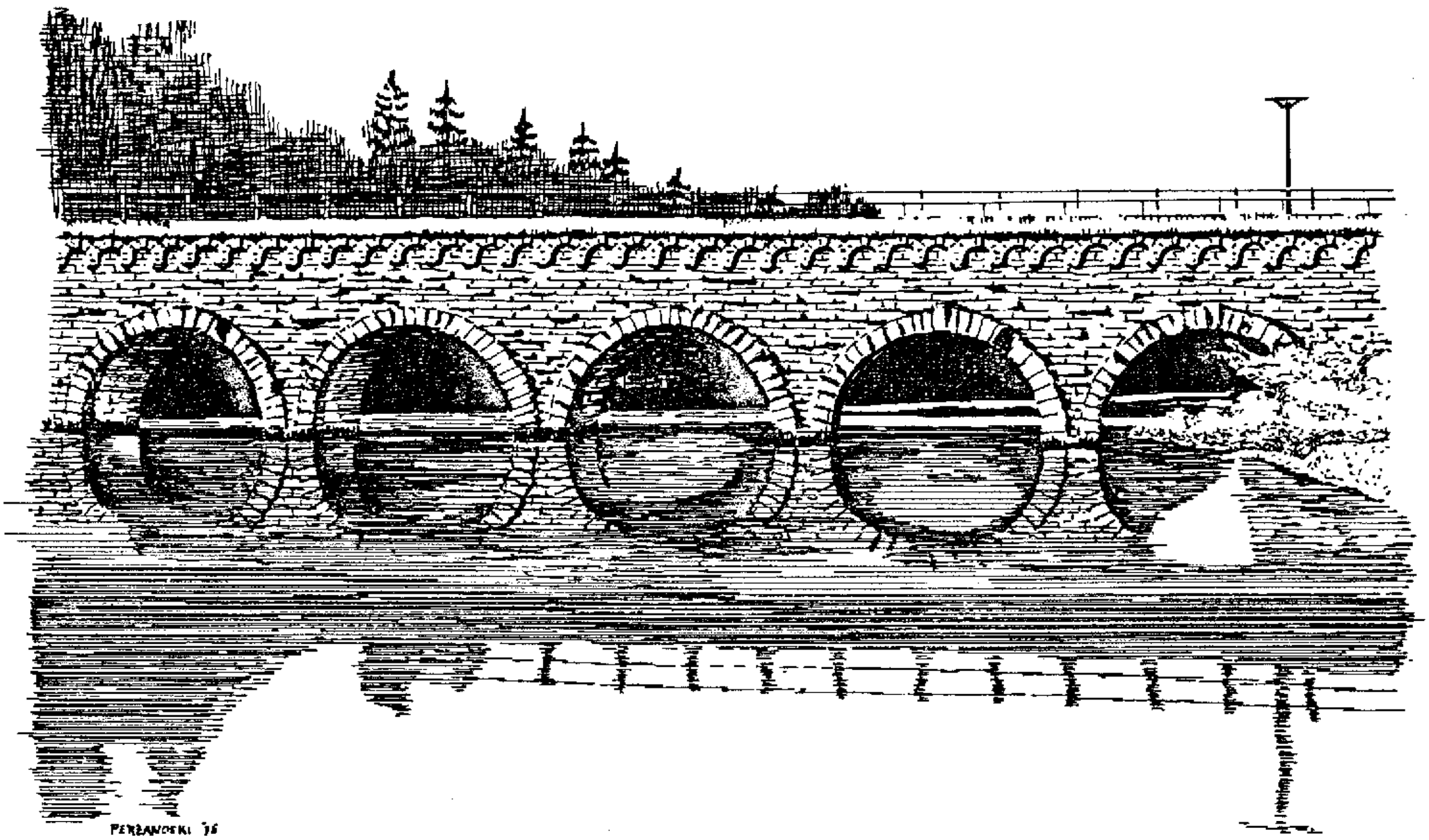
THE ASSABET RIVER



1974

part c

massachusetts water resources commission

DIVISION OF WATER POLLUTION CONTROL

thomas c. mcmahon, director

ASSABET RIVER

WATER QUALITY ANALYSIS

PAUL M. HOGAN

WATER QUALITY SECTION
DIVISION OF WATER POLLUTION CONTROL
MASSACHUSETTS WATER RESOURCES COMMISSION

WESTBOROUGH, MASSACHUSETTS

APRIL, 1975

COVER

AQUEDUCT TRAVERSING THE ASSABET RIVER

AT NORTHBOROUGH, MASSACHUSETTS

Approved by:
Alfred C. Holland
Purchasing Agent

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FOREWORD

The following report is a water quality analysis of the Assabet River. The report is part of a series of reports prepared by the Massachusetts Division of Water Pollution Control, that will culminate in a basin plan for the pollution abatement of the Assabet River. The analysis is based upon an intense investigation of water quality data obtained from surveys conducted in the years 1965, 1969 and 1974. Specific reasons for and the causes of the water quality problems are presented and a comparison of the three surveys is included in this report. Comprehensive plans for the improvement of water quality will be presented in a future report.

Many factors need to be investigated in order to present a complete picture of the water quality of the Assabet River. The economic and social history of the area gives a look at the reasons for the evolution of water quality problems. A physical description of the river helps familiarize the reader with the Assabet River. A description of the discharges into the river shows the major sources of water quality problems. A comparison of the different surveys will show if any improvement has taken place in the quality of the river.

Analyses of the survey samples (1965, 1969 and 1974 surveys) were conducted by the Massachusetts Department of Public Health, Lawrence Experiment Station. The Division of Water Pollution Control expresses its appreciation to the staff at the Lawrence Experiment Station for its most valuable assistance.

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HISTORIC AND ECONOMIC BACKGROUND

> "Rowing our boat against the current, between wide meadows, we turn aside into the Assabeth. A more lovely stream than this, for a mile above its junction with the Concord, has never flowed on earth - nowhere, indeed, except to lave the interior of a poet's imagination."
>
> Nathaniel Hawthorne

The origin of pollution problems on a river goes hand in hand with the development of towns and industry along the banks of the river. Densely populated areas create the problem of proper disposal of human wastes. Many industrial processes use water in their production creating vast amounts of chemically laden wastewater. The idea of people for thousands of years was to discard waste into the nearest waterway. Disposal of human wastes into streams and canals occurred during the time of the Roman Empire and occurred throughout history in the great cities of Europe. Disease was rampant through much of the history of Europe. Cholera and typhoid epidemics can almost certainly be traced to the presence of disease carrying human wastes in the waters of the cities.

Following is a synopsis of the settlement and development of the Assabet River basin. Changes in the lifestyle of the inhabitants brought major changes to the Assabet River. By examining the historic and economic development of the basin, we may better understand the reasons for the pollution of the river and we may get an insight into the ways to abate and prevent such pollution.

Archaeologists and historians believe that the area was inhabited as early as 2000 B.C. The "Red Paint" people were the first known settlers of the region but they were forced out of the area by the Algonquin Indians. It is believed that the Algonquins migrated from the area presently known as Ohio, bringing with them their agricultural talents for the cultivation of corn, beans, tobacco and pumpkins. Fertile land, ample supplies of water and a warm climate created ideal conditions for agricultural development. The warm climate may have been the most significant resource in their lifestyle. Around the time of 1200 B.C., the climate was much warmer than it is today. Agricultural products were the dominant food source but as the climate began to cool, the inhabitants turned their talents toward hunting and fishing to complement their food source. This gradual change in lifestyle created the necessity of travel in search of their food. The river became an intricate part of their lives--as a food supply and an ideal mode of transportation.

In the 1500's (A.D.) a subtribe of the Algonquins called the Nipmucks had villages established all along the river. In the summer, they would travel down the Assabet to the Musketaquid (Concord), to the Merrimack and into the Atlantic Ocean where they would harvest the abundant clams, lobsters and fish.

Through this travel, the Nipmucks came into contact with European fishermen, exchanging copper and brass for cloth. Through this interchange the Indians contracted the plague (1617) and small pox. Because of the great number of deaths from these diseases, in the early years of the settling of the Assabet and Concord River Basins (1635-1656), there remained only a few hundred Indians. Much of their skill in agriculture, hunting, fishing and their knowledge of the land died with them.

The first inland settlement in Massachusetts was at Concord in 1635. The large meadows of the Concord and Sudbury Rivers made fine grazing land and provided fertile land for the growing of crops. As the enthusiasm and pioneering spirit grew so did other settlements. Sudbury was founded in 1639, while Marlborough (including present area of Marlborough, Hudson, Westborough and Southborough) was established in 1656.

With the harvesting of crops in the fertile valley, there grew a need for gristmills. Streams in the basin provided the power to run the mills. Sawmills were also built during the early settlement. For example, in 1672, in the Town of Northborough, a sawmill was constructed on Cold Harbor Brook by John Brigham. In 1700, a mill for corn was built in the area of Hudson. This area was to be known as Feltonville for a distillery that made brandy from the apples that were (and remain) plentiful in the area.

In the early 1820's, the use of the Assabet River and its tributaries turned to producing power for the blossoming textile industry. "King Cotton" brought great industrial development to the banks of the Assabet River. For example, Amory Maynard and W. H. Knight built a mill that flourished in the manufacture of army blankets. Their products were used during the Civil War and three wars thereafter.

The mill owners purchased rights to lakes, streams and the Assabet River, constructing dams solely for the purpose of creating power to operate their factories. By using their riparian rights for the production of power, the mill owners were able to increase their production, but also altered the natural course of the river with the construction of these dams. By 1850, Hudson and Maynard had become centers of the manufacture of textile spindles and woolen products. The textile industry flourished for more than a hundred years. In the early 1900's Maynard had the largest woolen mill in the world. After World War II, the woolen mill industry collapsed in the north. In search of cheaper labor and to gain close proximity to the raw material, the industries moved south or overseas, leaving deserted mills throughout this area.

With this "industrial revolution", as many historians call it, came the real beginnings of the pollution problems of the Assabet River. Industrial and domestic wastes were dumped into the river, degrading the quality of the water. This onslaught of industry brought prosperity and money to many people but brought pollution and neglect to the river.

Recognition of pollution problems on the Assabet River came early. In 1663, the people of Marlborough voted "...that no person shall lay or put any flax or hemp into any pond or brooke within this town, where cattle drink, on penalty of paying to the Town's use twenty shillings for every offense; and whosoever hath now any flax or hemp in any pond or brooke as aforesaid, shall cause the same to be taken out within four and twenty hours after the date hereof, on penalty of paying the said sum" (21). Unfortunately, that was the last mention of pollution for over 200 years. In 1900, the State Board of Health issued a report of the gross pollution of the Assabet River. However, little was done and the problem lessened only because of the collapse of the woolen mill system.

As the mills closed and moved operations elsewhere, many towns in Massachusetts collapsed economically. Many towns, to date, have not recovered from the desertion of the mills and remain economically depressed areas. Fortunately for the people of the Assabet basin, the towns were eventually able to muster other industrial and manufacturing growth. The area diversified its industry and continued to grow and generally escaped the economic collapse.

Population and industrial growth continued into the 1970's (see Table 1). Construction of major interstate highways greatly strengthened the industrial potential of the area. The electronics industry has been the biggest economic "shot in the arm" for the Assabet basin. The Town of Maynard is now known as the "Mini-computer capital of the world". Increases in population (see Table 2) are expected as industrial development continues and as more people move to the suburbs.

As the industrial pollution lessened, the human wastes of the increasing population became (and remains so now) the major pollution problem. The proper treatment of the ever increasing amounts of sewage is the key to the future of the Assabet River. With the proper use of the technology available, the Assabet may once again be like the river of the Nipmucks.

TABLE 1

POPULATION GROWTH

ASSABET RIVER BASIN

MUNICIPALITY	POPULATION		
	1950	1960	1970
Acton	3,510	7,238	4,770
Berlin	1,349	1,742	2,099
Bolton	**	**	1,886
Boxborough	439	744	1,451
Carlisle	876	1,488	2,871
Concord	8,600	12,500	16,100
Hudson	8,211	9,666	16,084
Littleton	2,349	5,109	6,380
Marlborough	15,756	18,819	27,936
Maynard	6,978	7,695	9,710
Northborough	3,122	6,687	9,218
Shrewsbury	10,591	16,622	19,196
Stow	1,700	2,573	3,984
Westborough	7,378	9,599	12,594
Westford	4,262	6,261	10,368

* Source: Commonwealth of Massachusetts, Department of Commerce and Development - City & Town Monographs

** Data not available

TABLE 2

FUTURE POPULATION PROJECTIONS

ASSABET RIVER BASIN

MUNICIPALITY	POPULATION 1970	1990	2000	2020
Acton	14,770	26,500	32,800	43,000
Berlin	2,099	5,400	8,200	13,400
Bolton	1,886	3,324	**	3,458
Boxborough	1,451	5,300	8,200	13,300
Carlisle	2,871	11,500	14,900	20,400
Concord	16,100	24,200	29,400	39,400
Hudson	16,084	23,600	26,500	30,300
Littleton	6,400	11,100	14,000	20,300
Marlborough	27,936	35,300	38,700	43,600
Maynard	9,710	11,400	12,000	12,900
Northborough	9,218	14,600	18,600	26,300
Shrewsbury	19,196	26,550	**	31,950
Stow	3,984	6,600	8,300	12,000
Westborough	12,594	17,900	20,800	26,300
Westford	10,368	34,100	**	35,800

* Source: Metropolitan District Commission
: Corps.-Commonwealth Study
: Central Massachusetts Regional Planning Commission

** Data not available

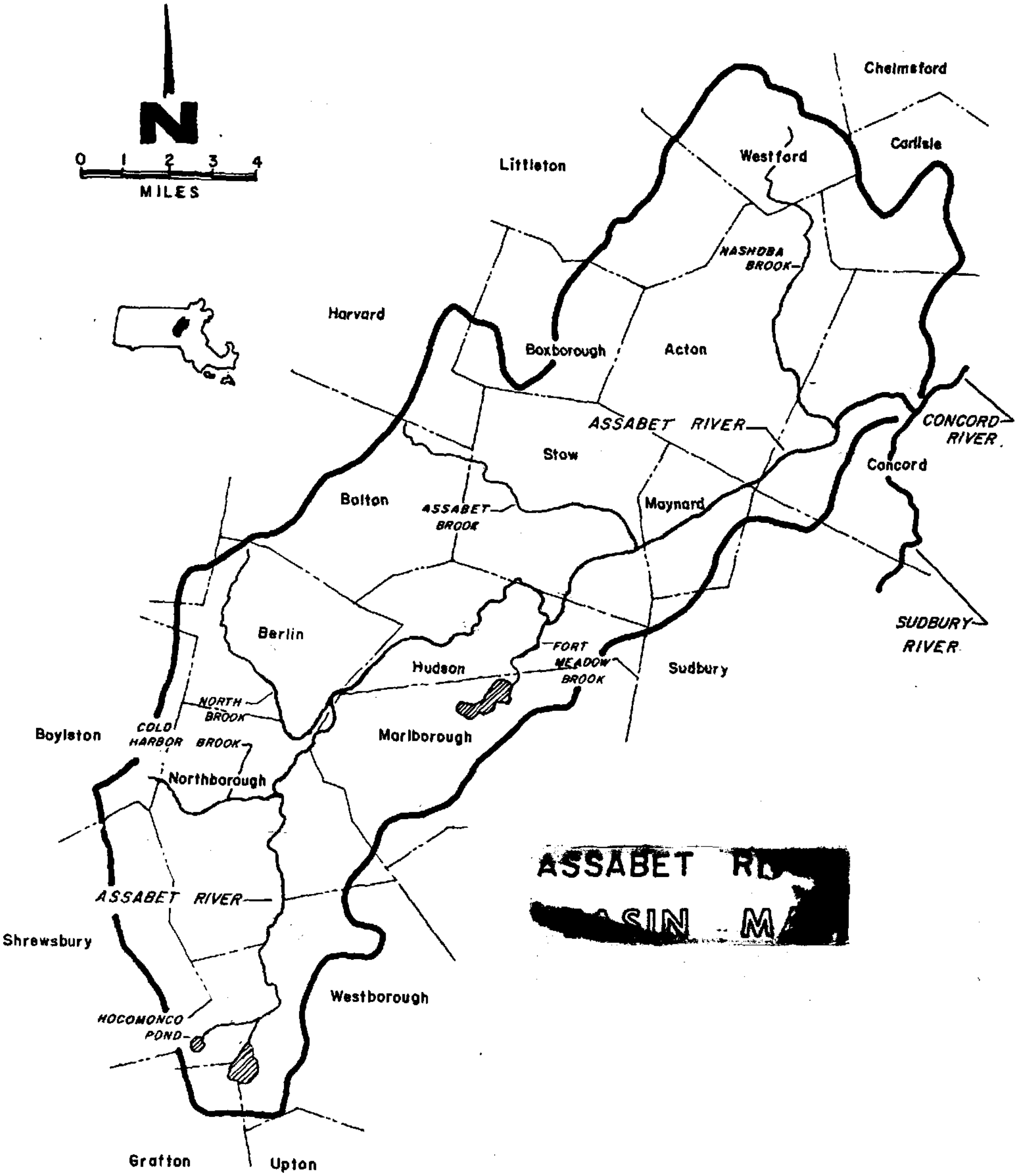

N
0 1 2 3 4
MILES
Chelmsford
Carlisle
Westford
Littleton
NASHOBA BROOK
Harvard
Boxborough
Acton
ASSABET RIVER
CONCORD RIVER
Stow
Concord
Bolton
ASSABET BROOK
Maynard
Berlin
SUDBURY RIVER
Hudson
FORT MEADOW BROOK
Sudbury
NORTH BROOK
Boylston
COLD HARBOR BROOK
Marlborough
Northborough
ASSABET
ASSABET RIVER
Shrewsbury
Westborough
HOCOMONCO POND
Grafton
Upton

FIGURE 1

BASIN DESCRIPTION

In the study of water quality, examination of the river basin hydraulics is necessary. The physical characteristics of a river (e.g. flow, velocity, dams) play a major role in the chemical and biological "activity" that occurs in the river. In the Assabet River the changing physical characteristics are a critical factor. The reoccurring presence of dams and slow moving, swampy impoundments is a vital factor in determining the water quality of the Assabet River. Figure 1 is a map of the Assabet River Basin showing towns included in the basin and tributaries. Figure 2 shows the Assabet River profile; changes in elevation, river miles, location of dams and of sewage treatment plant discharges. In the following description, the mile point from the confluence with the Sudbury River is shown in parentheses (m.p.). The quantity of flow during the surveys (1965, 1969, 1974) will be shown in a later section.

