by a system of flood-control reservoirs.

Because land for reservoir sites is so difficult to obtain, plans for acquisition should be made considerably ahead of the time of proposed construction. If the reservoirs are to be used for recreational sites as well as flood control, additional land will be needed for camping, hiking, and picnicking along the shores of the reservoirs. If the need is recognized, local zoning plans could help by preserving future reservoir sites.

The people of the Springfield-Holyoke area are lucky. Unlike people in the West and Southwest, they have lots of water to begin with. Their problem is not how to get it, but how to manage what they have to the best advantage, now and for the future. Such planning invariably involves conflicting choices—whether farmland should be flooded to prevent flooding of industries and homes downstream; whether a reservoir should be used for flood control, power-development storage, recreation, water supply, or some combination of these; whether a river should be used for sewage disposal or for fishing and swimming. As if such choices weren't difficult enough, the interested citizen in Springfield and Holyoke is not only responsible for wise decisions about the water flowing past his own door, but also for a share in decisions affecting people in upstate Massachusetts and people in Connecticut. In turn, people in three other States are concerned with plans which might affect people living in Springfield-Holyoke. Massachusetts has pollution compacts with other States to reduce pollution in rivers affecting two or more States. The Interstate Flood Control Compact includes Connecticut, Massachusetts, New Hampshire, and Vermont. Thus, all the people in the Connecticut River basin have a voice in whatever plans are made.

But let us suppose that time has passed and that somehow we have achieved our aims. Industries and communities have co-operated to reduce the pollution load of the Connecticut River and its tributaries in the Springfield-Holyoke area. All the reservoirs in the comprehensive flood-control plan have been built. Large tracts of land around lakes and reservoirs have been set aside as recreational areas and public access to them has been assured. New sources of surface and ground water have been located to provide for the ever-growing demand for water.

Will these achievements mean the end of water management problems? To quote Dr. Luna Leopold, Chief Hydraulic Engineer of the Water Resources Division of the Geological Survey, "I submit that what we call the water problem breaks down to a complicated and unending series of decisions, each of which has long-term and often widespread effects * * * How will reservoirs, levees or well fields affect the manner in which water will flow under the different hydrologic conditions of the future that will result from a wide variety of possible combinations of local rainfall, vegetation, infiltration, withdrawal, recharge, soil moisture and the rest? The particular situations for which actual forecasts were made constitute only a small part of the possible conditions which could indeed exist in the future."

In other words, there is no end to the decision-making. We will have to go on making choices as long as there is water. For this kind of planning, knowledge is needed—knowledge of the assets, liabilities, and potentialities of the water resources of the area. Information about streamflows, sources of ground water, methods of disposal of industrial wastes, and many other water facts is constantly being collected by the Geological Survey and other Federal and State government agencies.

This pamphlet is an introduction to some of these water facts, as they apply to an industrial area located on a great river. We hope it will help you think about and evaluate decisions on water policy and planning now and in the future.

FOR MORE INFORMATION ABOUT...

WATER AND OTHER RESOURCES IN THE SPRINGFIELD-HOLYOKE AREA:

Water resources of the Springfield-Holyoke area, Mass., by J. C. Kammerer, G. K. Wood, J. M. Weigle, and Daniel Tanski: U.S. Geological Survey open-file report, 125 pages, Washington, D.C., 1961.

Resources inventory, Springfield economic area, 3d edition, by Future Springfield, Inc., 68 pages, Springfield, Mass., 1960.

A master plan for Springfield, Mass., 1955, by Springfield City Planning Board, 52 pages, Springfield, Mass., 1957.

BASIC WATER FACTS, PRINCIPLES, AND PROBLEMS:

A primer on water, by L. B. Leopold and W. B. Langbein: U.S. Geological Survey special report, 50 pages.

Water facts for the Nation's future, uses and benefits of hydrologic data programs, by W. B. Langbein and W. G. Hoyt, 288 pages, Ronald Press Co., New York, N.Y., 1959.