The Assabet River has its beginning at the outlet of the recently completed George H. Nichols Multiple-Purpose Dam in the southwest section of the Town of Westborough. The dam was constructed for the purpose of "fish and wildlife development and flood prevention" by the Massachusetts Water Resources Commission. The dam creates a small impoundment of about 0.6 sq. mi. which collects water drainage from an area of about 7 sq. mi., much of which is from surrounding swamplands. The dam project will hopefully be able to store water during the "rainy" season and release water into the river during "low flow" periods of the summer. The increase in flow is supposed to serve a dual purpose--improve fishing and aid in pollution abatement (i.e. flow augmentation). However, to date, the project has not been a success. Trees and roots, not sufficiently cleared from the floor of the impoundment, supply large amounts of organic decay material (detritus), resulting in inferior quality water. Also, proper regulation of the amount of water released is absent. During the summer, extremely low water levels have left small pools of water scattered about the impoundment--filled with dead fish. With proper operation, the project could become a fine recreation area and an aid in flow augmentation.

Water released from this impoundment forms the beginnings of the Assabet River. After a short fast-flowing stretch, the river begins its characteristic sluggish flow. Hocomonco Stream joins the river just above the first of six municipal sewage discharges on the Assabet--the Town of Westborough Sewage Treatment Plant (30.2). Shortly downstream, the river is greeted by another sewage treatment plant discharge from the Town of Shrewsbury. The river meanders its way through swamplike lands, flowing through a picturesque golf course (to the dismay of many hackers) rejoining civilization at a dam very near Northborough Center (26.5). Here, a relatively steep gradient causes the river to accelerate through a small industrial complex. Then, taking a ninety degree turn, the Assabet enters the "headwater pool" of the Allen Road dam impoundment (25.4). Below this dam the river rapidly curves its way through pasture lands. At this point, the basic pattern of the river is repeated--the Marlborough West

Sewage Treatment Plant discharge (24.1) coincides with the slowing of the river flow. The river flows through swamplands until the dam at Route 85 in Hudson Center (18.2). Through Hudson Center the flow is constricted by industrial development on both banks. Passing out of Hudson center the pattern is again repeated--the Hudson Sewage Treatment Plant (16.0) discharges into the Assabet just above the swampland impoundment created by the Gleasondale dam (14.4). Following a short rapid section, the river flows in its characteristic slow meandering style for 4.5 miles through the Town of Stow. Throughout this impoundment, as in the others along the river, large amounts of aquatic vegetation are present.

Flowing over the American Woolen Dam (9.0) and into the Town of Maynard, the river's gradient sharply increases and the flow is channeled through the center of Maynard. The Assabet, for the fourth time, repeats its pattern--flowing into the Powder Mill impoundment and receiving the discharge from the Maynard Sewage Treatment Plant (6.3). From the Powder Mill dam to the confluence with the Sudbury River, the river's gradient is relatively uniform. The Assabet flows through West Concord (through the washed-out Damondale dam) receiving its final discharge from the Massachusetts Correctional Institution at West Concord (2.4). The river slowly reaches the Sudbury River just north of the center of historic Concord. The confluence of the Assabet and Sudbury rivers produces one main stream--the Concord River.

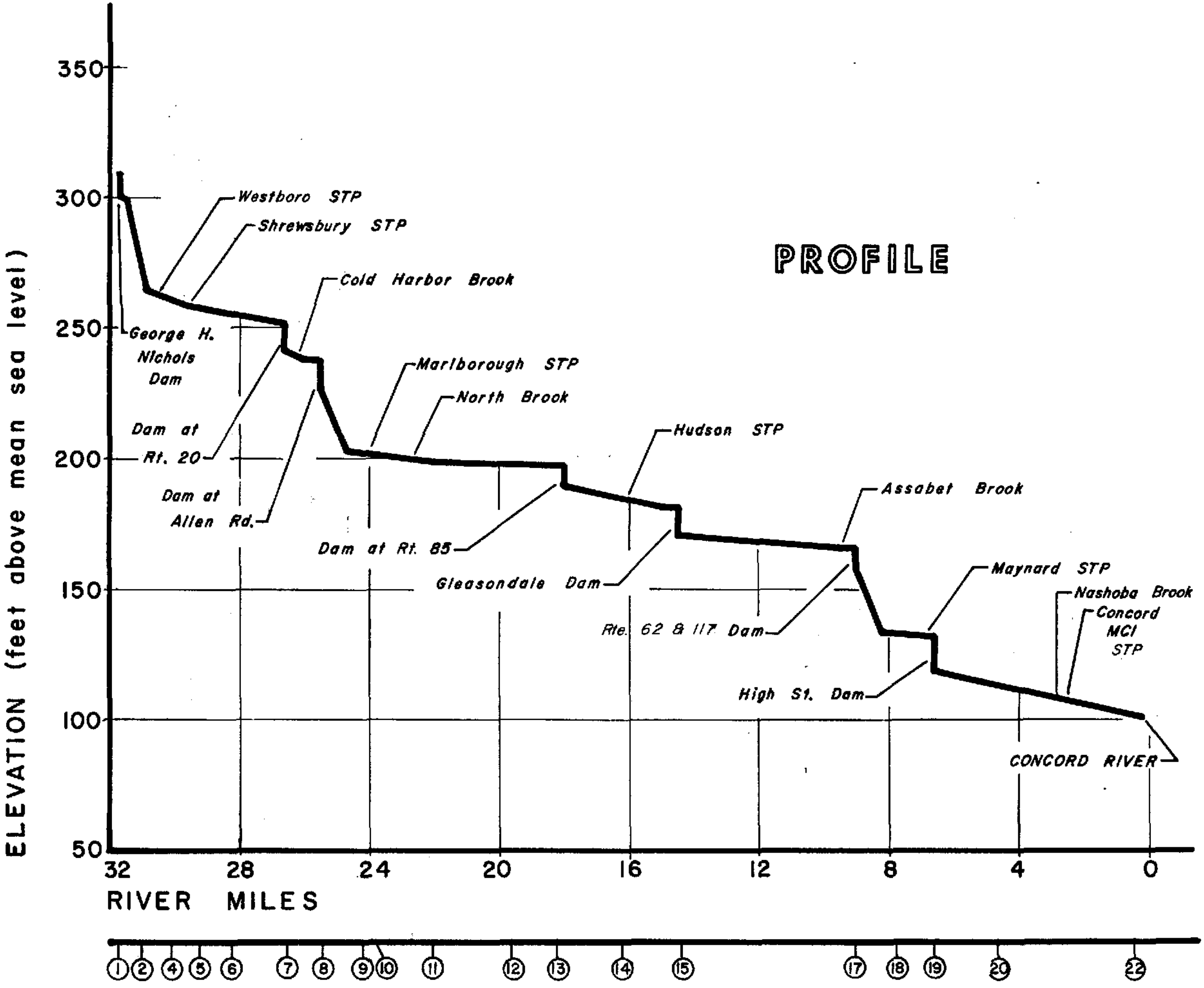

PROFILE
ELEVATION (feet above mean sea level)
350
300
250
200
150
100
50
Westboro STP
Shrewsbury STP
Cold Harbor Brook
George H. Nichols Dam
Dam at Rt. 20
Dam at Allen Rd.
Marlborough STP
North Brook
Dam at Rt. 85
Hudson STP
Gleasondale Dam
Assabet Brook
Rte. 62 & 117 Dam
Maynard STP
Nashoba Brook
Concord MCI STP
High St. Dam
CONCORD RIVER
32
28
24
20
16
12
8
4
0
RIVER MILES
1
2
4
5
6
7
8
9
10
11
12
13
14
15
17
18
19
20
22

FIGURE 2

TABLE 3

DAM LOCATIONS

ASSABET RIVER

LOCATION	MILE POINT	HEIGHT(ft.)	USES
George H. Nichols, Westborough	31.8	10	Wildlife habitat Flood prevention Recreation
Route 20, Northborough	26.5	7	
Allen Road, Northborough	25.4	10	Wildlife habitat
Route 85, Hudson	18.2	12	Wildlife habitat
Route 62, Gleasondale	14.4	8	Wildlife habitat
Routes 62 & 117, Maynard	9.0	5	Wildlife habitat
High Street, Acton	6.5	11	

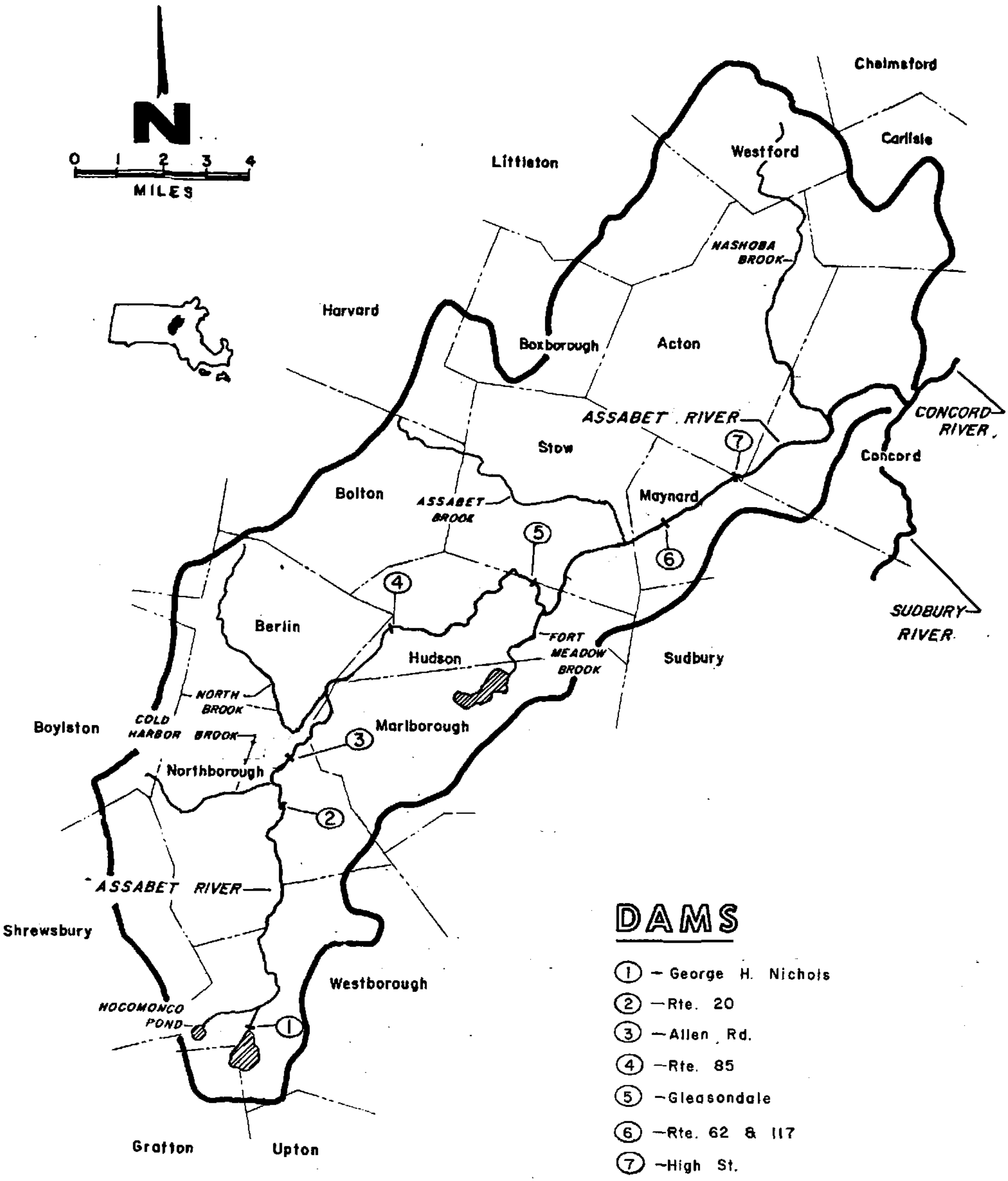

N
0 1 2 3 4
MILES
Chelmsford
Carlisle
Westford
Littleton
NASHOBA BROOK
Harvard
Boxborough
Acton
ASSABET RIVER
CONCORD RIVER
Stow
Concord
Bolton
ASSABET BROOK
Maynard
Berlin
Hudson
FORT MEADOW BROOK
Sudbury
SUDBURY RIVER
NORTH BROOK
COLD HARBOR BROOK
Boylston
Marlborough
Northborough
ASSABET RIVER
Shrewsbury
Westborough
HOCOMONCO POND
Grafton
Upton
DAMS
1 - George H. Nichols
2 - Rte. 20
3 - Allen Rd.
4 - Rte. 85
5 - Gleasondale
6 - Rte. 62 & 117
7 - High St.

FIGURE 3

PRESENT WATER USE

On April 24, 1967, at a public hearing in Lowell, the Division of Water Pollution Control proposed water use classification for the Assabet River. The river was given a B classification for its entirety, except for portions below the Westborough and the Hudson Sewage Treatment discharges which were given a C classification (Fig.4). The water use classifications are defined as follows:

Class A: Waters designated for use as sources of public water supplies.

Class B: Waters suitable for bathing, fishing, and acceptable for public water supply with treatment and disinfection.

Class C: Waters suitable for boating but not swimming, suitable habitat for wildlife and fish indigenous to the region and for certain industrial and agricultural uses.

Certain criteria of water quality must be met for each classification. If the minimum of the criteria is not met for at least a C classification, then the water is classified U. In the water quality analysis section of this report, it will be shown that the entire Assabet River still does not meet the classifications set in 1967.

The present water quality limits the recreational uses of the river. The Massachusetts Division of Fisheries and Game has curtailed its trout stocking program because of the quality of the Assabet. Areas in Westborough, Berlin and Stow are stocked only in preseason with between 5,000-7,000 brown, brook and rainbow trout. Low dissolved oxygen levels and high water temperatures (over 70°F) do not allow for the carry-over (year to year) of the fish populations. Hunting for native pheasant and duck is found in several areas of the basin.

The river is not suitable for swimming because of coliform bacteria levels. Canoeing is limited because of the presence of several dams on the river. During the winter freeze, skating is available in the several impoundments.

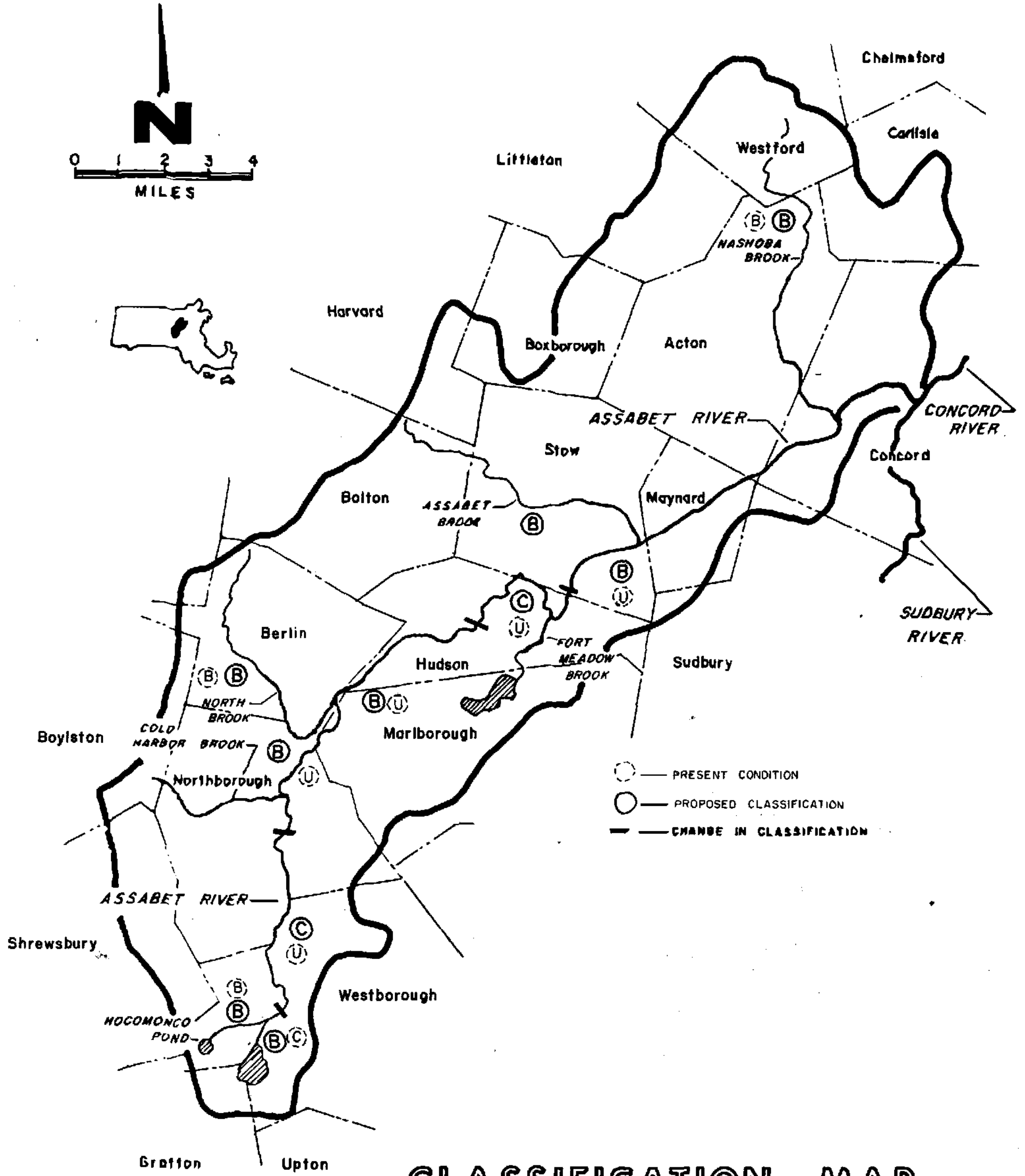
The river is no longer used for hydro-power. The dams originally created to provide this power create unique aquatic environments that sustain a certain biological population. The removal of the dams may be beneficial to the water quality of the Assabet River, but will change the habitat of the local wildlife populations. The river is not used as a water supply source. Table 5 shows the sources of potable water supplies for the towns in the basin. The Assabet is not seen as a future water supply because of its low flow in the summer and because of the presence of several sewage treatment plant effluents.

TABLE 4

RIVER CLASSIFICATION

ASSABET RIVER BASIN

SEGMENT	WATER QUALITY CLASS PRESENT CONDITION	WATER QUALITY CLASS CLASSIFICATION
Headwaters to the Westborough STP	C	B
Westborough STP to Brigham St. Bridge Northborough	U	C
Brigham Street Bridge, Northborough to Rte. 85 Dam, Hudson	U	B
Rte. 85 Dam, Hudson to Fort Meadow Brook, Hudson	U	C
Fort Meadow Brook, Hudson to Concord River	U	B



CLASSIFICATION MAP

FIGURE 4

TABLE 5

MUNICIPAL WATER SUPPLIES

ASSABET RIVER BASIN

MUNICIPALITY	SOURCE
Acton	Groundwater[1]
Berlin	No Public Supply[2]
Bolton	No Public Supply
Boxborough	No Public Supply
Carlisle	No Public Supply
Concord	Nagog Pond; groundwater
Hudson	Gates Pond; groundwater
Littleton	Groundwater
Marlborough	Milham Brook Reservoir; Lake Williams; Metropolitan District Commission
Maynard	White Pond
Northborough	Groundwater; Metropolitan District Commission
Shrewsbury	Groundwater
Stow	Groundwater
Westborough	Sandra Pond; groundwater
Westford	Groundwater

1 - Town operated wells
2 - Privately owned wells

WASTE DISCHARGES

The major discharges on the Assabet River are five municipal sewage treatment plants and a treatment plant that serves the Massachusetts Correctional Institute at Concord. The locations of the treatment plants are found on Figure 5. The Division of Water Pollution Control has surveyed these treatment plants over the past few years. The analyses of these discharges are found in Table 6. (See page 27 for a description of the various chemical parameters.) The following section is a description of these treatment plants and the problems they create in the Assabet River.

WESTBOROUGH

The Westborough Sewage Treatment Plant is the most upstream discharge on the Assabet River, very near the headwaters. The present facility employs the extended aeration process with seasonal use of sand filter beds and disinfection by chlorination. The plant went into use in February, 1971. The previous facility consisted of a settling tank and sand filter beds. Present flow of the plant is about 0.9 MGD (million gallons/day). Due to extensive infiltration, the flow during a "wet" period is about 1.6 MGD. In 1965, during sampling of the old facility the flow was 0.6 MGD. In the old plant high BOD (Biochemical Oxygen Demand) and extremely high nutrients (ammonia and phosphorus) were characteristic of the effluent. With a proper balance of the sensitive bacteria present in an extended aeration facility, nitrification may occasionally occur in this process; thereby reducing the ammonia and BOD of the effluent. This occurred during the March, 1973 sampling, but it is not the general rule for secondary treatment. Proper operation of sand filter beds will greatly reduce the BOD of the effluent. The problem inherent in the present facility is a high level of ammonia and phosphorus in the effluent and the resultant oxygen depletion caused by nitrification in the stream. Table 6 shows the results of sampling this discharge in March, 1973 and September, 1974. Samples were taken before the effluent was discharged to the sand filter beds. The analysis indicates that nitrification occurred in the plant in 1973, but not in 1974.

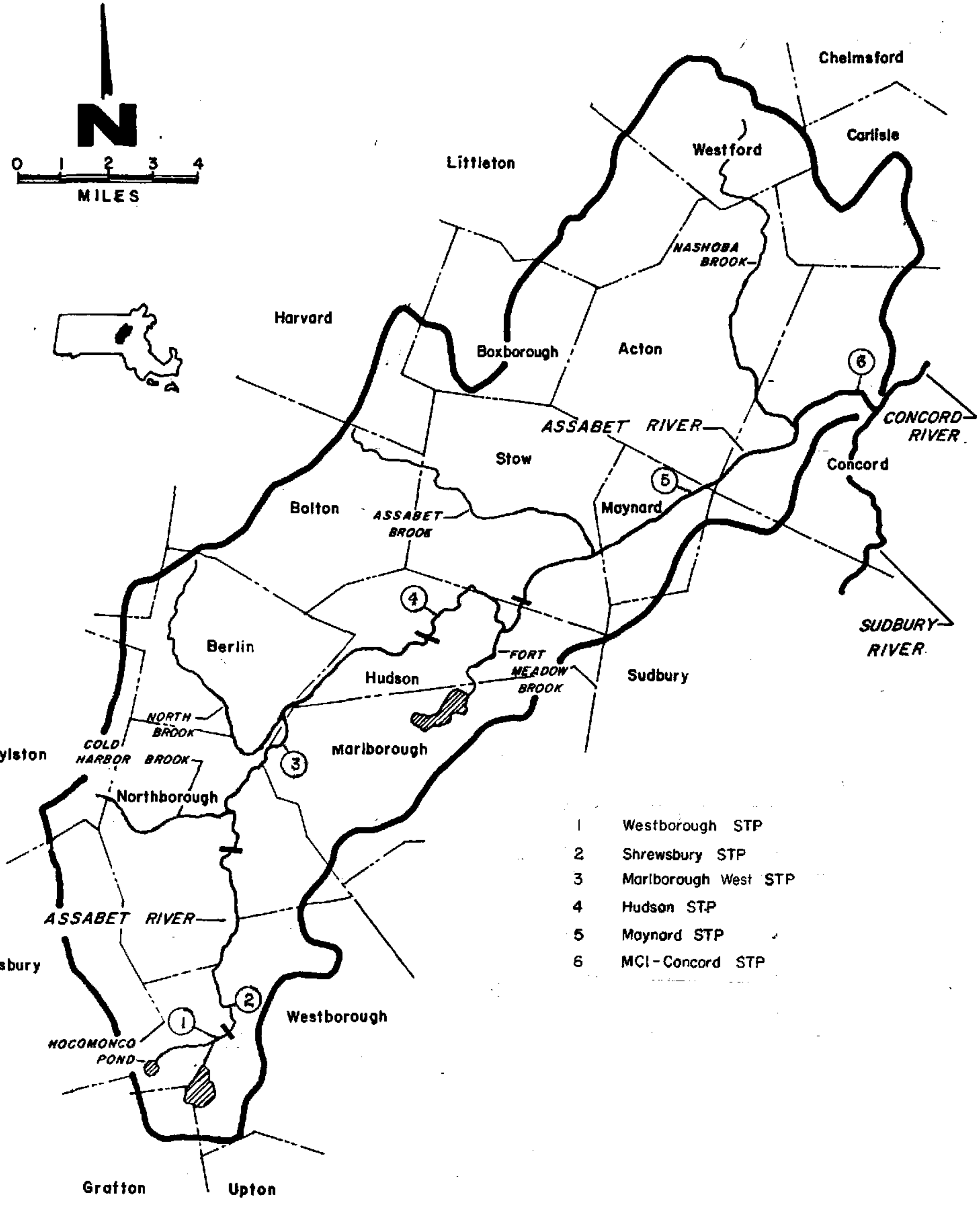
SHREWSBURY

Shortly downstream from the Westborough effluent, the Shrewsbury Sewage Treatment Plant discharge enters the Assabet River. The close proximity of the two discharges multiples the water quality problems.

The Shrewsbury plant began operation in 1963 and has the same system of treatment at the present time. A recently constructed grit chamber and increase in flow are the only major changes in the plant. The plant is a secondary treatment facility with primary settling, trickling filter, secondary settling and seasonal chlorination. The BOD removal is good but the effluent is extremely high in nutrients (see Table 6). Some nitrification occurs in a trickling filter process. The present flow averages 1.3 MGD while the flow in 1969 was about 1.1 MGD.

MARLBOROUGH WEST

About 5.4 miles downstream from the two previously mentioned plants, the Marlborough West Sewage Treatment Plant discharges about 1.3 MGD into the Assabet River. In operation since 1971, the plant is presently operating at about one-third of its hydraulic design capacity. The activated sludge process is used for treatment. The small amount of sewage presently



LOCATION OF MAJOR WASTEWATER DISCHARGES

Figure 5

TABLE 6

WASTEWATER DISCHARGE ANALYSIS

ASSABET RIVER BASIN

SOURCE	DATE SAMPLED	FLOW	BOD-5	TOTAL P	NH_3	NO_3
Westborough STP	3/21-22/73	0.8[1]	58.[2]	5.1	0.42	8.6
	9/17-18/74	0.9	99.	9.5	7.0	0.5
Shrewsbury STP	9/25-26/68	1.09	19.	13.	5.5	9.5
	9/17-18/74	1.25	27.	8.5	12.0	2.8
Marlborough West STP	9/17-18/74	1.35	2.7	3.0	0.2	2.3
Hudson STP	2/19-20/69	1.0	28.	10.	23.8	0.7
Maynard STP	7/30-31/69	0.8	78.	18.	20.5	-
Concord MCI	6/17/70	0.1	72.	7.0	3.0	-

1. All flow is given in MGD (million gallons per day)
2. All results given in mg/l (milligrams per liter)

being treated has a long detention time in the plant, which allows nitrification to occur. Phenomenal BOD removal was seen during the 1974 sampling; also, there was over 90% removal of ammonia (see Table 6). High levels of phosphorus were present in the effluent. In future years when the plant is operating at hydraulic capacity, nitrification will not readily occur in the plant and the BOD of the effluent will probably be higher.

HUDSON

At river mile point 16.0, the Hudson Sewage Treatment Plant enters the river with a present average flow of 1.3 MGD. In 1969, the average flow was about 1.0 MGD. The plant has a system of primary settling, trickling filters, secondary settling and seasonal chlorination. The effluent from the plant is extremely high in nutrients (see Table 6). In the water quality analysis section of this report, the effect of nutrients from the treatment plants will be explored.

MAYNARD

The Maynard Sewage Treatment Plant (mile point 6.8) is presently being upgraded to a process of activated sludge treatment. The old plant (in operation during the 1965, 1969 and 1974 surveys) consisted of primary settling, trickling filter and secondary settling. The new plant will still have an effluent high in nutrients which will cause problems in the Powder Millpond (the place of its discharge). The present flow is about 0.8 MGD.

CONCORD MCI

The Concord Correctional Institution (mile point 2.4) has a treatment process consisting of settling tanks and sand beds. The facility has a small flow of about 0.12 MGD; therefore, the effluent has only a slight effect on the river. Plans have been made to upgrade the present facility to employ the extended aeration process with effluent polishing through the use of high rate filters.

In low flow periods, the Assabet River has little assimilative capacity to handle the large volume of treatment plant effluent. The large amount of nutrients discharged is the main cause of the degradation of water quality in the river. The river's gradient, with its many slow moving impoundments, provides the conditions for nutrients to degrade the water quality. Algae proliferation is present during the summer months, producing dissolved oxygen diurnal variation and increasing the biochemical oxygen demand. In order for the Assabet River to approach its water quality classification, the nutrients must be removed to the highest degree possible.

NON-POINT SOURCES

Pollutional sources can be found in the Assabet River Basin which are not the result of a direct discharge (i.e. a piped effluent). These sources are designated "non-point" and are often difficult to assess as to their exact impact upon water quality. The Assabet River Basin can be characterized as a surburban area. The river flows through many towns and receives "urban runoff" which drains the streets of the towns and carries salts, sand, nutrients and coliform bacteria into the stream. Septic tanks in unsewered areas presents a problem when the density of homes is greater than the natural under-ground drainage can handle.

Other non-point sources are farmlands where animal wastes and fertilizers wash into the streams during rainstorms. The runoff carries nutrients and coliform bacteria into the river and may cause a water quality problem. Dumps located near a stream may contribute pollutants. Swamps which are located along much of the Assabet River contribute natural sources of materials which can cause water quality problems.

It is necessary to have a direct control (or total elimination) of the direct sources of pollution before the "non-point" sources can be properly identified and the proper measures taken to eliminate or control these sources. The impact of the "non-point" sources will be intensively examined in the SUASCO River Basin, Part D. Referral to that report is urged if further information on "non-point" sources is desired.

RESULTS OF WATER QUALITY SURVEYS

SURVEY PROCEDURES

The present program of water quality surveys on Massachusetts waters had its origin with the Department of Public Health, Division of Sanitary Engineering in the early 1960's. That Division, which at the time had the responsibility for water pollution control in the Commonwealth, began the practice of intensive sampling of a particular waterbody over a one or two week period. Under this method, samples are collected every six hours over twenty-four hour periods during a week. Surveys are conducted during the summer and early fall in order to observe conditions of low flow when pollution effects are most pronounced. Usually, the survey is performed once early in the summer, then repeated a month or more later. This enables data from the first survey to be analyzed in order to determine if additional sampling stations are required. In addition, it assures that all samples on a particular waterbody will not be collected when an industry which discharges wastes is on its summer shut-down.

Sampling locations are chosen in order to assess the effects of natural and man-made factors on water quality. In the case of a river, samples are usually taken above and below each major waste discharge. Additional samples are taken to assess the effects of tributary streams, dams and their impoundments, swamps and rapids sections. Dissolved oxygen samples are collected and fixed in the field. Other samples are collected for chemical and bacterial analysis. The chemical samples collected each day at each station are combined to produce one 24-hour composite sample. Chemical and bacterial analyses are performed at the Department of Public Health's Lawrence Experiment Station. Analytical methods follow the procedures set forth in the current edition of "Standard Methods for the Examination of Water and Wastewater" by the American Public Health Association.