National water resources and problems, by R. E. Oltman and others: U.S. Senate (86th Congress, 2d Session) Select Committee on National Water Resources, Committee Print 3, 42 pages.

WATER AND OTHER RESOURCES IN THE CONNECTICUT RIVER BASIN:

(for special reports on floods, see next section)

Average annual runoff and precipitation in the New England-New York area, by C. E. Knox and T. J. Nordenson: U.S. Geological Survey Hydrologic Investigations Atlas HA-7, U.S. Geological Survey, Washington, D.C., 1951.

Compilation of records of surface water of the United States, through September 1950, part 1-A, North Atlantic Slope basins, Maine to Connecticut: U.S. Geological Survey Water-Supply Paper 1301, 380 pages.

The Connecticut River; your valley, your future, by P. B. Sears and others, 58 pages, Connecticut River Watershed Council, Greenfield, Mass., 1953.

Ten rivers in America's future (volume 2 of 3-volume report), by the President's Water Resources Policy Commission, 801 pages. (Chapter 6, pages 467-519, describes the Connecticut River basin.)

Special report of the (Mass.) Water Resources Commission relative to methods of providing an adequate water supply to the cities and towns of the Commonwealth during a period of drought or other emergency: Massachusetts House Document 2791, Dec. 30, 1958, 40 pages, Boston, Mass., 1959.

Land and water resources of the New England-New York region, by the New England-New York Interagency Committee: U.S. Senate Document 14, 85th Congress, 1st Session, 429 pages.

Water resources development in Massachusetts, by the U.S. Army Corps of Engineers, 120 pages, U.S. Army Engineer Division, Waltham, Mass., 1961.

Thirteenth annual report, New England Interstate Water Pollution Control Commission, 36 pages, Boston, Mass., 1960.

Hearings before the Select Committee on National Water Resources, U.S. Senate, 86th Congress, 1st Session, part 19, Boston, Mass., Dec. 8, 1959, pages 2915-3048.

The flow of time in the Connecticut Valley, geological imprints, by G. W. Bain and H. A. Meyerhoff, 129 pages, Hampshire Bookshop, Northampton, Mass., 1942.

The geological history of the Connecticut Valley of Massachusetts, a popular account of its rocks and origin, by W. J. Miller, 74 pages, Hampshire Bookshop, Northampton, Mass., 1921.

Geology of Massachusetts and Rhode Island, by B. K. Emerson: U.S. Geological Survey Bulletin 597, 289 pages.

FLOODS IN THE CONNECTICUT RIVER BASIN:

Floods, by W. G. Hoyt and W. B. Langbein, 469 pages, Princeton University Press, Princeton, N.J., 1955.

Flood-control politics, the Connecticut River Valley problem, 1927-50, by W. E. Leuchtenberg, 339 pages, Harvard University Press, Cambridge, Mass., 1953.

Floods of August-October 1955, New England to North Carolina, by D. B. Bogart: U.S. Geological Survey Water-Supply Paper 1420, 854 pages.

Hurricane floods of September 1938, by C. G. Paulsen and others: U.S. Geological Survey Water-Supply Paper 867, 562 pages.

New Year flood of 1949 in New York and New England: U.S. Geological Survey Circular 155, 109 pages.

Hurricane rains and floods of August 1955, Carolinas to New England, by P. H. Kutschenreuter and others: U.S. Weather Bureau Technical Paper 26, 148 pages.

The floods of March 1936, part 1, New England rivers, by N. C. Grover and others: U.S. Geological Survey Water-Supply Paper 798, 466 pages.

The New England flood of November 1927, by H. B. Kinnison: U.S. Geological Survey Water-Supply Paper 636-C, pages 45-100.

MAJOR MANUFACTURERS IN THE SPRINGFIELD–HOLYOKE AREA[a]

[a] Employing 500 or more people

AGAWAM	
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