The original purpose of the sampling program was to examine and assess the quality of Massachusetts waters. Chemical analyses included pH, alkalinity, 5 day Biochemical Oxygen Demand (BOD) and suspended solids. Bacterial samples were collected for coliform analysis. Microscopic examinations and sediment analyses were also performed. In some instances, samples were tested for certain metals. In later years, other tests were added, such as phosphates, the nitrogen series and 2, 5 and 7 day BOD's.

In 1967, the Massachusetts Division of Water Pollution Control was established by an act of the legislature. Among the responsibilities of the new division was "to examine periodically the water quality of the various coastal waters and rivers, streams, lakes, and ponds of the Commonwealth and publish the findings." This formalized the survey program which became a function of the Division's Water Quality Section. That section has continued the survey program each year since and published the results of all surveys on Massachusetts rivers back to 1964.

Under a Division Research and Demonstration Project, work was begun on a computer model for river analysis in 1969. Prior to this, some stream analysis had been performed on survey results, but the complexity of the calculations involved had limited its use by an engineer with a slide rule. The use of the computer model allows that same engineer to evaluate all the factors influencing water quality, establish natural stream characteristics, and predict the effects of future waste loads and treatment schemes.

The model requires additional data, however, and the scope of the survey program had to be expanded. Long term BOD's were performed on the samples. Time of travel studies had to be performed under various flow conditions. A better understanding of basin hydrology and river geometry were required.

Basin planning requirements under the Federal Water Pollution Control Act, Amendments of 1972 (P1-92-500) called for an accelerated modeling program by the Commonwealth. In order to collect all the necessary data and develop models for each of the major drainage basins, the Division was awarded a State grant to hire additional personnel. This has enabled the Water Quality Section to conduct eleven major river surveys in the summer of 1973, as well as most of the additional studies needed to complete all river basin plans during 1974.

In order to understand the data obtained from water quality surveys, some background knowledge of stream analysis is required. The primary emphasis in stream surveys and subsequent computer analysis is on studying the dissolved oxygen (DO). This parameter refers to the uncombined oxygen in water which is available to aquatic life. DO is affected by numerous factors including physical characteristics of the stream (velocity, width, and depth), decomposition of wastes, temperature and aquatic organisms. The study of the DO in a stream, therefore, involves a comprehensive analysis of several parameters. Samples from stream surveys are analyzed for the following:

BIOCHEMICAL OXYGEN DEMAND (BOD) is a measure of the amount of oxygen required by bacteria to decompose organic matter. BOD is gradually exerted, usually in two stages. In the first stage, carbonaceous matter is stabilized; nitrogenous substances are broken down in the second. The exertion of both stages may require thirty days or more. Through repetition, the 5 day BOD has become the standard test in sanitary engineering. It is usually assumed that the 5 day BOD includes only carbonaceous decomposition; in some cases, however, this may not be the case. Long term BOD's, with readings at several intervals, are necessary to fully define the two stages.

SUSPENDED SOLIDS are the portion of the total solids which can be removed through filtration. The behavior of suspended solids in a stream is used to predict the settling of wastes. Where wastes settle out, bottom sludge deposits accumulate. Such deposits exert high oxygen demands.

NUTRIENTS are compounds which act as fertilizers for aquatic organisms. Small amounts are necessary to the ecological balance of a waterbody, but excessive amounts can upset the balance by causing nuisance growths of algae. Nutrients of carbon, nitrogen, and phosphorus are predominant in water bodies. Carbonaceous compounds are measured in the BOD test. Separate analyses are performed to measure the total phosphorus and forms of nitrogen. Nitrogen, besides acting as a nutrient, can exert a significant oxygen demand. Nitrogen appears in waterbodies as organic nitrogen, ammonia, nitrite, and nitrate. The conversion of one pound of ammonia to nitrite and, ultimately, to nitrate requires 4.57 pounds of oxygen. The progress of nitrification is usually predicted by observing disappearance of ammonia and appearance of nitrate.

COLIFORM BACTERIA are found in abundance in the intestinal tract of warmblooded animals. They are not harmful in themselves, but their presence indicates that pathogenic bacteria may also be present. Since their presence can be detected by relatively simple test procedures, coliform are used to indicate the extent of bacterial pollution. Fecal coliform make up about 90 per cent of the total coliform in fecal matter. Non-fecal coliform may originate in soil, grain, or decaying vegetation.

pH measures the hydrogen ion concentration on an inverse logarithmic scale ranging from 0 to 14, pH values under 7.0 indicate acidic solutions; values over 7.0 indicate alkaline solutions. Low pH values often indicate pollution from heavy metals which can be toxic to aquatic life.

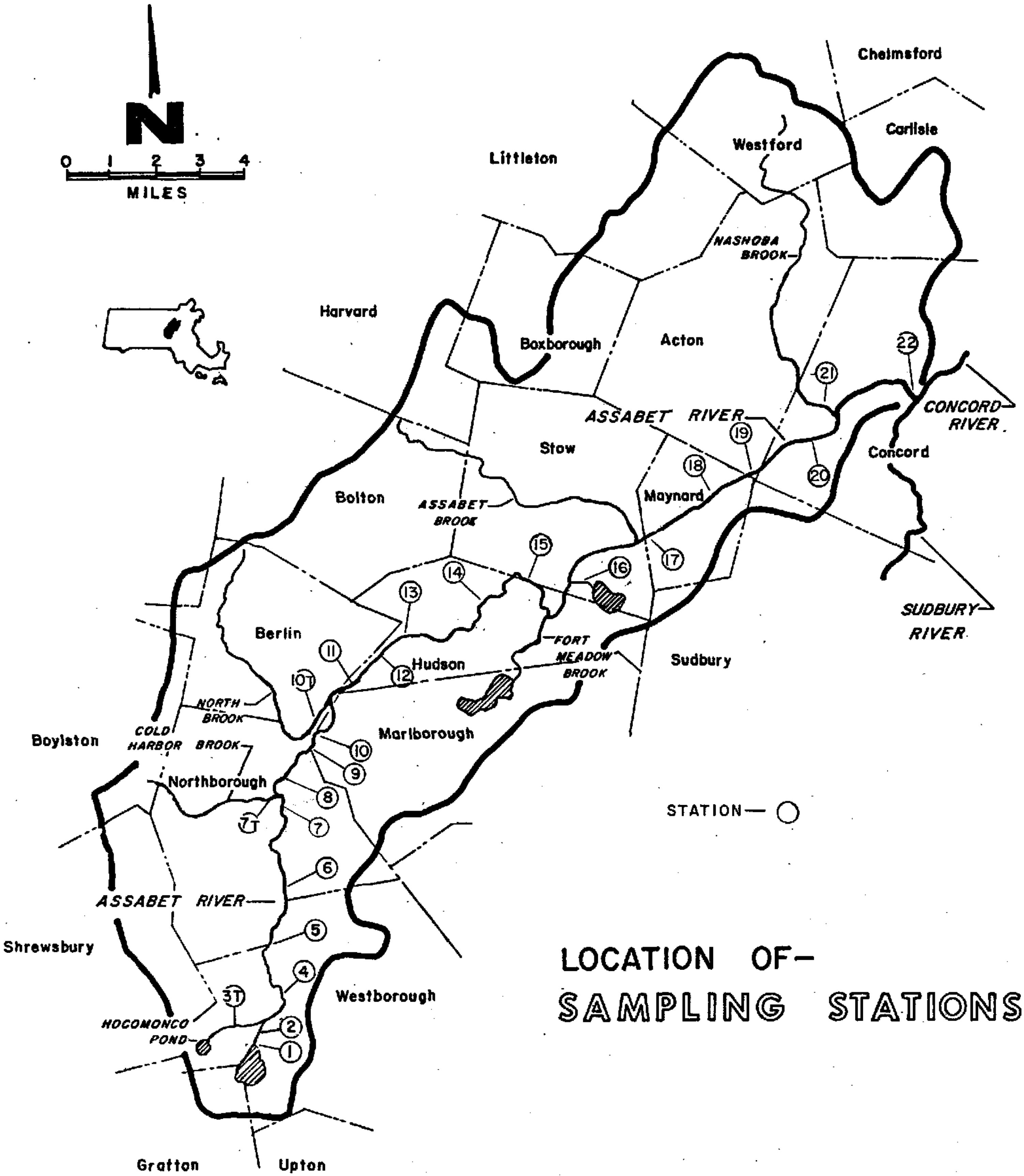
ASSABET RIVER BASIN SURVEYS

Stream surveys were conducted on the Assabet River in 1965 by the Massachusetts Department of Public Health and in 1969 and 1974 by the Massachusetts Division of Water Pollution Control. The 1965 survey was conducted on June 22 and 24 with ten stations on the main stream, one on a tributary and one on the Concord River. Samples were taken at each station four times over a 24 hour period for the two days. The samples were analyzed for dissolved oxygen, BOD, coliform bacteria, pH, alkalinity, suspended solids and microscopic analyses were conducted for algae. Unfortunately, analysis of nutrients was not performed. The data from these analyses can be found in the report, SUASCO RIVER STUDY 1965, published by the Division of Water Pollution Control.

The survey of 1969 of the Assabet River was conducted on August 19 and 21 and on October 21 and 23. The August sampling was for dissolved oxygen only while the October samples were analyzed for nutrients as well as those parameters mentioned above for the 1965 survey. During the 1969 survey, 15 stations were located on the main stem and two stations were located on tributaries. The sampling locations are shown in Figure 6 and Table 7.

In 1974, the most intensive survey undertaken by the Division on the Assabet River was conducted during the weeks of June 4-8 and September 16-20. Nineteen stations on the main stream and five tributaries were each sampled nineteen times over a 76 hour period. The sampling locations are shown in Figure 6 and Table 7. In addition to the lab analysis of the stream samples, the impoundments on the river were studied and the sewage treatment plants were sampled. Also, flow measurements were taken at various in-stream points along the river and at the USGS gage in Maynard.

The overall intensified effort will facilitate a better understanding of the river and its water quality problems. The data results of the surveys can be found in the report ASSABET RIVER PART A 1974 published by the Division of Water Pollution Control. The analysis of the September, 1974 survey will be the primary subject of the upcoming section. This data from 1974 provides the most complete and most recent information available. The data from 1969 and 1965 will be referred to when a comparison is needed, or when a significant difference in the water quality is observed.



LOCATION OF— SAMPLING STATIONS

FIGURE 6

TABLE 7

LOCATION OF SAMPLING STATIONS

1969 & 1974 SURVEYS

ASSABET RIVER BASIN

STATION NUMBER	LOCATION	RIVER MILE
*AS 01	At the water intake, George H. Nichols Dam, Westborough	31.8
AS 02	Bridge on Maynard Street, Westborough	31.0
AS 03T**	Outlet of Hocomonco Pond, Otis St., Westborough	30.5,0.5
AS 04	Bridge on Route 9, Westborough	30.1
AS 05	Bridge on Route 135, Westborough and Northborough Line	29.2
*AS 06	Bridge on School Street, Northborough	28.3
AS 07	Above dam, Route 20, Northborough	26.5
*AS 07T	Outlet of Cold Harbor Brook, Hudson Street, Northborough	26.2,0.1
AS 08	Above dam, Allen Road, Northborough	25.4
AS 09	Bridge on Boundary Street, Northborough and Marlborough Line	24.2
*AS 10	Bridge on Robin Hill Road, Marlborough	23.8
*AS 10T	North Brook at Bridge Road, Berlin	22.7,0.3
*AS 11	Bridge on Bigelow Street, Berlin	22.0
AS 12	Bridge on Chapin Road, Hudson	19.6
AS 13	Above dam, Route 85, Hudson	18.2
AS 14	Bridge on Cox Street, Hudson	16.2
AS 15	Above dam, Route 62, Gleasondale	14.4
AS 16T	Outlet of Boons Pond, Stow	12.4,0.2
AS 17	Above dam, Routes 62 & 117, Maynard	9.0
AS 18	At USGS gage, Routes 62 & 117, Maynard	7.7

TABLE 7 (CONTINUED)

STATION NUMBER	LOCATION	RIVER MILE
AS 19	Above dam, High Street, Acton	6.5
AS 20	Bridge on Route 62 at Damondale, West Concord	4.6
*AS 21T	Outlet of Warner's Pond, Commonwealth Avenue, West Concord	2.8,0.2
AS 22	Off the shore, at the base of Nashawtuc Hill, Concord	0.4

* - Sampled only in 1974.

** - T denotes a tributary of the main stream of the Assabet River.

ASSABET RIVER FLOW DATA

In the examination of water quality, the quantity of flow at the various sampling points must be compared for the different surveys. The United States Geological Survey maintains one gaging station on the main stem of the Assabet River. The gage (No.01097000) is located in the Town of Maynard, 150 ft. upstream from the bridge on State Highway 27, 7.7 miles upstream from the confluence with the Sudbury River.

The amount of flow varies greatly according to the time of year and the amount of rainfall. The maximum discharge recorded at the Maynard Gage (since 1886) was on August 20, 1955 with a discharge of 4,250 cfs (cubic feet per second). The minimum daily discharge was 0.2 cfs on February 7, 1965. Until 1972, the average daily flow over a thirty-one year period was 178 cfs.

The flow for the three periods considered in the water quality analysis (June 22-24, 1965, October 21-23, 1969 and September 17-19, 1974) was very much the same. Table 8 shows the average flow data for the above mentioned dates.

The almost identical flows for the 1969 and 1974 surveys allow for the direct comparison of the data for the two surveys. Lab analyses in milligrams per liter can be compared directly without conversion to adjust for different flows. This should be remembered in the section on water quality analysis.

TABLE 8

USGS GAGE AT MAYNARD

FLOW DATA

ASSABET RIVER BASIN

DATE	DISCHARGE (cfs)[1]
June 22, 1965	37
June 23, 1965	36
June 24, 1965	40
August 19, 1969	32
August 20, 1969	27
August 21, 1969	25
October 21, 1969	54
October 22, 1969	56
October 23, 1969	59
June 4, 1974	184
June 5, 1974	152
June 6, 1974	128
September 17, 1974	60
September 18, 1974	53
September 19, 1974	47

1. cfs: cubic feet per second

WATER QUALITY ANALYSIS

The following analysis will establish two things: the present water quality of the Assabet River and any differences in water quality from 1965, 1969 and 1974. Also, it will be shown if the river meets the designated classification (see page 18). Sections of the river will be analyzed that are affected by similar sources (e.g. effect of treatment plant effluent upon downstream stations). The analysis will begin at the impoundment at the headwaters in Westborough and proceed downstream to the confluence with the Sudbury River. Emphasis will be placed on major changes in water quality and the reasons for these changes. Several graphs and charts (Figures 7 to 16) will accompany the analyses and should be referred to when

The construction of the George A. Nichols dam created immediate problems. Tree stumps and roots, left after clearing an area for the impoundment, decay and create a dissolved oxygen demand and a probable source of ammonia. Studies of the impoundment show oxygen variation at different depths.

DEPTH (ft.)	DISSOLVED OXYGEN (mg/l)
5.0	0.0
4.0	2.8
2.0	6.5
surface	7.4

Ammonia content in the middle of the impoundment (0.4 mg/l) and at the outlet (0.24 mg/l) can have a significant effect on the downstream water quality. The presence of algae and a substantial diurnal variation of dissolved oxygen show the occurrence of photosynthesis at the outlet of the pond. Below the spillway, the average dissolved oxygen content was 6.0 mg/l, slightly below the class B standard. The BOD_5 at the outlet of 6.6 mg/l shows that an oxygen demand will be exerted downstream.

Going through a rapid moving section to the next sampling station at Maynard Street, Westborough, the river undergoes nitrification. Nitrification occurs when sufficient amounts of ammonia and oxygen are available and sufficient nitrifying bacteria (nitrosomonas and nitrobacters) are present. The bacteria attach themselves to rocks and vegetation in the stream and react with the chemical components. The chemical reaction of nitrification is given in the following equation:

$$NH_3 + O_2 \xrightarrow{\text{nitrosomonas}} NO_2 + O_2 \xrightarrow{\text{nitrobacter}} NO_3$$

The nitrate (NO_3) level at Maynard St. of 0.4 mg/l and the lower ammonia level of 0.18 mg/l indicate nitrification. The dissolved oxygen level in 1974 (6.3 mg/l) was lower than 1965 (7.7 mg/l) and 1969 (7.3 mg/l).

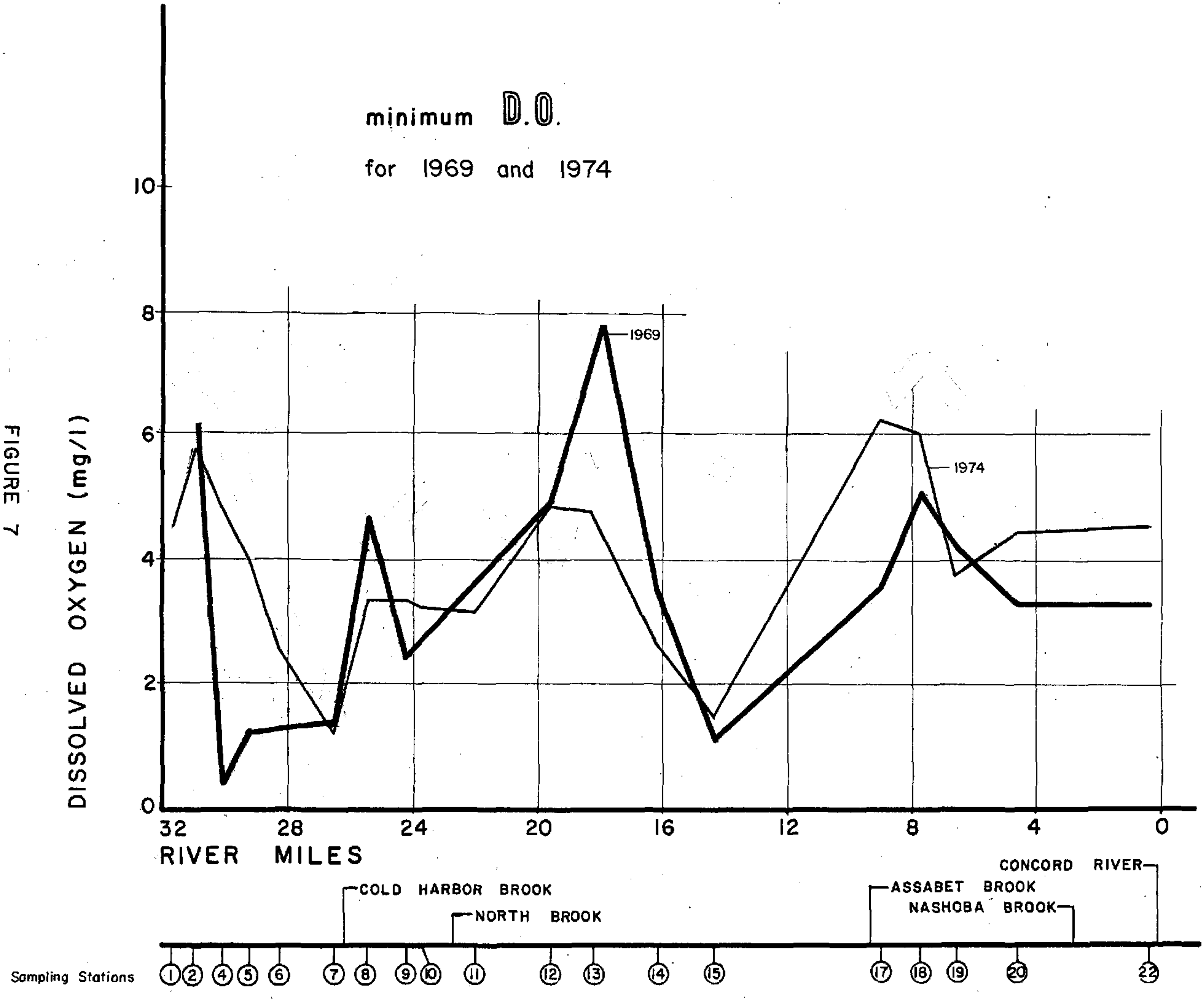

minimum D.O.
for 1969 and 1974
DISSOLVED OXYGEN (mg/l)
10
8
6
4
2
0
1969
1974
32
28
24
20
16
12
8
4
0
RIVER MILES
COLD HARBOR BROOK
NORTH BROOK
ASSABET BROOK
NASHOBA BROOK
CONCORD RIVER
Sampling Stations
1 2 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 22

FIGURE 7

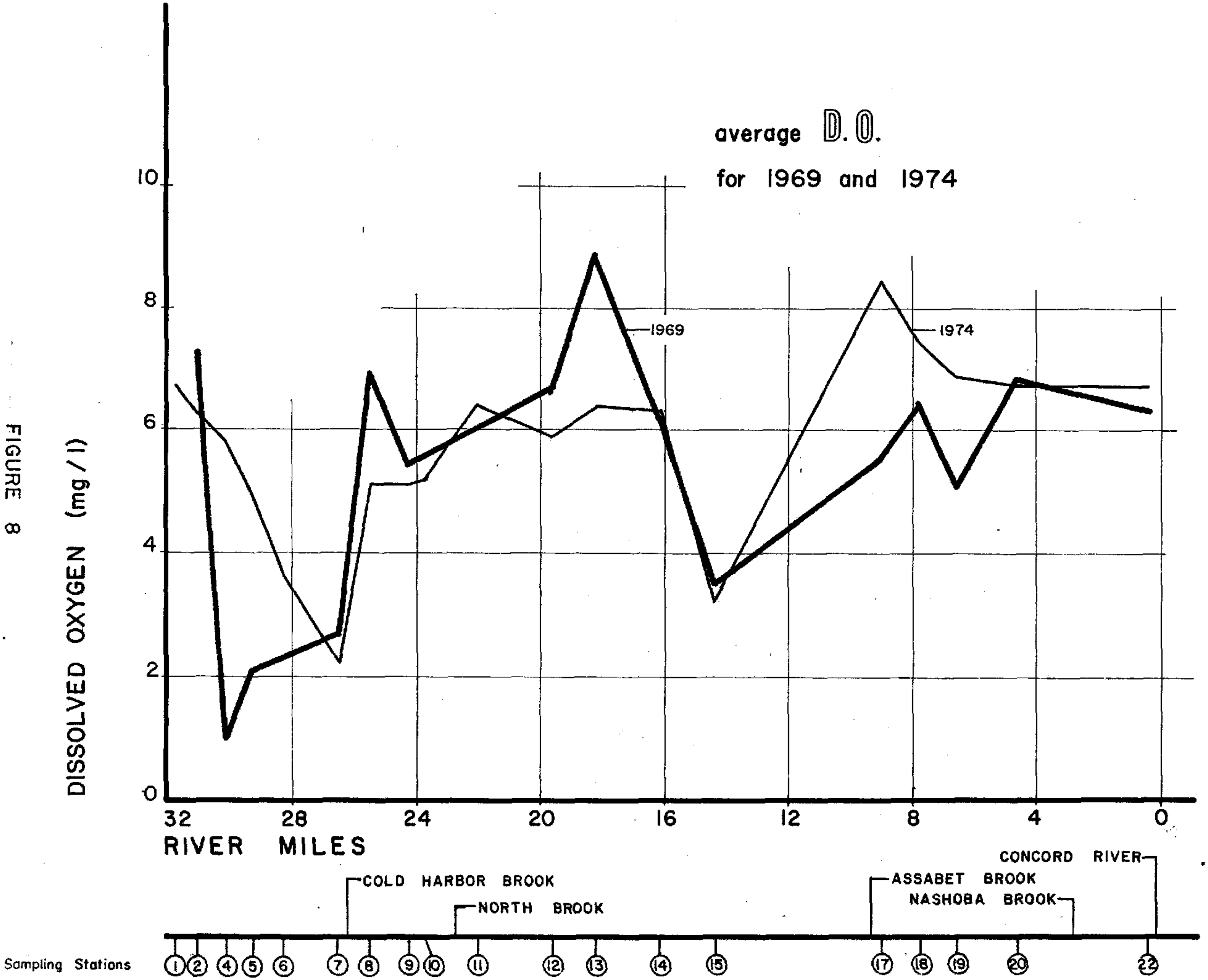

average D.O.
for 1969 and 1974
DISSOLVED OXYGEN (mg/l)
10
8
6
4
2
0
1969
1974
32
28
24
20
16
12
8
4
0
RIVER MILES
COLD HARBOR BROOK
NORTH BROOK
ASSABET BROOK
NASHOBA BROOK
CONCORD RIVER
Sampling Stations
1 2 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 22

FIGURE 8

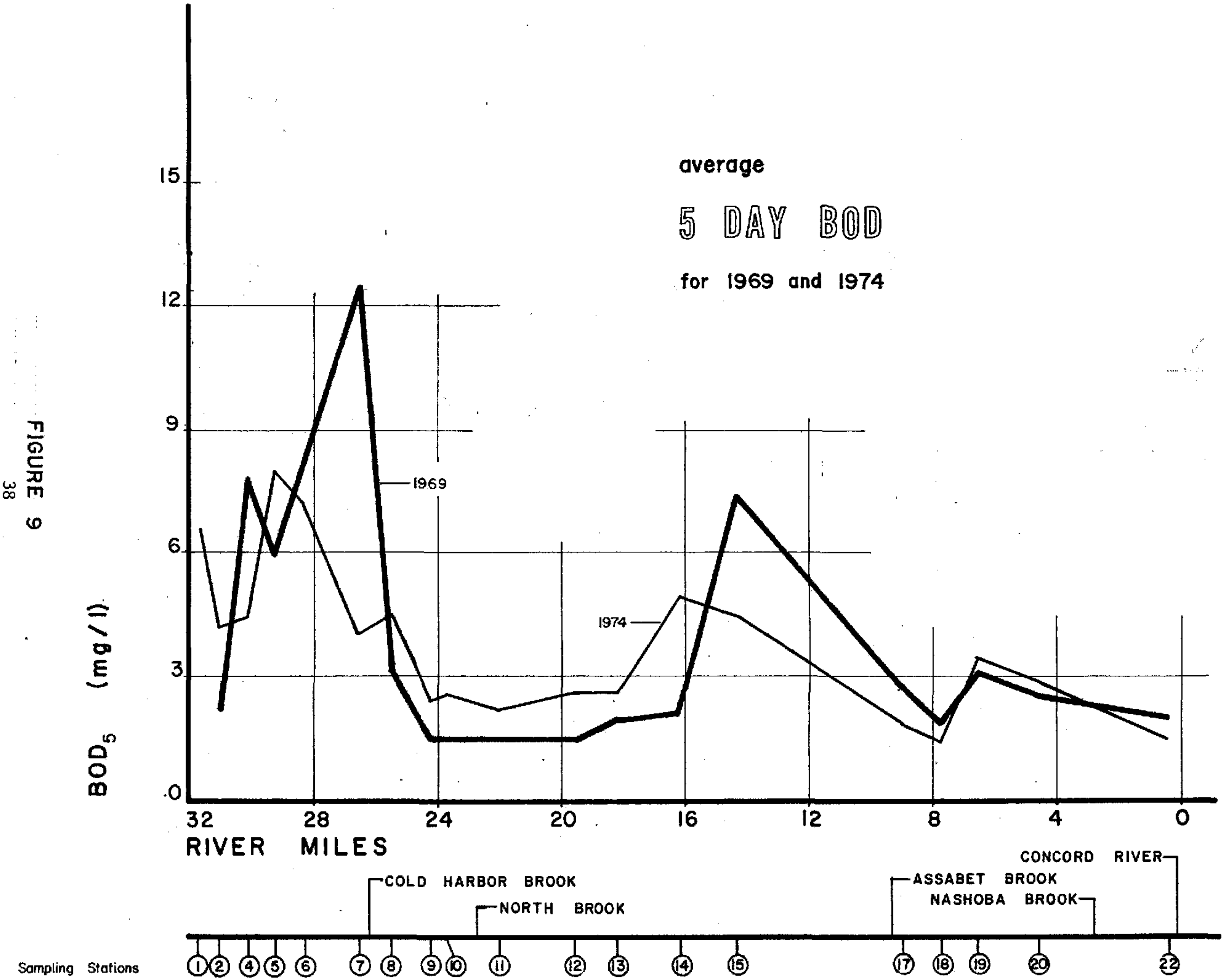

average
5 DAY BOD
for 1969 and 1974
15
12
9
6
3
.0
BOD_5 (mg/l)
1969
1974
32
28
24
20
16
12
8
4
0
RIVER MILES
COLD HARBOR BROOK
NORTH BROOK
ASSABET BROOK
NASHOBA BROOK
CONCORD RIVER
Sampling Stations
1 2 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 22

FIGURE 9

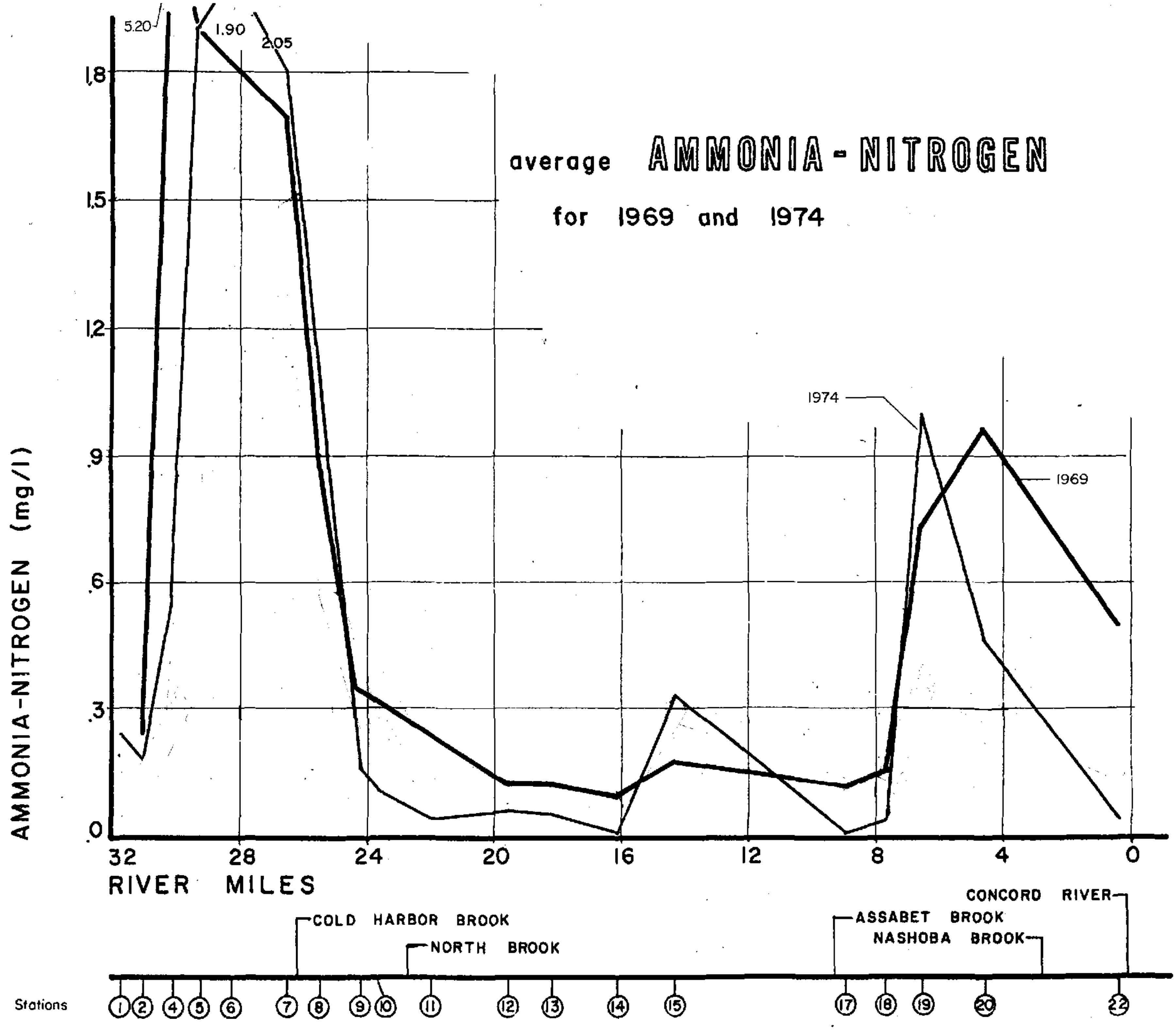
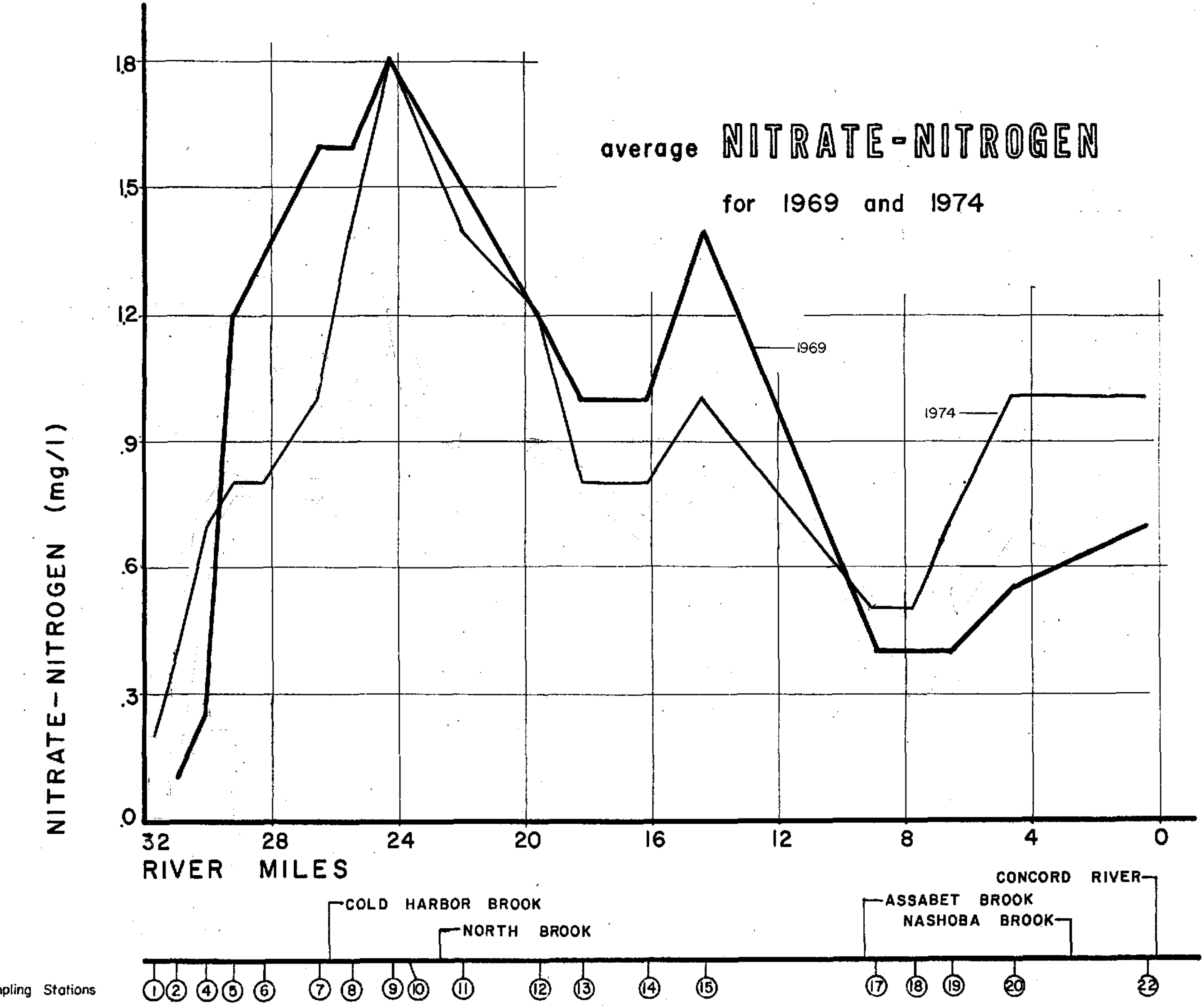

average AMMONIA - NITROGEN
for 1969 and 1974
AMMONIA-NITROGEN (mg/l)
1.8
1.5
1.2
.9
.6
.3
0
5.20
1.90
2.05
1974
1969
32
28
24
20
16
12
8
4
0
RIVER MILES
COLD HARBOR BROOK
NORTH BROOK
ASSABET BROOK
NASHOBA BROOK
CONCORD RIVER
Sampling Stations
1 2 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 22

FIGURE 10



average NITRATE-NITROGEN
for 1969 and 1974
NITRATE-NITROGEN (mg/l)
1.8
1.5
1.2
.9
.6
.3
.0
1969
1974
32
28
24
20
16
12
8
4
0
RIVER MILES
COLD HARBOR BROOK
NORTH BROOK
ASSABET BROOK
NASHOBA BROOK
CONCORD RIVER
Sampling Stations
1 2 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 22

FIGURE 11

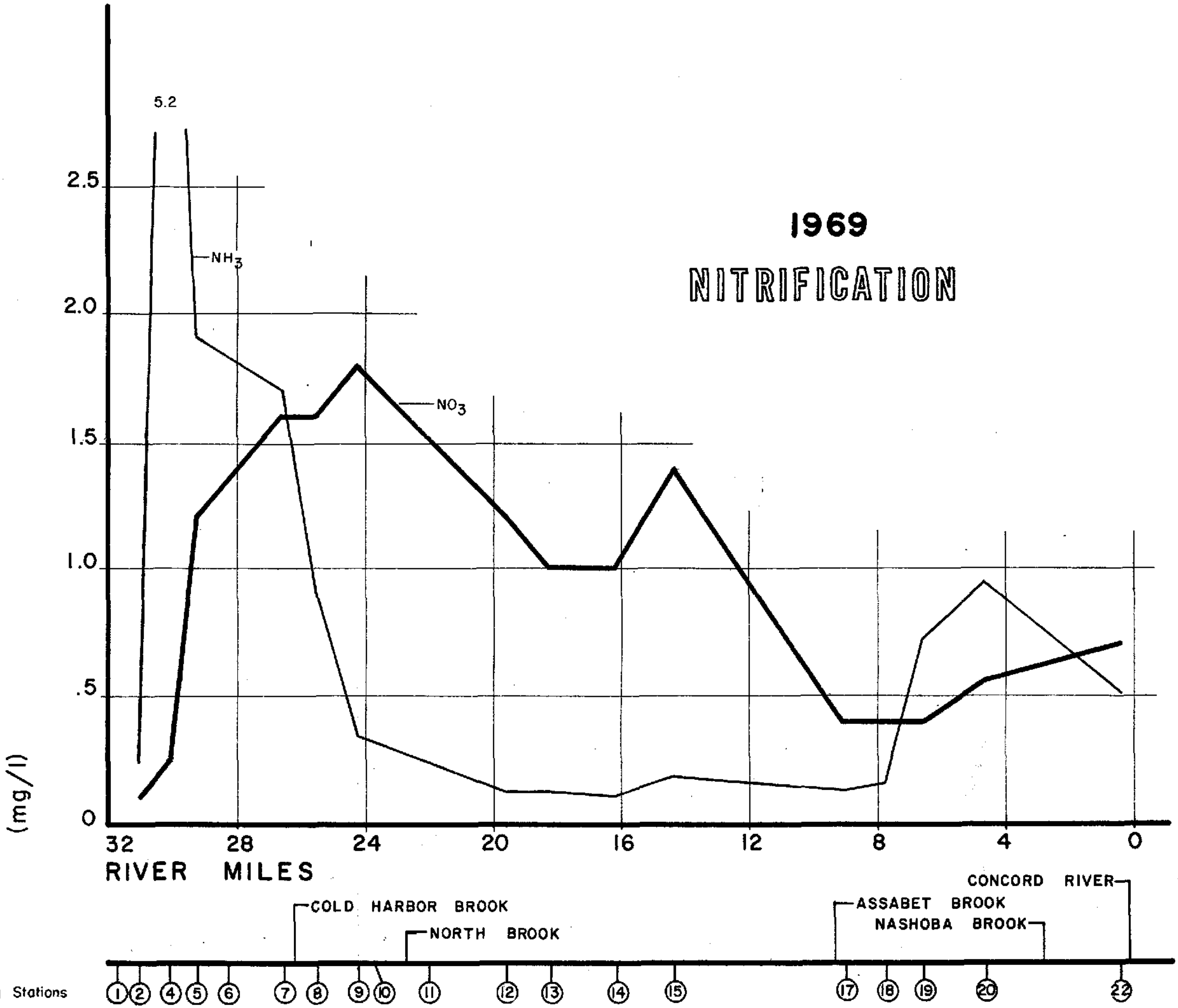

1969
NITRIFICATION
5.2
NH_3
NO_3
2.5
2.0
1.5
1.0
.5
0
(mg/l)
32
28
24
20
16
12
8
4
0
RIVER MILES
COLD HARBOR BROOK
NORTH BROOK
ASSABET BROOK
NASHOBA BROOK
CONCORD RIVER
Sampling Stations
1
2
4
5
6
7
8
9
10
11
12
13
14
15
17
18
19
20
22

FIGURE 12

41

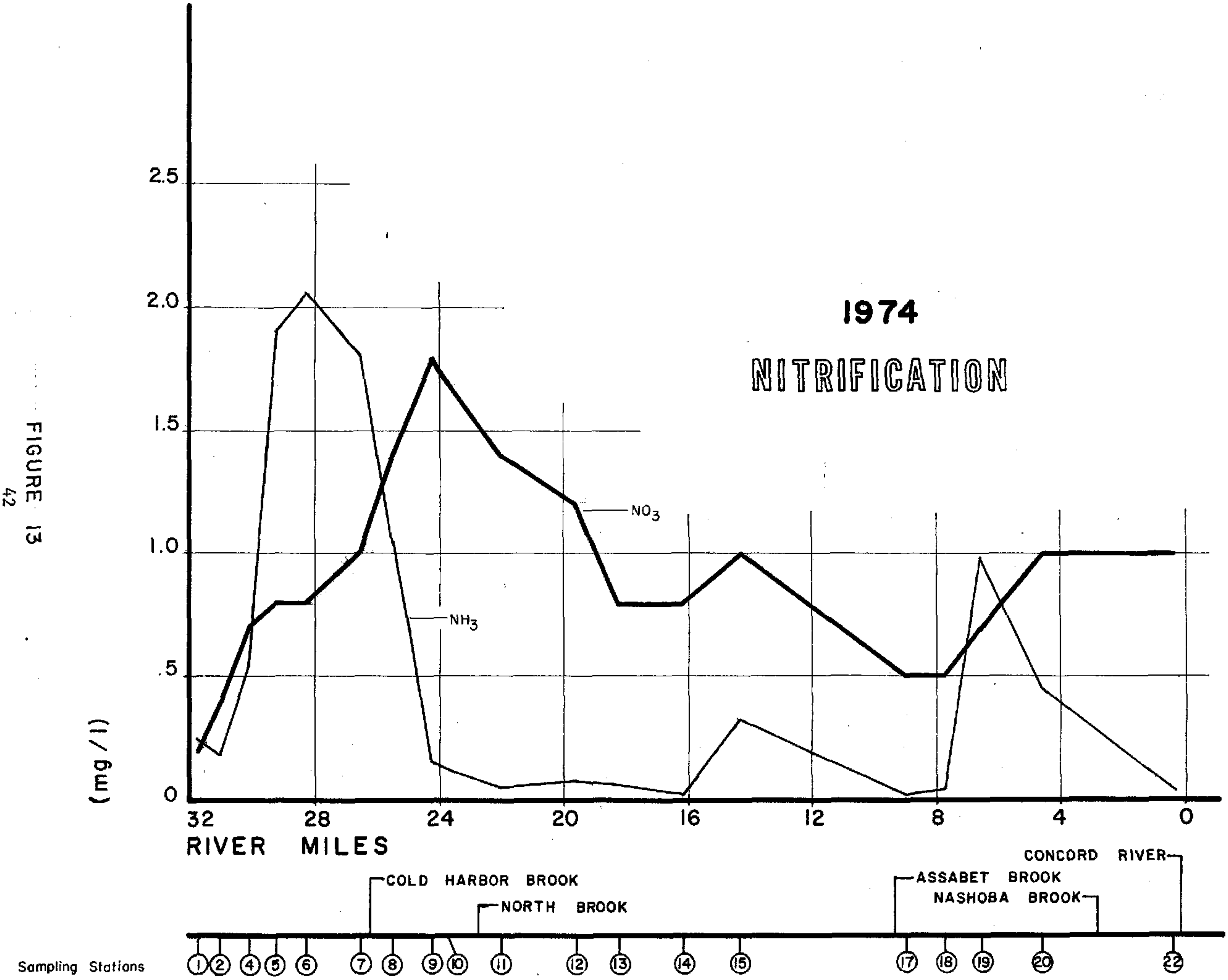

1974
NITRIFICATION
NO_3
NH_3
(mg / l)
2.5
2.0
1.5
1.0
.5
0
32
28
24
20
16
12
8
4
0
RIVER MILES
COLD HARBOR BROOK
NORTH BROOK
ASSABET BROOK
NASHOBA BROOK
CONCORD RIVER
Sampling Stations
1 2 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 22

FIGURE 13

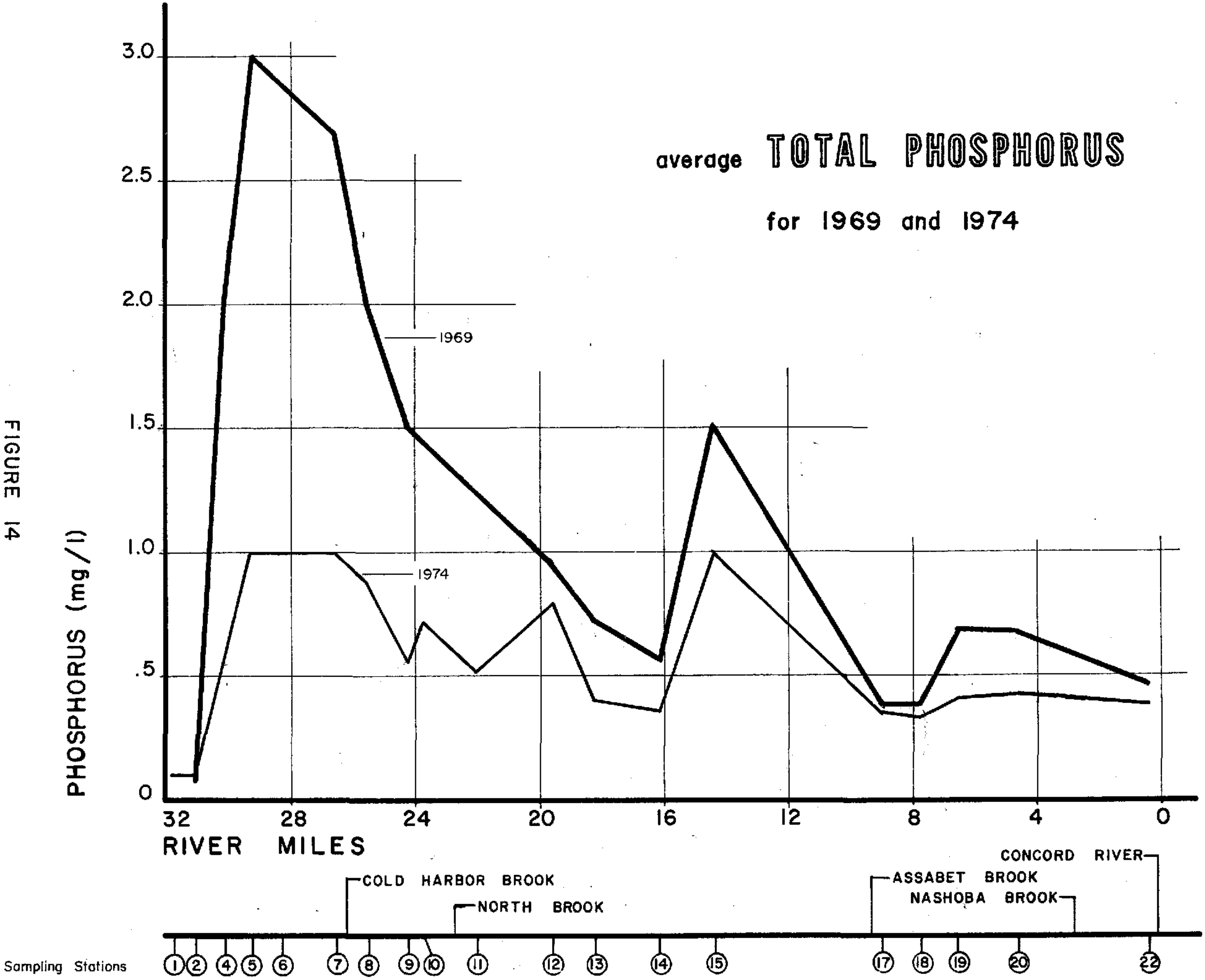
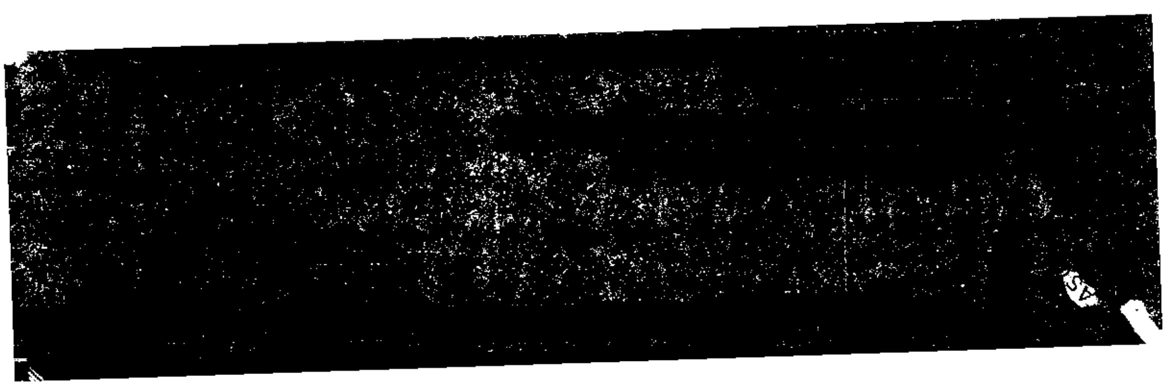
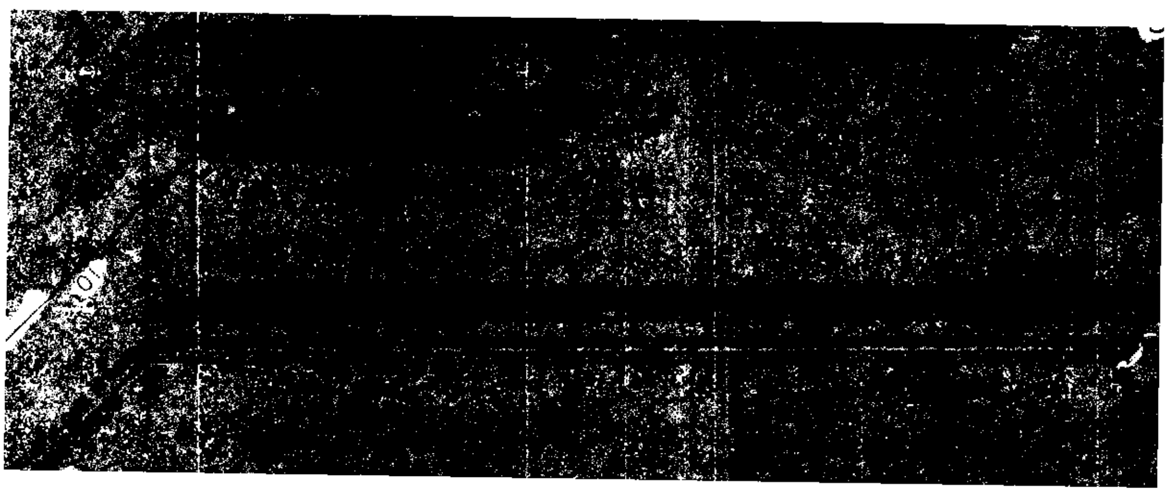

average TOTAL PHOSPHORUS
for 1969 and 1974
PHOSPHORUS (mg/l)
3.0
2.5
2.0
1.5
1.0
.5
0
1969
1974
32
28
24
20
16
12
8
4
0
RIVER MILES
COLD HARBOR BROOK
NORTH BROOK
ASSABET BROOK
NASHOBA BROOK
CONCORD RIVER
Sampling Stations
1 2 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 22

FIGURE 14





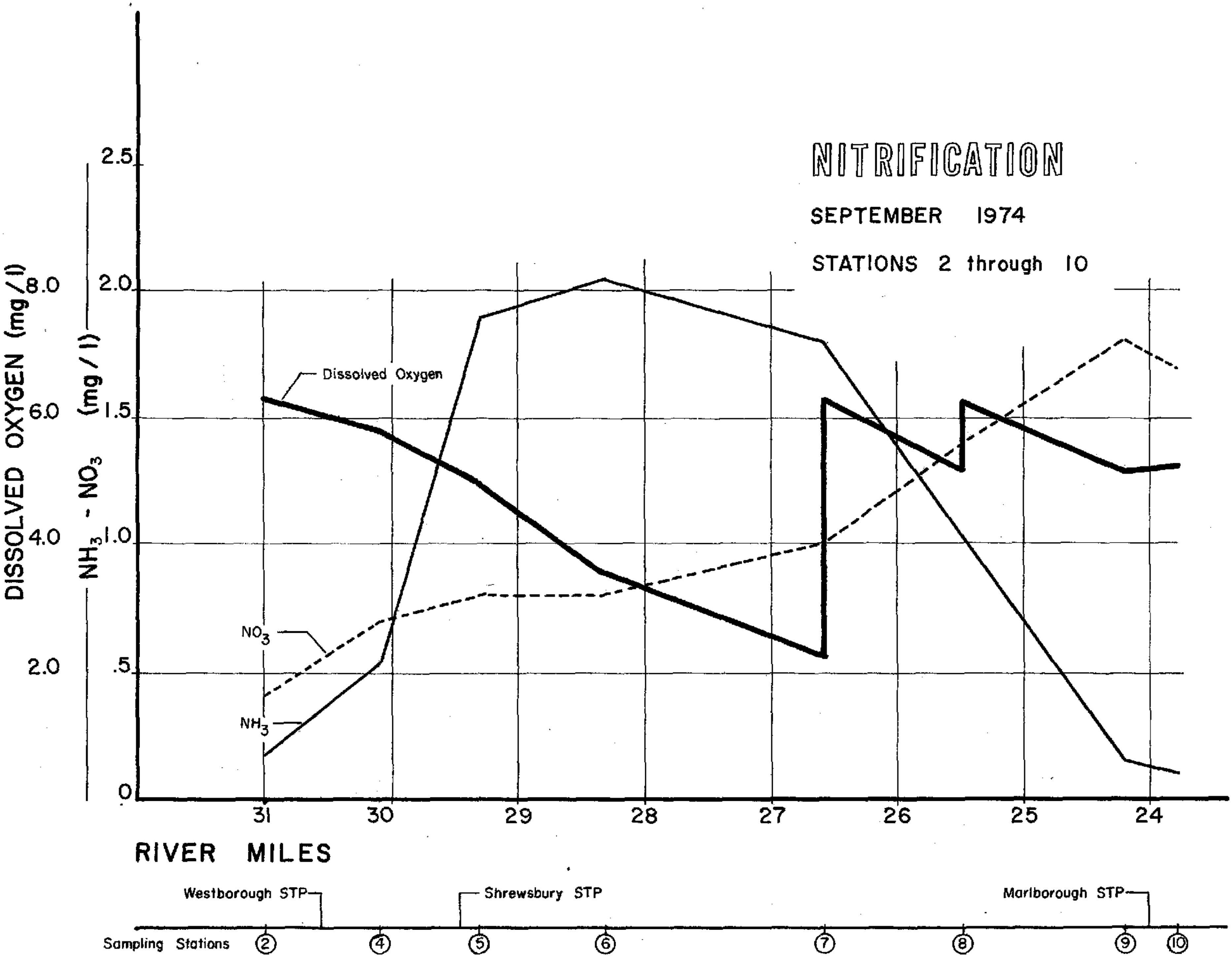

NITRIFICATION
SEPTEMBER 1974
STATIONS 2 through 10
DISSOLVED OXYGEN (mg/l)
NH3 - NO3 (mg/l)
8.0
6.0
4.0
2.0
2.5
2.0
1.5
1.0
.5
0
Dissolved Oxygen
NO3
NH3
31
30
29
28
27
26
25
24
RIVER MILES
Westborough STP
Shrewsbury STP
Marlborough STP
Sampling Stations
2
4
5
6
7
8
9
10

FIGURE 16

The nitrate level of 0.4 mg/l in 1974 was higher than the 1969 level of 0.1 mg/l. The quality of the water at this station has declined from 1969 to 1974, mainly due to the water coming from the upstream impoundment. The class B criteria were not met in this section of the river. The water in the impoundment may improve as less of the detritus remains to decay (either by natural decay or by a project to clean out the bottom of the impoundment).

Approaching the next station at Rte. 9, Westborough, two factors greatly affect the river. First, the river velocity slows considerably and secondly, (and most significantly) the Westborough Sewage Treatment Plant effluent enters the river a few hundred yards above Rte. 9. As was previously mentioned (pg. 21), the treatment plant was upgraded in 1971. Therefore, the best way to analyze this section of the river is to compare the 1969 and 1974 data. The average dissolved oxygen shows a major change, from 1.0 mg/l in 1969 to 5.8 mg/l in 1974. The ammonia and nitrate levels show a significant difference:

	NH_3	NO_3
1969	5.2 mg/l	0.25
1974	0.54	0.7

The reason for the differences is the upgrading of the Westborough Sewage Treatment Plant. In 1969, the BOD of the effluent was greater with carbonaceous demand dominant. In 1974, the oxygen demand was reduced, thus less of the stream oxygen was being used. Also in 1974, more aquatic growth was present because of the presence of nitrates ("food" for aquatic plants). The plants add some oxygen to the water. In 1969, the river was acting like the present secondary treatment plant which really just confines the area where the reactions take place. Even with the improvement from 1969 to 1974, the river does not meet the assigned class C standard.

As explained above, the Westborough Sewage Treatment Plant causes water quality problems at the Rte. 9 sampling station, just downstream of the effluent. The problems caused by the effluent are seen for miles downstream. One-half mile downstream from Rte. 9, the Shrewsbury Sewage Treatment Plant discharges its effluent into the Assabet River. The combined impact of these two treatment plant effluents causes the most serious water quality problems on the entire river. To properly evaluate these problems, we will examine the section of river most affected by the discharges--from sampling station 4 at Rte. 9, Westborough to station 9 at Boundary Street, Marlborough. The length of river between these stations is 5.5 miles. The discussion will deal mainly with the 1974 results. The table below and Figure No. 16 will be referred to during this discussion.

LAB ANALYSIS OF 1974 SAMPLES (mg/l)

STATION	D.O.avg.	D.O.min.	BOD-5	NH_3	NO_3	TOTAL P
4	5.8	4.8	4.4	0.54	0.7	0.55
5	4.9	3.9	8.0	1.9	0.8	1.0
6	3.6	2.5	7.2	2.0	0.8	1.0
7	2.2	1.2	4.0	1.8	1.0	1.0
8	5.1	3.3	4.5	1.04	1.4	0.88
9	5.1	3.3	2.4	0.16	1.8	0.55

At station 5, there is a significant increase in BOD_5, ammonia and phosphorus which reflects the presence of the Shrewsbury Sewage Treatment Plant effluent. This facility also provides secondary treatment which removes much of the carbonaceous BOD. As the river flows downstream, less carbonaceous BOD is present and more nitrogenous BOD is exerted. The BOD_5 at stations 6 and 7 declines, accompanied by a sharp decline in dissolved oxygen. The long term BOD analysis of samples at station 7 show that most of the BOD present is second stage or nitrogenous BOD. From station 4 to 7 nitrification is occurring at a slow but steady rate. The phosphorus level is stable because of the lack of algae to use the phosphorus as a food supply. Samples at station 7 were taken above the dam located at the sampling site. As the river flows over the dam, the water is aerated and increases greatly in dissolved oxygen content (2.2 mg/1 above and 6.2 mg/1 below). The increase in dissolved oxygen available to the nitrifying bacteria and the rapid section below the dam allow nitrification to occur at a faster rate. At station 8, above the Allen Rd. dam, the ammonia level has dropped to almost half of that at station 7. The nitrate level increases and the dissolved oxygen decreases at station 8. Nitrification occurred at a faster rate in the rapid section than in the impoundment above the dam. With the absence of a significant algae population to use phosphorus, the moderate decrease in phosphorus level was due to uptake by aquatic plants, settling and dilution.

As the river flows over the dam at Allen Rd., (station 8), the water is aerated and the dissolved oxygen increases to an average of 6.2 mg/1. The river flows rapidly through a shallow section for about one mile. The shallow water creates a large surface area for the nitrifying bacteria to attach themselves. The nitrification rate from station 8 to 9 is high (see Figure 16). At station 9, we see a large decrease in ammonia and an increase in nitrates. It is impossible to expect a one for one conversion of ammonia to nitrate because of the many reactions that the two nutrients undergo in a river system. Much of the ammonia is being converted to nitrate and some of the aquatic vegetation is using this nitrate.

The 1969 data reflects the same river conditions with the exception of higher phosphorus and ammonia levels found below the two treatment plant effluents. The dissolved oxygen sag was found at station 7 and nitrification occurred at its greatest rate between station 8 and 9 (see Figures 7 and 12).

With the low dissolved oxygen levels and the high nutrient levels, the section of river from Rte. 9 to Boundary Street does not meet the assigned classification. The cause of the poor water quality of this section of the Assabet River is attributable to the discharge of the Westborough and Shrewsbury Sewage Treatment Plants.

The next section of river to be examined is from station 9 at Boundary Street, Marlborough, to station 13 at the Rte. 85 dam in Hudson. This section is characteristically a slow moving and swampy area with large amounts of aquatic vegetation. Between station 12 at Chapin Road, Hudson and station 13, there is a large eutrophic impoundment about one mile long. The Marlborough West Sewage Treatment Plant discharges its effluent between stations 9 and 10 (see page no.21). It can be seen that the high quality effluent has little noticeable effect on the river.

The table below shows the lab analyses of the five stations of the 1974 samples:

STATION	D.O.avg.	BOD_5	$N.H._3$	NO_3	TOTAL P
9	5.1	2.4	0.16	1.8	0.55
10	5.2	2.6	0.11	1.7	0.72
11	6.4	2.2	0.04	1.4	0.50
12	5.9	2.6	0.06	1.2	0.78
13	6.4	2.6	0.05	0.8	0.40

At sample station 10, there is an increase in phosphorus due to the treatment plant effluent of 3.0 mg/l. With extremely low levels of BOD_5 and ammonia in the effluent, there is very little oxygen demand in this section of the river. The dense aquatic vegetation utilizes the nitrates and the phosphorus as a food source. The five stations exhibit some diurnal variation of dissolved oxygen because of the photosynthesis and respiration of the large amounts of aquatic vegetation. Lab analysis shows very small populations of algae present during the 1974 survey. For example, at stations 11 and 13, the following dissolved oxygen contents were found:

STATION 11

Time	0710	1055	1500	1940	2255	0254
Dissolved Oxygen mg/l	5.1	7.6	10.1	7.8	5.4	4.7

STATION 13

Time	0730	1113	1520	2000	2313	0312
Dissolved Oxygen mg/l	4.7	5.1	6.5	7.5	6.8	6.3

The dominant types of aquatic vegetation were duckweed (Lemna spp), pickerelweed (Pontederia spp.), pondweed (Potamogeton spp) and arrowhead (Sagittaria spp).

It is assumed that during periods of algae blooms, the diurnal variation of dissolved oxygen may be greater than that observed during the week of September, 1974. During weeks prior to the September, 1974 survey, visual observations showed that this section of the river had the characteristic "pea soup" green color associated with algal blooms.

The dissolved oxygen content of this section (and other impounded areas) is determined mainly by the following: (1) an abundance of nutrients for aquatic plant growth, (2) the photosynthesis of the aquatic vegetation, (3) the absence of any significant stream aeration and (4) the level of BOD present. The diurnal variation of dissolved oxygen is one of the reasons that this section does not meet its designated class B standard (i.e. dissolved oxygen never below 5.0 mg/l).

The data from the 1969 survey reinforce the same observations about this section of the Assabet River.

The next section of river is that which passes through Hudson Center, receives the Hudson Sewage Treatment Plant effluent and becomes impounded by a dam at Gleasondale. As the river goes through the Town of Hudson, there is evidence of urban runoff problems, or a possibility of a faulty sewage pumping station. As the river flows over the dam at Rte. 85, the water is aerated to an average dissolved oxygen content of 7.9 mg/1. The two sampling stations in this section of the river are No. 14 at Cox St., below Hudson center and above the treatment plant and No. 15 at the outlet of the Gleasondale impoundment. The 1974 analysis of the two stations shows both the existence of some pollutant source in the center of Hudson and the effect of the treatment plant upon water quality.

STATION	D.O.avg.	D.O.min.	BOD_5	NH_3	NO_3	Total P	Coliform
14	6.3	2.6	5.0	0.01	0.8	0.35	3600
15	3.2	1.4	4.5	0.32	1.0	1.0	1500

At the Cox St. station there is a significant rise in BOD, diurnal variation of dissolved oxygen and a higher level of coliform bacteria. The increase of these three parameters shows the evidence of some waste (e.g. urban runoff,faulty pumping station) going into the Assabet River in the center of Hudson. The exact source of waste is not known and needs investigation. The 1969 survey showed no increase in BOD, but an increase in coliform bacteria (4600 to 46,000). This again points out the possible presence of sewage or urban runoff. At station 15, there was an increase in ammonia, nitrate and phosphorus coupled with a sharp decrease in dissolved oxygen. This reflects the effects of the Hudson treatment plant effluent which is extremely high in ammonia and phosphorus (see page 24). The impoundment created by the Gleasondale dam creates a suitable area for nitrification to occur resulting in low levels of dissolved oxygen. In August 1969, with about half the flow as in October 1969 and with warmer temperatures, the dissolved oxygen levels were extremely low (3.5 mg/1 avg. and 1.1 mg/1 min.). In October, 1969, the dissolved oxygen levels were higher (5.3 mg/1 avg. and 4.0 mg/1 min.). However, the temperature was between 15-20°F lower in October. In 1974, the levels were very low (3.2 mg/1 avg. and 1.4 mg/1 min.). The Hudson Sewage Treatment Plant effluent definitely causes dissolved oxygen problems in this section of the river. The river does not meet its assigned C classification.

After flowing over the Gleasondale dam, the river flows for about one mile to the southeast, then flows to the northeast for about four miles to station No. 17, above the dam at Rte. 62 and 117. For these four miles, the river flows slowly through the apple country of the Town of Stow. In this section, the river has a chance to recover from the effects of the Hudson Sewage Treatment Plant. The 1974 analyses will show that at station 17, the river is in good condition:

	D.O.avg.	D.O.min.	BOD_5	NH_3	NO_3	Total P	Coliform
Station 17	8.4	6.2	1.8	.01	.5	.34	500

There is extensive aquatic growth in this section of the river with ample nutrients available for the vegetation. The area seems quite suitable for algae blooms during certain periods of the summer. In August, 1969, there was considerable diurnal variation as shown below:

STATION 17

Time	2300	0500	1000	1700	2300
Dissolved Oxygen	4.9	3.6	4.0	8.6	4.7

During the low flow of August 1969 the diurnal variation caused the river to fail to meet its B classification. The removal of a great percentage of the phosphorus from the Hudson Sewage Treatment Plant effluent may alleviate the diurnal variation caused by algae. However, even with phosphorus removal, there may still be enough phosphorus present in the effluent and in the overland runoff from the farmlands along the river to produce algae blooms. It may be unfeasible to stop the algae blooms.

As the river flows through the Town of Maynard, very little change is seen in the water quality at the next station at Rte. 27, east of the center of town. The 1974 analysis of the station is shown below:

STATION 18

D.O.avg.	D.O.min.	BOD5	NH_3	NO_3	Total P	Coliform
7.4	6.0	1.4	.04	0.5	.32	3500

The results show a rise in coliform bacteria from that found at station 17. The 1969 analysis shows a coliform count of 4600. Urban runoff is the probable cause of the rise in coliform bacteria. The B classification assigned to this section is not met because of these levels of bacteria. The phosphorus level was moderately high, while the ammonia level was very low. Dissolved oxygen levels are within the B classification.

The last section of river to examine is from the outlet of Powder Millpond at sampling station 19 to station 22, just above the confluence with the Sudbury River. Above station 19, the Maynard Sewage Treatment Plant discharges into the river in the impoundment created by Powder Millpond dam at High Street, Acton.

At station 19, we see the pattern below a treatment plant repeated again as shown in the 1974 analysis:

	D.O.avg.	D.O.min.	BOD5	NH_3	NO_3	Total P	Coliform
Station 19	6.8	3.7	3.4	.99	.7	.40	500,000
20	6.7	4.4	2.9	.45	1.0	.42	120,000
22	6.7	4.5	1.5	.04	1.0	.39	9,000

There is a rise in BOD and nutrients and a decrease in dissolved oxygen at the sampling stations downstream of the treatment plant. Nitrification occurs in Powder Millpond and increases as the Assabet flows downstream towards the confluence with the Sudbury River. As the river flows over the Powder Millpond dam, the water becomes aerated, increasing the oxygen content and the rate of nitrification. The decrease of ammonia levels at stations 19 to 22 shows increased nitrification (see Figure 13).

During the 1974 sampling, phosphorus was not being utilized rapidly because of the absence of a significant population of algae. In portions of this section of the Assabet, there is abundant aquatic growth which produces a diurnal dissolved oxygen variation even in the absence of algae. During the September, 1974 sampling, the following dissolved oxygen values were found:

STATION 20

Time	0357	0821	1210	1610	2005	2350
Dissolved Oxygen (mg/l)	5.3	5.7	9.1	9.1	6.3	4.4

During periods of the summer when algae blooms occur, a large diurnal variation of dissolved oxygen is expected to occur. During the August, 1969 sampling, the following results were found:

STATION 20

Time	0500	1100	1700	2300	0500
Dissolved Oxygen (mg/l)	3.8	8.8	9.7	3.3	3.6

During the surveys, the treatment plant did not chlorinate its effluent--thus the high levels of coliform bacteria. The river does not meet its class B criteria in this section of the river because of the low dissolved oxygen, the high level of nutrients and the very high levels of coliform bacteria.

The water of the Assabet River, at the confluence with the Sudbury River, can be characterized as being low in BOD, low in ammonia, high in nitrates and phosphates, high in coliform bacteria and having a wide diurnal variation of dissolved oxygen. It does not meet its B classification.

POLLUTION ABATEMENT PROGRAM

As seen in the section on water quality, little improvement has taken place in the quality of the Assabet River between 1969 and 1974. During that period, the Westborough Sewage Treatment Plant was upgraded to a secondary treatment facility. The present plant has helped improve the dissolved oxygen content of the river below the plant and partially reduced the amount of nutrients that are discharged into the stream. Also in that period, the Marlborough West Sewage Treatment Plant was built and put into operation, with its effluent discharging to the Assabet River. These two projects were the main changes affecting the Assabet River during the period 1969 to 1974.

Two minor water pollution projects were completed in the basin. A grit chamber was installed in the Shrewsbury Sewage Treatment Plant which should eliminate some of the operating problems at the plant. Also, the Town of Hudson built a new pumping station which is designed to eliminate the problem of overloading at the previous pumping station.

At the present time, the Maynard Sewage Treatment Plant is being upgraded to an activated sludge facility to replace the existing antiquated plant. The new plant is expected to be completed by September, 1975 and should produce a higher quality effluent.

A facilities plan is being developed for the Massachusetts Correctional Institute at Concord. The plan calls for the construction of an extended aeration treatment facility with effluent polishing.

In accordance with a plan previously set up by the Division for the Assabet River, all sewage treatment plants have (or soon will have) secondary treatment. The reasoning behind this plan was to assess the water quality of the river with secondary treatment at all plants. The results of the 1974 surveys definitely show that the Assabet River water quality classifications (see page 18) cannot be met with only secondary treatment. The nutrient levels of a secondary treatment plant effluent are much too high for the Assabet River to meet standards.

The abatement program for the development of advanced treatment plants on the Assabet River is only in its embryonic stages. Facilities plans for advanced waste treatment have not yet been developed but are part of the implementation program of the Division. Through the issuance of discharge permits (NPDES), municipalities are given definite dates for the development of a suitable water pollution control program. The program to date for the five municipalities with sewage treatment plants is as follows:

Westborough - must submit a facilities plan by May 1, 1977. This plan should reflect the need for advanced treatment and the possibility of regionalization.

Shrewsbury - must submit an engineering report by November 30, 1975. This report should reflect the need for advanced waste treatment and should study the possibility of regionalization.

Marlborough West - the permit states that the Regional Administrator of EPA and the Director of the Division of Water Pollution Control reserve the right to include an implementation schedule for the construction of nutrient removal facilities.

Hudson - must submit a facilities plan for wastewater treatment facilities by June 1, 1977.

Maynard - must submit an engineering report for upgraded wastewater treatment facilities by June 1, 1977.

The above permits are part of the overall plan of the Division to attempt to meet the water quality goals of PL-92-500 of the federal government and the Commonwealth of Massachusetts' standards. Part of this law is Section 303-e, (see page 54) which requires the formulation of a plan for water quality programs for all the basins in the Commonwealth (and the rest of the United States). This plan will be presented as the SUASCO RIVER BASIN - PART D 1975. The plan will be available to and reviewed by the general public. The contents of the plan will be presented at public meetings at locations within the basin.

PLANNING

The 1972 amendments to the Federal Clean Waters Act (PL-92-500) requires three types of plans to be formulated for the attainment of a comprehensive water quality management plan. The three plans are designated by the section number given to them in the amendments.

Section 201 is concerned with the preparation of a report for each municipal waste treatment facility. The plan will be prepared by an engineering consultant and will contain more comprehensive information than in previous reports. This report will include cost effectiveness analysis, evaluation of alternative flow and waste reduction measures, evaluation of alternative waste treatment management techniques, environmental assessment including social and economic impacts, identification of best practicable waste treatment technology, and an infiltration-inflow study of existing sewer systems.

Section 208 is concerned with area-wide wastewater management planning. The Governor designates the areas that have substantial water quality control problems and the representative organization capable of developing effective area-wide management plans. The designated representative will prepare a plan which includes: "the identification of treatment works necessary to meet the anticipated municipal and industrial waste treatment needs of the area over a twenty year period...the necessary wastewater collection system...a program to provide the necessary financial arrangements for the development of such treatment works." The plan should include a regulatory program to implement the plan; identification of those agencies necessary to construct, operate, and maintain all facilities required by the plan. The plan should also include the identification of non-point sources of pollution and the appropriate steps necessary to control those sources. The plan should identify the cost and the means of financing the implementation of such a plan.

Section 303 is a plan prepared by the Division that includes the following: the existing water quality of the river by segment; the identification of non-point sources; waste load allocations for each discharge; the present abatement program; the monitoring program for the river; the municipal needs for the communities in the basin; the future abatement strategy for the basin, including construction Priorities.

In the formulation of the basin plan (Section 303), the information provided by the Regional Planning Agencies is critical in the proper preparation of the basin plan. There are three planning agencies that represent communities within the Assabet River Basin. Table 9 shows the agencies and the communities that are included in their area. Figure 17 is a map of the communities and their designated planning agency.

The Central Massachusetts Regional Planning Commission prepared a regional sewerage study which included the identification of sewerage problems, the present and future needs and alternative plans to meet the sewerage needs. The report covered four communities (see Table 9 and Figure 17) in the Assabet River Basin.

The Metropolitan Area Planning Council prepared a report of the sewerage needs for the communities of Acton, Carlisle, Concord, Hudson, Littleton, Marlborough, Maynard and Stow. The report included future needs, construction costs and regional alternatives.

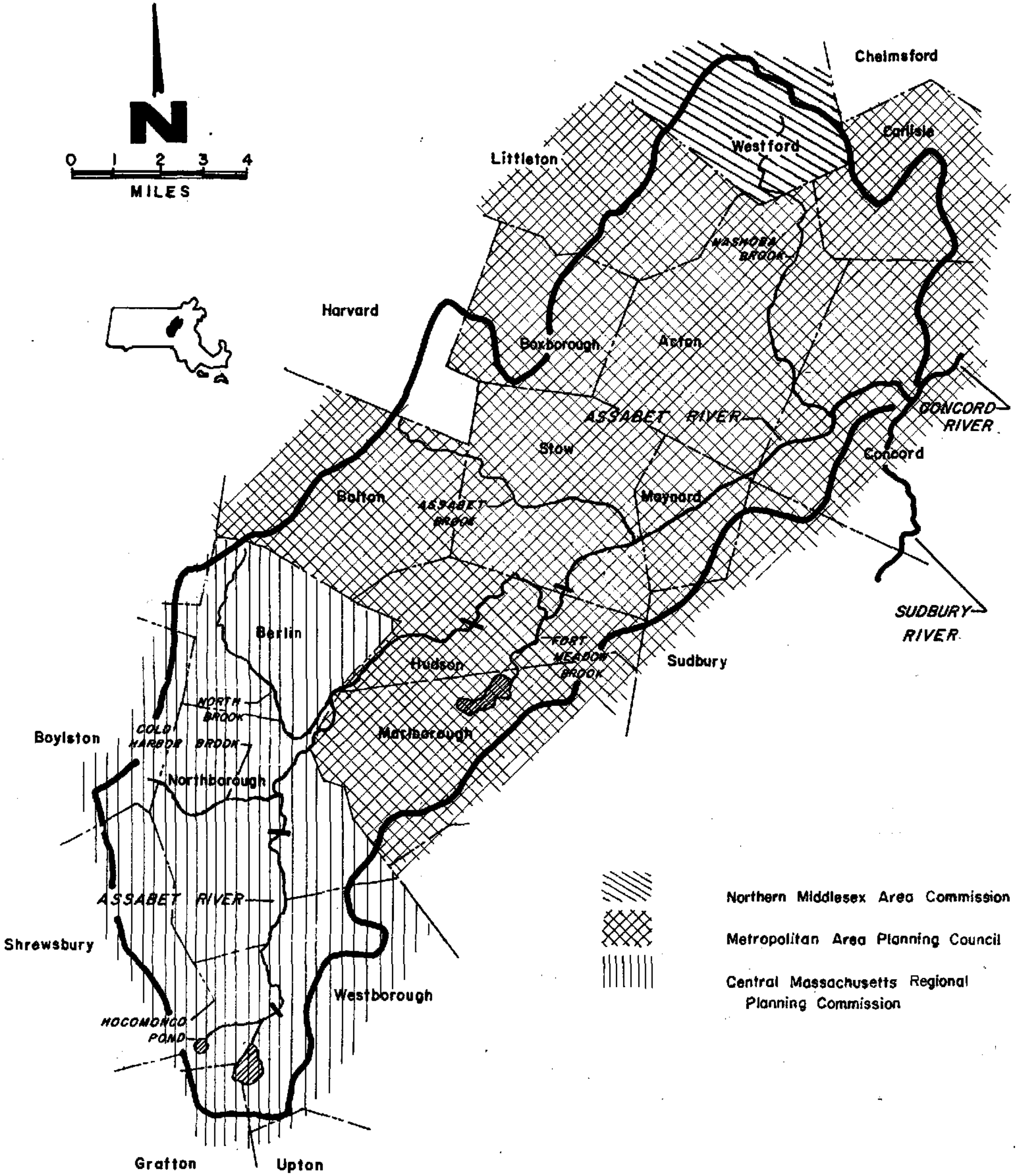
The Northern Middlesex Area Commission prepared a report that included the Town of Westford. The study included the existing problem areas, the municipal needs and plans to implement these needs.

TABLE 9

ASSABET RIVER BASIN

REGIONAL PLANNING AGENCIES

AGENCY	MUNICIPALITY
Metropolitan Area Planning Council	Acton Bolton Boxborough Carlisle Concord Hudson Littleton Marlborough Maynard Stow
Central Massachusetts Regional Planning Commission	Berlin Northborough Shrewsbury Westborough
Northern Middlesex Area Commission	Westford



REGIONAL PLANNING AGENCIES

FIGURE 17

OBSERVATIONS AND CONCLUSIONS

1. Interstate Highway 495, running through the basin, should continue to be an impetus to increasing manufacturing and economic development.

2. The projected population increases will be accompanied by increases in the effluent quantities from the sewage treatment facilities.

3. Because of its low flow conditions, the river cannot be used as a potential water supply.

4. With improved water quality, the stocking of trout would increase; without improvement the program may be stopped.

5. The Nichols dam project must have improved water in its discharge. The impoundment should be surveyed and possibly reconstructed. A definitive program must be established to give control and responsibility of the Nichols impoundment to the Water Resources Commission and the Department of Fisheries and Game. The flow to be released must be determined for definite periods of the year.

6. The removal of some (and possibly all) of the dams on the river may improve water quality. A program should be initiated to determine the practicality and feasibility of removing these dams.

7. Any new discharges added to the river must be treated to the highest degree of treatment available. Such an effluent could be beneficial to low flow augmentation.

8. The need of advanced waste treatment at the five municipal sewage treatment plants is vital. Nitrification and the removal of phosphorus should greatly improve the quality of the river. The eutrophic conditions can possibly be retarded and limited by the removal of these nutrients, but may not be eliminated due to nutrients from non-point sources.

9. The programs to abate pollution are several years behind, but with proper and realistic planning the river can be restored to a valuable resource.

FUTURE STUDY

In order to evaluate the progress of pollution abatement efforts being undertaken by the various communities in the Assabet basin, further study and research is necessary. The stream must be monitored to assess the anticipated improvement in quality of the water. To facilitate the continuing evaluation of the Assabet River, the following studies are recommended:

1. A yearly monitoring program of the Nichols impoundment should be established and necessary steps taken to improve the water flowing out of the impoundment.

2. A complete river survey should be conducted in 1979 in order to determine any changes in water quality. The survey should aid in evaluating the program set forth in the basin plan.

3. Time of travel studies should be conducted for various flows in order to provide a proper hydraulic understanding of the river.

4. Non-Point sources should be studied and recommendations made for their control or elimination.

5. The problem of eutrophication in the impoundments of the river should be further studied and if possible, recommendations made for the retardation of the problem.

6. The feasibility and the effects (both beneficial and detrimental) of the removal of some or all the dams on the river should be investigated.

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